Частина II

СТУДЕНТСТВО. НАУКА. ІНОЗЕМНА МОВА

Збірник наукових праць

Міністерство освіти і науки України

ХАРКІВСЬКИЙ НАЦІОНАЛЬНИЙ АВТОМОБІЛЬНО-ДОРОЖНІЙ УНІВЕРСИТЕТ

СТУДЕНТСТВО. НАУКА. ІНОЗЕМНА МОВА

Збірник наукових праць

Випуск 16
Частина 2

ТЕХНІЧНІ НАУКИ
ТРАНСПОРТНІ ТЕХНОЛОГІЇ

Харків
ХНАДУ
2024

УДК 33+621+004+009+620.9+5+61+34
ББК 65

Студентство. Наука. Іноземна мова : збірник наукових праць студентів, аспірантів та молодих науковців. Харків : ХНАДУ, 2024. Вип. 16. Частина 2. 326 с.

У збірнику подано статті іноземними мовами з викладенням результатів наукових досліджень студентів, аспірантів та молодих науковців у різних галузях, що можуть зацікавити світову наукову спільноту. Регулярні публікації робіт допоможуть виявити талановиту студентську молодь, здатну брати участь у міжнародному професійному, науковому та освітньому обміні та втілювати одержаний досвід у розвиток передових технологій.

Усі матеріали публікуються в авторській редакції.

Зміст

ENGINEERING

Aliev B. M

ELECTRO HYDRAULIC POWER STEERING SYSTEM

Language Advisor – Asst. Prof. Vorobiova S. V.

In 1994, Volkswagen produced the 3rd brand Golf Ecomatic, which used an electric pump so that power steering could work while the engine was turned off by a computer to save fuel. Electro-hydraulic systems can be found in some Ford, Volkswagen, Audi, Peugeot, Citroen, Skoda, Suzuki, Opel, MINI, Toyota, Honda, and Mazda vehicles.

Servotronic ensures that power steering is precisely speed-dependent, in which the number of connected servomotors depends on the driving speed, and thus provides even more comfort to the driver. The amount of gain is stronger at low speeds, such as when parking a car. More support makes it easier to manoeuvre the vehicle. At higher speeds, the electronic sensor system gradually reduces the level of control gain. In this way, the driver can control the vehicle even more precisely (with standard power steering, the power steering is completely switched off when the speed is increased). Servotronic is used by many automakers, including Audi, General Motors, BMW, Volkswagen, Volvo, Seat, and Porsche. Servotronic is a trademark of AM General Corp.

The system allows engineers to adapt the steering gear to the variable speeds and shock absorption of the suspension system, to achieve the perfect combination of smoothing ride and steering for each vehicle. On Fiat cars, the amount of gain can be adjusted by pressing a button labeled "CITY", which switches between two different turning paths, while most other EPS systems have a boost variable that allows for more assistance when reducing the vehicle's speed and less assistance from the system during fast driving. In the event of a failure of this component, mechanical connections such as the rack and gear roller serve as redundant, similar to a hydraulic system. Electric power steering is not to be confused with servo or wired steering systems, which use electric motors to drive the wheels, but without any mechanical connection to the steering wheel.

Electric systems have a slight advantage in fuel efficiency because there is no belt-driven hydraulic pump running at all times whether assistance is needed or not, and this is the main reason for their introduction. Another major advantage is the elimination of a belt-driven machine component, with multiple high-pressure hydraulic hoses between the hydraulic pump mounted on the engine and the control mechanism mounted on the chassis. This greatly simplifies production and maintenance. By engaging Electronic Stability Control, the electric power steering systems can instantly change the level of support by adjusting the torque to assist the driver with corrective manoeuvres. The maximum net power of the vehicle's electrical system limits the limits of the electrical assistance system's capabilities. A 12-volt electrical system, for example, is limited to 80 amps of current, which in turn limits the size of the motor to less than 1 kW. This amount of energy is more suitable for small sized vehicles. There are other types of electrical systems, such as 24-volt and other varieties used in hybrid cars and electric vehicles. They have a large output capacity, which allows the use of higher power engines required for large and medium-sized vehicles.

The first electric control systems appeared on the Honda NSX in 1990, the Fiat Punto Mk2 in 1999, the Honda S2000 in 1999, the Toyota Prius in 2000 and the BMW z4 2002. Today, many manufacturers use electronic controls.

Electrohydraulic power steering is - an electrically assisted power steering system from TRW which combines the advantages of electronically controlled, demand-based steering with robust hydraulic actuation. EHPS from TRW is the combination of a compact motor pump unit (MPU) and a conventional rack-andpinion steering. As other electrical steering solutions, EHPS operates independently of the combustion engine, reducing the fuel consumption of the vehicle.

Electro-hydraulic power steering system provides the same feel of a conventional hydraulic power steering system while improving fuel economy by using an electric motor to power the pump. The system is comprised of the electro-hydraulic pump assembly, control module and steering gear. The power steering module is on top of the pump, and the motor controls the speed of the power steering pump according to vehicle speed and steering angle. By changing the pump speed, the module controls the steering assist force. The control module is connected to the hi-speed CAN bus that ties the engine control module (ECM) and ABS module. The ABS module provides vehicle speed and steering angle, and torque data to the power steering system. The connection to the ECM allows the alternator to provide enough power when the pump is running. The control module monitors the hydraulic pressure output and temperature. After the engine started, the hydraulic pump electric power steering system performs a self-diagnostic test. If a malfunction occurs in the system, the fail-safe function stops the hydraulic pump or restricts operation.

When the hydraulic pump is operating and assist force is generated, the hydraulic pump electric power steering warning lamp is OFF. When the hydraulic pump electric power steering system is stopped by the fail-safe or protective functions and steering assist force is not being generated, the steering will go to a manual operation. The electric power steering warning lamp turns ON. The system is trying to prevent the pump from operating without fluid, which will damage the pump unit. The control module also monitors the temperature of the motor and pump. During regular operation, the fluid temperature should not exceed 194° F. When the system sees temperatures more than the limit, the warning lamp turns ON and assist is limited or turned off completely. There are several causes of excessive internal temperatures. For example, if the driver performs parking maneuvers for a long time with rapid movement of the steering wheel lock-to-lock, the pump can overheat. If the steering is held at full lock, the pump can overheat. When this happens, the system will store code C160A if an overheating condition has occurred. If the alignment is out of specification and the driver is fighting a steering pull, it can cause the power steering pump to work harder and generate more heat. It can also happen if the tire inflation pressure is not equal and the speed of the pump depends on the angle of the steering and the speed of the vehicle.

References

1. Markel, A. (2023). *Nissan Electro Hydraulic Steering*. https://www.import-car.com/nissan-electro-hydraulic-steering/
2. *Function Principle of Electro-Hydraulic Power Steering*. https://aftermarket.zf.com/us/aftermarket-portal/for-workshops/useful-tips/steering/function-principle-of-electrohydraulic-power-steering/
3. Semmel, D. (2016). *Hydraulic Power Supply*. https://link.springer.com/chapter/10.1007/978-3-319-05449-0_13

Anosov R. V.

TECHNICAL JUSTIFICATION OF THE CONSTRUCTION OF THE GENERAL-PURPOSE AGRICULTURAL TRACTOR

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Ukrainian agriculture needs wheeled tractors with a nominal hook pulling force of up to 30 kN, which can perform not only field work but also other farm maintenance operations.

A tractor engineered according to the assignment is related to the general-purpose agricultural tractor. Typically, tractor of this type is characterised by high engine power.

In order to rationally use engine power, mobile tractor units are created, that operate at higher speeds with the transfer of power to agricultural machines through power take-off shafts (PTOs) and combine processing operations. To do this, the tractor is equipped with a rear mounted device in accordance with GOST 10677-82 and a two-speed independent PTO shaft driven by the engine through a cardan gear and a two-speed variable hydraulic gearbox with an output shaft speed of 540 and 1000 rpm.

The tractor is combined with trailed machines using the TSU-1M (pendulum) or TSU-1Zh (rigid) coupling device according to GOST 3481-79.

Tractors are widely used with gearboxes that shift gears without interrupting the power flow. They are a transition to the stepless transmissions, that maintain high efficiency and improves control conditions.

The tractor is equipped with a stepped gearbox with permanent-mesh gears with on-the-fly gear shifting using hydraulic clutches.

Based on the analysis of the design of the tractor prototypes, following parameters of transmission components are chosen:

1. The main clutch – frictional, dry, double-disc, permanently closed.
2. Transmission – manual, with gear shifting by means of hydraulic lift clutches without interrupting the power flow.
3. The transfer case – two-staged.
4. Cardan gear – universal, rigid, open type with needle roller bearings.
5. Main gear – bevel spiral gear.
6. Final gear – single-stage planetary gearbox.

These transmission units are arranged on the tractor in such a way that the gearbox and transfer case are combined in a unit with the engine and main clutch at the front of the tractor, while the axles and final transmissions are also combined in separate units.

Today, more and more attention is being paid to improving working conditions, development of measures to improve tractor safety. At the operator's workplace the following is offered:

1. standardised seats with adjustable spring elements; control system are conveniently placed in the cab;
2. high vibration and noise isolation;
3. air conditioners and air filtration devices;
4. active and passive safety devices;
5. strong safety frame.

Analysis of the frame structures of Class 3 prototype tractors allows us to choose riveted articulated frames. It is distinguished by its simplicity of the constructions, low metal content and increased reliability.

The tractor's frame is a riveted articulated frame with transverse cast bars and ties, consisting of two half-frames: front and rear, connected by vertical and horizontal hinges. The vertical hinge is used to turn the tractor, while the horizontal hinge is used to adjust the wheels to the ground and relieve the frame of additional torsional forces.

A water-cooled diesel engine is placed on the front half-frame. The engine is started by the starter motor from the tractor driver's seat. Directly behind the engine located the tractor's power transmission mechanisms: clutch with spacer enclosure, gearbox and transfer case, mounted in separate enclosures and forming a single unit with the engine, mounted on the frame on rubber shock absorbers.

The transmission is manual, four-speed, with gears of constant grip, hydraulic pressure clutch and stroke reducer in combination with the transfer case, that provides twelve forward and three reverse speeds. The hydraulic system of the gearbox includes a hydraulic pump, intake filter, injection line filter, bypass distributor with safety valve, shift distributor with diverter valves, radiator with bypass valve, tank, hoses and pipework. The transfer case transmits torque to the permanently engaged front and disengaged rear axle of the tractor. A central brake is installed on the drive to the front axle. The transfer case enclosure the drives for the pumps of the hydraulic systems of the gearbox, steering and rear hinged attachment, as well as the gear for the independent PTO.

Wheel axle enclosures are flanged on the sleeves of the drive axle enclosures

Gearboxes, complete with wheel brakes, forming a single unit. The front drive axle is mounted to the semi-frame on semi-elliptical leaf springs. The rear axle is rigidly mounted to the half-frame.

The tractor is turned by "breaking" the tractor frame around the vertical hinge by the hydraulic steering system that can be angled to either side of the initial position.

In front of the engine, on the frame, there are water and oil engine radiators and oil cooler of the hydraulic transmission system. The engine and its systems are protected by a cowling with lifting sidewalls and quick-release shields that provide convenient access to engine components and assemblies.

The tractor wheels are fitted with same-sized low-pressure pneumatic tyres. By rearranging the wheels, the track of the tractor can be changed.

The tractor cab is a full-metal two-seater, mounted on the front half-frame on four rubber shock absorbers, sealed, thermo- and noise-isolated, equipped with ventilation and heating with windscreen blower.

An independently driven PTO gearbox is mounted on the rear half-frame to the lower spar frame shelves.

Rear attached device is leveraged, hydraulically operated, mounted on the rear half-frame.

Improvements to the suspension systems are aimed at reducing the compaction effect on the ground, increasing the service and smoothness of the ride.

Experience of operating tractors of this class in agricultural farms of various forms of ownership in the sector shows that tractors are used for transport work for a significant part of the time. This is due to the poor condition of roads and access roads, and the fact that the use of tractor is more cost-effective than the use of automobile vehicles for short-distance transport within the farm.

The use of universal tractors with low transport speeds on paved roads does not have the desired effect. It is economically impractical to use a tractor designed for transport work only.

The proposed tractor design can be used both for transport work and for a range of agricultural operations. This allows the tractor to be fully loaded at any time of the year. The use of the designed tractor makes it possible to release agricultural tractors from technological work not characterised for them. Especially during the autumn-spring off-road season, the use of this tractor, which has increased passability, preserves the life of motor vehicles and reduces operating costs.

References

1. Надикто, В. Т., Крижачківський, М. Л., Кюрчев, В. М., & Абдула, С. Л. (2005). *Нові мобільні енергетичні засоби України. Теоретичні основи використання в землеробстві*.

2. Білоконь, Я. Ю., Окоча, А. В. (2002). *Трактори і автомобілі.*

3. Лебедєв, А. Т., Антощенков, В. М., & Бойко, М. Ф. et al. (2004). *Трактори та автомобілі. Ч. 3. Шасі*.

Bielov D. O.

ASSESSMENT OF INCREASING THE ENERGY EFFICIENCY OF VEHICLES WITH RATIONAL REDUCTION OF ENGINE POWER

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At the end of the 20th century, energy saving as a type of practical activity and an important component of the scientific area related to energy became widely developed. This was preceded by two waves of the energy crisis of the 70s and 80s of the last century, humanity's awareness of the environmental hazard of man-made activities, as well as the limitation of natural resources, in particular, fossil fuels. The term “energy saving” encompasses a wide range of technical and economic issues. However, it does not clearly reflect the goals and objectives of this scientific and practical direction of engineering activity. It is more correct to talk about “energy efficiency” – the development of technologies, methods, technical solutions and economic mechanisms that contribute to the efficient use of energy resources.

On a global scale, improving energy efficiency is an integral part of the overall system, which includes natural and artificial (man-made) energy components intended for obtaining, transforming, distributing and consuming energy resources in social production. According to experts, the potential for energy saving in Ukraine is about 42–46% of the total consumption of energy resources. That is, their rational use practically makes it possible to abandon the import of fossil fuels to Ukraine (Podrygalo et al., 2015).

The trend towards a decrease in the displacement of internal combustion engines, which has emerged in recent years in the world automotive industry, is due to the need to improve the environmental situation and energy efficiency of road transport.

This article presents the results of the research, which made it possible to prove the possibility of reducing the power of the internal combustion engine while maintaining the given maximum speed and the given level of indicators of the dynamic properties of vehicles. The relationship between the increase in the degree of use of the rated power of internal combustion engines and the change in the effective specific fuel consumption for a carburetor gasoline engine, an engine with direct injection of gasoline and a diesel engine is determined.

Energy efficiency is an operational property that characterizes the rational use of engine energy (or other source of mechanical energy) in the process of performing transport work by a vehicle.

The aim of the study is to improve the energy efficiency of vehicles by rationally reducing the maximum effective engine power.

To achieve this goal, it was necessary to solve the following tasks:

– to determine the relationship between the degree of use of the maximum effective engine power and the effective specific fuel consumption;

– to assess the reduction of the vehicle’s fuel consumption with a rational reduction in the maximum effective engine power.

To determine the relationship between the degree of use of the maximum effective engine power and the effective specific fuel consumption, the load characteristics of carburetor gasoline and diesel engines given in the paper by Artyemov et al. (2012) are used.

A comparative analysis of the nature of the δg_e (δN_e) curves for different types of internal combustion engines shows that for CBD, a decrease in the degree of use of the maximum effective engine power δN_e entails an increase in the effective specific fuel consumption δge. A different picture appears in diesel and engines with direct gasoline injection, in diesel at $\delta N_e = 0.3$-0.96. $\delta N_e<1$. For an engine with direct gasoline injection, $\delta N_e<1$ at $\delta g_e=0.653$-0.982.

A reduction in fuel consumption was determined on the example of the ZAZ-1103 “Slavuta” car with a rational reduction in engine power.

An analysis of the calculation results shows that with a carburetor gasoline engine, a rational reduction in the maximum effective power can decrese the effective specific fuel consumption by 9.5%. This value is proportional to the absolute fuel consumption. It results in the fact that the expected reduction in fuel consumption will also be 9.5%.

When using engines with direct gasoline injection, on the contrary, a decrease in the maximum effective engine power will lead to an increase in effective specific fuel consumption. This increase will be 6.7%.

A similar situation arises when installing a diesel engine on ZAZ-1103 “Slavuta”. In this case, a decrease in the maximum effective power of the engine will lead to an increase in effective specific fuel consumption by 20.3%.

With these indicators, we can conclude the following:

1. The results of well-known scientific studies made it possible to draw a conclusion about the possibility of rational reduction of the maximum effective engine power while maintaining the specified maximum speed and level of dynamic properties of the vehicle.

2. Since the power realized is the same when installing a serial engine and an engine with a reduced effective power value, the degree of realization of maximum power in the latter case is higher. The relationship between the degree of use of the maximum engine power and the relative change in the effective specific fuel consumption of a carburetor gasoline engine with direct injection of gasoline and diesel is determined.

3. Calculations performed on the example of the ZAZ-1103 “Slavuta” car showed that a rational reduction in effective power allows for CBD to reduce fuel consumption by 9.5%, and for engines with direct injection of gasoline and diesel engines, this leads to an increase in fuel consumption by 6.7% and 20.3%, respectively.

References

1. Podrygalo, M. A., Abramov, D. V., Tarasov, Yu. V., & Yefimchuk, V. M. (2015). Energy economy of a car and its evaluation criteria. *Bulletin of the National Technical University "KhPI". Series: Automotive and Tractor construction.* 10(1119), 28-37.

2. Artemov, N. P., Lebedev, A. T., & Podrygalo, M. A. et al. (2012). *The method of partial accelerations and its application in the dynamics of mobile machines.* Miskdruk.

Bilenko R. O.

HOW TO BUY A USED HARLEY-DAVIDSON

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When it comes to buying a used motorcycle, the wisest choice is to buy a Harley-Davidson. There are two reasons for this. First, the analysis of the market shows that Harley-Davidson retains its value just like any other well-established brand today. Whether you are looking at a modern Twin Cam or a vintage Flathead, Harleys are a smart investment in terms of value and getting your money worth when the time comes to sell them. Besides, this American brand rewards its owners with riding comfort and pleasures. For over 100 years, Harley owners have enjoyed hitting the road on their motorcycles. This great American riding ritual shows no signs of slowing down, which means there should always be enthusiasts looking for buying the used Harleys.

These considerations lead to the next question: Which Harley model should you consider? The best Harley for you is the one you like. Do you want a vintage Harley, a motorcycle that is basic by today's standards but boasts an old-school character not found in any modern motorcycle? And if you prefer an older motorcycle, are you buying it for investment or as a racer? Will this be a bike you won't hesitate to take to the highway? Or do you want a newer Harley model that has all the features and conveniences that modern motorcycle technology has to offer, making it a bike you can ride anywhere, anytime?

Chances are, if you are shopping for a classic or vintage Harley, you are already familiar with some of the models. If you have analyzed the available information, you know exactly what you are looking for. If you are not as knowledgeable about these older motorcycles as you think you are when purchasing, it might be wise to find an expert you can rely on for valuable information and feedback. This can save you money in the long run.

The post-1983 era represents the "new" Harley-Davidson Motor Company. These are the years when the motorcycles were conceived and developed by members of the consortium that bought the company in 1981 from American Machine and Foundry (AMF). Although many different models have been offered since 1984, virtually all have been based on one of five basic platforms: Sportster (XL), Dyna (FX and its predecessor FXR), Softail (FX or FLS), Touring (FL) and V-Rod (VRSC).

In 1984, the Big Twin engine received its first major redesign since the OHV E model was introduced in 1936. The all-new 1984 Evolution V2 engine took Harley-Davidson to a higher level in the overall motorcycle market. The 80-cubic-inch alloy engine produced more power and consumed less fuel than the Shovelhead it replaced, and for the most part, its owners were rewarded with motorcycles that were as reliable as any Harley-Davidson model ever before.

But be careful: some 1984 and even 1985 motorcycles were built using parts and components carried over from the Shovelhead era. In an effort to maximize profits from the various new models, production managers collected remaining parts to adapt them to the new models. Some mechanics call these motorcycles "parts bin specials." Be careful with motorcycles of these years, as it can be very difficult to determine the exact part numbers.

By 1986, some of the technology used in the Evo was incorporated into the Sportster engine. The new Sportster engine was available in 883 cc and 1000 cc models. More changes came in 1999 when Harley introduced another design, the Twin Cam 88, to replace the aging 80-inch Evo engine that had been on the market since 1984 (Rides, 2023).

Despite these and many other engineering improvements, the heart and soul of the Harley V-twin design (Big Twins and Sportster) remains unchanged. The company can be said to be on the rise, offering enthusiasts modern classic motorcycles that combine the fun of everyday riding with the nostalgic charm and heritage associated with motorcycles of yesteryear.

Armed with this information, the process of buying motorcycles and checking them out to see if they're worth buying becomes a question of the "dos" and "don'ts" associated with purchasing any used motorcycle. So, let's talk about some basic dos and don'ts when buying a used Harley (How to buy a used motorcycle & used motorcycle, 2023).

Here is a word of caution: Some authorized Harley-Davidson dealers choose not to work on motorcycles that are 15 years or older. This means that their service center has absolutely no Evolution-powered Harleys – only Twin Cams, late-model Sportsters, and V-Rods.

When it comes time to take a closer look at the motorcycle, an important thing to consider is the number of add-ons that can be found on the motorcycle itself. It is a fact: Harley-Davidson owners love to personalize their motorcycles, so the chance of finding a completely original Harley or a Harley in factory condition is almost zero. On used Harleys you can usually find exhaust systems, seats, handlebars, handles, controls and pedals, passenger or non-female bars, wheels and tires, even custom paint.

Check for corrosion on the ends of the gas tank or fenders; there may be damage, such as a final drive belt or a bent wheel rim.

If you take a closer look, owners tend to choose at their own discretion accessories such as personalizing the original or standard exhaust system, seats, passenger seats, whether they add comfort.

Another thing to consider is motorcycle wheels. Harleys come with cast aluminum wheels and spoked rims. Cast wheels have a clear advantage; they allow you to quickly repair a flat tire on the road because they do not have a tube.

While the spoked rim gives the bike a more nostalgic look, those spokes also mean they have a tube on them, so you won’t be able to use a quick patch on them if you get a flat tire. They also take longer to clean compared to cast or polished forged wheels.

Also check for accident damage. Telltale signs of an accident often appear at the ends of handles and levers. Dents or scratches on the gas tank or fenders may be another sign of damage.

Chassis damage, such as a bent frame or fork legs, is more difficult to detect, but sometimes you can see that the frame is damaged by checking the final drive belt or chain alignment. Another way to check for bent chassis components is to look for unusual patterns of wear on the tire tread. If the fork is not aligned with the frame, the front and rear wheels will likely not be aligned. It is so simple.

You may also want to do a quick check of the engine, transmission, and primary drive first, checking for oil leaks. If they pass the test, ask the owner to start the engine and then listen for strange noises while the engine is idling. If the owner won't allow a test drive, ask to put the car into gear and gently release the clutch lever to feel resistance or slipping (and other strange sounds). After stopping the engine, check again for oil leaks to be sure.

These are just a few quick tips to get you started on your search for a used Harley. Perhaps the best advice is to be patient and take your time when inspecting your motorcycle. Try viewing it in daylight to see all the details. Finally, if the bike looks really good, it might be worth spending a little more money on a qualified mechanic to take a closer look at it.

References

1. Rides, B. (2023). 5 Reasons to Buy a Second-Hand Harley-Davidson. https://medium.com/@bossrides/5-reasons-to-buy-a-second-hand-harley-davidson-c51658e9b9b5
2. How to Buy a Used Motorcycle & Used Motorcycle FAQs. (2023). https://www.harley-davidson.com/us/en/content/expert-advice/how-to-guides/how-to-buy-used-motorcycle.html

Biriukov V. O.

ANALYSIS OF THE PROBLEMS OF THE ROAD CONSTRUCTION AND REPAIR MARKET

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In accordance with current legislation, technical supervision is carried out by the customer for the purpose of monitoring compliance with design decisions and requirements of state standards, building codes and regulations, as well as monitoring the quality of work performed and their scope during the construction or alteration (including through demolition) of the facility urban planning.

Architectural and construction control is carried out by state architectural and construction control bodies in accordance with the Law "On architectural activity", the procedure for technical supervision during the construction of an architectural object, approved by Resolution No. 903 of the Cabinet of Ministers of Ukraine dated

July 11, 2007, but this applies to works during new construction, reconstruction and major repairs.

Resolution No. 1065 dated December 28, 2016 "On approval of requirements for quality control of works on new construction, reconstruction and capital repair of public highways." According to the State Construction Regulations, quality control is a set of technical and organizational measures for effective quality management at all stages of the creation of a construction object, including:

1. control of quality indicators of materials, products, structures and equipment;
2. control of technological processes;
3. ensuring the execution of construction works in compliance with the requirements for:

– fire safety;
– people's safety;
– impact on the environment;
– exposure to noise and vibration.

That is, for those works where the legislation provides for putting them into operation (construction, reconstruction and major repairs), state (DABI bodies) and production control (contractor), author's (general designer) and technical supervision (customer) are carried out.

According to data provided by Ukravtodor in 2018, road works were distributed as follows:

Construction – 12.68%

Reconstruction – 7.99%

Overhaul – 19.23%

Current average repair – 43.25%

Operational maintenance (removal of pitting) – 16.84%

Summarizing by types of work for which quality control is carried out:

Construction, reconstruction, overhaul – 40%

Current average repair (operational maintenance) – 60%

That is, the indicator for 2018 has improved, as the percentage of average current repairs that were not subject to architectural and construction control by state bodies previously reached almost 90% (88.2%).

Nataliya Forsiuk, director of the National Secretariat of GOST in Ukraine, repeatedly pointed out the problem of the prevalence of repair road works without mandatory state control. In particular, she noted that the quality of the road surface is under control at the state-owned enterprise, which is part of the management of Ukravtodor. The structure belonging to the customer controls the objects of the same customer[1].

Today, 4-level quality control of works is carried out:

1. Customer control (regional road services, certified inspectors).
2. Road quality control – a service in Ukravtodor (222 objects checked) a condition is written in the contracts that prohibits payment to the Customer without a positive conclusion of this service).
3. Engineering supervision – as a rule, on objects financed by MFIs. However, with the adoption of Resolution No. 1065, it is planned to extend this type of control to all objects.
4. Public control.

Regarding quality control of works by independent consulting engineers, in accordance with Resolution No. 1065 of December 28, 2016, they relate only to new construction, reconstruction, and capital repair of public highways and relate to objects whose design began on January 1, 2018.

The performance of technical supervision of the construction of public highways by a consulting engineer does not relieve the public highway management body and the contractor of responsibility for the quality of road works.

In particular, the consulting engineer is obliged to: monitor the quality and volume of road works performed by the contractor; carry out an inspection and assessment of completed road works, which will be impossible to carry out at the next stages of their implementation (hidden works); monitor the contractor's compliance with the schedule of road works approved by the customer; supervise the implementation of input and operational control by the contractor; carry out continuous or selective control of the quality and volume of completed road works using visual and instrumental control methods, etc. within the framework of technical supervision of the construction of public highways.

Along with this, the consulting engineer has the right: to inspect road works during their execution; to require the contractor to perform work in accordance with the approved project documentation, to comply with the requirements of building regulations; require the contractor to submit executive documentation for road works; submit written demands to the contractor's officials on the elimination of violations and the causes of their occurrence; to require the contractor to eliminate identified violations within the established time frame; to require the contractor to take measures to eliminate identified violations that occurred during the execution of road works that do not meet the design documentation, the requirements of building regulations, as well as the execution of road works that were not actually performed by the contractor; to submit proposals to the customer regarding the termination of the contract for the performance of road works with contractors who systematically violate the rules of their performance.

The contract between the customer and the consulting engineer is concluded based on the results of the tender for the purchase of road consulting services conducted in accordance with the requirements of the Law of Ukraine "On Public Procurement".

The interaction between the consulting engineer and the contractor is carried out in accordance with the schedule of road works agreed and approved by the customer. The consulting engineer is legally responsible for the road consulting services provided.

References

1. Притоманов, В., Иельник, З., & Шляхетко, А. (2019) *Зелена книга Будівництво та ремонт автомобільних доріг. Офіс ефективного регулювання* BRDO.

Boiko D. S.

MODERNISATION OF THE ELECTRONIC INJECTION SYSTEM ON THE MEMZ-245 ENGINE

Language Advisor – Asst. Prof. Shamray O. V.

The modernization of the national MeMZ-245 engine is an urgent matter. This engine has a long history. It has equipped many national cars. However, over time, it became clear that this engine was becoming obsolete and was in need of modernization. The engine's most obsolete system is the one that feeds the fuel mixture into the cylinder and emits the exhaust gases. This system creates a layered mixture in the combustion chamber.

The direct fuel injection system has the same sensors as the LH2.2-Jetronink system. Direct injection is a fuel delivery system common in modern cars with gas and diesel engines. Rather than a fuel/air mixture entering the engine's cylinders through the intake valves, an injector sprays fuel directly into the combustion chamber in an engine with direct injection: The IDI system has a small swirl chamber above the cylinder, where the fuel is injected; there is also a glow plug in the chamber, needed to help start the engine. In the DI system, the injection nozzle is fixed to the top of the combustion chamber. The piston is generally crown-shaped to create a swirl of air: the system control unit has various settings. The Bosch high-pressure direct injection system for petrol engines is based on a fuel tank and fuel rail, into which the high-pressure fuel pump pumps fuel at the required pressure, up to 12 MPa. Thanks to this high pressure, the fuel can be injected directly into the combustion chamber using piezoelectric injectors (in the early types of system, electromagnetic injectors were used).

The throttle valve controls the flow of air into the engine. The mass air flow meter calculates the quantity of air entering the engine. To monitor the quality of the mixture, an oxygen sensor is placed in the exhaust pipe - a λ probe, which can measure the value of λ from 0.8 to infinity.

Analysis of the engine's fuel injection system has led to the conclusion that this injection system is perfect in its indicators. The most realistic way to modernize this system is to change the method of mixture formation, i.e. to rework certain elements of the injection system and the engine itself to move from an external method of mixture formation to an internal mixture formation. A striking example of such a system is the GDI (Gasoline Direct Injection) system. The gasoline direct injection system is more economical than traditional systems for injecting fuel into the intake manifold of internal combustion engines.

The advantages of the in-cylinder injection system are as follows:

– reduced NOx and CO emissions thanks to layer-by-layer mixing and the additional exhaust gas neutralizer;

– 10-15% reduction in fuel consumption;

– increased engine efficiency thanks to improved fuel evaporation in the internal combustion engine cylinder and modified heat exchange with the walls.

Engine efficiency is enhanced by improved fuel evaporation in the engine cylinder and changes in heat transfer to the cylinder walls. Direct injection is another effective way of optimizing combustion and increasing efficiency.

A gasoline engine uses simple principles. It sprays fuel more abundantly, mixes it better with air and uses the finished mixture more efficiently in the engine's various operating modes. The aim is to achieve greater efficiency while maintaining or even increasing power and reducing harmful emissions. The main advantage of direct injection is that the engine runs at idle with a very lean mixture, with an air/petrol ratio of up to 40:1.

The main component to equip the system is a direct-acting piezoelectric nozzle. Piezo atomizers work by applying an alternating electrical current to a piezoelectric transducer, which causes it to vibrate at ultrasonic frequencies. This vibration is then transferred to a liquid, which breaks up into a fine mist of droplets. Piezoelectric elements have a unique characteristic whereby the element elongates or vibrates when an external voltage is applied, similar to how it generates electricity when external pressure is applied

The linear movement of the piezoelectric element's head is transmitted to the plunger, which presses on the lever (petals) and raises the nozzle needle. Its main weakness is the lack of flexibility in production. The petals of are supported by a nozzle, which is screwed into the nozzle body at the end of the nozzle assembly. On the other side of the nozzle, body is a plastic connector that receives fuel from the fuel rail. From the connector, fuel enters the needle area through a channel in the body and a hole in the plunger.

The connector is fitted with electrical terminals to supply an electrical signal to the piezoelectric element. The needle lift height is 0.1 mm and the plunger stroke is 30 µm. The compression force of the piezoelectric element is 1000 N. The proposed injector differs from the injectors of world-renowned fuel system manufacturers, such as Bosch and Siemens, in the reduced number of parts and the fact that the injector is based on a packaged piezoelectric element. This explains the injector's lower price. The injector nozzle is manufactured specifically to fit the injector in an adapted spark plug. In the spark-generating process, the injector acts as a ground, meaning that a spark slides between the spark plug electrode and the injector, igniting the fuel mixture obtained previously.

Thanks to this upgrade, the engine meets all declared environmental, fuel efficiency and speed standards. Specifically, effective power has increased by 10%, torque by 15% and the quantity of harmful substances in the exhaust gases by 25%.

References

1. Авраменко, А. М., Тесленко, Е В., & Єфремов, А. О. (2022). *Методичні вказівки до виконання розрахунків основних деталей двигунів внутрішнього згоряння на міцність у курсових і дипломних проектах студентів спеціальності 142 Енергетичне машинобудування*. ХНАДУ.

Bondarenko A. E.

DEVELOPMENT OF THE ROAD NETWORK OF UKRAINE

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Capital investment in the road sector is a proven driver of economic development in the world. The construction of new roads and improvement of the quality of the existing network contributes to the emergence of new transportation routes, better allocation of productive forces, and more efficient use of the country's resources.

Today, Ukraine's worn-out road infrastructure is one of the obstacles to increasing the country's competitiveness in the foreign market. This is due to the fact that for a long time Ukraine has been financing roads on a residual basis, based on budgetary capacity. Since 2017, road development has become one of the priorities of the Ukrainian government and active road construction has been carried out on many problematic sites, but the aggressor's invasion of our territory has stopped this process.

The length of the road network in Ukraine is about 170 thousand kilometers (including Crimea and the temporarily occupied territories in the East of Ukraine), including 166 thousand kilometers of paved roads and 3.6 thousand kilometers of unpaved roads. About 52 thousand km are roads of state importance (international, national, regional, territorial) and 117 thousand km are roads of local importance (regional, district).

The density of the road network is 5-7 times lower than in Western Europe and the United States, at 280 meters per 1 km2 of territory. In terms of road quality, Ukraine ranks last in international rankings. For example, according to the World Economic Forum, in 2018, Ukraine was ranked 123rd in the world out of 137 countries participating in the ranking, between Zimbabwe and Costa Rica.

The quality of Ukraine's roads varies considerably from one section to another, depending on their importance to the country's economy. Most international and national roads are in satisfactory condition, but some sections of local roads are in poor or disrepair.

According to the World Economic Forum's Infrastructure sub-index, Ukraine was ranked 78th out of 137 countries with a score of 3.9, showing a drop of 3 points from the previous year and 10 points compared to 2014, being at the level of Vietnam (3.9 points), Armenia (3.9 points), Argentina (3.9 points) and Tunisia (3.8 points).

The development of the road network in any country of the world is, on the one hand, a consequence of its economic development, and on the other hand, one of the key factors contributing to this development. The United States is a good example. Since the 50s of the last century, the construction of highways has become one of the priorities of government policy. Today, the United States has the most developed highway network in the world, with a length of 6.5 million kilometers, which has had a significant impact on the development of the economy. This includes significant regional development, reduced logistics costs for carriers (resulting in the creation of a single national market and making goods more competitive in foreign markets), and reduced road accidents.

The benefits received by the US economy from the implementation of the highway network project are estimated at trillions of dollars. According to American experts, for every dollar invested in road construction, the economy received more than $16 in GDP growth over 40 years from the date of project completion.

It should be noted that not only for the United States, but also for most developed countries in Western Europe (Germany, Italy, France) and Asia (China, Japan), infrastructure development, including the road network, is one of the priorities of state policy. The rapid development of the economies of each of these countries was accompanied by the active development of the road network. For example, today the world leader in road construction is China, whose economy has been developing rapidly over the past 15 years. Every year, the country produces more than 1 billion tons of cement and builds about 30 thousand kilometers of highways. Almost all of China's highways have been built over the past 20 years.

For obvious reasons, the main pre-war presidential project, the Great Construction, slowed down sharply in 2022. For example, in the first nine months of last year, the state road fund received UAH 16.7 billion. According to the Accounting Chamber, this amounted to 15.6% of the annual plan. For comparison, in the same period of 2021, the road fund revenues amounted to UAH 93.3 billion.

In the first months of the full-scale war, the government stopped capital spending on road repairs. In particular, in March, the Cabinet of Ministers withdrew UAH 7.13 billion accumulated for the Big Construction project and transferred it to the state budget reserve fund. It is from this fund that the Ukrainian army and the needs of the defense industry are financed.

Among the key losses for Ukraine's economy due to poorly developed road infrastructure are the following: a decrease in the country's investment attractiveness. The presence of roads of unsatisfactory quality (more than 90%) and a poorly developed road network actually repel investors, both foreign and domestic, which hinders the country's economic development. Increase in logistics costs for transportation companies, which leads to higher product costs that are passed on to the end consumer.

The consequences of this development of the road infrastructure also include increased costs for vehicle repairs due to poor road quality (cars break down more often); increased fuel costs due to a poorly developed road network - routes are becoming longer (by 20-30%) compared to Europe; traffic jams, especially in large cities; and increased road accidents.

Uneven roads (pits, potholes, ruts), traffic jams, which require a lot of time. This is especially true in the capital and major regional centers, which causes discomfort for drivers and passengers, irritation, and leads to an increase in road accidents. Today, the mortality rate in Ukraine's traffic jams is 5-6 times higher than in European countries (taking into account the motorization factor: the number of cars per 1000 inhabitants in Ukraine is 2-3 times less than in most Western European countries).

In this difficult time for us, road construction does not cease to be a lever in the economy, but it is clear that "Big Construction" is not possible and has been officially suspended since the large-scale invasion. However, this does not mean that construction in the country has frozen. Even under martial law, construction is still necessary. For example, in the Ternopil region, the construction of a traffic interchange on the M-19 Domanovo-Chernivtsi-Tereblechia highway has resumed. This is a highway of international importance on the route to Romania (humanitarian aid is brought in and goods are exported), and it really needs to have a good capacity. The cities are under the threat of rocket attacks, but businesses need to work: grow food, bake bread, there are many needs that need to be met regardless of the fact that there is a war in the country.

References

1. Притоманов, В., Мельник, З., & Шляхетко, А. (2019). *Зелена книга Будівництво та ремонт автомобільних доріг,* 9–21.

2. *Альбом типових проектних рішень конструкцій земляного полотна автомобільних доріг загального користування. АД А.2.4- 37641918-006:2018. Державне агентство автомобільних доріг України, Національний транспортний університет. 2018.* (2022). Укравтодор, ДП «ДЕРЖДОРНДІ».

3. *Державні будівельні норми України. Автомобільні дороги. Споруди транспорту. ДБН В.2.3-4:2023*. (2023).

Budko A. O.

HISTORY OF CONSTRUCTION OF CEMENT CONCRETE COATINGS

Language Advisor – Asst. Prof. Ponikarovska S. V.

Both in general history and in historical and technical works, the issue of highway development has not been given enough attention until now. In published general historical works, little is said about roads and even automobile roads, mainly attention is paid to waterways and railway transport. As for the issue of highway construction technologies, with the use of materials and mechanisms, they are mainly considered only in technical works.

The relevance of the article is due to the price competitiveness of cement-concrete coatings, associated with a significant increase in the price of bitumen and a slight change in the cost of cement. On the other hand, with the increase in the intensity of traffic on highways and the number of heavy vehicles in the traffic flow, there are objectively increased requirements for the strength and durability of the coatings, the safety of vehicles and their minimal impact on the environment. To the greatest extent, these requirements are met by cement-concrete coatings.

However, the events of recent times forced to put another reason in the first place in justifying the relevance of this article – the energy security of the state, which is ensured by partial substitution of imported bitumen or oil, as a raw material for its production, with domestic cement.

Cement concrete is the main competitor of asphalt concrete. A service life of 20-25 years before repair is common for cement concrete pavements in the USA, and in the Netherlands, Germany and Austria it often exceeds 30-40 years, which is about 2-3 times longer than the repair life of asphalt concrete.

Hard means a coating whose stiffness and strength are practically independent of temperature, load duration and humidity, and cement concrete is just such a coating. The stiffness and strength of the asphalt concrete pavement significantly decrease with an increase in temperature or an increase in the duration of the load.

Road cement concrete is not a panacea for two primordial domestic problems, no matter how many experts and road users think otherwise. According to various data, the prevalence of cement concrete on roads around the world is only 10-60%.

Thus, the distribution of cement concrete roads in some developed countries is as follows:

– Germany – 12 thousand km or 25% of state roads;

– USA – 100,000 km (400,000 km based on a 2-lane road);

– Ukraine – 2.1 thousand km less than 1.3%, and should be at least 25 ... 30% of the total network and 50% for roads of higher categories.

In Germany, the ratio of cement concrete is: asphalt concrete coverings on the road network was 70%:30% in the 70s; 80-x 60%: 40%, the second half of 90s 38%: 62%, that is, it constantly increased with increasing loads.

Before talking about the new, let's remember the long-forgotten old.

Until the 20s of the last century, Ukraine was part of various empires on the periphery, so the development of roads was appropriate. The main transport artery is the unpaved Milky Way from the Crimea to the center and western Ukraine, through which salt was supplied, food and bread were transported, and it fell into disrepair due to the condition of the roads, which became impassable during the spring and autumn roadlessness and due to the development of the railway in the 1970s and 1980s last century The appearance of cars with internal combustion engines in the late 1890s and the subsequent motorization caused a rapid development of roads, including those with cement concrete surfaces.

In 1892 Balefontein (USA – state of Ohio) first built a pedestrian path, and then a street with a cement concrete surface. The composition of cement concrete was T:P:W = 1:1.5:3. The first modern concrete pavement of city streets was built in 1905 in Chicago and in 1909 in Detroit, USA. Sections with a length of about 1.6 km served for 60 years. This event is marked as the century of the appearance of the first concrete roads.

The first recommendations for the construction of concrete coatings were issued in 1925.

The first airfield concrete pavement was built in Michigan in 1928 and Ohio in 1929. The first network of concrete highways (approximately 14,000 km) 1926–1933 (Germany). In the USA in 1930, 59,064 km of concrete roads were built on Portland cement. The first recommendations for the construction of concrete highways – in 1933.

At that time, in the former USSR, it was recommended to build dirt roads. The successes of the leading countries were seen, and at the beginning of the third five-year plan (which was to last from 1938 to 1942) in the former USSR, the construction of roads with a cement concrete surface began. However, in the conditions of local frosts, when the soil was overmoistened, the inhomogeneity of the unreinforced sand base, the laying of concrete slabs 18-24 cm thick, connected by reinforcement, turned out to be unsuccessful: the coatings quickly collapsed.

The first airfields made of hexagonal concrete slabs were built after 1945 (Zhuliany airport). (Boryspil Airport – military sector airfield, dismantled BU-813 in the process of reconstruction).

The first road made of cement concrete began to be built in 1949 on the section Kyiv – Kovel in the Volyn region.

Concrete roads in Ukraine, as in the entire former USSR, began to develop relatively actively in the 1960s-1980s. In numerical terms, actively means hundreds and thousands of kilometers, and not tens, as it was before on the eve of the Second World War.

The impetus was the visit of Secretary General Nikita Khrushchev to the United States. He was impressed by the quality and prevalence of concrete roads and, upon returning home, ordered the purchase of an American concrete placing kit with a sliding formwork. In order to spread this business in practice, domestic mechanical engineering in the image and likeness of this wonderful technique established the production of concrete pavers with sliding formwork, profilers and seam cutters.

References

1. Гамеляк, І. П., Корецький, А. С., & Корецький, С. С. (2013). Про необхідність будівництва в Україні автомобільних доріг із цементобетонним покриттям. *Дорожня галузь України*, 46-51.

2. Толмачов, С. М. (2013). Будівництво автошляхів з цементним покриттям в Україні – реальність сьогодення. *Автомобільні дороги. Будівництво.* (4), 36-40.

Chabanov I. O.

ANALYSIS OF GEODETIC SURVEYING METHODS

Language Advisor – Asst. Prof. Ponikarovska S. V.

The term geodetic surveying is a generally accepted concept applicable to all types of surveying performed in geodesy. The choice of a certain type of work from a wide variety of different methods of obtaining and processing information depends on the requirements and further scope of application of the survey results

When performing a geodetic survey, the mutual plan-height location of specified points on the ground is investigated, which are the main ones in identifying the characteristics of an object. This kind of work allows you to get topographic plans and maps in paper and electronic form, as well as in digital terrain models. Topographic surveying is a set of field and desk-based works to determine the relative plan-height location of characteristic points of the terrain, performed in order to obtain topographic maps and plans, as well as their electronic analogues – electronic maps and digital terrain models.

Topographic surveying can be performed for construction sites, landscape work, and design. This type of geodetic survey is especially needed in construction, air and sea navigation, mineral prospecting, and geophysical work. But at the same time, this type of research is not always used exclusively for engineering purposes: the work of topographers and surveyors also needed when drawing up maps for tourists and drivers.

Theodolite surveying, like other surveys, is carried out according to the basic rule of geodesy "from the general to the specific". Before carrying out measurements on the ground, all the tops (turning points) of polygons and passages, depending on their purpose and the timing of the work, are fixed with stakes, poles and other signs. After the points are fixed, the angles and lengths of the sides of the polygons and lines are measured. Before measuring the lines, prepare to remove stones, bushes, bumps, etc. from the measured line. The lengths of the sides of a theodolite course (inclined ranges) are measured using steel tapes, roulette, and various rangefinders.

Tacheometric survey is the type of topographic survey that produces a plan of the area with a detailed image of the relief. It is performed for a small area of land on a fairly large scale (from 1:500). Specialists in the field of geodesy recognize the effective and cost-effective solution of using a total station survey for laying power lines, roads, and pipeline routes.

Surface leveling. In this case, we are talking about surveying on the ground, during which points are located with using certain rules, the height of each is determined using geometric leveling technology. Most often, the method of squares and highways is used in practice. As a result of the work, a detailed image of the relief is obtained.

Depending on the chosen method, surface leveling can be carried out to obtain a topographic survey of an open area of terrain that has a smooth relief, to create a vertical layout and to make accurate calculations of the volume of land works on a large scale (within 1:500 to 1:5000). In this case, the height of the relief should be between 0.1 m and 0.5 m.

Laser scanning. This 3D scanning technology allows you to prepare 3D models and 2D documentation for any industrial or engineering facilities. It is a modern alternative to traditional surveying technologies in case the traditional methods are unable to provide sufficiently accurate and complete information about an object due to problems with its accessibility and security. The main areas of application for this type of topographic survey are open pit mines, building structures under repair, tall objects, factory workshops, hydraulic facilities, road junctions, railways, tunnels, and bridges.

Aerial photography is carried out using various aircraft (usually drones) in cases where ground work is not possible at all. For example wetlands, landslide areas, and areas contaminated with chemical waste. The result of survey depicted in digital orthophotomaps and models. The main areas of usage of aerial photography are urban planning, agronomy, environmental research, large-scale cadastral work, and it is actively used by the military, archaeologists, and builders. In cartography, this technology is used to update maps and plans.

Geodetic surveying is a complex and important process that requires a high level of accuracy and professional expertise.

The method of trigonometric leveling has proven to be effective in determining the elevation differences of points on the ground using trigonometric calculations and known geodetic points.

The satellite geodesy method allows you to obtain the geospatial coordinates of points on the ground using satellite navigation systems such as GPS. This method provides accurate results over a wide range of scales and geographic areas.

Photogrammetric surveying methods and tools allow you to obtain spatial information using aerial photos and image processing. This is an effective way to obtain detailed geospatial data, especially in hard-to-reach or large areas.

To summarize, geodetic surveying uses a variety of methods, equipment, and techniques to obtain accurate geospatial data that are important in the modern geodesy and cartography. Only a combination of different approaches allows to obtain complete and reliable results of geodetic surveying for various tasks and disciplines. Each of these surveying methods has advantages and disadvantages, but by using them all, there is a possibility to survey any terrain accurately.

Reference

1. Баран, П. І. (2012). *Інженерна геодезія*.
2. Островський, А. Л., Мороз, О. І., Тарнавський, В. Л. (2012). *Геодезія.*
3. Войтенко, С. П. (2012). *Інженерна геодезія*. (2-ге вид.).

Danilenko O. S.

FAST ANNEALING OF COLD ROLLED STRIPS WITH ALUMINUM ALLOYS

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Cold-rolled thin-rolled products are made using cold sheet stamping technology, which has a number of undeniable advantages - a high metal utilization ratio, low energy consumption, and a fairly low cost of production in mass production (Sologub, Rozhnetsky, & Nekoz et al., 2002; Aftandilyants, Zazymko, Lopatko, & Polishchuk, 2017). For cold-rolled sheet aluminum alloys that are not strengthened by heat treatment, in order to increase plasticity and improve stamping, recrystallization and low annealing of rolled products in garden furnaces are used (Aftandilyants, Zazymko, Lopatko, & Polishchuk 2017; Kutsova, Pogrebna, Khokhlova, Myronova, & Nosko, 2004; Horbatenko, 2012).

However, such annealing often does not meet modern requirements for the properties of rolled products, so as the influence on the quality of the product of the duration of heating, the atmosphere of the furnace design and the method of its management are not taken into account. As a result, in the practice of enterprises that manufacture parts from sheet blanks using cold stamping methods, poor-quality stamping of blanks often occurs, which leads to significant economic losses, because aluminum alloys have a rather high cost (compared to iron-based alloys, about 5 times more expensive). There are no methods of improving the deformability of the already finished sheet, because heat treatment furnaces use rolled steel and are not suitable for improving the quality of the blanks. It is also not possible on industrial equipment to obtain individual rolled rolls with increased properties and improved surface quality at the request of consumers.

As evidenced by the experience (Doshchechkina, 2021) and few literature data (Jones, 2000) it is possible to improve the properties and the ability to qualitatively deform and thus reduce the shortage of blanks intended for cold stamping of products by applying annealing with continuous high-speed electric heating of a cold-rolled sheet by the contact method. The work is devoted to the solution of this important problem.

Thin-sheet blanks from cold-rolled deformable aluminum alloys AD1, AMц, AMг3, which are not strengthened by heat treatment, were chosen as the object of research.

In order to weaken cold-rolled strips with a thickness of 1 mm, the strips were subjected to continuous recrystallization high-speed annealing in a unit with heat exchange contact drums.

The microstructure was studied using a metallographic microscope UIT MicroMet – I–102 BD. To reveal the microstructure, a pickling agent was used for etching aluminum-based alloys – 10 g of sodium hydroxide per 100 ml of water. Mechanical properties were determined after tensile testing using standard methods.

The surface quality of the sheet was evaluated according to the surface roughness, which is regulated by GOST 4784-97. The surface roughness and profile were determined using a profilometer-profilograph TR 200, in accordance with the ISO 4287-1997 standard.

The ability to draw during cold stamping of sheet aluminum alloys in different states was assessed by the Eriksen technological test. Samples in the form of tape with a width of 40 mm. and a sheet thickness of 1 mm. were used for the test. The length of the sample ensured the extrusion of three holes with distances between the centers not less than the width of the sample and from the ends not less than half of this size.

The possibility and expediency of continuous high-speed recrystallization annealing of cold-rolled strip and strip blanks from AD1, AMg3, AMc alloys with a thickness of 0.5 to 1.2 mm. has been established in order to increase technological plasticity without loss of strength and improve cold pressure treatment when obtaining finished products.

Rational energy-saving annealing regimes have been developed, which provide cold-rolled sheet alloys with a fully recrystallized fine-grained structure with the best combination of strength and plasticity characteristics and high surface quality.

For the annealed AD1 alloy, which is used in the largest volumes for semi-finished products in a soft state, an interval of the degree (from 10 to 15%) of further mechanical tempering has been established in order to obtain indicators of increased strength in combination with sufficient plasticity, which is required by high-quality production of products by methods of cold deformation with deep and sometimes complex drawing.

The possibility of easy adjustment of the temperature regime of continuous annealing, as well as the uniform heating of the sheet (strips), make it possible to obtain metal with different degrees of tempering (slander) by partial weakening of the cold-rolled metal due to incomplete recrystallization, which cannot be achieved by annealing in garden furnaces.

High-speed continuous recrystallization annealing according to the developed temperature and time parameters can be recommended for improving the stamping of blanks from the already finished sheet of deformable aluminum alloys, which will lead to a reduction in scrap, saving metal and reducing economic costs in the manufacture of thin sheet products by cold deformation with deep and complex drawing.

References

1. Sologub, M. A., Rozhnetsky, I. O., & Nekoz, O. I. et al. (2002). *Technology of structural materials.* (2nd ed). Vyshcha shk.

2. Aftandilyants, E. H., Zazymko, O. V., Lopatko, K. G., & Polishchuk A. V. (2017). *Construction materials technology and materials science. Synopsis of lectures. Ch.II, Metallurgy*. NUBiP.

3. Kutsova, V. Z., Pogrebna, N. E., Khokhlova, T. S., Myronova, T. M., & Nosko, O. A. (2004). *Aluminum and alloys based on it: Study guide. for students technical of universities. National metallurgist.* Acad. of Ukraine. Porogy Publishing House.

4. Horbatenko, V. P. (2012). *Non-ferrous metals and alloys: textbook for students. higher education classes, which teach. in the direction of training Engineering Materials Science*. DonNTU Higher Secondary School.

5. Doshchechkina, I. V. (2021). Reducing the shortage of sheet blanks made of steel 08 intended for cold stamping. *Bulletin of the Khnadu.* (94), 47-54.

6. Jones, W. (2000). *Investigation of the effect of recrystallization annealing on the structure and mechanical properties of cold-rolled sheets of aluminum and its alloys*.

7. Vilitok, Y. A. (2019). *Statistical processing of the results of drawing studies by the Eriksen method. Technical sciences*, (2).

Datsina Y. H.

POST-TENSIONING SYSTEMS

Language Advisor – Asst. Prof. Vorobieva S. V.

This article discusses the application of post-tensioning of reinforced concrete structures with the DYWIDAG system.

DYWIDAG systems for post-tensioning of reinforced concrete structures are globally recognized for their exceptional reliability and outstanding performance. They are suitable for use in virtually all areas where reinforcement tensioning is required "on the concrete". They cover the entire spectrum of building structures -

from transportation facilities to civil and industrial buildings, in construction both above and below ground.

Reliable corrosion protection methods for DYWIDAG post-tensioning systems contribute to the durability of modern structures. The high fatigue strength is achieved by optimized material selection and careful selection of all components when assembling the system.

In the post-tensioning industry, an extremely versatile product range provides cost-effective solutions for virtually any technical application. Despite their high level of technology and technical sophistication, post-tensioning equipment is easy to operate at all stages: assembly, pushing, tensioning and, finally, injection.

DYWIDAG post-tensioning systems consist of the following components:

– rope fittings;

– corrugated ducts;

– anchoring elements.

Rope fittings. The rope is made of 7 separate cold-drawn wires, 6 outer wires are spirally wound around one central wire. The physical and mechanical properties of the rope, as well as its corrosion protection are of the utmost importance to DYWIDAG.

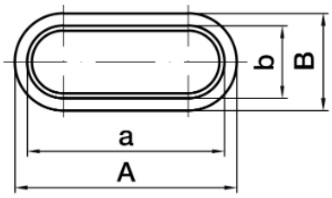
As a rule, ropes are supplied in so-called coils, which can weigh up to 3.5 tons.

Technical characteristics of the ropes are given in Table 1.

Table 1. – Technical characteristics of the ropes.

CODE/SPECIFICATION TYPE	UNITS	ASTM A 416		UNITS	ASTM A 416	
		0.5" (13mm)	0.6" (15mm)		0.5" (13mm)	0.6" (15mm)
Yield Strength f_y 1)	ksi	243	243	N/mm²	1,670	1,670
Ultimate Strength f_u	ksi	270	270	N/mm²	1,860	1,860
Nom. Diameter	in	0.5	0.6	mm	12.7	15.24
Cross-Sectional Area	in²	0.153	0.217	mm²	98.71	140
Weight	lbs/ft	0.52	0.74	kg/m	0.775	1.102
Ultimate Load	kips	41.3	58.6	kN	183.7	260.7
Modulus of Elasticity	ksi	28,000	28,000	N/mm²	195,000	195,000
Relaxtion after 2) 1,000 h at 0.7 x 9013	%	2.5	2.5	%	2.5	2.5

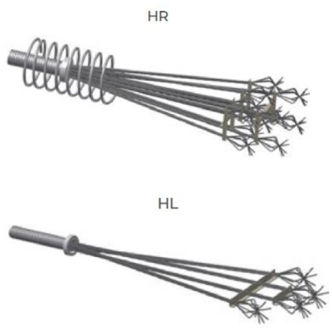
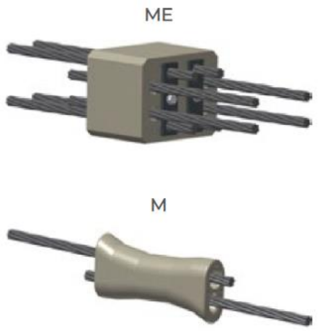
Corrugated channelizers. There are three types of channel formers: metal, round and flat made of polyethylene/polypropylene (PE/PP).

	**Metal channelizers** are the most cost-effective method of creating voids for prestressed ropes. These thin-walled corrugated channels, made of 0.25-0.60 mm thick metal sheet, are able to provide secondary corrosion protection along with excellent adhesion between the rope bundle and the concrete.
	**Round channelizers** made of polyethylene / polypropylene (PE/PP) provide long-term secondary corrosion protection, especially in aggressive environments (e.g. in wastewater treatment plants, acid tanks, silos or de-icing salt storage facilities).
	**Flat channelizers** made of polyethylene/polypropylene (PE/PP) are used for tensioned bundles of 3 to 5 ropes.

Anchoring. The anchoring of beams in the channel formers is performed by using different types of anchors, each of which is designed for specific purposes.

	The *MA multi-plane anchor* is used for longitudinal beams in the construction of bridges and other beam structures. The design of the anchor from separate parts (anchor block and body) makes it possible to insert the ropes after the structure has been concreted in the formwork.

	The *SD anchor*, consisting of one part, is designed for tensioning slab structures as well as for transverse stressing of bridge structures. Small "in light" and center-to-center distances of the anchors allow for efficient use of the anchors in compressed conditions.
	The *ED anchor* consists of two parts (anchor block and body), which can be used in slabs and similar structures, for example, in the transverse stressing of bridge roadway slabs.
	*Coupler P*, fixed, is designed to connect already installed and tensioned bundles. The coupler consists of a multi-plane anchor body and a coupler anchor block in which the ropes overlap. The ropes that are not interrupted can be installed independently of the others, without any difficulty
	The *D Coupler* is used to lengthen unstressed tendons in segmental bridge construction. The coupler consists of two spring-loaded wedges that connect two strands individually
	*HV loop anchoring* is often used in large slab structures (e.g. for reinforcement tensioning in retaining walls or liquefied natural gas storage tanks, which are subject to mostly static loads). The 180-degree loop is located in the center of the rope bundle to ensure that there is no slippage when the bundles are pulled from both ends simultaneously.

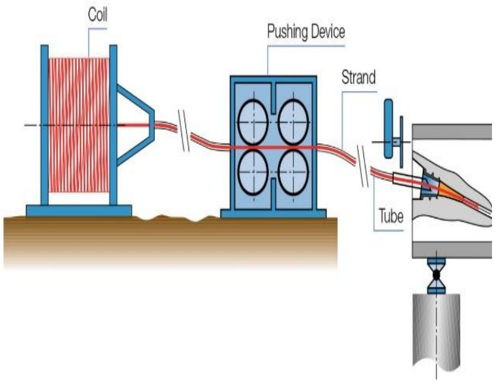
	The *HL/HR* blind anchor is typically used on pre-manufactured rope bundles, but can also be installed on the construction site. For this purpose, the rope wires are plastically deformed to ensure reliable force transmission up to the anchor's load-bearing capacity under both static and dynamic loads.
	The *Coupler M/ME*, a movable anchor block, is used in symmetrical shell structures (such as water tanks, cooling towers, vaults, large diameter pipes, etc.) that require post-tensioning in a circular manner.
	The *FMA flat multi-plane ancho*r is designed to carry up to 5 ropes with a diameter of 0.62" in one plane. They are intended for post-tensioning of thin-walled elements such as the top plate of box girder bridge structures (in the transverse direction).

The peculiarity of the *MA anchor* and the *ED anchor* is that the anchor block is independently centered on the anchor body, ensuring consistent assembly and pulling, as well as uninterrupted tensioning of the ropes.

DYWIDAG has developed three methods of rope placement in the channel formers, such as pushing, pulling, and the use of pre-assembled bundles.

Pushing is the most efficient method of rope installation available for use before or after concrete construction.

Rope installation by pulling ropes through channel formers can be extremely effective when used in special constructions, for example, with loop anchors.



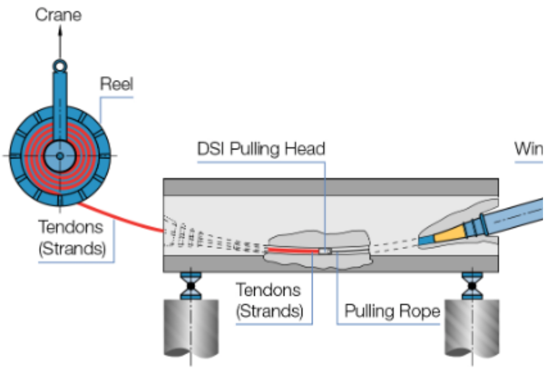


Figure 1. – Scheme of pushing operations *Figure 2. – Scheme of pulling works*

Pre-assembling rope bundles in the workshop or on the construction site can be very cost-effective, especially for short lengths or short transportation distances.

The design tension level is achieved by using hydraulic jacks and pumping stations. The required versatility is achieved through interchangeable elements that make one set of equipment suitable for use with different numbers of ropes in a bundle.

The reliability and durability of post-tensioned structures depends primarily on the correct injection of the channelizers. The hardened cement mortar provides the bond between the concrete of the structure and the wire rope bundle. The injection work is based on the use of a thixotropic, highly plasticized mortar using appropriate equipment. The injection is always performed from the lowest point of the rope bundle.

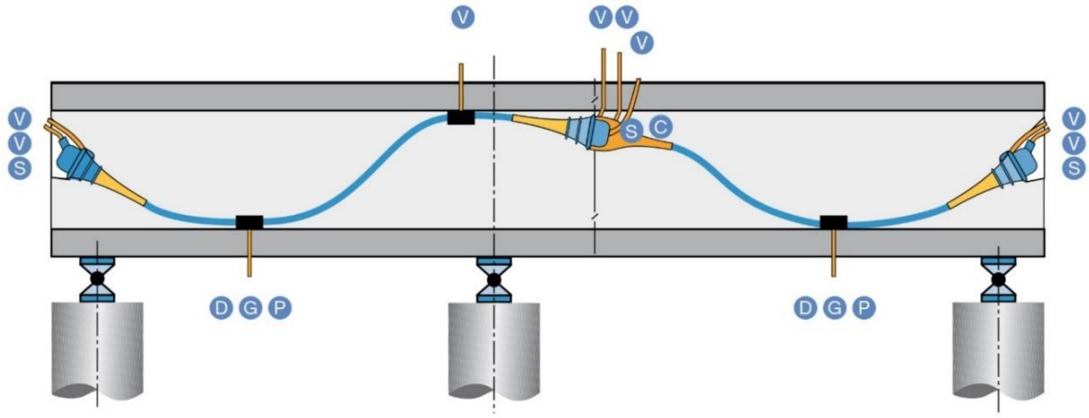


Figure 3. – Stress diagram with the injection system (D – drainage; V – ventilation; S – tension; C – connection; G – injection; P – post-injection)

References

1. Р В.3.2-03450778-832:2013 Рекомендації з проектування монолітних попередньо-напружених мостів з напруженням на бетон (пост-напружені системи). https://online.budstandart.com/ua/catalog/doc-page?id_doc=56838
2. DYWIDAG. (2020). Post-Tensioning Systems. https://assets.ctfassets.net/wz1xpzqb46pe/5H0PI4ZQ2UwGyqns9ZvGgZ/b1cc268cb2926e96dd9cbdbed933a3d0/LM_2020_PT_Repair_Strengthening_EN_04190_digital__2_.pdf.
3. Ковальчик, Я. І. (2016). Рекомендації з проектування та технології зведення монолітних попередньо напружених залізобетонних прогонових будов. Київ. Національна академія образотворчого мистецтва і архітектури.

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RESTORATION AND DEVELOPMENT PROSPECTS OF THE PUBLIC ROAD NETWORK OF THE KHARKIV REGION

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Language Advisor – CandSc (Education), Assoc. Prof. Borzenko O. P.

At all times, roads have been transporting arteries that contributed to the development of both social and economic life in any country in the world. Ukraine is no exception. Thanks to its geographical location in the center of Europe, our state connects the countries of the Middle East, Baltic and Eastern Europe. The roads of the Kharkiv region are an integral part of the transport network of Ukraine. The

Europe-Asia international corridor passes through it. The length of the public road network is approximately ten thousand kilometers.

In 2018, the long-awaited road reform was carried out in Ukraine. The Road Fund was created as the main source of financing the construction, repair and operation of public roads, which contributed to the increase in the amount of funds received for the above-mentioned needs.

The Government of Ukraine has developed the Program for the development of the country's road network. The basis is the restoration of arteries connecting cities with a population of over a million, port cities and checkpoints on the country's borders. Roads of national and regional significance became a priority within the regions.

During the period from 2018 to 2022, 562.0 kilometers of roads were overhauled and restored in the Kharkiv region. When implementing the above-mentioned projects, due to the improper condition of the pavement, modern technologies and materials were used to restore it. To restore the base of the road pavement, cold recycling technology was used in some areas, and a mixture of reused materials, i.e. SFOV (the mixture milled and treated with a binder) was used in others. In order to prevent the formation of rutting, cracks and other deformations, geocells and geogrids were used. To control the weight of cargo transportation by heavy-duty vehicles, the roads were equipped with dynamic transport weighing systems (WIM). In order to prevent road traffic accidents, lighting has been installed in accident-prone areas. During the implementation of the projects, measures were implemented to facilitate the movement of people with limited mobility and the safety of all road users by arranging pedestrian crossings, traffic lights, traffic stops, road markings, footpaths, fences, ramps, etc.

During the period 2020-2021, design and estimate documentation was developed for the restoration and overhaul of other highways in the Kharkiv region. Work on these areas was planned to begin in 2022, but due to the full-scale Russian invasion and hostilities in the Kharkiv region, the plans have not yet been implemented. It should be noted that the condition of the roads for which projects were developed has deteriorated significantly, so technologies, repair methods and scope of work require revision and adjustment. This involves raising additional funds, which is currently impossible with extremely limited funding, as well as starting work.

Unfortunately, today hostilities and the impossibility of carrying out planned and routine maintenance on public roads have led to the destruction of both artificial structures and road pavement. As of today, almost 613 km of roads require the overhaul, and many kilometers of highways in the region are damaged. A lot of money is needed to restore destroyed or damaged road infrastructure. Taking into account the fact that the receipt of funds from the Road Fund does not provide full financing, it is extremely difficult to plan and determine the timing of the restoration and development of the network.

Therefore, it should be noted that the urgent restoration of the work of the Road Fund and the involvement of international financial organizations in cooperation will allow to renew the pace of development of the Kharkiv region's road network and eliminate the destruction caused by hostilities, and, as a result, to increase the level of economic and social growth of well-being in Kharkiv region and Ukraine in general.

References

1. *Автомобільні дороги. Частина І. Проектування. Частина ІІ. Будівництво.* (2015). *ДБН В.2.3-4:2015*. Міністерство регіонального розвитку, будівництва та житлово-комунального господарства України.

2. *Автомобільні дороги. Частина I. Проектування. Частина II. Будівництво,* Зміна №1. (2019). *ДБН В.2.3-4:2015.* Міністерство регіонального розвитку, будівництва та житлово-комунального господарства України.

3. *Автомобільні дороги. Частина I. Проектування. Частина II. Будівництво*, Зміна №2. (2021). *ДБН В.2.3-4:2015*. Міністерство розвитку громад та територій України.

4. *На Харківщині 27 мостів зруйновані внаслідок вторгнення. Скільки з них відновлюють.* https://suspilne.media/537749-na-harkivsini-27-mostiv-zrujnovani-vnaslidok-vijni-skilki-z-nih-vidnovluut/

Dibrov V. K.

MODERN PROBLEMS OF EXPLORING BRAKING FEATURES OF VEHICLES IN ENGINEERING AND TRANSPORTATION EXPERTISE

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Road traffic accidents are one of the most important problems facing most countries with a high level of motorization. The number of traffic accidents, which is constantly increasing in the world in general and in Ukraine in particular, has led to the development of forensic auto technical examination to find out the truth in the case of traffic accidents.

Automotive technical expertise, which is a type of engineering and transport expertise, is of great importance for consideration of traffic accident cases.

Forensic auto-technical expertise has its own scientific basis – forensic auto-technology, which is a developing integration branch and contains engineering and forensic knowledge about the regularities of road accidents and the methodology of their investigation.

Referring to the “Instructions on the Appointment and Conduct of Forensic Examinations and Expert Studies” (1998), the main tasks of the auto technical expertise are:

– establishment of malfunctions of the vehicle that threatened traffic safety, the causes of their formation and the time of their occurrence (before the traffic accident, as a result of it, or after it);

– the possibility of detecting a malfunction by methods of monitoring the technical condition of the vehicle;

– determination of the mechanism of the malfunction influence on the occurrence and development of the event;

– establishment of the mechanism of a traffic accident and its elements: speed of movement, braking distance, trajectory of movement, distance covered by a car in certain time intervals;

– spatial and dynamic characteristics of the event;

– establishing compliance of the actions of the driver of the vehicle in a specific road situation with the technical requirements of the Road Traffic Rules;

– the driver has the technical ability to prevent the accident from the moment of danger;

– establishing a cause-and-effect relationship between the driver's actions and the traffic incident.

Braking properties of motor vehicles are the most important factor determining their active safety. The development of requirements for brake properties, methods and criteria for their assessment is always in the focus of many international and domestic specialized organizations. These requirements, methods and criteria are regulated in relevant regulatory and technical documents, in particular:

– UNECE regulations No. 13 “Uniform regulations concerning the official approval of vehicles in relation to braking”;

– GOST 22895-77 “Brake systems of motor vehicles. Technical requirements” and the automotive industry standard OST 37.001.016-70 “Braking properties of automotive rolling stock”;

– Traffic rules of Ukraine;

– GOST 25478-82 “Cars, trucks, buses, road trains. Safety and technical condition requirements. Verification methods”.

During an expert investigation of a traffic accident, in order to answer the questions posed by the investigator (court), there is often a need to experimentally determine braking parameters.

Methodological recommendations are intended for conducting an expert study of vehicle braking parameters with the aim of:

a) assessing their compliance with the requirements of regulatory and technical documentation for braking properties;

b) determining the actual values of these parameters for a specific motor vehicle and conditions as close as possible to those in which the accident occurred.

The braking efficiency of motor vehicles during an expert study is determined only by the method of road tests. During the tests, experts establish the braking parameters of the working braking system, as well as the braking system that was used to brake in the event of an accident.

At the current stage of the development of advanced energy-saving technologies in the automotive industry, the use of electric motors in transport is gaining relevance. More than a dozen Western companies are already actively working in this direction and have achieved significant results in the development and production of electric vehicles.

In accordance with Part 3 of Art. 8 of the Law of Ukraine “On Forensic Expertise”, Resolution of the Cabinet of Ministers of Ukraine, No. 595 dated by 02.07.2008, approved the Procedure for Certification and State Registration of Forensic Expertise Methods, which provides for maintaining a register of certified methods. This regulatory document summarized all currently available methods, having organized them according to all types of forensic examinations and expert specialties.

In modern expert practice, specialists research and use methods of braking parameters of wheeled and rail vehicles (Goncharenko & Gora, 2015). The braking efficiency of motor vehicles with a single source of motive power – an electric motor – has not been expertly investigated to date. That is, it is said that during the braking of a car with an electric motor, the traditional braking system, which is also available in the rest of the vehicles, works. Besides, braking occurs with the help of an electric motor, which slows down the car in case of braking (j), which is significantly different from the indicators currently used in expert practice. Other braking parameters will also differ (t_2, t_3, $P_т$, j_{st}, j_{max}), which, in turn, will change the value of the total specific braking force (On forensic expertise,1994).

To date, in expert practice, the braking parameters of cars with electric motors have not yet been established. At the same time, taking into account the growing pace of transition of large automobile corporations from traditional internal combustion engines to electric motors, this direction in the development of new braking parameters will become even more relevant.

So, it can be concluded that it is necessary to carry out experiments in order to determine the braking parameters of cars with electric motors.

References

1. *Інструкція про призначення та проведення судових експертиз та експертних досліджень*. Наказ Міністерства юстиції України від 08.10.1998, № 53/5. https://zakon.rada.gov.ua/laws/show/z0705-98#Text

2. Гончаренко, В. Г., & Гора, І. В. (2015). Експертизи у судочинстві України: науково-практичний посібник. Юрінком Інтер, 2015.

3. Про судову експертизу. Закон України від 25.02.1994 № 4038-XII. https://zakon.rada.gov.ua/laws/show/4038-12#Text

Drobotenko O. D.

IMPROVEMENT OF TECHNOLOGICAL PROCESSES IN THE REPAIR OF BRIDGE ELEMENTS

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Bridges are one of the most important components of the transport infrastructure. Bridges are objects of the highest, 4th and 5th categories of complexity and danger (State Building Regulations of Ukraine, 2009). Bridges on highways in Ukraine differ in age, structural features, material, and purpose. The total number of operational road bridges is more than 20,000, the total length of which is about 540 m. The vast majority of bridges are reinforced concrete. Unfortunately, as practice has shown, the durability of reinforced concrete structures of span buildings, even with normal operation, does not exceed seventy years.

In the scientific community, there is an opinion that the main reason for the short life span of bridges is their unsatisfactory maintenance. Bridges built in the 60s and 80s of the last century due to careless operation by road organizations have reached a critical limit, so a significant number of them require capital repair, or strengthening, or reconstruction (Bilchenko, 2021).

During operation, they are exposed to temporary and dynamic loads that are constantly changing. The constant increase in the intensity of motor vehicle traffic and the increase in the weight of the car contributes to intensive physical wear and tear, or degradation of elements of bridge structures. In addition, about 30 bridges in war zones in Ukraine were destroyed, which is incompatible with further operation without major repairs or restoration of span structures and supports.

In order to assess the technical condition and predict the residual resource of bridge elements, it is necessary to carry out their inspection (State Building Regulations of Ukraine, 2009). The survey itself provides material for drawing conclusions about the physical condition of the structures, calculating the amount of defects and damage and identifying their causes, determining the carrying capacity and suitability for further operation, assessing repairability, as well as developing recommendations for the mode of operation, repair, strengthening, reconstruction. When inspecting bridges, it is necessary to take into account that span structures, in turn, represent a system consisting of a number of elements (main beams, slabs, a complex of bridge deck elements). Therefore, it is necessary to operate with indicators of reliability and durability of individual building components to determine "weak spots" in elements from the least reliable structural solutions and their effect on reducing the durability of other elements. For example, the unsatisfactory state of waterproofing and other elements of the carriageway contributes to the intensive destruction of span structures, which leads to a decrease in their bearing capacity and durability.

Let's consider the analysis of surveys of existing bridges made of precast reinforced concrete diaphragmless beams. Most of these bridges were built according to the standards, which were changed several times. The most common defects of span structures in such bridges are: leakage of waterproofing of the bridge deck, destruction of expansion joints, exposure and corrosion of working fittings, chipping, shells, cracks in concrete, carbonization of the protective layer of concrete. The consequence of the appearance of defects is a decrease in the load-bearing capacity of the entire structure. In general, the analysis of the technical condition of the existing bridges gives a reason to draw conclusions about the expediency of their overhaul with the expansion of span structures and the simultaneous provision of load capacity for the perception of normative temporary loads, as well as the provision of reliable operation and durability of the existing structures of span structures (National Standard of Ukraine, 2013). Since there are structural elements in bridges that have different lifetimes, they require replacement as needed, but its main elements should certainly not be replaced, but strengthened in the extent of their destruction. In view of the dissonance between the rates of growth of loads on bridges and the degradation of elements of reinforced concrete structures, in the latest regulatory documents a requirement will be introduced, which provides for the installation of a continuous monolithic reinforced concrete overlay slab with protruding consoles during major repairs of the carriageway. The use of a monolithic overlay plate allows you to reliably ensure its joint operation with existing beams (Bilchenko, 2021). The overlay plate is arranged on top of the existing beams. Its cantilever parts have a variable section profile. Joint operation of the overlay plate with the existing beams is provided by their union with flexible loop reinforcement anchors welded to the local exposure of the upper longitudinal reinforcement in the ribs of the beams.

The technological process of arranging a monolithic reinforced concrete slab has certain features and difficulties, since in addition to the arrangement of consoles and anchors, it is necessary to take into account the excellent strength and granulometric composition of concrete of existing structures and slabs, coefficients of working conditions, reliability by load and materials. There is a technology that requires the installation of scaffolding and mobile formwork, which consists of a large number of mobile elements, for the installation of overlay slab consoles.

At the Department of Bridges, Structures and Construction Mechanics named after V. O. Rosiyskiy developed more rational solutions for this process due to the installation of fixed metal formwork, as well as the use of a method of reinforcing and concreting the consoles simultaneously with a monolithic reinforced concrete slab. The technology of installing fixed formwork differs from the generally accepted one in that fixed formwork consists of a metal sheet that is attached to the shelves of existing beams and a rod system - risers and ties, which are also attached to existing beams without the installation of scaffolding. The technology of concreting the cantilever part of the slab is carried out simultaneously with the installation of the overlay slab, however, after concreting, the metal sheet of the formwork remains on the building and performs the function of the external lower armature of the console. The upper armature of the console is pre-installed simultaneously with the reinforcement of the overlay plate. The metal sheet and the upper armature of the console are connected by vertical rods. After the strength of the concrete of the monolithic slab with cantilevers is set, the rod system of risers and ties is cut.

Also, other methods of bridge repairs have been developed at the department. For example, the method used to repair span structures of reinforced concrete bridges. To ensure spatial operation, the main beams are connected to each other along the slab of the carriageway, or along the diaphragms with the help of embedded parts. The failure of embedded parts on the extreme beams leads to a loss of their stability and a fall. The developed method of bridge repair includes the repair of the span structure, aimed at restoring the functions of the main beams by applying screeds between the beams in the places of deformation joints along the upper part of the ends of the beams without dismantling the carriageway. This makes it possible to extend the operability of the bridge and its carrying capacity.

Another development of the repair method allows repair of the roll support parts on which the main beams rest, if they have critical angles of inclination. For this, four vertical rods are hammered around the supporting part, which are joined with clamps, wooden formwork is arranged and concreted. This method makes it possible to repair the roll support part of the span structure of the bridge without dismantling it and stopping vehicles.

So:

1. Bridges consist of a large number of structural elements, that is, they are the most complex and responsible technical systems.

2. In order to make a timely decision on the further operation of bridges, it is necessary to assess the technical condition of the elements of the bridges, the structure as a whole and forecast their service life.

3. The analysis of survey data reflects the level of degradation of elements and reveals the "weak spots" of the system - elements related to the complex of the bridge deck.

4. To increase the reliability and durability of these elements, it is necessary to carry out major repairs due to the installation of a monolithic reinforced concrete slab, which not only strengthens the upper part of the span structures, but also distributes the operational load over a larger area.

5. When installing monolithic slab consoles, it is recommended to use non-removable metal formwork, which remains on the building after concreting as external lower armature of the console.

References

1. *Держані будівельні норми України. (2009). Система забезпечення надійності та безпеки будівельних об'єктів. Загальні принципи забезпечення надійності та конструктивної безпеки будівель, споруд, будівельних конструкцій та основ*. Мінрегіонбуд України.

2. Більченко, А. В., Кіслов, О. Г., & Ігнатенко, А. В. (2021). *Особливості негативних ситуацій, що склалися в мостовому господарстві країни.* ХНУБА.

3. *Держані будівельні норми України. Споруди транспорту.* (2009). Мости та труби. Обстеження і випробування. Мінрегіонбуд України.

4. *Національний стандарт України.* (2013). Настанова з оцінювання і прогнозування технічного стану автодорожніх мостів. Мінрегіон України.

5. Більченко, А. В., Кіслов, О. Г. (2021). *Вплив технології виготовлення монолітної плити на фізико-механічні характеристики покриття.* ХНАДУ.

Dulich D. V.

HYDRODYNAMIC EXTRUSION AS A REPLACEMENT OF HYDRAULIC PRESSING IN MANUFACTURING PRODUCTS FROM HIGH-STRENGTH NON-DUCTILE STEELS

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Language Advisor – CandSc (Education), Assoc. Prof. Rudenko N. V.

To find out the possibility and expediency of using the GDV method for manufacturing workpieces of heavily loaded parts from high-strength, low-plasticity steel 45ChN2MFA blanks (diameter 20 mm) were chosen as the research object.

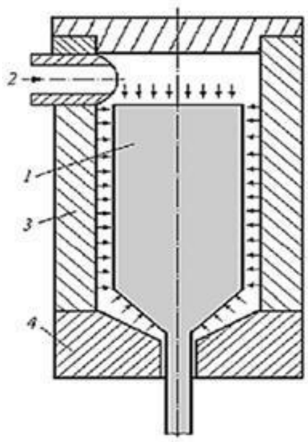
Steel 45ChN2MFA is used for manufacturing heavily loaded springs and springs which are subjected to the combined influence of large bending loads of varying sign while operating.

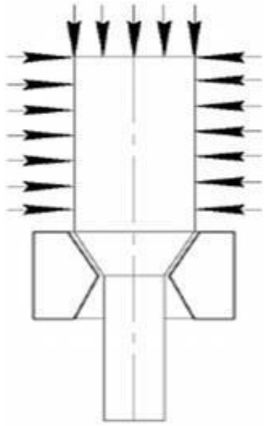
Table 1. – Chemical composition and critical points of the studied steel.

Steel	Mass fraction of elements, % (not more)							Critical points, ºC	
	C	Mn	Si	Cr	Ni	Mo	V	Ac1	c3
45ChN2MFA	0.45	0.61	0.31	0.96	1.56	0.25	0.15	740	90

The method of hydrostatic pressing or hydroextrusion (HE) is applied to manufacture products from low-plastic materials. Hydroextrusion is the pressing of products with a liquid under high pressure (from 10^3 to 10^4 MPa).

The scheme of comprehensive volumetric compression is implemented and the metal becomes more plastic, and its deformability increases almost 8 times, which allows very fragile materials to be deformed without the formation of cracks.





1. workpiece;
2. high pressure liquid;
3. container;
4. matrix.

Figure 1

The comprehensive compression and tensile stresses are significantly reduced

Figure 2

The metal is squeezed out through the matrix channel under the influence of high-pressure liquid. During pressure on the product in a liquid or semi-liquid environment, the conditions for comprehensive compression of the material are created. The fully tensile stresses are excluded.

Grinding of the grain occurs, the formation of a cellular structure with disorientation (up to 10º) and, as a result, the strength, plasticity and impact toughness increase, that is, the structural strength increases.

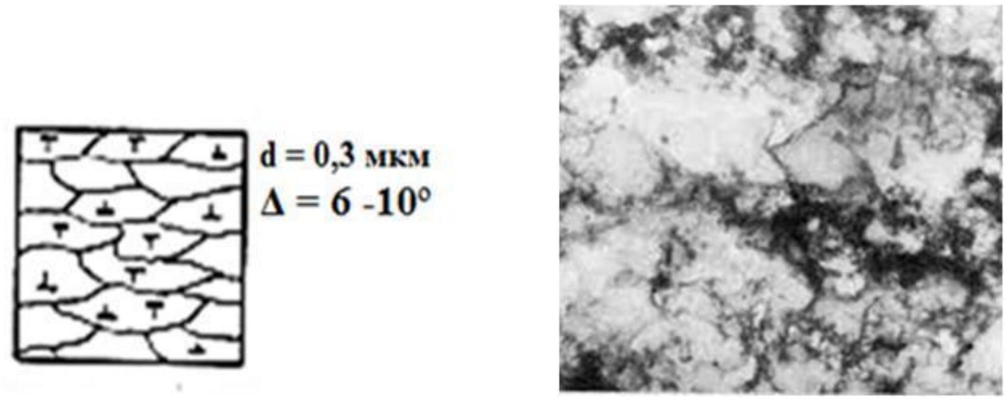


Figure 3

Significant disadvantages of the method are the following:

– the complexity of constructions and operation of equipment for creating and maintaining liquid pressure up to 3000 MPa and higher;

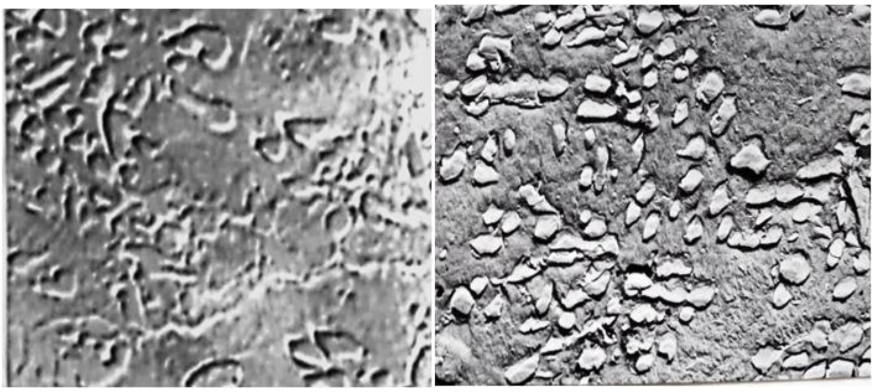
– a sharp increase in the speed of movement of the extruded product with increasing liquid pressure (ball speed);

– the lack of installations at many enterprises.

We used the simplest and cheapest method of hydrodynamic extrusion (HDE) instead of GE for the production of blanks from alloyed low-plastic steels.

According to the GDV scheme, before placing the workpiece in the container, it is thickly lubricated with spindle oil, which is a kind of quasi-liquid medium. Under pressure, this medium acts only on the cylindrical surface of the workpiece, and its upper end is in direct contact with the metal plunger. With a significant pressure of the plunger on the lubricant, the conditions of hydrodynamic extrusion are created, the scheme of comprehensive compression of the material is implemented.

Before the deformation an incomplete spheroidizing annealing was performed at a temperature of 700 ºC for 4 hours to form a ferrite-carbide mixture with a grain structure (spheroidization of the carbide phase) and to increase the homogeneity of the structure.



225 HBW ×5000 187 HBW

a) *b)*

Figure 4. – Steel microstructure before (a) and after spheroidizing annealing (b)

Annealing at the temperatures from 300 to 350 ºC leads to the improvement of the cellular substructure and its strengthening with dispersed carbide particles, it becomes more stable. After deformation tempering in the specified temperature range is the most favorable and effective.

Figure 5. – Annealing at 350º C, for 2 hours, ×25000

In conclusion, it should be noticed that to reduce deformation forces and ensure uniformity of deformation of strong and low-plastic 45ChN2MFA steel before hydrodynamic extrusion, it is necessary to carry out preliminary spheroidizing annealing at a temperature from 680 to 700º C for 4 hours.

During deformation by hydrodynamic extrusion, a developed cellular substructure is formed, which ensures the strengthening of steel while maintaining a sufficiently high margin of plasticity and impact toughness.

Post-deformation tempering in the temperature range from 300 to 400 ºC leads to the improvement of the cellular substructure and its fixation with dispersed carbide particles, which ensures the stability of such a structure before further strengthening heat treatment of the product.

References

1. Дяченко, С. С., Дощечкіна І. В., Пономаренко І. В., & Бондаренко С. І. (2015). *Матеріали різного призначення, їх обробка та властивості*. ХНАДУ.

2. Guo, L., Yang, H. (2014). *Casting, Semi-Solid Forming and Hot Metal Forming. Comprehensive Materials Processing*. https://www.sciencedirect.com/topics/engineering/hydrostatic-extrusion

3. P. Yu. Volosevich, D. L. Vashchuk, and O. A. Davydenko, (2020). Process of Hydroextrusion as a Result of Occurrence of Hydrodynamic State of Material in Field of External Stress Concentrator, Metallofiz. Noveishie Tekhnol. 42(8), 1149–1168.

Haidamachenko I. V.

SCIENTIFIC BASIS OF DEVELOPING HYBRID POWER DRIVES IN ENERGY-EFFICIENT ROAD CONSTRUCTION MACHINES

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The development of an energy-saving drive is an important concept in scientific and technical fields that will help to increase the productivity and efficiency of excavators by converting, accumulating and redistributing energy between machine elements in accordance with their energy intensity during operations.

The purpose of the research is to develop the concept of creating energy-efficient road construction machines with hybrid drives of working bodies and engines. Its implementation will be based on existing and prospective methods of increasing fuel and environmental efficiency, as well as machine reliability. Over the past few decades, the problems of environmental pollution and climate change have become increasingly urgent. One of the most common sources of carbon dioxide emissions is transportation, especially during the construction phase. Fortunately, there are new solutions that allow you to reduce fuel consumption and reduce gas emissions. One of them is the use of hybrid road construction machines. Hybrid road construction vehicles are vehicles that use both fuel and electric engines. This allows us to reduce fuel consumption and emissions of harmful gases.

In addition, hybrid machines are more efficient because the electric motor helps provide additional power when working with heavy machinery. Caterpillar is one of the leading manufacturers of hybrid road construction equipment. It has developed a hybrid forklift that uses a hydraulic system to charge the battery and an electric motor to provide power. This forklift can reduce fuel consumption by 25% compared to conventional machines. Another major manufacturer is Komatsu, which has developed a hybrid bulldozer.

This machine implies a system that automatically switches between a diesel engine and an electric engine depending on the need for electricity. A study of the energy intensity of the working processes of the machines indicates that, today hydrogenated machines make up more than 80% of the total number of the fleet. In the process of excavating the soil environment, the operation of hydraulic drives is 85% during the entire life cycle. Heavy load modes determine the performance of basic functional operations conditionally from 50 to 70% of the time. Earthmoving machines have a large number of activations of power hydraulic motors and elements that significantly affect the loading of the hydraulic drive and its dynamics. Therefore, energy-intensive operations make up from 50% to 70% of the working time of the machine and require a significant number of activations of the hydraulic drive.

One of the possible ways to increase the energy efficiency of machines is to apply more efficient engineering solutions. More effective engineering solutions, in particular, this is the improvement of the hydrodynamic properties of the elements. Optimization of operating modes, weight reduction, optimization of element dimensions is also an urgent issue. The common ways to improve the energy efficiency of machines include the use of alternative energy sources such as using alternative energy sources such as electric motors and hybrid systems.

Using alternative energy sources includes such as electric motors and hybrid systems. The process is based on the above scheme based on the algorithm, taking into account the impact to date and the results achieved. There are several problems with using motor graders. This is insufficient soil compaction and poor adaptation of the chassis to soil conditions. For example, poor adaptation to soil conditions. One way to increase machine efficiency One way to increase machine efficiency is to improve the propulsion system.

The driving system needs to be improved by using pneumatic tires of different diameters and suspension balancing. As for changing the diameter of pneumatic tires, to achieve the goal a new design of the motor grader was developed. The design of the motor grader includes a self-propelled chassis, a frame and a frame balancer, a balancer with an axle, empty tires of different diameters, tires of different diameters, a cab, a grader and a bulldozer dump.

The balancer beam additionally has a balancer frame with a pair of axles. A pair of axles with pneumatic tires is installed on each bridge. Each axis consistently meets certain diameter requirements. In order to study the properties of wheels, a virtual experimental study was conducted based on tires for large motor graders Ya-140A DZ-98.

The improvement of the BMD hydraulic storage system consists of the following improvements of the BMD hydraulic storage system related to the primary engine and a hydraulic pump. The hydraulic pump can be turned off with various modes of operation with low load. The use of control clutches in the hydro-accumulating system allows at the expense of the hydro-accumulating system.

References

1. Klanfar, M., Korman, T., & Kujundžić, T. (2016). Fuel consumption and engine load factors of equipment in quarrying of crushed stone. *Tehnički vjesnik*. 23(1), 163-169.
2. Rieznikov, O. et al. *Modelling and Simulation of Metal Construction Stress-Strain Behaivour When Designing Road-Building Machines Mathematical Modeling and Simulation of Systems (MODS 2020).* Selected Papers of 15th International Scientific-practical Conference (2021 June 29-July 01), (pp. 92-100). https://link.springer.com/chapter/10.1007%2F978-3-030-58124-4_9
3. Kalinin, Y. et al. (2020). *Information system for controlling transport-technological unit with variable mass.* ICTERI, 303-312. http://ceur-ws.org/Vol-2732/20200303.pdf
4. Kecojevic, V., & Komljenovic, D. (2010). Haul Truck Fuel Consumption and CO2 Emission under Various Engine Load Conditions. *Mining Engineering*. 62(12), 44 – 48.
5. Klets, D. et al. (2019). *Selecting a Rational Operation Mode of Mobile Power Unit Using Measuring and Control Complex.* ICTERI, 141– 151. URL:http://ceur-ws.org/Vol-2387/20190141.pdf
6. Dukan, P., Bosanac, B., Mrvoš, Lj., Paskojević, A. (2009). Građevinar, Zagreb, 1991. Strojevi u građevinarstvu (Machines in Civil Engineering)
7. Komatsu. Specification & Application Handbook. Edition 30, Komatsu Ltd. (2009).

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BRAKING PROPERTIES OF VEHICLES AND THEIR IMPACT ON TRAFFIC SAFETY

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When turning, the braking distance increases, since part of the vehicle's adhesive weight is used to create lateral reactions on the wheels, preventing lateral displacement of the front and rear axles. The road capacity depends on the interval between two sequentially moving vehicles. The main part of the minimum permissible interval between vehicles is the braking distance. Therefore, when turning, the interval between vehicles should increase. If the turn interval cannot be increased, it is necessary to reduce the speed of the vehicle.

The expansion of the road network and the improvement of their quality is accompanied by an increase in the design speed of traffic and the number of vehicles (Волков, 2003). This causes an increase in the number of traffic accidents associated with insufficient braking efficiency, loss of stability and controllability (Волков, 2003). The work (Бегишев, 1998) analyzed the impact of the turning radius of the road on the increase in the number of accidents (Table 1) (Бегишев, 1998). In Table 1, the number of accidents while driving on a straight section of the road is taken as 100%.

Table 1. – The relation between the turning radius and the increase in the number of accidents

The turning radius V, m	∞	1000	800	600	400	250	200	0
The increase in the number of accidents, %	0	45	55	175	185	210	220	∞

Table 1 shows that as the turning radius decreases, vehicle accidents increase. The causes of accidents are too long a braking distance and loss of stability and controllability of the vehicle, which is caused by the appearance of the lateral force of inertia at the turn. Obviously, as the turning radius of the road decreases, it is necessary to decrease the speed of the vehicle.

Table 2 shows the values of the minimum turning radii (Бегишев, 1998), the basic V and the average technical V_T of the traffic speeds (Бендас, & Бігунов, 1972), which correspond to roads of different categories. The value of the coefficient of wheel adhesion to the road φ (Бегишев, 1998) and statistical data on the number of activations of the braking system per 100 km of the road (Бендас, & Бігунов, 1972) are also given there.

Table 2. – Characteristics of roads (Бендас, & Бігунов, 1972)

The road category	I	II	III	IV	V
The minimum turning radius R_{min}, m	1000	600	400	250	125
The basic movement speed V, km/h	150	120	100	80	60
The average technical speed V_T, km/h	40	30	22	15	
The type of road surface	asphalt concrete	paving stones	soil	forest road	
The coefficient of wheel adhesion to the road φ	0.6-0.75	0.4-0.5	0.5-0.7	0.65-0.75	
The number of activations of the braking system per 100 km	65	153	103	745	

The increase in the braking distance of a vehicle when turning is due to a decrease in the limiting braking force under adhesion conditions, since part of the vehicle's adhesion weight is used to create lateral reactions on the wheels oppose the inertia force. If the braking force is not reduced when turning, the vehicle will lose stability and controllability.

To determine the limiting braking force under adhesion conditions in the case of a lateral force, a circular diagram is used (Бендас, & Бігунов, 1972), named the "Kamm circle" after the author who proposed it (Figure 1).

The works of a number of researchers are devoted to the study of braking properties of vehicles when turning (Волков, 2003; Волков, 2003; Бегишев, 1998; Бендас, & Бігунов, 1972). In work (Бендас, & Бігунов, 1972) calculated relations were obtained for the braking distance of a vehicle on a turn.

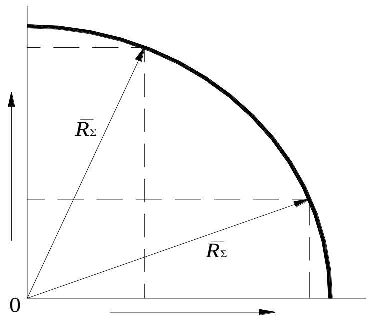

Figure 1. – Kamm circle

With a constant distribution of braking forces between the axles and sides, as well as with a limitation of the total braking force in accordance with the circular diagram (Figure 1), the relation for determining the braking distance under the action of the central lateral force was obtained in work (Бендас, & Бігунов, 1972):

$$S_T = \frac{V_0}{3,6}\left(\tau_C + 0,5\tau_H\right) - \frac{R\left(1-\beta_\partial\right)}{4\varphi \frac{h}{B}\left(\frac{a}{L} - \varphi\frac{h}{L}\right)} \ln\left|1 - \frac{2h}{\beta_Д R}\cdot\frac{V_0^2}{13}\right|, \quad (1)$$

where: S_T – the braking distance of vehicles, m;

V_0 – the initial braking speed, km/h;

τ_C, τ_H – the delay time for turning on the braking system and the time for the braking force to increase to its maximum value, c;

h, B, L – the height of the center of mass, the track and the wheel base of the vehicle, m;

R – the turning radius, m;

a – the distance from the front axle to the projection of the center of mass on the plane passing through the front and rear axles of the vehicle, m;

β_∂ – the actual distribution coefficient of the braking force on the front axle,

$$\beta_\partial = \frac{P_{T1}}{P_{T1} + P_{T2}}; \qquad (2)$$

P_{T1}, P_{T2} – the braking forces on the front and rear axles of the vehicle.

Thus, when turning, additional restrictions are imposed on the operation of the brake control caused by the need to maintain the vehicle’s stability and controllability. The efficiency of braking on a turn, even with the maximum use of the vehicle's traction capabilities, is lower than when braking on a straight line. However, the current normative documents do not regulate the checking of the vehicle's braking properties while driving on curved sections of the road.

References

1. Волков, В. П. (2003). *Забезпечення стабільності гальмових властивостей автотранспортних засобів.* ХНАДУ.
2. Волков, В. П. (2003). *Теорія експлуатаційних властивостей автомобіля.* ХНАДУ.
3. Бегишев, Д. (1998). Шифровка ESP. *Motor News*, 11, 70-71.
4. Бендас, І. М., & Бігунов, Л. О. (1972). Про гальмування автомобіля на криволинійні частині шляху. *Автомобільний транспорт*, 14, 61-65.

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ANALYSING THE CHARACTERISTICS OF A DIGITAL TERRAIN MODEL

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A digital terrain model comprises planned coordinates and elevations, representing data about a collection of model points. Digital terrain information is highly advantageous for electronic representation and storage, facilitating the swift and convenient transfer of terrain data.

The digital terrain model proves effective in analytical design work, enabling the rapid execution of automated design for artificial structures, vertical planning of terrain based on specified parameters, determination of earthwork volumes, reduction in time and cost for developing design solutions, and enhancement of overall quality.

Digital models handle various types of information. Metric information encompasses the transmission of metric (measurement) characteristics related to objects, including the coordinates of elements within the scenario, their sizes, and more. This information is relatively straightforward and uniform in structure, making it highly standardized

There are logical and physical structures within digital terrain models. The concept of the logical and physical structure of a digital terrain model extends from the concepts of logical and physical data models. The logical structure of a digital terrain model is established as a collection of schemes and logical records describing the model. This characteristic is descriptive. The schemes defining the logical structure of a digital terrain model can vary based on purpose and construction principles. The logical structure of a digital terrain model is influenced by the underlying concept and modeling methodology. It may encompass diagrams illustrating the connections between components of the digital terrain model in nature and within the database. Additionally, it may include diagrams depicting connections between properties of the digital terrain model and diagrams outlining the construction of the model. This structure comprises logical records that form the foundation of the information. A logical record is an elemental part of the logical structure of a digital terrain model.

We should distinguish between integrity, discreteness and multifunctionality of digital terrain models. The integrity is a property of a digital terrain model. When processing data in a database, it is not enough for a digital terrain model to simply reflect real-world objects. It is imperative that such a mapping is unambiguous and consistent. In this case, the digital terrain model is considered to meet the integrity requirements. The integrity of a digital terrain model has two meanings: as a database object; as a model of a real object. The integrity of the digital terrain model as a database object is determined by the requirements of the database management system and corresponds to the concept of information integrity in the database.

Invariant modelling relies on construction with data that are either fully or partially standardized. This type of modelling utilizes group operations, thereby enhancing productivity compared to individual modelling. Invariance establishes conditions for the widespread use of software and technology sets that are not dependent on the specific type or features of the modelled object. It implies the application of general properties to modelled objects irrespective of the technical means and specific characteristics of individual objects.

This modelling approach offers a substantial increase in information processing performance, particularly in the modelling or processing of graphical objects. However, its implementation is feasible only when utilizing structurally separated graphical models. The lower level of these models should be invariant to specific model features, while the upper level contains individual model properties. In essence, this modelling type necessitates specialized software and linguistic tools that consider the properties of the modelled objects and the potential for structuring them into specific graphical primitives.

Information modelling is closely tied to the process of generating and converting various forms of information, such as graphical or textual data, into formats required by users. The effectiveness of information modelling relies on the preliminary development of an integrated information framework and the utilization of databases. In modern automated systems, digital terrain models are presented using automated documentary support systems. It's important to note that all the modelling types discussed are applicable at various system levels, albeit to different extents. The description of a digital model is a dynamic process that evolves or expands with the emergence of new tasks, processing methods, and technological advancements in design automation.

Constructing a digital terrain model is a complex process involving a substantial number of interrelated operations conducted during the desk-based processing of geodetic measurements obtained from engineering and geodetic surveys. The quality of the final modelling result is contingent on the excellence of each stage of digital terrain model construction. Therefore, it is crucial to give due consideration to all technological processes involved in model construction.

Reference

1. Лабенко, Д. П. (2012). *Геоінформаційні системи.*
2. Ратушняк, Г. С. (2009). *Інженерні вишукування.*
3. Лященко, А. А. (2002). Концептуальне моделювання геоінформаційних систем. *Вісник геодезії та картографії*, 4 (27), 44–50.

Hil Y. B.

CHOIX DU SCHEMA DE CONCEPTION POUR LA DETERMINATION DES DEFLEXIONS DE LA CHAUSSEE D'UN PONT EN BETON ARME

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Assurer la durabilité des structures de pont est une tâche urgente dans l'ingénierie des ponts. Dans la conception des structures de pont modernes, les calculs théoriques et les résultats des études expérimentales pertinentes sont utilisés pour calculer leurs principales caractéristiques : résistance, rigidité, stabilité. Ces deux approches sont interdépendantes, car la portée du travail expérimental dépend largement de la précision des méthodes de calcul utilisées. Par conséquent, le développement et la mise en œuvre de méthodes améliorées pour le calcul des éléments de la structure des bâtiments dans la pratique de l'ingénierie est une tâche urgente.

À ce jour, les plus répandues sont les méthodes de projection, les méthodes variationnelles directes et la méthode des éléments finis, qui est une extension logique et une amélioration des méthodes de projection, interprétées comme une projection d'une solution exacte d'un espace de Hilbert de dimension infinie vers un sous-espace de dimension finie (Ігнатишин, (2017).

Dans la modélisation numérique de structures de pont réelles, le résultat dépend du niveau d'adéquation du modèle à l'objet réel, du degré de décomposition du modèle en éléments finis et de la stabilité de la solution de l'équation différentielle correspondante pour un nombre donné d'éléments finis.

L'article considère une chaussée de pont représentée par une dalle monolithique en béton armé de classe C32/40, qui est modélisée par une plaque en forme de parallélogramme de dimensions 24,2×14,52 m et de 0,25 m d'épaisseur. Par le bas, la plaque est soutenue par huit poutres en béton armé de 1,1 m de haut avec une section transversale de poutre en T, qui sont fabriquées dans une usine de béton armé à partir de béton C20/25 et livrées directement sur le chantier pendant la construction.

À ce stade de la recherche, il était nécessaire de déterminer l'ampleur et la nature des déviations verticales de la surface de la structure de la travée sous l'effet de son propre poids à l'aide de la méthode des éléments finis. Pour résoudre ce problème, le complexe informatique SCAD++ version 23.1.1.1 (Обчислювальний комплекс для міцнісного аналізу конструкцій методом скінченних елементів) a été utilisé. Les calculs ont été effectués à l'aide de deux variantes des schémas de conception illustrés à la figure 1, qui diffèrent l'une de l'autre par l'utilisation d'inserts absolument rigides entre la dalle monolithique et la poutre.

a)

b)

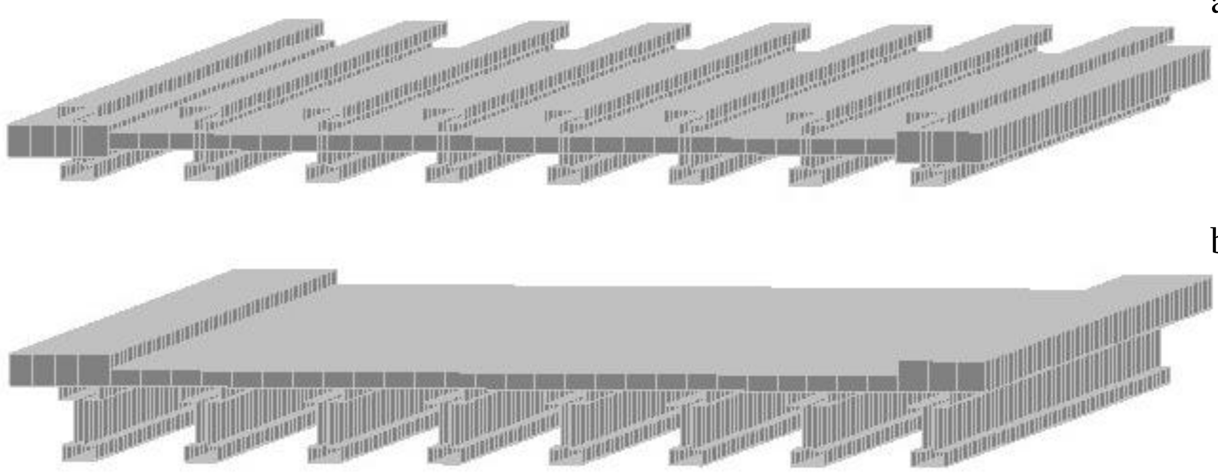

Figure 1. – Schéma de conception d'une structure en travée sans inserts rigides (a) et avec inserts rigides (b)

Les résultats de la modélisation présentés dans la Figure 2 indiquent que dans le premier schéma de conception, la déviation verticale la plus importante est observée au milieu de la structure de la travée et est de 58,43 mm. La valeur maximale obtenue répond aux exigences du document réglementaire actuel

(ДСТУ Б В.1.2-3:2006, 2006), qui autorise les déviations maximales des éléments jusqu'à *l*/250 pour une longueur de travée donnée.

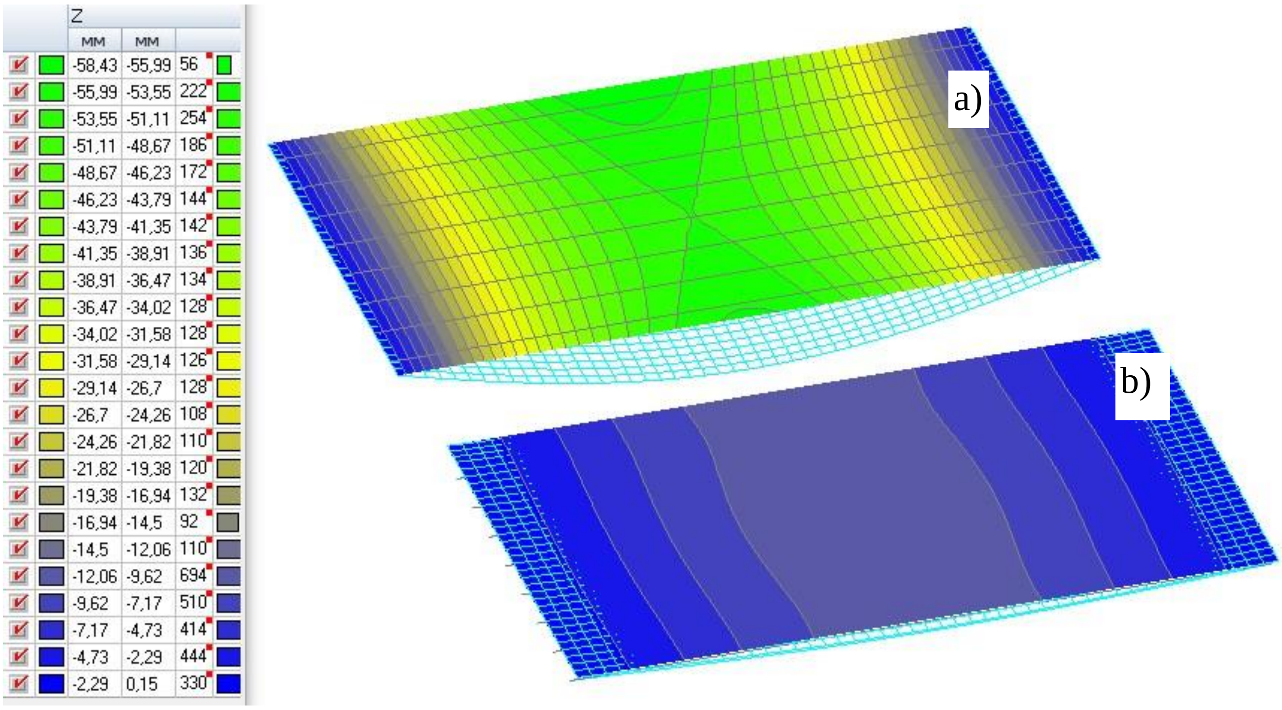

Figure 2. – Résultats de la détermination des déformations verticales d'une structure en travée à partir de son propre poids selon le schéma de conception sans inserts rigides (a) et avec inserts rigides (b)

L'utilisation d'inserts rigides dans le schéma de conception de la structure de la travée du pont rapproche le plus possible son fonctionnement des conditions réelles, ne modifie pas la nature de la distribution des champs de déflexion par rapport à la première option, et affine considérablement le calcul, comme en témoigne la réduction par cinq de la valeur absolue des déplacements, qui n'atteint que 11,48 mm au milieu de la chaussée.

Références

1. Ігнатишин, М. І. (2017). *Механіко-математичне моделювання елементів мостових конструкцій (опора, балка, плита)*. РВВ МДУ.

2. Обчислювальний комплекс для міцнісного аналізу конструкцій методом скінченних елементів. https://scadsoft.com/ua/products/scad

3. ДСТУ Б В.1.2-3:2006. (2006). *Система забезпечення надійності та безпеки будівельних об'єктів. Прогини і переміщення. Вимоги проектування. Чинний від 2007-01-01*. Вид. офіц. МІНБУД УКРАЇНИ.

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DESIGN FEATURES OF MOBILE LIFTS

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A mobile lift with a working platform is a lifting machine designed to move working personnel with tools and materials placed on the working platform during work within the working area and consisting of a base chassis, lifting equipment and a working platform.

The main components of mobile lifts with a working platform include floor mounted mobile lifts, they are very compact, mobile devices designed to lift people and objects to a great height. This equipment provides safe and efficient access to hard-to-reach areas such as building structures, equipment and warehouses, as well as other places where work is required at height. One of the main features of floor lifts is their portability and mobility. Since they are always equipped with wheels or tracks, they can be easily moved from one place to another. This allows operators to easily install and use the lift where it is needed, without the need for a fixed structure. The design of a mobile lift includes a frame or platform that is raised and lowered by a hydraulic system or mechanical mechanism. Safety is an important factor, so a number of safety systems are provided, including fences, seat belts, emergency stop and rollover stabilization systems. Mobile lifts come in a variety of sizes and maximum lifting heights. Models range from compact single-axis machines to large multi-axis machines. Some models can extend up to 20-30 m. and provide access to tall buildings and structures. Mobile lifts have other features and capabilities to meet a wide range of needs. Some of them are equipped with a rotary platform, which allows operators to move freely around the object during operation. Some models are also equipped with a retractable platform that can provide a larger work surface for performing operations. Mobile lifts are also available with other types of drives. The most common ones are hydraulic and electric. Hydraulic lifts work with a hydraulic system, where the movement of the platform is controlled by hydraulic cylinders. Electric hoists require electrical energy to operate the hydraulic motor and pump. Each of these types has its own advantages and limitations and must be selected according to specific requirements and operating conditions. Mobile lifts are available with different types of platforms. Some models have a standard rectangular platform with space for several workers and tools. Others have platforms with limited depth for working at height or in a limited space. Some lifts have specialized platforms for performing certain tasks, such as platforms with cargo crates for handling materials or platforms with extended cargo platforms for transporting complex objects. Mobile lifts can be operated from the platform or from ground level. Many models are equipped with remote control, which allows the operator to control the lift from a safe distance. This is especially useful where the operator needs a better overview or where access to the platform is limited. In addition, some models are equipped with automatic movement programs that allow the lift to independently perform pre-defined sequences of movements or positioning. An important feature of mobile lifts is safety. To ensure safety during operation, they are often equipped with various protection systems, such as emergency stop systems, overload sensors, and auto-off systems. In addition, lifts usually have stabilization systems that prevent them from swaying or tipping over in lifting mode. Thus, mobile lifts are mobile equipment that is used for safe and efficient access to heights. They are available in a variety of sizes, platform types, and functions, and can perform a wide range of tasks. Because of their portability and Mobility, mobile lifts are widely used in industries that require high-altitude work, such as construction, maintenance, and storage.

The working height of scissor lifts ranges from 6.5 M to 18.5 m, and the load capacity ranges from 226 kg to 1000 kg. This type of lifting equipment has a wide range of applications, from servicing various types of equipment in low-lying areas to construction and installation work at height. Self-propelled scissor lifts are useful when a large work area, service area and large load capacity are required.

Self-propelled lifts with articulated boom have a working height of 12-41 M and a load capacity of 200-250 kg. This type of Lift is characterized by the ability to work at height and in hard-to-reach places. The low load capacity and relatively small platform of this type of self-propelled lift is compensated by a curved boom. Self-propelled telescopic lift Telescopic self-propelled lifts have the highest working height from 21m. to 43m. and a load capacity from 227 kg. to 450 kg. Unlike articulated boom lifts, access to hard-to-reach areas is limited, but this is compensated by the increased load capacity and lifting height. This type of Lift is used for outdoor work and requires a lot of free space. Another advantage is that telescopic self-propelled lifts usually do not require construction rails. All three types of lifts are very similar to scissor lifts, with the only difference being that while conventional hydraulic lifts are installed in a pit (usually a one-time installation), self-propelled hydraulic lifts are mobile and easily transported in terms of space, which allows them to be used on each new facility.

The main characteristics of a self-propelled lift are as follows:

1. working height: the maximum height that the self-propelled lifting platform can reach. The working height varies from a few meters to several tens of meters, depending on the model.

2. horizontal reach: the maximum distance that the working platform can be extended horizontally. This feature is important for reaching remote work areas, especially in confined spaces.

3. load capacity: the maximum permissible load that the lift can lift together with the working platform. The load includes the operator, tools, materials, and other equipment.

4. platform size: the size of the platform determines the area where the operator can work and the size of the cargo that can be placed on the platform. The larger the platform, the larger the work area and more space for materials and tools.

5. additional features. Some self-propelled lifts are equipped with additional features such as tilt platforms, rotating platforms, flexible tool holders, safety systems (e.g. automatic shutdown in the event of an accident) and other features that increase productivity and safety.

References

1. *Самохідні підйомники.* http://kievlift.com.ua/ua/samohidni-pidjomniki-561/

2. *Класифікація підйомників*. https://gardenunion.com.ua/vidi-samohidnih-pidjomnikiv-48/

3. *Вантажопідіймальні машини та обладнання.* https://revolution.allbest.ru/construction/00460939_0.htm

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AUTOMOTIVE ENGINE WITH A POWER OF 65 KW BASED ON ENGINE 4CH 8.2/7.2

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The engine is a four-stroke gasoline engine, four-cylinder with a vertical arrangement of cylinders in a row, has sixteen valves and two camshafts. The operating order of the cylinders is 1-3-4-2. The power supply system is phased split injection. The engine cylinders are one piece together with the upper part of the crankcase, a monolithically cast cylinder block.

The aim of this work is to modernize the prototype engine in order to improve its technical and economic performance using a cylinder-stop system. Engines equipped with a cylinder deactivation system first appeared in 1981. Cadillac was the first to install them on cars. Electromagnetic coils controlled by the control unit close the intake and exhaust valves of these engines.

The principle of operation of cylinder shutdown systems is theoretically the same for all cylinders and consists in the fact that certain cylinders are no longer supply with fuel and air. In addition, spark generation is stopped for these cylinders. This happens as follows: the intake valves stop in the closed position; the fuel supply via the injectors is cut off; the spark circuits are disconnected; the exhaust valves stop in the closed position when there are exhaust gases in the cylinders.

The deactivated cylinders connect to the intake stroke. This allows the deactivated cylinders to start working, freeing them from the exhaust gases. The use of cylinder deactivation technology results in significant fuel savings. In town, savings of up to 1 liter of fuel per 100 km can achieve, and on the motorway at cruising speed, fuel consumption can reduce by up to 20%.

In some cases, the engine's cylinders can operate by forced shutdown. Cylinder stoppage in an emergency (force majeure), which may occur far from the usual car repair services. The engine stalls, there is no power and it is impossible to move.

Cylinder deactivation is used to diagnose an engine. As well as deactivating the cylinders during the engine compression test, there is another way of testing engine performance. The engine's cylinders shut down during what we refer to as the "force balance" test. This test is carried out when the engine is clearly unstable. The test determines the contribution of a particular cylinder to the engine and identifies the problem cylinder. The cylinders in question for this test are deactivated by switching off the fuel injectors or by stopping the spark (ignition) from the spark plug.

The test mode can have manual control by switching off the fuel supply or ignition to a particular cylinder. The scan tool can also deactivate a cylinder by switching to drive control mode or operate in automatic or semi-automatic mode with an engine tester that supports this test. If the diagnostic mode is automatic, the device disables the cylinders and performs the measurements independently. The procedure for connecting the engine tester should refer to its operating instructions.

Analyzing the results of cylinder diagnostics indicates the cylinder with the problem, but naturally does not determine the cause of the problem. Engine cylinder deactivation indicates the cylinder to check. Cylinder deactivation occurs in engine operating modes when only a small amount of engine power is required, for example to maintain the vehicle's cruising speed.

When part of the cylinder is deactivated, the throttle valve opens wider, helping to reduce pumping losses. This also reduces the energy needed to turn the camshaft and cooling losses. The mechanical components required to disconnect the cylinders are surprisingly simple. All three manufacturers' systems use computer-controlled solenoids to move the rods in the valve lifters (DaimlerChrysler and GM systems) or in the valve rocker arm halves (Honda). Honda's VCM system is a variant of its proprietary VTEC variable valve timing system; instead of selecting a large or small valve opening in the VTEC system, the VCM system adjusts the rocker arm to ensure full valve closure.

One of the most widely used solutions for cylinder deactivation is the lift-pin control mechanism from Italian automotive supplier Delphi Automotive Systems. There are currently two types of this method: controlled deactivation of cylinders as a single unit (cylinders are deactivated simultaneously); controlled deactivation of individual cylinders (cylinders can be deactivated separately). The first type is used on V and opposed engines, while the second is mainly used on in-line engines.

Advantages of engines equipped with a cylinder deactivation system: increased fuel efficiency (10-20%); reduction in harmful emissions into the atmosphere (20-30%), improved filling of the engine with fresh air, and reduced pumping losses.

Disadvantages of the system: engine imbalance when deactivation mode is activated, which can lead to strong vibrations and increased noise levels. This problem is solved by more accurate motor balancing calculations and the use of hydraulic motor supports and noise-absorbing materials; an increase in the cost of manufacturing the engine, but the use of this system reduces fuel costs; a slight increase in weight; and maintenance and repair difficulties due to the complexity of the system.

References

2. Марченко, А. П., Рязанцев, М. К., Шеховцов, А. Ф. (2004). *Двигуни внутрішнього згоряння: Серія підручників у 6 томах.* (Т.1) Розробка конструкцій форсованих двигунів наземних транспортних машин. Прапор.

3. Гунько, І. В., Галущак, О. О., & Кравець, С. М. (2019). *Аналіз технологічних систем. Обґрунтування інженерних рішень*. ВНАУ.

4. Невлюдов, І. Ш. (2019). Техніко-економічне обґрунтування інженерних рішень. Криворізький коледж НАУ.

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OVERVIEW OF LOADERS AND THEIR DEVELOPMENT PROSPECTS

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Front-end loaders are indispensable equipment in many industries, including construction and industrial sectors, for performing loading and unloading as well as lifting and transporting operations. These machines have almost completely replaced excavators in loading operations due to advantages such as (Виробництво Група компаній ТДС; Shcherbak et al., 2021):

- High traveling speed and mobility, allowing them to service multiple sites (pits) in quarries with a single machine.
- High manoeuvrability, enabling them to work in relatively confined spaces.
- Versatility in application, capable of efficiently clearing the base of a pit.
- The ratio of real lifting capacity to its weight is 2-2.5 times higher than that of hydraulic excavators.
- Specific cost per 1 m3 bucket capacity is 1.5-2 times lower than that of hydraulic excavators.

The popularity of loaders is also facilitated by a wide range of interchangeable equipment.

Loaders can be classified based on several criteria. Particularly, by the type of frame, loaders are categorized into those with a rigid frame and articulated loaders. Machines with a rigid frame are more stable, but the presence of articulation enhances manoeuvrability, providing certain advantages in confined spaces or uneven terrain as they can easily overcome obstacles.

Based on the positioning of the working equipment, loaders can be front-end loaders, as well as those with the bucket located behind or on the side. The most common type is front-end loaders, which have the bucket positioned in the front. These loaders are frequently used for loading materials onto trucks, moving cargo on construction sites, and in warehouse logistics.

Loaders with a bucket positioned behind the machine are used for excavation and material removal from trenches and excavations. They are also utilized for digging and loading cargo.

Side loaders, on the other hand, have a bucket that can be lifted and rotated from the side of the machine. They are typically employed for operations in narrow spaces and for moving cargo from side to side, such as in dense warehouse configurations.

Based on the type of chassis, loaders can be divided into two main groups: tracked and wheeled. Tracked loaders (Figure 1) have high specific power and excellent off-road capabilities, making them suitable for working on soft or uneven terrain. However, a significant drawback is that they require transport trucks with platforms for relocation. Therefore, tracked loaders are primarily used on large construction sites. An example of such a loader is the John Deere 655K, which, with a weight of almost 18.5 tons, has a breakout force of 15 tons and a capacity of 1.9 m^3.

Figure 1. – Loader with tracks John Deere 655K

Wheeled loaders are more versatile and, therefore, encountered much more frequently. Based on the size of the machine and its load capacity, loaders can be classified as follows:

- Mini-loaders (up to 5 tons in weight and up to 2 tons of load capacity);
- Small loaders (up to 15 tons in weight and up to 4 tons of load capacity);
- Medium loaders (up to 25 tons in weight and 10 tons of load capacity);
- Large loaders.

Mini and small loaders are typically used for simple tasks in urban conditions, such as snow removal, earthmoving operations, etc. In manufacturing, they are essential for working with bulk materials. Medium and large loaders find application in quarries and large-scale industrial production.

Despite the already widespread popularity of loaders, the design of loaders continues to evolve. Recently, to expand the range of tasks performed by loaders and enhance their efficiency, modern manufacturers, alongside loaders of traditional design, are constantly updating, developing, and producing new loader designs.

A current trend in the modern world is the use of unmanned vehicles, and this has also impacted loaders. A leader in this direction is the company Volvo (see Figure 6). In 2018, the company, in collaboration with LEGO, developed a toy model of such a loader, and now they have produced a non-series instance of a commercial product called LX03 based on the toy (Figure 2). In this case, most of the mechanisms will be used in the serial product L25 (L120 – Michigan: Volvo Construction Equipment). Industrial unmanned vehicles have significant advantages, the main of which is increased efficiency in hazardous environments. This can include either contamination or areas that are simply challenging to work in, such as quarries and mines (Volvo Construction Equipment and LEGO®).

Figure 2. – Unmade loader Volvo LX03

Thus, despite the widespread and popular use of loaders, manufacturers do not stand still and continually evolve their products to enhance functionality. Research focused on the full automation of loaders, capable of performing work processes autonomously without operator intervention, is a promising avenue for exploration.

References

1. Виробництво Група компаній ТДС. Група компаній ТДС. https://tdc.ua/production
2. Shcherbak, O., Suminov, A., & Khachaturian, S. (2021). Development of a method for designing specialized machinery based on a hinge tractor. *Bulletin of Kharkov National Automobile and Highway University*, 95(32). https://doi.org/10.30977/bul.2219-5548.2021.95.0.32
3. Deere, J. https://www.deere.com/en/loaders/crawler-loaders/655k-crawler-loader/
4. *L120 – Michigan: Volvo Construction Equipment. Volvo Construction Equipment.* https://www.volvoce.com/global/en/products-and-services/past-products/wheel-loaders/michigan/l120/

5. *Volvo Construction Equipment and LEGO® Technic team up with children to create an autonomous concept wheel loader of the future.* https://www.volvoce.com/global/en/news-and-events/news-and-stories/2018/volvo-construction-equipment-and-lego-technic-team-up/

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NATURAL GAS VEHICLES AND HYBRID GAS VEHICLES: THEIR USFULLNESS AND POPULARISATION IN FUTURE

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Gas engines in cars represent a promising direction for the development of the automotive industry. They have a number of advantages over traditional gasoline and diesel engines, such as lower emissions, higher efficiency and fuel economy. One of the most promising types of gas engines is the engine running on liquefied natural gas (LNG) or methane. These engines have a high compression ratio, which allows them to provide higher efficiency than traditional engines. In addition, the use of methane as fuel can significantly reduce emissions of carbon dioxide and other harmful substances. In recent years, the technology of gas hybrid engines, which combine the advantages of gas and electric engines, has also been actively developing. These engines can run on either gas or electric power, reducing emissions and improving fuel economy.

Parallel hybrid. In a parallel hybrid bus, the combustion engine and the electric motor are connected to the transmission independently. The electric motor is designed to provide power during stop-and-go traffic while at highway speeds the vehicle is powered solely by the internal combustion engine. During acceleration, both the electric motor and the combustion engine power the transmission. In addition, through a process called regenerative breaking, energy loss due to braking is recovered and utilized to charge the battery (Ranganathan, 2005).

Series hybrid. A series hybrid bus is exclusively propelled by the electric motor. In a series hybrid bus, the Internal Combustion Engine (ICE) is connected to an electric generator which converts the energy produced by the ICE into electric power. This electricity supplies to a motor which turns the wheels of the vehicle. The generator also recharges a battery pack which provides supplemental power to the motor. Since the ICE is not connected to the wheels, it can operate at an optimum rate and can even be switched off for short periods of time for a temporary all-electric operation of the bus (Ranganathan, 2005). Parallel hybrids have a higher efficiency than series hybrids at constant speeds whereas series hybrids are better off for driving in traffic.

Providing clean, quiet, affordable alternatives to the diesel is a complex challenge that goes beyond simply replacing vehicle fleets or retro-fitting engines. If we do choose to move to a hydrogen economy there is also a potential role for hydrogen powered vehicles:

• Hydrogen is finally coming on stream as a viable fuel to power vehicles.

• Two decades after they launched petrol-electric hybrids, Toyota recently started producing fuel-cell vehicles, underlining its plan to eliminate petrol and diesel vehicles from its fleet by 2050. Other car manufacturers are also investing in hydrogen.

• Fuel-cell technology – which is effectively hydrogen-electric hybrids – is also being developed by other car manufacturers who see it as an integral part of a fossil-free future.

Vehicles and infrastructure. To put it simply, more vehicles and infrastructure as well as the supporting supply chain, are needed. But the previous lack of available Compressed natural gas (CNG) vehicles is just one of the factors holding up gas as a viable alternative fuel option. Until recently, vehicles had to be retro-fitted to run on CNG, or run on a blend of diesel and CNG.

The current lack of filling stations to support a bigger fleet of CNG vehicles is also a barrier, with only 15 dedicated sites currently in operation, five of which are accessible for public. Where companies are investing in CNG fleets, they have tended to build their own support infrastructure to realise the benefits. Finally, a supply chain needs training in new engine technologies to maintain the vehicles, and must be able to manage, supply and transport the fuel itself to support thousands of CNG HGVs and buses. It would also require a policy framework which supports operators who move to gas.

Efficiency and emissions. Natural gas engines produce fewer emissions, have a lower carbon footprint and are 50 per cent less noisy than diesel engines, so they are ideal for enabling night-time deliveries, for example. Tests show they outperform Euro VI diesel engines on NOx, Sulphur Oxide (SOx), Particulate Matter (PM) and CO2 emissions.

With retro-fitted vehicles, “methane slip” could be an issue due to incomplete combustion of the methane in the engine, which escapes into the atmosphere. As methane itself is a significant greenhouse gas, even more powerful than CO2, any slippage might negate some of the benefits of using gas as a greener energy source for vehicles. An analysis to date which aims to quantify CO2 emissions in transport has been inconsistent and contains a number of uncertainties. To address this, the researchers have developed a consistent vehicles test protocol, with the low carbon vehicle partnership carrying out real world mission testing under controlled conditions. It is hoped that the results from these tests will strengthen the case for CNG for use with trucks and buses (2016).

Driving change. The potential of gas as a road transport fuel is incorporated in the Low Carbon Vehicle Partnership’s infrastructure road map to 2030.

But of course any move to CNG must work in commercial terms for fleet operators – providing the freight and bus sector with reliable returns on their investment. Getting this balance right between costs, noise and emissions as well as certainty of supply of CNG should attract more and more companies to opt for this lower carbon technology and away from diesel.

References

1. *Ranganathan, S. (2005). Hybrid Costs and Benefits.* http://www.eesi.org/files/eesi_ hybrid_bus_032007.pdf.
2. *The future of gas*. (2016). https://www.eua.org.uk/uploads/577147EB5BAC5.pdf?dm_i=1UMB,4C37P,MSB96Z,FW10K,1

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COMPETITIVENESS OF UKRAINIAN MECHANICAL ENGINEERING ENTERPRISES COMPARED WITH EUROPEAN ONES

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The main problem of mechanical engineering in Ukraine is finding large sales markets. New high-capacity sales markets are characterized by high competition, requiring high quality products, the introduction of the latest technologies and high production efficiency. In reality, mechanical engineering products are often morally obsolete, which is caused by the use of outdated production technologies, wear and tear of equipment, and a minimal level of innovative activity. The mechanical engineering complex of Ukraine covers more than 20 specialized industries, that is, almost all industries.

Domestic mechanical engineering enterprises are losing competition to European ones for three main reasons:

Firstly, huge experience in the field of creating machines and aggregates; modern technologies provide European companies with a significant scientific and technical lead compared to domestic manufacturers in terms of quality, reliability and durability;

Secondly, the world's leading European firms have the experience and capabilities to implement turnkey projects, which significantly reduces the customer's transaction costs;

Thirdly, European machine manufacturers are able to fulfill orders on credit, at low interest rates with deferred payment for several years, which is especially actually for Ukrainian companies in conditions of liquidity shortage.

Among the main problems of enterprises of the mechanical engineering complex of Ukraine, the following can be distinguished:

The main production assets do not allow to fill the domestic market and satisfy the demand for nationally produced goods; lack of working capital in enterprises. An insufficient amount of highly liquid funds leads to the fact that enterprises cannot settle with counterparties, that is, they lose their solvency, which in turn reduces their competitiveness.

The profitability of production decreases. Based on this, mechanical engineering has turned into one of the least profitable fields of industry. In this regard, investors began to finance enterprises less.

Low level of innovative activity of enterprises. Their low investment attractiveness. Financing of the innovative activities of the industry occurs mainly at the expense of the enterprises' own funds and loans.

Absence of a number of high-tech industries. First of all, a number of key export positions of mechanical engineering are missing: the IT industry, the production of complex medical equipment, many instruments for scientific research, and modern passenger cars.

Low competitiveness of many types of enterprise products. In terms of quality and technological solutions, radio electronics products, household appliances, agricultural and road construction machines, as well as a number of other products are significantly inferior to their European counterparts. In this area, characteristic waste technologies continue to be used on a large scale, which in turn leads to an increase in the resource capacity of products and prevents the reduction of production costs and the release of innovative products in other sectors of the economy.

Insufficient number of qualified workers. At a low level of remuneration, young specialists do not want to work in this field, and the vast majority of experienced workers are of retirement age.

Competition is one of the key factors stimulating increased productivity and sustainable economic development.

The goal of reforms in the mechanical engineering sector is to create conditions for the development of a competitive mechanical engineering sector.

It should be noted that in recent years of the development of the economy of Ukraine, the activity of innovation and investment activities in the mechanical engineering industry is increasing. The development of the industry is impossible without making significant investments and solving the problem of restoring the production potential of the industry. Therefore, there is a need to make significant efforts to stimulate the investment activity of the mechanical engineering industry and the development of science.

The priority areas of development of the industry should be: overcoming the scientific and technological lag behind industrially developed European countries, increasing the level of scientific developments in the field of mechanical engineering, increasing the innovative activity of enterprises, and creating conditions for increasing the volume of production of high-tech products.

References

1. Бородіна, О. М. (2011). *Конкурентоспроможність економки України: стан і перспективи підвищення.* Основа.

2. Горбашевська, М. О. (2011). Перспективи співпраці України з ЄС на прикладі машинобудівельного комплексу. *Науковий вісник Волинського національного університету ім. Лесі Української.*

4. Данилишин, Б. М. (2007). *Машинобудування в Україні: тенденції, проблеми, перспективи.* Аспект-Поліграф.

5. Малащук, Д. В. (2013). *Особливості інноваційного потенціалу машинобудування України.* Право.

6. Мосій, А. В. (2011). Аналіз розвитку вітчизняного машинобудування. *Соціально - економічні проблеми і держава*, 2.

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GENERAL APPROACH TO VEHICLE BRAKING

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The braking properties of vehicles are an important factor ensuring road safety. The stability of braking properties throughout the entire period of operation ensures the required technical level and competitiveness of the vehicle. The kinetic energy of the vehicle during braking is used to overcome: friction in the braking mechanisms; air resistance; vehicle rolling resistance; friction in the vehicle transmission and friction between the tire and the road. The energy balance of the vehicle when the wheels are rolling without blocking is equal to (Единообразні приписи, що торкаються офіційного затвердження транспортних засобів в відношенні гальмування,1973):

$$\frac{\delta' + G \cdot V^2}{2g} = T_{cp} \cdot \frac{r_{mp}}{r_{\partial}} \cdot (1 - S) \cdot S_{\tau} + P_w \cdot S_{\tau} +$$
$$+ G \cdot f \cdot (1 - S) \cdot S_{\tau} + \frac{M_r}{r_{\partial}} \cdot (1 - S) \cdot S_{\tau} + G \cdot \varphi_x \cdot S_{\tau} \tag{1}$$

where δ' – the rotational mass coefficient (with the engine turned off);

T_{cp} – the average value of the resulting friction force between the drum (disc) and the pads;

R_{mp}– the radius of the friction;

S – the slip coefficient of the braked wheel;

S_{τ} – the length of the braking distance;

M_r – the average torque of transmission friction forces.

A significant improvement in the energy balance of a vehicle during braking can be achieved by using brake force regulators, anti-lock devices and other devices [2].

The external forces acting on the vehicle are shown in Figure 1. The main forces providing vehicle braking are the total tangential reactions $\Sigma R_{x\text{г}1}$ and $\Sigma R_{x\text{г}2}$ directed against the movement of the wheels in the contact plane. They may differ in different cases of braking: $\Sigma R_{x\text{г}1}=\Sigma R_{z1} \cdot \varphi_{x1}$ and $\Sigma R_{x\text{г}2}=\Sigma R_{z2} \cdot \varphi_{x2}$.

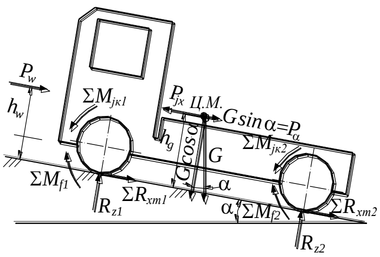

Figure 1. – Diagram of forces and torques acting on the vehicle during braking

During emergency braking, they can reach the maximum values $\Sigma R_{x\text{г}1\max}=\Sigma R_{z1}\cdot\varphi_{x\max1}$ and $\Sigma R_{x\text{г}2\max}=\Sigma R_{z2}\cdot\varphi_{x\max2}$, when they simultaneously reach their maximum values on all wheels and $\varphi_1=\varphi_2=\varphi_{\max}$, they can be represented as:

$$\Sigma R_{xm1\max} + \Sigma R_{xm2\max} = \varphi_{x\max} \cdot \left(\Sigma R_{z1} + \Sigma R_{z2}\right) = G \cdot \cos\alpha \cdot \varphi_{x\max} = \Sigma R_{xm\max} \quad (2)$$

where $\Sigma R_{x\text{г}\max}$ – the maximum value of the total tangential reaction (braking force) acting on all wheels of the vehicle during braking with full use of the clutch forces.

In the process of braking on a vehicle, in addition to the braking force, longitudinal forces also act, the dynamic balance of which can be expressed by the equation:

$$\Sigma R_{xm1} + \Sigma R_{xm2} + P_w + P_\alpha = P_{jx} \quad (3)$$

In (4), instead of ΣR_{xm1} and ΣR_{xm2}, we substitute their values:

$$\frac{M_{m1}}{r_{\partial 1}} + \Sigma P_{f1} - \frac{\Sigma J_{\kappa 1}}{r_{\partial 1}} \cdot \frac{d\omega_{\kappa 1}}{dt} + \frac{M_{m2}}{r_{\partial 2}} + \Sigma P_{f2} - \frac{\Sigma J_{\kappa 2}}{r_{\partial 2}} \cdot \frac{d\omega_{\kappa 2}}{dt} + \\ + P_w + P_\alpha = P_{jx} \quad (4)$$

where $\Sigma P_{f1}+\Sigma P_{f2}=P_f$ – the rolling resistance force of vehicle wheels;

$\Sigma J_{\kappa 1}$ and $\Sigma J_{\kappa 2}$ – the total moments of inertia of the driven and driving wheels of the vehicle.

Using assumption (4), we combine:

$$\frac{\Sigma J_{\kappa 1}}{r_{\partial 1}} \cdot \frac{d\omega_{\kappa 1}}{dt} + \frac{\Sigma J_{\kappa 2}}{r_{\partial 2}} \cdot \frac{d\omega_{\kappa 2}}{dt} = \frac{\Sigma J_{\kappa}}{r_{\partial}} \cdot \frac{d\omega_{\kappa}}{dt} = \frac{\Sigma J_{\kappa}}{r_{\partial}^2} \cdot \frac{dV}{dt} \quad (5)$$

and

$$\frac{M_{m1}}{r_{\partial 1}} + \frac{M_{m2}}{r_{\partial 2}} = \frac{M_m}{r_\partial} = P_m \quad (6)$$

where $M_\text{г}$ and $P_\text{г}$ – the total braking torque and braking force on the wheels of the vehicle.

Taking into account the transformations made, we combine the terms of equality: (5), related to the inertia of the translational movement and the inertia of the rotating parts:

$$\frac{\Sigma J_{\kappa}}{r_{\partial}^{2}} \cdot \frac{dV}{dt} + P_{jx} = \frac{\Sigma J_{\kappa}}{r_{\partial}^{2}} \cdot \frac{dV}{dt} + \frac{G}{g} \cdot \frac{dV}{dt} = \frac{G}{g} \cdot \frac{dV}{dt}\left(1 + \frac{\Sigma J_{\kappa}}{r_{\partial}^{2}} \cdot \frac{g}{G}\right) \tag{7}$$

The part of expression (8) enclosed in brackets is the coefficient $\delta^{'}$, which takes into account the influence of the inertia of the rotating parts of the vehicle during braking:

$$\delta^{'} = 1 + \frac{\Sigma J_{\kappa}}{r_{\partial}^{2}} \cdot \frac{g}{G} \tag{8}$$

Then the inertia force of progressively moving masses and rotating parts can be expressed:

$$P_j = P_{jx} \cdot \delta^{'} = \frac{G}{g} \cdot \delta^{'} \cdot \frac{dV}{dt} \tag{9}$$

Taking into account the transformations made, we obtain the equation of motion of the vehicle during braking:

$$\frac{M_m}{r_{\partial}} + P_f + P_w + P_{\alpha} = P_j \tag{10}$$

or

$$P_m + P_f + P_w + P_{\alpha} = P_j \tag{11}$$

The average value of vehicle deceleration during the constant braking phase is called constant deceleration j_{cm}. Let's determine the value of j_{cm} during emergency braking with full use of clutch forces. Provided that V is small and P_w=0, and $\delta^{'}\approx 1.0$ (in the case of wheel locking), we obtain:

$$\Sigma R_{xm\,\max} + P_{\alpha} = P_{jx} \text{ or } \varphi \cdot G \cdot \cos\alpha + G \cdot i = \frac{G}{g} \cdot j_{ycm} \tag{12}$$

where from:

$$j_{cm} = (\varphi \cdot \cos\alpha + i) \cdot g \tag{13}$$

and on a horizontal road:

$$j_{cm} = \varphi \cdot g \tag{14}$$

Next, we determine j_{cm} during service braking of the vehicle, taking into account the influence of all forces on it:

$$j_{cm} = \frac{(P_m + P_f + P_\alpha + P_w)}{G \cdot \delta'} \cdot g \tag{15}$$

Equating the kinetic energy of the vehicle at the beginning of braking, the maximum under the condition of clutch, to the braking force, assuming that P_w=0, and braking distance $S_{г.э}$ during emergency braking on a horizontal road:

$$\frac{G \cdot V_н^2 \cdot \delta'}{3{,}6^2 \cdot 2 \cdot g} = \varphi_{x\max} \cdot G \cdot S_{г.э} \tag{16}$$

where from:

$$S_{г.э} = \frac{V_н^2 \cdot \delta'}{254 \cdot \varphi_{x\max}} \tag{17}$$

With the previously considered case and the accepted assumptions, the braking distance during emergency braking on a slope and service braking, respectively, will be equal to:

$$S_{г.э} = \frac{G \cdot \delta'}{254 \cdot (\varphi_{x\max} + i)} \tag{18}$$

where $S_{г.с}$ – the braking distance of the vehicle during service braking, and taking into account all the forces acting on the vehicle:

$$S_{m.c.} = \frac{G \cdot V_н^2 \cdot \delta'}{254 \cdot (P_m + P_f + P_\alpha + P_w)} \tag{19}$$

Formulas (16) and (17) show that the main influence on $S_г$ is the speed V_n, with which braking begins, and the clutch coefficient φ_x, moreover, the speed value affects the length of $S_г$.

The stopping braking distance can be approximately calculated using the formula (Генбом, Гудз, Дем'янюк, Кизман, & Кобилянський, 1974):

$$S_{г.ост} = \frac{V_н}{3{,}6} \cdot \left(t_1 + t_2^{'} + \frac{t_2^{''}}{2} \right) + \frac{K_э \cdot V_н^2 \cdot \delta^{'}}{254 \cdot \varphi_{x\max}} \tag{20}$$

The formula is based on the dependence $S=V{\cdot}t$ for constant motion. During time $t_1+t'_2$ the path covered by the vehicle is $S_{t_1+t_2^{'}} = V_н / 3{,}6 \cdot (t_1 + t_2^{'})$. During this period, the vehicle moves at a constant speed without delay. During the time t''_2 there is some decrease in speed as a result of the appearance of deceleration, and the path $S_{t_2} \approx \frac{V_н}{3{,}6} \cdot \frac{t_2^{''}}{2}$, where time t_1 – the driver's reaction time; time t'_2 – the delay time of braking system activation; time t''_2 – the time from the activation of the braking system to the constant braking phase.

References

1. Единообразні приписи, що торкаються офіційного затвердження транспортних засобів в відношенні гальмування. (1973). *Правила ЄЕК ООН*, 13, 41.
2. Волков, В. П. (2003). *Теорія експлуатаційних властивостей автомобіля*. ХНАДУ.
3. Генбом, Б. Б., Гудз, Г. С., Дем'янюк, В. А., Кизман, А. М., & Кобилянський, В. Н. (1974). *Питання динаміки гальмування і теорії робочих процесів гальмових систем автомобілів*. Вища школа.

Korol V. Yu.

MODERN APPROACHES TO CREATION OF ORTHOPHOTOPLAN AND DIGITAL ELEVATION MODEL WITH UAV

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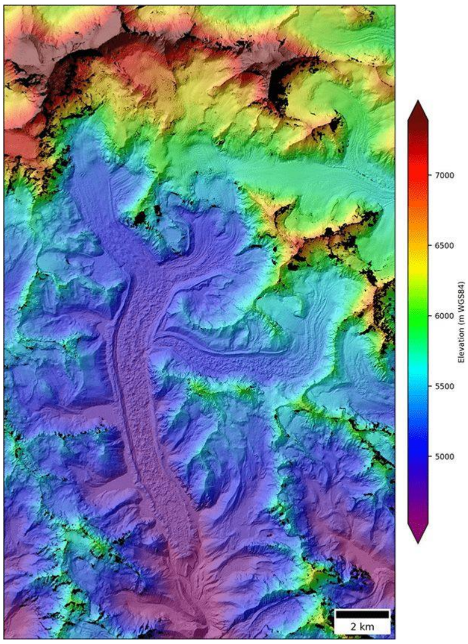
With the advent of flying machines, people immediately began to use them for drawing up maps and plans, describing the topography of the area being explored. At first, these were primitive sketches of the contours of the territory from the air, then the era of photo technology came. Both the aviation base and the physical methods of collecting topo-geodetic data were gradually improved. Currently, some companies that provide geodetic services have begun to create orthophotoplans and digital elevation model with the help of unmanned aerial vehicles (drones and quadcopters, hereinafter – UAVs), which turned out to be quite profitable and convenient for saving time and resources for field surveys. Orthophotoplans and relief models play the role of primary materials for creating databases of various geoinformation systems and obtaining high-quality topographic maps based on them.

Obtaining orthophotoplans consists in processing photo materials obtained during route or continuous aerial photography using a UAV. This process is called orthocorrection or orthorectification. During it, a computer transformation of the initial images is carried out, which compensates for perspective and other distortions caused by the influence of the topography, the change in the angle of the optical axis of photography and other reasons. Orthorectification is necessary even with a very high level of quality of the initial UAV photos. As a result of its implementation, the obtained orthophoto plans are in no way inferior to topographic maps obtained by ground survey methods in terms of the degree of image reliability, and can be effectively used in the following fields: updating topographic maps, creating a digital topographic basis for various computer applications, designing architectural and construction objects, geological sounding, searches and exploration, in the field of land cadaster and land management, etc.

More and more specialists in geodesy and cartography prefer to use reliable, productive and low-maintenance UAVs. When photographing photo materials for orthophotoplanes from a UAV, tilted photogrammetry is successfully used – capturing the image with several lenses. These multiple lenses are combined into one array with fixed axis angles. In the resulting images, you can see details that can sometimes be missing or missed when shooting only vertical photos. For example, these are details covered by vegetation or tall buildings. But modern UAVs have a solution that removes the need for tilted multi-camera shooting technology by using a single camera that can rotate the lens to the desired angles during the mission.



UAV can shoot almost anywhere and in almost any weather. In this regard, there is no need for the geodetic team to work in dangerous areas. Compared to manned aircraft, UAVs do not require special airfields and landing sites. They are easily carried in a case and are ready for use within minutes of arriving at the site. Compared to an airplane, a type of UAV such as a quadcopter can fly at a low altitude, which greatly improves the quality of shooting. No special knowledge and skills are required to manage the UAV, it is enough to teach one or two employees how to pilot, and the program will do the rest for a person.

Digital terrain models obtained by UAV can be divided into:

- two-dimensional, where relief forms are transmitted horizontally (imaginary lines connecting points of the same height);
- three-dimensional, in the form of various 3D projections and block diagrams.

Modern technologies make it possible to obtain digital models of the earth's surface with the help of UAVs not only by processing photo materials obtained as a result of aerial photography, but also by the following methods:

- by the method of laser scanning of the territory with the help of lidars. Lidar are scanning devices, i.e. active optical systems that work on the principle of emitting and receiving reflected laser radiation;
- by the method of radar detection of objects located on the surface of the earth.

Various programs capable of photogrammetric processing and image analysis are used to process photo materials to create orthophoto plans. Below are some of the most commonly used programs: ESRI's Drone2Map, Pix4D, Agisoft Metashape, DroneDeploy, Trimble Inpho. These programs allow you to process photo materials from various sources, creating orthophoto maps and 3D models for use in geodesy, cartography, architecture and other fields.

References

1. Янчук, Р. М., Трохимець, С. М. (2017). Створення картографічної основи для розробки генеральних планів населених пунктів за матеріалами аерознімання з непрофесійних БПЛА. *Вісник НУВГП. Серія «Технічні науки»*, 1(77), 32–39.
2. Вовк, А. et al. (2015) Аналіз результатів для створення ортофотопланів та цифрових моделей рельєфу із застосуванням БПЛА TRIMBLE UX-5. *Геодезія, картографія і аерофотознімання*, 81, 90–103.

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WINTER ROAD MAINTENANCE. WINTER SLIPPERINESS CONTROL. RELEVANCE OF THE ISSUE

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Winter road maintenance is a set of works carried out by road maintenance organizations to ensure uninterrupted and safe traffic on roads in winter, and includes clearing roads of snow, protecting them from snow drifts and winter slipperiness control, according to the "Unified rules of winter road maintenance" PG.1-218-118 (П-Г.1-218-113:2009 Технічні правила ремонту та утримання автомобільних доріг загального користування України; П-Г.1-218-118:2005 Єдині правила зимового утримання автомобільних доріг).

Every year during the winter, road organizations do everything possible to ensure safe and uninterrupted traffic on roads.

The main obstacle to the safe movement of vehicles in winter is the formation of winter slipperiness. This phenomenon helps to reduce the adhesion coefficient of a vehicle's wheel with a coating to values of 0.33-0.35, which is unacceptable according to DSTU 3587-97 (standard value $К_{зч}$=0.45) and causes the possibility of a road traffic accident (RTA) with serious consequences. The formation of winter slipperiness can lead to a decrease in the speed of traffic flow by 2-2.5 times, a decrease in productivity by 30-40%, and an increase in the cost of transportation by 25-30%.

Types of winter slipperiness (ДСТУ 9185:2022 Настанова щодо зимового утримання автомобільних доріг, 2022): glaze (glassy ice), granular deposit, granular hoarfrost, loose snow, snow roll, snow-ice roll.

To ensure the safe movement of vehicles, winter slipperiness must be promptly detected and eliminated by operational road services. Measures to control winter slipperiness should ensure good transport and operational condition of roads. Therefore, one of the important issues of winter road maintenance is the winter slipperiness control. Having extensive experience in creating and improving ways to control slipperiness, this problem has still not been completely solved.

The winter slipperiness control must be carried out first of all in: accident-hazardous areas; on areas with a slope of more than 6%; visibility less than 350 m; radii in the plan are less than 600 m; within settlements; at intersections at the same level; within bus stops; on artificial structures and approaches to them.

There are several ways to control winter slippage: mechanical, frictional, physical & chemical, chemical & chemical-frictional methods (ДСТУ 9185:2022 Настанова щодо зимового утримання автомобільних доріг, 2022).

The mechanical method consists in shaking off the ice from the surface of the coating and removing it beyond the roadside.

The friction method consists of scattering friction materials over the icy surface, which increase the adhesion coefficient, but do not eliminate winter slipperiness.

The physical & chemical method consists of pre-treating coatings with chemical reagents that improve the hydrophobic properties of the coating surface.

With the chemical method, pure de-icing materials (DIM), which have the properties of melting ice, are distributed. Solid DIM and their solutions are used to control icing.

The chemical & friction method involves mixing crystalline DIM with inert materials (sand, screenings from stone crushing, fine gravel, etc.) in an amount that ensures the distribution of DIM, as with the chemical method. Such a mixture is better fixed on the ice surface, and the grains of the friction material provide an increase in surface roughness (Боротьба із зимовою слизькістю і потреба в протиожеледних матеріалах).

Also, the thermal method of winter slipperiness control is gaining wide application. Based on world experience, this method of controlling snowstorms, glassy ice and slipperiness on road surfaces can be considered promising due to the environmental friendliness of the design, the use of new effective materials for construction and alternative energy sources.

Some of the most effective alternative sources are solar energy (solar panels), wind energy (windmills), and internal energy of the Earth (heat pumps).

Consequently, this issue is quite relevant; winter road maintenance requires the adoption of a number of operational, important and systematic decisions that arise on the road. All over the world, scientific research and searches are being conducted for more and more effective and environmentally friendly ways to control winter slipperiness. The development of technologies is impressive, it is necessary to take a progressive approach to this issue in order to save on the consumption of material resources of operational organizations that are engaged in winter road maintenance.

References

1. П-Г.1-218-113:2009 Технічні правила ремонту та утримання автомобільних доріг загального користування України.
2. П-Г.1-218-118:2005 Єдині правила зимового утримання автомобільних доріг.
3. ДСТУ 9185:2022 Настанова щодо зимового утримання автомобільних доріг. [Чинний від 2022-07-06]. Технічний комітет стандартизації ТК 307 Автомобільні дороги і транспортні споруди.
4. Боротьба із зимовою слизькістю і потреба в протиожеледних матеріалах. https://studfile.net/preview/5200637/page:20/

Kozub V. R.

ENHANCING INFRASTRUCTURE: TECHNOLOGICAL ADVANCES IN LIFTING CRANES

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The evolution of lifting cranes reflects the dynamic demands of the construction industry, with innovations reshaping their role in modern projects. From humble beginnings relying on manual labor, lifting cranes have undergone a remarkable transformation driven by technological advancements.

Modern lifting cranes are a diverse array of specialized types, tailored to specific tasks. Tower cranes dominate construction sites with unparalleled vertical reach, mobile cranes offer flexibility across zones, crawler cranes navigate challenging terrains, and overhead cranes optimize space in factories. This diversity ensures there's a crane for every lifting need, showcasing the adaptability of crane technology.

Technological features have played a pivotal role in enhancing the efficiency and safety of lifting cranes. Remote control capabilities empower operators to manage cranes from a safe distance, improving precision and reducing risks. Sensor technology provides real-time monitoring of critical parameters like load capacity and stability, ensuring safer operations. Telematics and data analytics enable predictive maintenance, minimizing downtime and maximizing overall efficiency.

The integration of smart technologies has given rise to intelligent crane systems, with automated features like anti-sway technology ensuring smoother and more controlled lifting operations. Collision avoidance systems contribute to safety on busy construction sites, preventing accidents and prioritizing the well-being of workers.

Materials and design have also seen significant improvements. High-strength alloys and advanced composites contribute to robust crane structures without compromising weight. Innovative design approaches optimize the balance between strength, weight, and stability, resulting in cranes that are both powerful and agile.

Having analyzed the environmental sustainability, lifting crane manufacturers are incorporating eco-friendly features, such as energy-efficient systems and the use of recyclable materials. This aligns the construction industry with broader efforts to reduce its ecological footprint, emphasizing the importance of responsible practices in crane technology.

Looking ahead, the future of lifting cranes holds exciting prospects. The integration of artificial intelligence and machine learning is set to enhance automation and decision-making processes further. Drones may become integral in surveying and monitoring construction sites, providing valuable data to optimize crane operations. As technology advances, lifting cranes will continue to play a crucial role in shaping the skylines of tomorrow, ensuring safer, more efficient, and environmentally conscious construction practices.

The technological evolution of lifting cranes mirrors the dynamic needs of the construction industry. From manual labor to smart, automated systems, lifting cranes have become indispensable in modern construction projects. Embracing innovation and sustainability, the future promises even more groundbreaking developments in the world of lifting cranes.

The evolution of cranes not only reflects the dynamic needs of the construction industry but also highlights key directions for the future. With the integration of artificial intelligence and machine learning, automation and decision-making processes in lifting cranes will significantly improve. This will not only enhance operational efficiency but also reduce risks associated with human factors.

Unmanned aerial vehicles (drones) are also poised to play a crucial role. They can become indispensable in surveying and monitoring construction sites, providing valuable data to optimize crane operations. This will not only improve safety but also expedite planning and coordination processes.

Considering the growing emphasis on environmental sustainability, the future of cranes will be inseparable from the development of technologies that reduce environmental impact. We can expect further strides in energy efficiency and the use of renewable materials, making the construction industry more responsible and sustainable.

The future of lifting cranes promises exciting innovations in technology and design, with a focus on automation, environmental sustainability, and safety. These changes will not only improve construction processes but also contribute to the creation of smarter and more responsible cities.

Therefore, the future trajectory of lifting cranes anticipates captivating advancements in technology and design, emphasizing automation, environmental sustainability, and safety. These developments are poised to not only refine construction processes but also play a pivotal role in shaping urban landscapes that are both intelligent and responsible. As we navigate towards this future, the integration of artificial intelligence, machine learning, and drone technology will likely redefine the capabilities and efficiency of lifting cranes, ensuring a harmonious blend of innovation, ecological consciousness, and enhanced safety standards in the construction industry.

The synergy of cutting-edge technologies will usher in a new era for lifting cranes. The seamless integration of artificial intelligence and machine learning algorithms will not only optimize crane operations but also enable predictive analytics for preemptive maintenance, further reducing downtime and enhancing overall productivity.

The role of drones in construction is poised to expand, offering real-time data for site management, surveying, and safety monitoring. These aerial assistants will become invaluable in providing a comprehensive overview of construction projects, aiding in decision-making and resource allocation.

In the realm of environmental consciousness, the future of lifting cranes will witness a paradigm shift. Advancements in energy-efficient systems, coupled with the incorporation of recyclable materials, will not just meet industry standards but propel the construction sector towards a greener and more sustainable future.

Moreover, as smart cities continue to emerge, lifting cranes will play a central role in the vertical development of urban landscapes. Their integration into intelligent city planning will not only ensure efficient construction practices but also contribute to the creation of aesthetically pleasing and functional spaces.

In conclusion, the evolving landscape of lifting cranes is marked by a convergence of sophisticated technologies, environmental stewardship and urban planning. The future promises not just advancements in machinery but a holistic transformation in how we approach construction, emphasizing efficiency, safety, and sustainability on a global scale. As we embrace these innovations, lifting cranes will stand as iconic symbols of progress in the ever-evolving construction industry.

References

1. Smith, J. (2021). Evolution of Lifting Cranes: A Historical Perspective. *Construction Technology Journal*, 25(2), 45-62.
2. Johnson, A. et al. (2022). Smart Crane Systems: Enhancing Safety and Efficiency. *Journal of Construction Engineering and Management*, 38(4), 112-130.
3. Davis, M. (2023). Drones in Construction: A Comprehensive Review of Applications. *International Journal of Civil Engineering and Technology*, 12(7), 183-198.
4. Greenberg, R. (2022). Toward Sustainable Construction: Eco-friendly Features in Lifting Cranes. *Environmental Engineering Research*, 28(3), 301-315.
5. Robotics and Automation Society. (2023). Artificial Intelligence in Lifting Cranes: Current Trends and Future Prospects. *IEEE Transactions on Automation Science and Engineering*, 19(1), 78-94.

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DIGITIZATION OF OCCUPATIONAL SAFETY

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Digital technologies have a significant impact on the field of occupational health and safety. These technologies automate many processes and open up new opportunities for risk prediction and accident prevention.

One of the main trends in the digitalization of occupational health and safety is the use of machine learning and artificial intelligence to analyse large amounts of workplace safety data (Costantino et al, 2021). This allows forecasting systems to more accurately identify potential risks and develop more effective prevention strategies, efficiently analyse large amounts of data and identify complex patterns (Radu, 2015).

One of the key benefits is the ability to anticipate potential dangerous situations in the workplace. Machine learning makes it possible to create systems that analyse safety information based on historical data, identify risks, and even predict possible events that could lead to accidents (Arana-Landín et al, 2023).

In addition, machine learning helps to improve risk management processes by automating the monitoring and analysis of potential threats (Malik, 2022; Badri et al, 2018). This allows you to respond quickly to risky situations and take timely measures to prevent them.

Let us consider the main machine learning methods and technologies applied in the field of occupational health and safety (Table 1). These machine learning methods and technologies play an important role in identifying, predicting, and managing risks in the workplace, contributing to improving occupational safety and preventing accidents. These methods and technologies also have the potential to be used in occupational health and safety, complementing and expanding the possibilities of applying machine learning in this area.

Table 1. – Machine learning methods and technologies in occupational health and safety

Method / Technology	Description of application in labour protection
Classification	It is used to recognize and classify risks in the workplace based on previous data (identifying risky areas based on accident history).
Clustering	Assists in grouping events and situations by analysing common features (to identify risk groups or common hazard factors).
Prognostication	It is used to predict possible hazardous scenarios based on data dynamics and previous patterns, allowing you to avoid potential accidents or incidents.
Regression	It is used to analyse and predict the impact of various factors on occupational safety, considering the dependencies between different variables and risks.
Neural networks	They are used to processing data from sensors and cameras to detect dangerous situations (detecting safety violations, dangerous areas in the workplace).
Association rules	They are used to identifying associative links between different events and conditions in the workplace, which may indicate potential hazardous situations.
Reinforcement Learning	It is used to develop strategies and models that learn to make decisions in real time based on learning from their own mistakes, which can be useful in situations with production risk.
Deep Learning	It is used to analyse complex data and identify complex dependencies in large amounts of information, which can be useful for recognizing complex risks and hazards in the workplace.
Genetic algorithms	They are used to finding optimal solutions and strategies in occupational health and safety by

	simulating natural selection and selecting the most effective risk management methods.

Machine learning is widely used to predict risks in various fields, including occupational safety. Its application allows you to identify potential dangerous situations and events in the workplace in advance, allowing you to take preventive measures to avoid accidents.

One of the main methods is to use data mining and previous patterns. Machine learning systems can analyse large amounts of historical workplace safety data to identify factors that lead to accidents or incidents. They identify patterns and patterns that can be indicators of possible future risks.

Additionally, machine learning models, such as neural networks or classification algorithms, can predict potential dangerous scenarios based on actual data. They consider various factors that can affect workplace safety, allowing for a preliminary risk assessment and informed decisions to prevent accidents.

Many global companies are using machine learning to improve workplace safety and risk management. For example:

1. The automotive company Tesla uses machine learning systems to support the safe driving of its cars. Tesla's autopilot uses machine learning algorithms to recognise road conditions, other vehicles, and obstacles to avoid accidents and ensure safe driving.

2. General Electric (GE) uses machine learning to predict the technical condition and safety of industrial equipment. They create models that analyse large amounts of sensor data to predict possible breakdowns and avoid accidents.

3. BMW uses machine learning to develop safety systems in their cars. Collision prediction systems, parking assistance systems, and other safety aspects are based on machine learning algorithms to help avoid accidents and ensure the safety of drivers and passengers.

4. Ford uses machine learning to develop automatic braking and collision warning systems. They use data analytics and machine learning models to respond to dangerous situations on the road and minimise the risk of accidents.

5. The Volkswagen Group uses machine learning to develop systems for predicting road risks and improving car safety. They use algorithms to recognise traffic patterns and predict possible conflicts on the road.

Mercedes-Benz is also actively using machine learning to develop safety technologies in its vehicles. Mercedes-Benz is implementing various machine learning-based systems to ensure the safety of drivers and passengers:

– Driving assistance systems. Mercedes-Benz develops driving assistance systems that use machine learning to analyse data from various sensors and cameras. These systems can recognise road signs and obstacles on the road and automatically react to them to maintain safe driving.

– Automatic braking systems. Mercedes-Benz uses machine learning algorithms for automatic braking systems, which allows the vehicle to react to potential threats or emergencies and attempt to avoid or mitigate the consequences.

– Collision warning systems. Mercedes-Benz uses data from various sensors and video surveillance systems to recognise risky situations that could lead to a collision and informs the driver of potential dangers.

– Parking assistance systems. Machine learning is also used to develop automated parking systems that help drivers avoid collisions and control the car while parking.

These machine learning-based technologies implemented by Mercedes-Benz are aimed at improving the safety of automotive systems and helping to avoid accidents on the road.

The way companies are using machine learning to develop advanced safety systems in cars to improve road safety and minimise the risk of road accidents, for various aspects of occupational safety, from risk management in the workplace to safe operation of vehicles, shows the importance of this technology in ensuring safety and preventing risks in the workplace.

References

1. Costantino, F., Falegnami, A., Fedele, L., Bernabei, M., Stabile, S., & Bentivenga, R. (2021). New and Emerging Hazards for Health and Safety within Digitalized Manufacturing Systems. *Sustainability*, 13(19), 10948. https://doi.org/10.3390/su131910948
2. Radu, M. (2015). The Impact of Political Determinants on Economic Growth in CEE Countries. *Procedia - Social and Behavioral Sciences*, 197, 1990–1996. https://doi.org/10.1016/j.sbspro.2015.07.579
3. Arana-Landín, G., Laskurain-Iturbe, I., Iturrate, M., Landeta-Manzano, B. (2023). *Assessing the influence of industry 4.0 technologies on occupational health and safety.* Heliyon, e13720. https://doi.org/10.1016/j.heliyon.2023.e13720
4. Malik, R. N. (2022). *Machines like us? An occupational health perspective on machine learning (artificial intelligence)*(Master's thesis, uis). http://surl.li/pbtyk
5. Badri, A., Boudreau-Trudel, B., Souissi, A. S. (2018). Occupational health and safety in the industry 4.0 era: A cause for major concern? *Safety Science*, 109, 403–411. https://doi.org/10.1016/j.ssci.2018.06.012

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SELF-DRIVING VEHICLES: PROSPECTS AND CHALLENGERS

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Researchers and engineers all over the world wonder what transport of the future will be like. Completely new modes of transport will displace the existing ones, fundamentally changing the transport sector and causing a paradigm shift. Autonomous cars have become a mascot of future transportation, but the new era is not only limited by them, it also includes many other changes that amaze and offer a stunning transformative potential for the world we inhabit.

The latest developments in the field of cloud computing and the state-of-the-art technologies, such as AI (artificial intelligence), IoT (Internet of things) and LiDAR, have turned autonomous cars from a dream into a reality. Many companies announced their plans to launch autonomous cars, and tests on these cars are already underway in various cities around the world.

An autonomous vehicle is a vehicle capable of receiving data about its environment and navigating without the participation of a person who drives it.

An autonomous vehicle is able to navigate using various devices and methods such as radar, lidar, GPS, odometers and computer vision. Modern control systems are able to interpret information from sensors to determine the correct direction of movement, as well as to identify obstacles and relevant indicators. Autonomous cars have control systems that can analyze sensor data and distinguish between other vehicles on the road, which is very useful when planning a route to a chosen destination.

The two most serious obstacles on the way of autonomous vehicles developers are complexity and high cost of technologies. If we, for example, consider a lidar, we can see that it is complex in manufacturing and costs much more than cameras with radars, but at the same time it is so far irreplaceable.

The artificial intelligence of the autonomous vehicles must have enormous powers and process gigantic masses of information. It is required not only to fix obstacles, but also to predict behaviour of surrounding objects: other cars, pedestrians, animals.

We must not forget about the weather conditions: heavy precipitation or decrease of visibility All this also affects the capabilities of the car. And at the same time, special cartography is needed, because the ordinary GPS will not be sufficient for the car as here accuracy to the centimeter will be required (Technologies and Science Blog, 2023).

However, despite the obstacles, many key players in the auto market are constantly working on self-driving cars: General Motors, Tesla, Waymo, Uber, Lyft, Baidu.

Levels of self-driving cars autonomy

The U.S. National Highway Traffic Safety Administration (NHTSA) sets up six levels of automation, beginning with Level 0, at which humans drive the car, to fully autonomous cars. Here are the five levels that follow Level 0 of automation:

Level 1: an advanced driver assistance system (ADAS) aids the human driver with steering, braking or accelerating. ADAS includes rear view cameras and features like a vibrating warning to alert drivers when they drift out of the traveling lane.

Level 2: ADAS that can steer, and either brake or accelerate simultaneously while the driver remains behind the wheel and continues to act as the driver.

Level 3: The automated driving system (ADS) can perform all driving tasks under certain circumstances, e.g. parking the car. In these conditions, the human driver must be ready to retake control and is still required to be the main driver of the vehicle.

Level 4: The ADS can perform all driving tasks and monitor the driving environment in certain circumstances. In those circumstances, the ADS is reliable enough and the human driver needn't pay attention to the road.

Level 5: The vehicle's ADS acts as a virtual driver and performs all the driving tasks in all circumstances. The human occupants are passengers and are not expected to drive the vehicle (Svitlyk, 2023).

Concerning self-driving vehicle safety and challenges, autonomous cars must learn to identify countless objects in the vehicle's path, from branches and litter to animals and people. Other challenges on the road are tunnels that interfere with the GPS, construction projects that cause lane changes or complex decisions, like where to stop to allow emergency vehicles to pass.

The systems need to make instantaneous decisions on when to slow down, swerve or continue acceleration normally. This is a continuing challenge for designers, and there are reports of self-driving cars hesitating and hanging unnecessarily when objects are detected on or near the roadways.

This problem was evident in a fatal accident in March 2018, which involved an autonomous car operated by Uber. The company reported that the vehicle's software identified a pedestrian but perceived him as a mistake and failed to swerve to avoid hitting him. This crash caused Toyota to temporarily cease autonomous car testing on public roads, but their testing will continue elsewhere. The Toyota Research Institute is constructing a test facility on a 60-acre site in Michigan to further develop automated vehicle technology.

The problem of liability also arises because of crashes, and lawmakers have yet to define who is liable when an autonomous car is involved in an accident. There are also serious concerns that the software used to operate autonomous vehicles can be hacked, and automotive companies are working to address cybersecurity risks.

Self-driving cars are not yet legal on most roads. In June 2011, Nevada became the first jurisdiction in the world to allow driverless cars to be tested on public roadways; California, Florida, Ohio and Washington, D.C., have followed the suit.

The history of driverless cars goes back much further than that. Leonardo da Vinci designed the first prototype around 1478. Da Vinci's car was designed as a self-propelled robot powered by springs, with programmable steering and the ability to run predetermined routes.

References

1. Що таке безпілотний автомобіль і як він працює? (2023). *Technologies and Science Blog*. https://futurenow.com.ua/shho-take-bezpilotnyj-avtomobil-i-yak-vin-pratsyuye/
2. Світлик, Ю. (2023). *Безпілотні автомобілі: чи довго ще чекати на революцію?* https://root-nation.com/ua/articles-ua/avtomobili-ua/ua-self-driving-cars-revolution/

Kurianoy D. O.

LOAD-LIFTING CRANES, THEIR TYPES AND DESIGN

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The important factor of increasing industrial production is the state of mechanization and automation of productive processes in industry, building, transport, and agriculture. One of the main facilities of mechanization of moving of mass loads there are lifting-transport machines in all industries of the national economy.

Efficiency of application of lifting-transport machines depends on the quality of machines and their external environments. The productivity, economy, reliability of machine and other indexes of quality, is set at her planning, however in the process of making they can be mionectic through inefficient technology of production of machines, or sub zero technologicalness of their construction, in the process of editing, through the wrong production of assembling works, or sub zero assembling technologicalness.

In the process of exploitation and repair the indexes of quality and reliability of machines go down considerably, if her construction does not answer external and repair environments. Thus, designing lifting-transport machines is necessary taking into account technology of their production, editing, exploitation and repair.

Scientific and technical progress on the basis of modern technologies allows to bring in substantial changes in the construction of machines, offering the new modern methods of their production, editing, exploitation and repair.

A traveling electric crane is the most widespread type of faucet. It is used in all industries of industry and intended for transferring of loads to the productive workshops, compositions, loads in productive workshops, compositions, assembling halls of power-stations and other objects.

To the faucets of bridge type belong: single-beam bridge faucets-beams, two- and single-beam traveling cranes, a hook to the goat and semi-goat, cantilever with a light cart, roadways of stack cranes, faucets-manipulators, etc.

The traveling cranes are intended for freight-unloading and transport operations in the workshops of modern industrial enterprises, on erection conveyor sites, on open and closed compositions. They move on rail track ways, located on a considerable height from sex, occupy small useful space of workshop and provide maintenance of almost all areas of workshop. On open compositions, erection and container sites use traveling cranes that move on ways (rails), located on earth.

A traveling electric crane is the most widespread type of faucet. It is used in all industries of industry and intended for transferring of loads to the productive workshops, compositions, assembling halls of power-stations and other Objects.

The Travelling cranes can be divided into single-beam and two beams. In such classification the type of bridge undertakes warp wise.

On the basis of constructions of traveling cranes roadways are executed magnetic, grapples, metallurgical, faucets-pilers, container and other constructions.

Setting and structure of traveling container cranes. Efficiency of the use of container faucets in a considerable measure is determined by their productivity, that on a line depends on the operational technician parameters of the applied spreader, speeds of mechanisms of faucet, professional skills of work of machinist of faucet and т. other

A faucet is a bridge container with a carrying capacity of 32 т intended for the overload of heavy-duty containers on the freight court of container point. At the use of containers, time of loading and unloading of loads that is transported, grows short.

A faucet can be exploited outdoors at a temperature from minus 400^0C to plus 400^0 C. A traveling container crane has four basic parts: bridge, freight light cart, mechanism of movement of faucet and management booth.

The bridge (metal construction) of the faucet shows a soba cooked construction that consists of two flight and two eventual beams.

Flight and eventual beams have the basket crossing, for providing inflexibility into them transversal diaphragms and longitudinal ribs of inflexibility are set. On the overhead belts of flight beams the fixed rails a freight light cart moves on that. Motion of light cart is limited to supports.

Fastening of rails comes true by means of the special brackets and gibs. Brackets are welded on to the overhead belts of beams, and gibs cuddle screw-bolts and are removable. Such a method of fastening of rails provides the possibility of their replacement. Rails in joints unite by means of fish-plates and screw-bolts.

From the exteriority of both flight beams the located grounds are with protections for placing and maintenance of mechanisms of movement of faucet and for maintenance of crane light cart and power lines to the faucet and light cart.

A container light cart consists of next basic mechanisms and knots: frames of light cart; to the mechanism of getting (what combines four lifting winches) up; polypasta, that includes the system of set about rope blocks, for prevention of loosening of load; to the mechanism of movement of light cart; semi-automatic capture device (spreader); power lines to the spreader; protections; electrical equipment of light cart.

The mechanism of getting up consists of next elements: an electric motor of alternating current, a pad brake, a reducing gear horizontal cylindrical, the drum rope steel, cooked, a muff is toothed.

A rotation from an electric motor through a muff and reducing gear is passed on a drum wire-rope. A mechanism to impose brakes is stopped. Stopping of mechanism at extreme positions comes true by a switch.

The feature of a light cart or container faucet is a presence of spreader and cable power lines to it, for which, on the frame of capture, the special basket is envisaged with the aim of cabling. Application of cable basket appears especially a necessity at the large height of getting (at much tier warehousing of containers) up.

The mechanism of movement of the light cart consists of next elements: electric motor of alternating current, vertical cylindrical reducing gear, toothed muff, pad brake, toothed muff connecting the slow billow of reducing gear with working wheels, working wheels.

Working wheels steel forged two-board with tempering of the surface of rolling. The roller bearing is used in the bearing knots of working wheels.

The mechanism of movement of faucet is intended for moving of faucet on a rail track way above the zone of overload and warehousing of containers.

The mechanism of movement is executed on two separate occasions. Contains two drive and two not drive wheels that are set in bearing accommodated in the angular axle-bearing of fastened on the eventual beams of bridge by screw-bolts.

Every occasion is set on one ground of the bridge and contains the electric motor united by means of insert shaft, through two toothed muffs (one of that with a brake pulley), with a horizontal cylindrical reducing gear. Working wheels, steel forged two-board with tempering of the surface of rolling. In connection of billows with wheels, connection of the key is applied. On the billow of reducing gear, on a brake pulley the set brake.

The Travelling container cranes can be equipped by universal telescopic spreaders, which gives an opportunity complex to mechanize freight-unloading works with containers. The management of faucet all mechanisms comes true from the booth of management of the closed type.

References

1. Johnson, A. Et al. (2022). Smart Crane Systems: Enhancing Safety and Efficiency. *Journal of Construction Engineering and Management*, 38(4), 112-130.
2. Davis, M. (2023). Drones in Construction: A Comprehensive Review of Applications. *International Journal of Civil Engineering and Technology*, 12(7), 183-198.
3. Greenberg, R. et al. (2022). Toward Sustainable Construction: Ecofriendly Features in Lifting Cranes. *Environmental Engineering Research*, 28(3), 301-315.

Kusterskyi A. E.

ANALYSIS OF THE LOAD ON THE STRUCTURAL ELEMENTS OF THE WORKING EQUIPMENT OF A TELESCOPIC BOOM LOADER

Language Advisor – Asst. Prof. Ponikarovska S. V.

The current pace of construction and reconstruction places significant demands on quality, competitiveness and technical level of the equipment used. These requirements necessitate the modernization of existing equipment or the design of new, highly efficient and reliable working equipment.

Wheeled front-end loaders are used to carry out technological operations. The use of telescopic working equipment increases the capabilities of this machine, but also leads to higher material costs during design and production.

During the implementation of technological operations, external loads are transmitted through the main working body to all elements of the suspension mechanism of the working equipment, components and parts of the machine as a whole.

In modern conditions, it is impossible to study the load of working equipment at the design or modernization stages without the use of specialized software. It allows for virtual modeling and analysis of the interaction of components with each other and with the external environment. Based on the data obtained, it is possible to reduce the cost of the final product and sometimes find new ways of implementation without costly field tests.

To do this, it is necessary to first model the corresponding three-dimensional models of parts, components and assemblies that will interact in a complex system.

For this purpose, we chose the Dynamic Simulation environment of the Autodesk Inventor software package.

This environment allows you to use the initial stages of designing or modernizing the working equipment. equipment at the initial stages of designing or modernizing the robot. and force analyses of the modeled equipment to verify the performance of all nodes that will interact on the designed or existing machines.

The scope of work determines the need to use machines that are small in size and capable of solving multifunctional tasks in a limited space on construction sites. One of the types of such machines is forklifts with telescopic working equipment.

Researching the sources, we can conclude that the working equipment of modern loaders is determined by an increase in their main parameters: bucket capacity, unloading height, boom reach, and load capacity.

The aim is to analyze the kinematic and force analysis of the process of bucket immersion in a stack of bulk material in a separate way.

To achieve this goal, it is necessary to build a three-dimensional model of the working equipment with the subsequent imposition of calculated forces, to determine the patterns of changes in the reactions in the joints of individual elements of the equipment depending on the geometric position of the of the bucket edge.

Based on the achievements of scientists and our own research, a three-dimensional model of the working equipment of the loader with a telescopic boom is built using Autodesk Inventor software.

The paper considers the process of separate scooping of bulk material in a stack. It consists in immersing the bucket into the stack in a translational motion, followed by stopping the loader and turning the bucket. The force of horizontal resistance becomes maximum, and the loader stops due to the exhaustion of its traction capabilities in terms of traction or other technical limitations.

When the bucket and boom continue to rotate, the stack material is cut along the cylindrical surface formed by the trajectory of the bucket's cutting edge.

The force values obtained in the study using the Dynamic Simulation environment can be used for further analysis of the stress-strain state of individual structural elements or as input data for design optimization using the Shape Generator environment.

This technology is integrated into the Autodesk Inventor software product, which allows you to use it directly in the design process. Shape Generator creates a 3D finite element model that can be used as a guide for optimizing the design elements.

A force analysis of the interaction of the working equipment of a telescopic loader in the process of separate bucket scooping of bulk material in a stack is carried out. The second stage is considered - the rotation of the bucket and boom in the stack, during which the material is cut along a cylindrical surface, formed by the trajectory of the bucket cutting edge.

References

1. Рагулін, В. М.,Ярижко, О. В., & Назарько, О. О. (2022) Комп'ютерне моделювання як метод та засіб удосконалення будівельних машин. *Міжвідомчий науково-технічний збірник Прикладна геометрія та інженерна графіка*, (102), 181–187.
2. Рагулін, В. М., Мєшалкіна, Т. С., & Палій, М. Р. (2018). Аналіз модернізованої підвіски робочого обладнання автогрейдера з використанням комп'ютерного моделювання. *Міжвідомчий нау-ково-технічний збірник Прикладна геометрія та інженерна графіка*, (94), 95–99.
3.Ярижко, О. В., Рагулін, В. М., Єфремов, О. В., & Зятюк, А. І. (2023). Комп’ютерне моделювання силової взаємодії елементів робочого устаткування навантажувача. *Proceedings of the XIII International Scientific and Practical Conference A substantive representation of the system of scientific knowledge*, 27–28 March. Riga: Latvia by the InterSci, 88–90.

Leheza O. V.

HYBRID AND ELECTRIC VEHICLES

Language Advisor – Asst. Prof. Vorobiova S. V.

Hybrid is the latest buzzword in the automobile industry. Automobile engineers all around the world are actively working on developing and improving hybrid cars. Despite the high cost, hybrid cars are gradually gaining popularity among car users across the world.

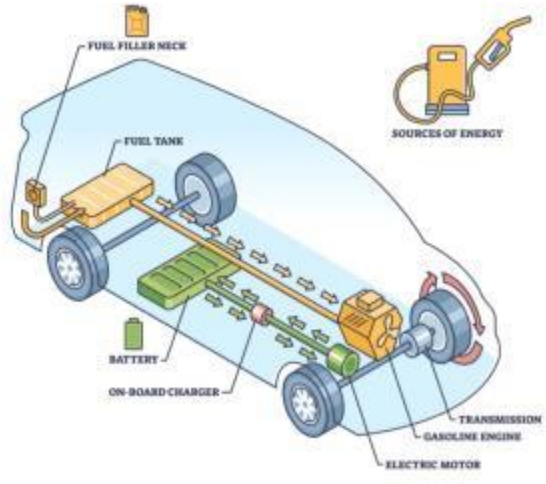
Unlike traditional combustion engine cars, hybrid cars address the crucial and urgent global agenda of environmental preservation. With global warming and increasing environmental pollution, any innovation that reduces or restricts carbon footprint is a welcome step. Hybrid cars make this possible and are sustainable.

Hybrid Vehicle

Combining the benefits of gas-powered engines and electric motors, hybrid vehicles use a conventional internal combustion engine but also use an electric motor and battery to supplement the vehicle's power. Using both types of engines means that hybrid vehicles deliver better gas mileage and have fewer emissions than a traditional gas-powered car.

Hybrids not only use the auto start and stop and regenerative braking that EVs use to maximize fuel economy, but also electric power assist. The hybrid's electric motor delivers power to help the engine when it needs a boost while accelerating, climbing hills or passing another vehicle. With this assist, manufacturers can use a smaller gas engine that is more efficient.

There are 3 types of hybrid vehicles which must be explained. Firstly, the most notable idea of a hybrid is the full hybrid (FHEV) is that it operates fully by the ICE, fully on electric motor, or a combination of the two. Secondly, the mild hybrid (MHEV) is that the vehicle cannot be solely powered by the electric motor. Thirdly, the plug-in hybrid (PHEV) like the full hybrid except that the battery can be charged externally by plugging into an external source.



Hybrid Vehicle Main Components

Batteries: Batteries power the electric motor in hybrid vehicles. Additionally, the batteries can recover energy from the electric motor. This is one method to extend their lives.

Electric Motor and Gasoline Engine: Hybrid vehicles are powered by electric motor and gasoline. The gasoline is used to power the internal combustion.

Generator: Converts the gasoline into electrical energy for the motor and the battery.

Transmission: The transmission drives the wheels mechanically by transferring power from the engine and/or electric traction motor.

Electric Vehicle

Concerns over the future availability of gas as well as the environmental impact of the internal combustion engine has led vehicle manufacturers to a race to be the first to develop an electric vehicle that enjoys widespread adoption by the driving public. Electric vehicles rely upon batteries to power the motor and move the vehicle down the road.

While you can't typically tell the difference between a gas-powered vehicle and an electric vehicle, one look under the hood and there is no question which type of vehicle you're looking at.

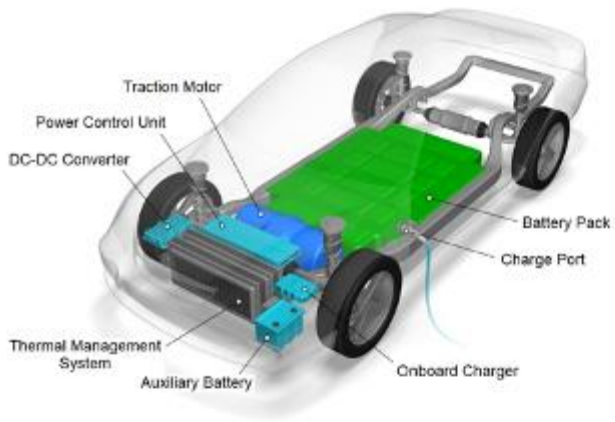


Figure 1. – Main Components of an EV

Electric Vehicle Main Components

Auxiliary Batteries: Auxiliary batteries supply power to electric vehicle accessories. If the main battery fails, the auxiliary batteries will keep the vehicle charged.

Charge Port (Only for PHEV): The electric car connects to an external supply through the charge port. The charge port is the gateway that enables charging to the battery pack. Typically, it is located near the vehicle's front or rear.

Controller: The controller determines how the electric vehicle is operated. It regulates the flow of electricity from batteries to electric motors. The speed of the car and the frequency of voltage variation input to the motor are determined by the pedal set by the driver. The controller also regulates the torque generated.

DC-DC Converter: The DC-DC converter distributes the battery's output power to the required level. It further supplies the voltage that is required to re-charge the auxiliary battery.

Electric Motor: This is a major part of an electric vehicle. Electrical energy is transformed into kinetic energy by the motor. This energy turns the wheels of the vehicle. The major element that sets an electric vehicle apart from conventional vehicles is its electric motor.

Onboard Charger: The onboard charger converts the alternating current power from the charge port to direct current power. The on-board charger is installed and is located within the vehicle. It monitors various battery characteristics and controls the current that flows through the battery pack.

Power Inverter: The power inverter is what converts the batteries' DC power into AC power. Additionally, it transforms the AC current created by regenerative braking into DC current. The batteries are also recharged with this.

Transmission: Transmission is what transfers mechanical power from the electric motor to the wheels via a gearbox. Electric vehicles have the advantage of not requiring multi-speed transmissions. To avoid power loss, transmission efficiency should be high.

Thermal System (Cooling): The thermal management system oversees maintaining a constant operating temperature for the main components of an electric vehicle, such as the electric motor and controller. It also operates while charging to ensure peak performance. It makes use of thermoelectric, forced air, and liquid cooling.

Table 1. – Difference between hybrid and electric cars

Specifications	**Hybrid Cars**	**Electric Cars**
Power/Fuel Source	Electricity and Fossil Fuel (Petrol and Diesel)	Electricity Through Battery Pack (DC)
Engine	Internal Combustion Engine (ICE) and Electric Motor(s)	Electric Motor(s)
Fuel Efficiency	Combination of ICE and Battery Range	Depends on Battery Range
Emission Levels	Higher Compared to Electric Cars	Lower Compared to ICE and Hybrid Cars
Price Range	Similar to Conventional ICE Cars	High
Charging	Not Needed	Needed

Advantages of hybrid electric cars

Hybrid electric cars are the future of the environment-friendly automobile sector innovation. They come with a wide range of advantages such as:

Low emissions: Compared to internal combustion engines, hybrid cars use both internal combustion and electric engines. As a result, emissions are reduced, making them highly beneficial in checking environmental degradation.

Reduced use of combustion fuels: Hybrid electric cars have electric motors that run on batteries. This reduces the load on the combustion engine and the use of fuels such as petrol and diesel.

Smaller combustion engine: Since combustion fuels do not have to run the whole vehicle, hybrid electric cars come with a smaller combustion engine compared to standard petrol or diesel cars.

The benefit of dual engines: Hybrid electric cars have the benefit of two engines. Subsequently, they offer higher fuel efficiency and much better performance.

Regenerative braking system: In a hybrid car, the electric generator produces electricity and recharges the battery every time the brake is used. As a result, until and unless the battery is completely exhausted, there is no need to stop the car to charge the battery.

Higher resale value: Given the ever-increasing price of petrol and diesel, and the continuous degradation of the environment, people are consciously moving towards hybrid and electric cars. Hence, the demand for such cars is high and so is their resale value.

Disadvantages of hybrid electric cars

Some of the cons of using hybrid electric cars include:

Compromised performance: Hybrid electric cars in India are in demand primarily because of fuel efficiency. Lower use of combustion fuels is the prime objective here. In doing so, aspects such as power and acceleration are often ignored.

Inefficient for long commutes: Since a hybrid electric car has low accommodation for combustion fuel, the remaining need for power is met by electric motors. Now, this setup is not the optimal one for long commutes or long-distance drive through the countryside or highways.

High price: This is a perennial issue with hybrid electric cars and electric vehicles in general. Most of them are quite expensive for the general public. Though automobile companies are trying to reduce the cost, still itis a long shot.

High cost of maintenance: Due to the numerous mechanical components and two types of engines that power hybrid vehicles, maintenance costs are still on the higher side. Additionally, not all mechanics are skilled or qualified enough to work on hybrid vehicles.

Conclusion

To recap, today's hybrids can cost the same as or less than a comparable gas-powered vehicle—or at least save you money over time. Most are reliable and have high owner satisfaction ratings, and many drive better than their nonhybrid counterparts. They don't need to be plugged in, and they can be filled up at any gas station.

Fully electric vehicles do not have a gasoline engine, and they need to be plugged in to recharge the battery. They can often go more than 200 miles on a charge and can be recharged at home or at public chargers.

However, recharging an EV takes much longer than gassing up a car anywhere from 20 minutes to a few hours, depending on how many miles you need and how fast the charger you're using is and finding a charging station on the road isn't as easy as finding a gas station. That makes hybrids more convenient for people who don't live near EV charging stations, who can't charge at home, or who often take long road trips.

CR's analysis shows that pure electric vehicles are more efficient than hybrids, and often cost less to maintain and repair. They're also often eligible for tax credits that hybrids can't get. However, in some cases, a hybrid can cost less to own and operate than a similar electric vehicle. That's especially true for small SUVs and compact cars, and even more so if you live somewhere with high electricity costs. A key reason: They cost less to purchase.

References

1. Бажинов, О. В., Смирнов, О. П., Сєріков, С. А., Гнатов, А. В., & Колєсніков А. В. (2008). *Гібридні автомобілі.* ХНАДУ.
2. Гібридний автомобіль: пат. 95263 Україна: МПК (2011.01) B60K6/00. Харківський автомобільно-дорожній університет. № a200807448; заявл. 30.05.2008; опубл. 25.07.2011, Бюл. № 14.
3. Кужель, В. П. (2013) Сучасні гібридні силові установки для легкових автомобілів. *Збірник наукових праць*. ВНТУ.
4. Кужель, В. П., Стаднійчук Д. С. (2013). Матеріали VI міжнародної науково-практичної конференції Сучасні технології та перспективи розвитку автомобільного транспорту. *Збірник наукових праць.* ВНТУ.
5. Кужель, В. П. (2017) *Варіанти застосування гібридних силових установок на автомобілях.* ВНТУ.

Liapko D. E.

DESIGN OF A 10-TON GANTRY CRANE WITH A GRAPPLER BUCKET

Language Advisor – Asst. Prof. Ponikarovska S. V.

Lifting and transporting machines (LTM) and mechanisms are the main means of mechanization and automation of loading and unloading operations in all branches of industry and agriculture. In connection with the intensification of processes, the amount of time spent on lifting and transport operations has increased significantly.

A sharp increase in labor productivity, which is necessary during the transition to new conditions of development and management, can be achieved through the mechanization and automation of lifting-transport and load-unloading operations, which are less automated than technological.

LTMs are very metal-intensive, therefore, they require a large amount of material and labor costs. Therefore, it is necessary to create low-metal, perfect, reliable and rational designs. Engineering and technical workers are engaged in the design, selection and installation of LTM not only in highly specialized organizations and enterprises, but also in various branches of industry. Lifting and transport equipment is an integral part of almost any scheme of mechanization of any production process in every branch of the economy. Therefore, LTM is of exceptional methodological interest as a design object in the training of engineers and designers of a wide profile.

Classification of gantry cranes.

The gantry crane belongs to the bridge type of lifting and transport equipment and is a running structure mounted on trolleys. The supports have one or two racks and are moved by a crane. Gantry cranes are used for work on open and sometimes closed platforms. Such lifting mechanisms are used to move containers, wood and other artificial cargo. They are used in shipbuilding, industrial and civil construction, and also serve warehouses and hydroelectric power plants.

Design features of gantry cranes. Despite the common name (due to the external similarity of the supports with installation gantry cranes), there are different types of gantry cranes. They differ in purpose, bridge design, number of consoles, type of drive and load-grabbing mechanism. Each design feature directly affects the range of tasks solved by lifting equipment.

Purpose of bridge-type gantry cranes.

1. Gantry cranes of general purpose (overloading). These are two-console electric gantry cranes on a rail track with a load capacity of 3.2-32 t and above. The

length of their flight is from 4 to 40 meters, and the height can reach 15 meters or more. Overloading gantry cranes are used for loading and unloading operations and transport operations in open warehouses and areas for the production of reinforced concrete products and metal structures.

2. Construction and installation gantry cranes Designed for assembly of modular civil and industrial buildings, as well as installation of equipment at enterprises. The load capacity of such cranes can reach 400 tons, the length of the span is up to 80 meters, and the height is up to 30 meters.

3. There are special-purpose gantry cranes used to service hydrotechnical structures, ports and large railway junctions. The length of the span of such a crane can be more than 130 meters, the lifting height reaches 80 meters, and the load capacity is up to 500 tons.

Mechanisms are classified into two types according to the type of construction of the span structure.

Single-beam gantry cranes are easy to maintain, due to the availability of individual units, they are easily treated with anti-corrosion materials. Cross beams of the old model have a tubular section or are made in the form of a lattice truss. In modern samples, a box-type girder structure is used.

A double-beam gantry crane is more reliable than a single-beam gantry crane and has a longer service life. The span structure is a box structure, as in the single-beam type. The box design has smaller dimensions and is easier to transport. The load capacity of double-girder gantry cranes is constant along the entire length of the bridge, including the consoles. Limit load capacity is up to 50 tons. In cranes for special purposes, this figure can be up to 1600 tons. The console is part of the span structure that extends beyond the support and serves to expand the working area of the crane. According to the type of consoles, there are three types of gantry crane.

Console-less gantry cranes are lifting and transport equipment in which the cargo trolley moves only along the main span. They are used for construction and assembly works.

Single-cantilever gantry cranes are crane equipment in which a part of the girder structure extends beyond the support on one side only.

Most of the gantry cranes are two-console, both parts of the bridge extend beyond the supports.

Gantry cranes can have different load-catching devices.

Hooked Universal load-catching device, made in the form of a one-horned or two-horned hook. The two-horned hook is designed to work with loads weighing more than 50 tons. The load is hung on the hook using special grips or flexible slings.

Magnetic. The cargo handling device is a direct current electromagnet with a load capacity of up to 30 tons. This type of cargo handling mechanism is designed to work with steel and cast iron cargo.

Grapple. It is made in the form of a bucket with two jaws and is actuated by cables or by means of a hydraulic device. It is used for lifting loose and artificial materials, it is used in agriculture, coal mining industry, logging enterprises and other areas.

According to the drive type, gantry cranes are classified into two types:

Manual. They are used in open areas and in closed workshops. A wheel mechanism is provided for their movement. The load-lifting device can be a manual hoist, and even an electric hoist.

Electric. They are used in open areas. Their movement is carried out on under-crane tracks. Each node of the device works on the basis of an electric motor. The crane is controlled in several ways: from the cabin, using a remote control or radio control.

The majority of gantry cranes, the basis of which is a bridge span, have similar parts and construction. Along with them, models with more significant differences are used:

Semi-gantry. They have a distinctive device for moving the crane. A running carriage is used on one side, and an end beam on the other. This beam is made similarly to a bridge crane. This feature makes it possible to install them on overhead crane tracks located at different height levels. If we compare with bridge cranes, they have less weight and their design does not provide for the presence of consoles.

Mobile cargo cranes. They have small dimensions. Quick and easy to install. They are distinguished by a high level of mobility. They have a small cost. They use a gear hoist or an electric hoist as a lifting mechanism. Such cranes have a low level of load capacity - up to 16 tons. The length of their flight is within 5-30 meters, and the height of the rise is 6-18 meters.

References

1. Конструктивні особливості та характеристика козлових кранів. https://budtehnika.pp.ua/8211-konstruktivn-osoblivost-ta-harakteristika-kozlovih-kranv.html
2. Григоров, О. В. (2011). *Металеві конструкції підйомно-транспортних, будівельних, дорожніх, меліоративних машин.* НТУ ХПІ.
3. Жигулін, О. А., Махмудов, І. І., Жигуліна, Н. А. (2020). *Підйомно-транспортні машини.* Ніжинський агротехнічний інститут.
4. Нікітін, В. Г., Бундза, О. З. (2020). *Методичні вказівки до виконання практичних робіт та курсового проектування з курсу Вантажопідйомна, транспортуюча та транспортна техніка*.

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BRAKING TESTS OF VEHICLES

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The braking properties of vehicles are an important factor that ensures the safety of road traffic. The purpose of brake tests of vehicles is to determine the efficiency of braking systems: working, spare, parking and auxiliary.

Methods for performing experiments are regulated by international (Единообразні приписи, що торкаються офіційного затвердження транспортних засобів в відношенні гальмування, 1973) and national standards (Засобі транспортні дорожні. Експлуатаційні вимоги безпеки до технічного стану та методики контролю, 1999). The main normalized parameters are the initial braking speed and the effort to control the braking process.

In order to obtain indicators corresponding to the braking properties of the vehicle in operation, the friction elements of the brakes of the new vehicle must undergo a run-in before the tests, the mode of which is established by the method of a specific test.

The efficiency of the working braking system is evaluated during of road tests by the values S_m and $j_{уст}$, as well as ΣP_m and $\tau_{ср}$ (for trailers and semi-trailers).

Depending on the driving and braking conditions of the vehicle and, accordingly, the thermal condition of the brakes, tests are divided into: type 0, I, II (Единообразні приписи, що торкаються офіційного затвердження транспортних засобів в відношенні гальмування, 1973; Волков, 2003).

The working braking system is tested in all modes, and the spare one is tested only in type 0 mode.

Type 0 test aims to determine the effectiveness of the braking system and its individual circuits during "cold" brakes. Brake mechanisms are considered to be cold, in which the temperature on the braking surfaces of the brake discs or drums is within 50 - 100˚C.

Type I test is carried out for determination of the efficiency of the working braking system of vehicles with heated brake mechanisms. Heating of braking mechanisms of vehicles is produced by successive braking, and trailers and semi-trailers are produced by towing a braked trailer by a tractor with a normalized force in the coupling device for a given distance at a given speed. To obtain reliable data, it is advisable to carry out the type I test at least twice with an interval sufficient for cooling the brakes.

Type II tests are intended to determine the effectiveness of the working braking system during driving on long descents. As in the case of type I tests, during the preliminary stage of type II tests, the brakes are heated and then control brakes is applied using the type 0 test method.

The tests of the spare brake system are carried out with various options of the intentional activation of the brakes of one or two wheels, according to the test method (type 0), with the engine turned off (Единообразні приписи, що торкаються офіційного затвердження транспортних засобів в відношенні гальмування, 1973; Засобі транспортні дорожні. Експлуатаційні вимоги безпеки до технічного стану та методики контролю,1999).

The efficiency of the parking brake system is determined by the total braking force developed by the braking mechanisms of the system and the movement resistance. The tests are carried out on a section of the road with a longitudinal slope specified by the technical conditions of the vehicle.

A vehicle with a full load is installed on the test section sequentially in two directions. The parking brake must reliably hold the vehicle (with a given force on the control part) on the specified slope for at least 5 minutes.

The effectiveness of the auxiliary braking system is determined by the amount of the total braking force developed by the mechanisms of this system and the movement resistance. The tests are carried out by the following methods: descent of a braked vehicle on a road section with a longitudinal gradient of 7% and a length of

6 km. At the same time, the system must ensure descent of the tested vehicle at a stable speed of 30±2 km/h with a retarder and 30±5 km/h with engine braking; towing a braked vehicle on a horizontal road using a tractor connected to the tested vehicle by a rigid coupling with a dynamometric link; partial braking, i.e. braking in a specified range of speeds (from 35 to 25 km/h), which is carried out with the gear in the transmission that meets the requirements of the tests (type II).

For vehicles with the braking system, which has an anti-lock system, tests are carried out when braking on a turn, in the mode of changing traffic and on a road on which the adhesion coefficients under the left and right wheels are different. For braking on a turn, the road is marked as shown in Figure 1*a*. The vehicle passes section S_1, straight-line movement, transitional S_2, the width of which varies from B_1 to $B_1+\Delta$, curvilinear with an angle φ_3 with a constant radius R and reaches to the final straight section of the road S_4.

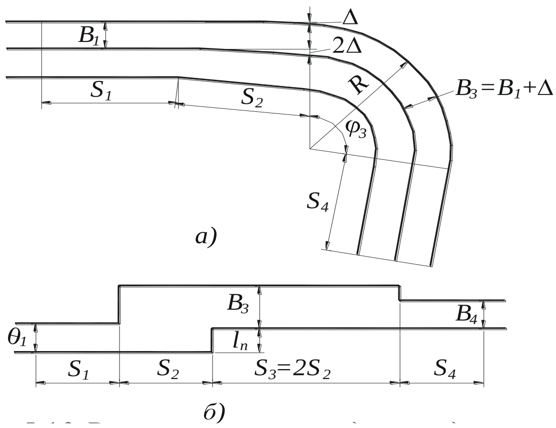

Figure 1. – Marking of the road section for braking tests

Braking when changing rows is carried out in the area marked according to Figure 1*b* in four stages. The first section of the road is a control section, in the second section the direction of movement is changed, in the third section vehicles are put into a new row, and in the fourth section straight traffic is controlled. Tests are carried out with the engine connected to the transmission and disconnected from it, as well as with partial and full load.

The instability of the braking torques on the wheels does not significantly affect the reduction of the total braking force in the presence of amplifiers in the drive, but it significantly affects the stability of the vehicle during braking, as it causes a significant change in the distribution coefficient of braking forces between the axles and the appearance of their on-board unevenness. Carrying out braking tests is an integral part of creating a vehicle's braking system.

References

1. Единообразні приписи, що торкаються офіційного затвердження транспортних засобів в відношенні гальмування. (1973). *Правила ЄЕК ООН*, 13, 41.
2. Волков, В. П. (2003). *Теорія експлуатаційних властивостей автомобіля.* ХНАДУ.
3. Засобі транспортні дорожні. Експлуатаційні вимоги безпеки до технічного стану та методики контролю. (1999). *ДСТУ 3649-97 чинний від 01.01.1999*. Видавництво стандартів.
4. Волков, В. П. (2003). Забезпечення стабільності гальмових властивостей автотранспортних засобів. ХНАДУ.

Lopatin A. V.

CHANGES IN THE STRUCTURAL STATE OF AUSTENITIC STEEL UNDER THE INFLUENCE OF HEATING

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Austenitic steels are an important material with properties that ensure their wide application in various industries, in particular in the oil and gas, medical, food and aviation industries. Austenitic steels have several advantages compared to other types of steel:

- high corrosion resistance: austenitic steels have high corrosion resistance in various environments, including acids and salts.
- good machinability: austenitic steels can be easily machined using various techniques such as cutting, drilling, milling, welding, etc.

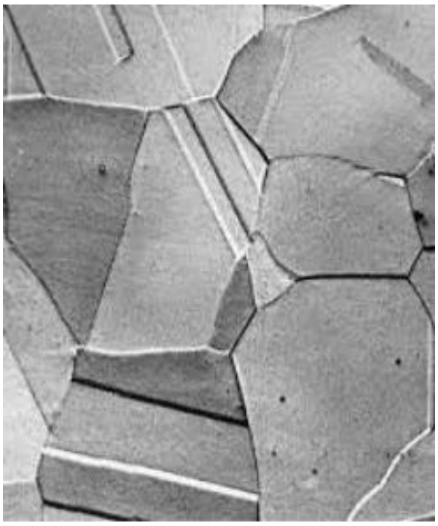


Figure 1. – Microstructure of austenite x325

However, austenitic steels have some disadvantages, such as:

- high price: the production of austenitic steels is quite complex and expensive, which leads to a high cost of the final product.
- low strength: compared to other types of steel, austenitic steels have low strength.
- insufficient hardness: austenitic steels are not the hardest materials, which can lead to wear and damage in some service conditions.

Samples of 12X18N10T steel were hardened from a temperature of 1,050 °C with cooling in water. To protect them from the oxidizing atmosphere, they were placed in trays that were filled with graphite. After hardening, the samples were annealed at temperatures of 600 °C, 700 °C, 800 °C with different holding times - from 5 to 15 g. Cooling was carried out in the air. Table 1 shows the mode of heat treatment of stainless steels.

Table 1. – Mode of heat treatment of stainless steels

Type of heat treatment	T_n °C	τ_{type} g	Cooling type
Hardening	1050	0.08	water
Annealing	600	5 10 15	air
Annealing	700	5 10 15	air
Annealing	800	5 10 15	air

The goal of electrolytic etching was to increase the optical contrast between different structural components and to identify grain boundaries. For stainless steel etching, 10% oxalic acid was used, the current density was 5–10 A, a stainless steel spatula served as the cathode, and the sample served as the anode. Microslides of the samples were studied at a magnification of 500 (on a dry lens).

Chromium-nickel steels of the 12Kh18N10T and 08Kh12N10T brands, which differ in carbon content and titanium-to-carbon ratio, are the most widely used in industry among stainless steels. Steel grades 12X18H10T and 08X12H10T are used as corrosion-resistant, heat-resistant and heat-resistant material. Steels are used in welded structures that work in contact with nitric acid and other oxidizing environments; some organic acids of medium concentrations, organic solvents, atmospheric conditions, etc.

Aggressive environments (nitric acid) cause intergranular corrosion even in cases where the steel is hardened to austenite and the carbon content is no more than 0.02%. Intergranular corrosion consists in the rapid selective dissolution of metal grain boundaries, which is accompanied by a loss of strength and plasticity. This type of corrosion occurs during the service of those materials that have high corrosion resistance in this environment.

The effect of chromium content in austenite on carbide formation near the grain boundary and on the distribution of chromium in the grain body.

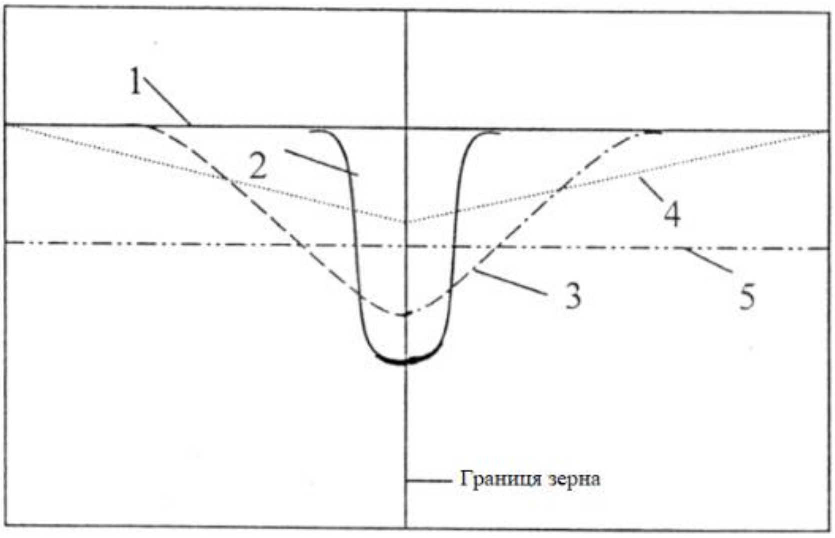


Figure 2.

5 – minimum chromium content, which ensures corrosion resistance

Austenitic chrome-nickel steels have a number of features due to their structure:

- non-magnetism;
- insensitivity to hardening;
- increased heat resistance;
- excellent weldability.

Insensitivity to hardening is understood in the sense that chrome-nickel steels, in contrast to carbon and low-alloy steels, are not hardened in the generally accepted sense of the word, that is, they do not acquire high hardness and strength during rapid cooling from high temperatures.

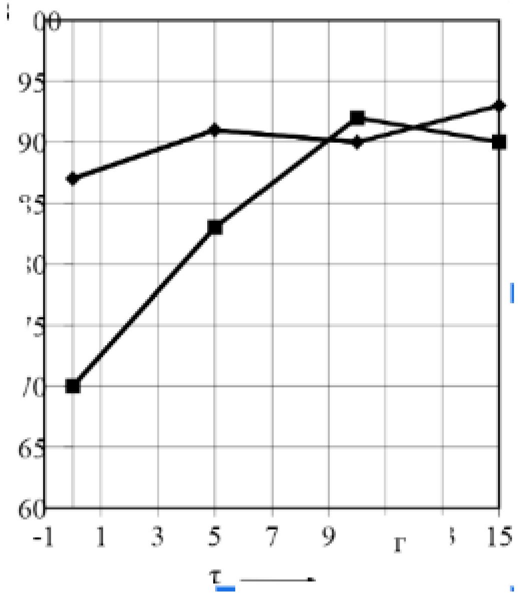


Figure 3. – The results of hardness measurement

■ *– steel 08X12H10T,* ♦ *– steel 12X18H10T*

Change in hardness of steels 08Kh18N10T and 12Kh18N10T after annealing, top = 600 °C is presented above.

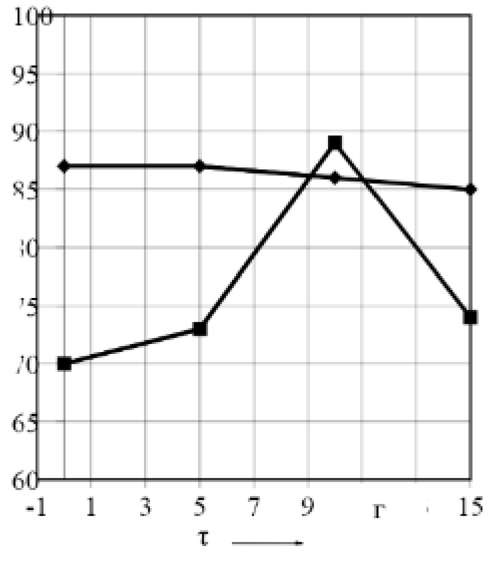
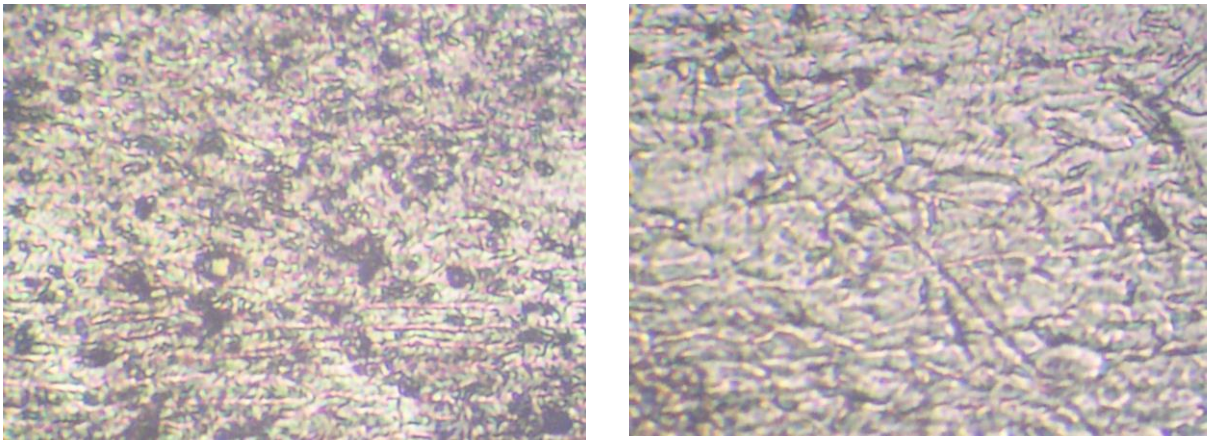


Figure 4. – The results of hardness measurement

■ *– steel 08X12H10T,* ♦ *– steel 12X18H10T*

Change in hardness of steels 08Kh18N10T and 12Kh18N10T after annealing, top = 700 °C is given above.



a) b)

Figure 5. – Microstructure of Steel

a) 12X18H10T, x500, b) Steel 08X18H10T, x500

Having analyzed the obtained experimental results of the study of the influence of annealing parameters on the structure and properties of 08Kh12N10T and 12Kh18N10T steels, the following conclusions can be drawn. The aging process negatively affects the properties of stainless steels. In the process of heat treatment, steel 12X18N10T, unlike steel 08X18N10T, shows the ability to artificial aging, thereby reducing its corrosion properties. An increase in the concentration of carbon in stainless steels reduces their ability to resist corrosion. An increase in the annealing temperature accelerates the hardening process of chromium-nickel steels, but the increase in hardness at the same time decreases.

References

1. Broom, D. P. (2011). Hydrogen storage materials. The characterization of their storage properties. *Springer*.
2. Gussev, M. N, Busby, J. T, Tan, L, & Garner, F. A. (2014). Magnetic phase formation in irradiated austenitic alloys. J Nucl Mater. 448:294–300.
3. Mine, Y, Horita, Z, & Murakami, Y. (2009). Effect of hydrogen on martensite formation in austenitic stainless steels in high-pressure torsion. Acta Mater. 57:2993–3002.

Lukin D. O.

MAIN FACTORS OF TEMPERATURE INFLUENCE ON BRIDGE CONSTRUCTION

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Bridges are critically important structures that ensure the normal functioning of the entire road and transport infrastructure. From the stage of construction and operation of the bridge structure, it is exposed to many different loads and influences. So, one of the permanent influences on bridges is temperature.

Thermal loads on bridges directly depend on the climatic conditions of the area in which the bridge was built, the structural features of the bridge and the material from which the elements of the bridge are made, its height and the presence of a river under it. The following main factors that cause a change (heating or cooling) of the bridge temperature can be identified (Radolli, & Green, 1975):

1. heat exchange with the environment;
2. solar radiation;
3. radiation reflected from nearby objects, etc.

In the work (Joseph, & Jack, 1974) two main temperature cycles affecting the operation of the bridge are identified: daily and annual. The daily cycle during which the temperature of the air and the bridge usually changes insignificantly and reaches its minimum at night, before dawn, and its maximum during the day. The temperature fluctuations of the bridge during the daily cycle are significantly affected by the presence of wind and cloudiness or sudden changes in the weather, which leads to a sharp change in the temperature of the bridge. The annual cycle of the temperature of the bridge depends on the change of the seasons caused by the position of the Earth relative to the Sun. Temperature changes along this cycle are larger, but they are smoother and more predictable. An engineer must take these temperature cycles into account when designing a bridge and determining structural features.

According to (Єврокод 1. Дії на конструкції. Частина 1-5. Загальні дії. Теплові дії (EN 1991-1-5:2003, IDT), 1991), the thermal effect on the bridge consists of two parts: uniformly distributed temperature and temperature difference. The uniformly distributed temperature component depends on the maximum and minimum temperatures that the bridge structure reaches. This temperature is called uniformly distributed or effective. It is usually used to determine the longitudinal linear deformations of a bridge.

Thus, a change in the effective temperature of the span structure of the bridge will cause expansion (in case of an increase in temperature) and compression (in case of a decrease in temperature). The values of these longitudinal linear movements can be determined by the formula (Споруди транспорту. Навантаження та впливи. Мости та труби, 2009):

$$\delta = L \times \alpha \times \Delta T_{max}$$

where: L – the length of the span structure of the bridge;

α – the coefficient of thermal expansion of the span structure material;

ΔT_{max} – the maximum temperature amplitude by which the temperature of the span structure changes.

Thus, when designing a bridge, an engineer can predict linear longitudinal movements of the span structure of the bridge and make design decisions according to the determined data.

The second component (Єврокод 1. Дії на конструкції. Частина 1-5. Загальні дії. Теплові дії (EN 1991-1-5:2003, IDT), 1991) of the thermal effect on the bridge is the vertical temperature difference that occurs due to the fact that part of the cross-section is exposed to direct solar radiation (the upper part), and part is in the shade (the lower part). Such a temperature difference across the cross-section of the structure is also called a temperature gradient.

The temperature gradient, depending on the temperature values, causes internal stresses and deformations of the span structure elements, which affects the operational characteristics of the bridge, primarily the crack resistance.

The magnitude of such a temperature difference may depend on the following factors (Radolli, & Green, 1975):

1. latitude of the area;
2. orientation of the bridge relative to the sun;
3. time of day and seasons;
4. level of cloudiness and relative humidity;
5. characteristics and color of the bridge structure surface;
6. thermal properties of the materials that make up the bridge structure, etc.

Thus, taking into account the above-mentioned main factors arising from the influence of temperature during the design or operation of the bridge, its reliable operation and proper functioning can be ensured.

References

1. Radolli, M., & Green, R. (1975). Thermal stresses in concrete bridge superstructures under summer conditions. *Transportation Research Record*, 547, 23-36.

2. Joseph, C. R., & Jack, H. E. (1974). Thermal stresses and movements in bridges. *Journal of the Structural Division,* 100.1, 63-78.

3. Єврокод 1. Дії на конструкції. Частина 1-5. Загальні дії. Теплові дії (EN 1991-1-5:2003, IDT). (2012). *ДСТУ-Н Б EN 1991-1-5:2012 чинний від 01.07.2014*. Київ: Міністерство регіонального розвитку, будівництва та житлово-комунального господарства України.

5. Споруди транспорту. Навантаження та впливи. Мости та труби. (2009). *ДБН В.1.2-15:2009 чинний від 01.03.2010.* Мінрегіонбуд України.

Lytvyn V. Yu.

ELECTRIC VEHICLE BATTERIES: RECYCLING AND REUSE FOR A SUSTAINABLE FUTURE

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Electric vehicles are becoming increasingly popular worldwide. They are environmentally friendly, cost-efficient, and convenient to use. The growing number of electric vehicles presents a new challenge: battery recycling.

Lithium, cobalt, and nickel are hazardous substances present in electric vehicle batteries. If these substances enter the environment, they have the potential to cause significant harm. Battery recycling for electric vehicles is a crucial aspect of environmental sustainability.

According to a study published in the journal Nature, over 1 million electric vehicles have been sold worldwide to date. The authors estimate that from this number, we will eventually accumulate 250 thousand tons of spent batteries. The risk of “thermal runaway” increases if they end up in landfills. This is a chemical reaction that can heat the battery enough to cause a fire (Harper et al., 2019).

There are several ways to recycle electric vehicle batteries. One method is recycling, where valuable materials such as lithium, cobalt, and nickel are extracted from the batteries. These materials can be used to manufacture new batteries, reducing the need for mining new minerals.

However, battery recycling for electric vehicles is complex and costly. Batteries consist of numerous components that need to be separated and cleaned. Additionally, batteries contain hazardous substances that require safe recycling methods.

Another method is repurposing electric vehicle batteries. Spent batteries can be utilized to store energy in energy storage systems. For instance, Tesla actively employs old electric vehicle batteries in energy storage systems for homes and businesses.

Stationary energy-saving systems are another problem. Installing old batteries into energy-saving systems to maintain power in large facilities or networks is a viable option. An example is Nissan's initiative to create stationary storage systems based on their Leaf electric vehicle batteries (Website Focus, 2023).

The used batteries from Honda and Nissan electric cars are known to get a second life.

In California, the USA, the B2U Storage Solutions company launched a huge solar energy storage facility that utilizers the used batteries from Honda and Nissan electric vehicles as batteries. Currently, the storage uses 1,300 end-of-life batteries that, instead of being sent for recycling, have been given a second life as solar energy containers. The Lancaster solar facility now has a capacity of 25 MWh.

The company B2U (stands for “Battery Second Use”) sells electricity to local electricity suppliers for the population and earns almost $1 million a year from solar energy.

Nevertheless, repurposing electric vehicle batteries also has limitations. Batteries that no longer provide sufficient range for an electric vehicle may be suitable for other applications, but their capacity will be diminished.

To address the challenge of battery recycling for electric vehicles, the following tasks need to be addressed:

– enhancing the ease of disassembling batteries, enabling automated and safer disassembly processes;

– implementing uniform production standards for batteries, facilitating automated disassembly and recycling;

– developing more efficient battery recycling methods, reducing costs and enhancing environmental friendliness.

Battery manufacturers, governments, and other stakeholders need to collaborate to solve these tasks, ensuring an environmentally friendly future for electric vehicles. Furthermore, attention should be directed towards education and training. Battery recycling programs can include courses and training for waste disposal and recycling specialists, fostering a professional community capable of efficiently managing the battery recycling process in compliance with all environmental and safety standards.

Battery recycling for electric vehicles represents a critically important area in sustainability and environmental conservation. While various methods and approaches exist for recycling, addressing this challenge effectively requires concerted efforts from manufacturers, governments, and society at large.

Implementing battery recycling and repurposing with safety, economic efficiency, and environmental cleanliness in mind is a crucial step toward a sustainable future for electric vehicles (Chokshi & Browning, 2022).

Thus, one of the challenges of recycling lithium-ion batteries is obtaining materials that can be reused in the production cycle. This is fully consistent with the circular economy model, which aims to achieve zero waste disposal.

References

1. Harper, G., Sommerville, R., Kendrick, E., Driscoll, L., Slater, P., & Stolkin, R. (2019). Recycling lithium-ion batteries from electric vehicles. *Nature*, 575, 75–86.
2. Зі старих акумуляторів зробили мегасховище енергії: як воно працює [Mega energy storage was made from old batteries: how it works]. Website Focus. (2023). https://focus.ua/uk/digital/548943-iz-starych-akumulyatorov-sdelali-mega-hranilishche-energii-kak-ono-rabotaet
3. Chokshi, N., & Browning, K. (2022). Electric Cars Are Taking Off, but When Will Battery Recycling Follow? *The New York Times*, December 21. https://www.nytimes.com/2022/12/21/business/energy-environment/battery-recycling-electric-vehicles.html

Marusiak O. I.

PSYCHOPHYSIOLOGICAL PERCEPTION OF DRIVERS OF INFORMATION SUPPORT MEANS

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The driver and his perception of the environment, timely and effective receipt of information play an important role in safe, smooth, high-quality road traffic. It is known that one of the ways to provide information to the driver is road signs. The driving process largely depends on their quality and correct placement. Numerous studies show that the more experienced a driver is, the fewer signs he consciously notices. Such inattention often leads to critical situations on the road, especially when there have been changes in traffic regulations.

The driver must perceive large volumes of information about traffic participants, means of organization and regulation of road traffic, the condition of the road and the environment, as well as the operation of the vehicle systems and units. In addition, the traffic situation must be continuously analyzed and appropriate decisions must be made, often under severe time pressure. While driving, the driver has to make difficult decisions involving a large number of factors and parameters. Processing of received information is accompanied by a comparison of possible solutions based on developed skills, management experience, knowledge and understanding of traffic rules. The perceived information is evaluated by the driver from the point of view of its safety or danger. It takes some time to assess the situation and make the right decision, which depends on the visibility of the road situation, the experience and driving skills, and the speed of the vehicle.

When driving a car, it is necessary to maintain an optimal psychological state for a long time, in which information is quickly and efficiently perceived and processed. Deviation of the psychological state from the norm increases the probability of wrong actions of the driver.

The driver's reaction to any element of the road situation is aimed at changing emotional tension caused by the complication of driving, the influence of unexpected maneuvers of other vehicles and the decrease in visibility distance. The reaction time depends on the driver’s age, gender, state of health, professional qualities and psychological properties.

The reaction process can be conditionally divided into three stages: assessment of the situation; decision making and execution of appropriate actions. The driver's reaction time when driving a vehicle is measured by the interval from the moment of perception of danger to the start of specific actions.

The reaction can be simple or complex. A simple reaction is associated with the expectation of a single stimulus known to the driver, in response to which the driver must perform certain actions, while this time is 0.2-0.15 s. An example of a simple reaction would be pressing a button on a car panel to a light or sound stimulus. Assessment and decision-making about specific actions is a complex reaction, the time of which is 0.4-1.5 s, depending on the professional experience and individual psychophysiological characteristics of the driver's body.

While driving a car, the driver constantly moves his gaze to different objects in his line of sight and to different elements of the road. As a result of gaze movements, road signs are detected - the presence of a sign in the line of sight is established. After detecting a road sign, the driver fixes his gaze on it for 0.2-0.3 s. During this time, recognition, identification and decoding of the sign takes place. At the recognition stage, the driver determines general features: installation location, brightness and color, size and shape of the sign. At the identification stage, the driver compares the main features on the sign with the standards stored in his memory. The final stage of perception of road signs is decoding, that is, assessment of the semantic content of the sign.

The problem of road traffic reliability requires knowledge of the connection between the psychophysiological indicators of the driver's work while driving and the road conditions of the vehicle. Moreover, due to the still insufficient knowledge of the psychophysiological indicators of a human, it is possible to determine most of the characteristics of the reliability of the driver's work only empirically.

The driver's psychological perception of road information and the influence of external factors show that the driver is influenced by the surrounding world. This influence is especially felt when some changes occur in the driver’s familiar environment. A certain period of time, during which adaptation to the new environment and information support takes place, the driver may make mistakes in decision-making.

Attention and the level of reaction, which is determined by the number of objects that the driver is able to notice, perceive and correctly react to, have an important influence on the speed of perception of road conditions by drivers; based on the analysis of the stages of the course of psychological processes, manifested in the emotional excitement and general mobility of a person, a ranking was established regarding the ability of a person to perform the duties of a driver depending on temperament; it was established that the phlegmatic person is the most inhibited in favor of road conditions and decision-making in conditions of time shortage.

References

1. Гайдукевич, В. А., & Потійчук, О. Б. (2012). *Г12 Основи транспортної психології.* НУВГП.
2. Кищун, В. А., Кузнєцов, Р. М., Мурований, І. С., & Лаба, О. В. (2010). *Безпека дорожнього руху та деякі правові аспекти.* РВВ ЛНТУ.

Marynenko M. S.

MODERNIZATION OF A METAL STRUCTURE OF A SMALL-DIMENSIONED FRONT LOADER

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Small-sized front-end loader is a universal machine in the field of construction and cargo work. It is a powerful and effective tool that provides a variety of tasks in various industries, from construction to agriculture. A compact front loader is a compact machine with a front loader, which is widely used in various fields of activity. It is equipped with a special front bucket loading system that allows you to lift and move large loads, construction materials, earth, garbage and other objects. One of the most important advantages of compact front loaders is their compactness and maneuverability. They can work in confined spaces, such as construction sites or warehouses, where access to large machines is limited. Their compact size allows for convenient maneuvering among obstacles and efficient performance of tasks. In addition, compact front loaders are very powerful and reliable machines. They are capable of lifting heavy loads and operating in a variety of conditions, including rough terrain and harsh weather conditions. This makes them indispensable assistants at construction sites, ports, warehouses, farms and many other places where it is necessary to transport and move large loads. In the field of construction, compact front-end loaders are used for loading and unloading construction materials, digging pits, leveling soil and many other jobs. In general, compact front loaders are indispensable assistants in the field of construction, industry and agriculture. They combine compactness, maneuverability, power.

A compact front-end loader is a compact, universal engineering device that is used for lifting and moving loads on construction sites, warehouses and other premises where mobility and efficiency of cargo operations are required.

The history of the creation of compact front loaders began in the second half of the 20th century. The first devices resembling modern front loaders were developed in the 1950s. The idea was to create a compact machine with a front loader that would allow the operator to maneuver and move the load with ease.

The first compact front loaders were developed in Europe and the USA. JCB, Bobcat, Caterpillar and several other companies pioneered such equipment.

Over time and popularity, compact front loaders began to improve and innovate. New models appeared with increased maneuverability, increased power, convenient control and functional safety.

As for the place of creation, compact front loaders are manufactured by different companies in different countries of the world. Such countries as the USA, Great Britain, Sweden, Germany, China and Japan are known for their canvas manufacturers.

The main manufacturers of compact front loaders are:

JCB: The British company JCB is one of the leading manufacturers of construction and agricultural machinery. They offer a wide range of compact front loaders under the JCB Loadall brand. These machines are characterized by high productivity and reliability.

Bobcat is an American manufacturer of construction and agricultural equipment, best known for its compact wheel loaders. They produce models of different sizes and specifications to meet different needs of customers.

Caterpillar: Caterpillar is a leading global manufacturer of construction and mining equipment. They also offer compact front loaders that are characterized by high performance, quality and efficiency for a variety of tasks.

All manufacturers are constantly working on improving their compact front loaders. These include the introduction of new technologies, increased productivity and operational efficiency, improved operator safety and design optimization. Today's compact wheel loaders are equipped with advanced features such as hydraulic quick couplers, ergonomic controls, stabilization and load control systems, and advanced track or wheel controls.

Single-bucket loaders are required for the development and loading of loose materials, site planning, digging and moving soils of category 1-3 with loading into a dump or vehicles. It is possible to use forklifts in warehouses to move construction materials or soil over a short distance. According to the purpose of single-bucket loaders, they are widely used in transportation, residential and hydraulic construction, in the mining industry, in railway construction, etc. In road construction, loaders are most often used in quarries of building materials, in warehouses of sand, crushed stone, and gravel. The domestic industry serially produces single-bucket loaders with frontal, tilting and semi-rotating working bodies. The working process of loaders is determined by the type of work performed and the method of unloading the bucket. In front-end loaders, when loading blue materials into transport, it consists of the following.

On the first gear, which corresponds to the speed of the loader up to 4 km/h, the bucket is introduced from below into the stack of bulk material to a depth of 0.3-0.5 m. The bottom of the bucket must be inclined to the supporting surface at an angle of 5-7 degrees. The bucket of the loader on the track is introduced as a result of the compressive force developed by the basic tractor. Wheeled front loaders introduce the bucket into the stack due to the pressure force and the reserve of kinetic energy acquired in the acceleration process.

Taking this into account, the length of the acceleration path should be 3-4 m. At the time of application or after it, bulk material is scooped up. Then, in reverse, usually in a lower gear, the loader moves away from the stack and maneuvers to approach the vehicle as quickly as possible. If there is enough space, it is advisable for the loader to make only straight-line movements. But at the same time, the transport also maneuvers. The bucket of the front loader is unloaded by tipping forward.

The idle stroke is performed at a speed that is 25-40% higher than the speed of the working stroke. Loaders with semi-rotating and tipping buckets perform the same working movements as front loaders. Delivery of vehicles to them and unloading of buckets is carried out in accordance with the rules.

In general, the market for compact front loaders is constantly evolving, with new models appearing with improved capabilities and adaptability to various industries such as construction, warehousing, agriculture and other industries. Compact front loaders are widely used in various industries. It is used for lifting and moving building materials, earth and sand and other loads on construction sites. It helps to move pallets, containers and other goods quickly and easily in warehouse logistics. It is also used in agriculture to transport hay, straw, mineral fertilizers and other materials.

One of the main advantages of compact wheel loaders is their compact size, which allows them to be used in tight spaces such as narrow aisles, warehouse floors or construction sites with limited working space. This makes them particularly useful for construction jobs in urban areas where access to work areas may be restricted.

The compact front loader is also characterized by high mobility and ease of use. The operator can easily control the machine, perform precise movements and comfortably control the load. This helps increase productivity and reduce working time. Small front loaders have become indispensable work tools in various fields where speed, mobility and efficiency are required during loading and unloading operations.

References

1. Кириченко, І. Г., Назаров, Л. В., & Нічке, В. В. et al. (2003). *Наукові основи створення високоефективних землерийно-транспортних машин*.
2. Хмара, Л. А., Кравець, С. В., & Нічке, В. В. et al. (2010). *Машини для земляних робіт*.
3. Хмара, Л.А., Шипілов, О.С., Мусійко, В.Д. та ін. (2013). *Дорожні машини: Машини для будівництва, ремонту та утримання автомобільних доріг.*

Maslov D. O.

HOW TO CREATE A DIGITAL ELEVATION MODEL USING ARCSCENE (ARCGIS)

Language Advisor – Asst. Prof. Ponikarovska S. V.

Data sources for creating a digital elevation model (DEM) can include remote sensing data, aerial photographs, photogrammetric measurements, satellite positioning system data, ground surveys, measurement and echo sounding data, laser scanning, map data, etc. The method of obtaining information by scanning maps with subsequent semi-automatic vectorization using vectorization software is widely used. Such a vectorizer is Easy Trace, which is compatible with the most common software: ArcGIS, ArcInfo, ArcView GIS, MapInfo, WinGIS, AutoCAD, MicroStation, etc.

In ArcGIS, 3D modeling functions are implemented using the ArcScene module, which uses data on the height of an object obtained from its geometry, object attributes, layer properties, or a given 3D surface. Each layer of a 3D image can be processed separately from the others. Data with different spatial reference will be re-projected or displayed using only relative coordinates. ArcScene is fully integrated into the geoprocessing environment, which makes it possible to use numerous analytical tools and functions.

The primary data of digital elevation modeling can be visually represented in the form of two most common ways of representing surfaces: an irregular triangulation network (TIN – triangulated irregular network) or a regular height network (GRID model).

TIN (Triangulated Irregular Network) TIN (Triangulated Irregular Network) is an irregular triangulation network, a system of non-overlapping triangles. The vertices of the triangles are the initial reference points. In this case, the terrain is represented by a polyhedral surface, each face of which is described by either a linear function (polyhedral model) or a polynomial surface, the coefficients of which are determined by the values at the vertices of the triangles' faces. To obtain a surface model, you need to connect pairs of points with edges in a certain way, which is called Delaunay triangulation (Figure 1).

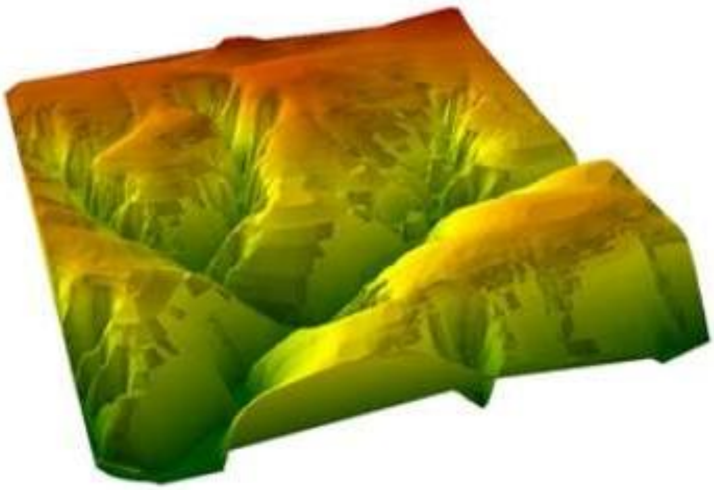

Figure 1. – TIN model

The GRID model has a raster structure formed by dividing the space into identical indivisible cells or pixels. The latter are usually square in shape and contain information about the height of the earth's surface above sea level. A GRID model is a regular matrix of elevation values obtained by interpolating the original data. For each cell of the matrix, the height is calculated based on interpolation, in fact, itis a grid whose dimensions are set according to the accuracy requirements of the specific task being solved. The regular grid corresponds to the earth's surface, not the image (Figure 2).

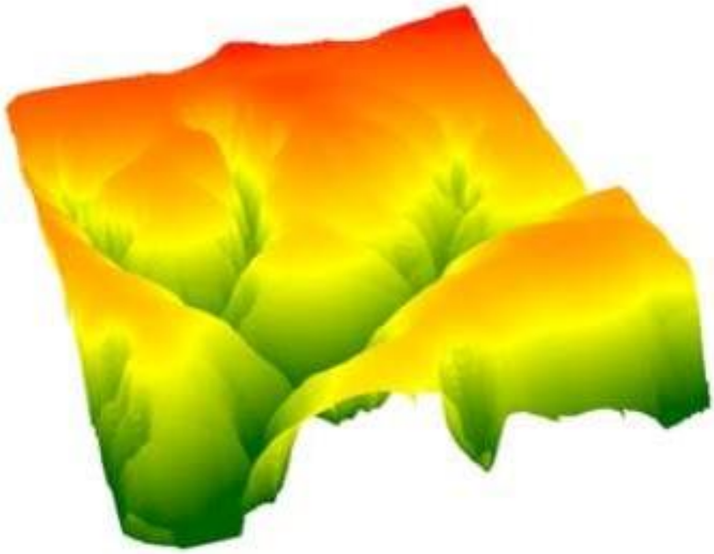

Figure 2. – The GRID model

TGRID is a model that combines elements of the TIN and GRID models. Such models have their own advantages, for example, they allow using additional data to describe complex terrain forms (cliffs, rocky outcrops).

Each model has its advantages and disadvantages. TIN takes up several times less space in the computer memory than GRID, due to its vector structure. It also requires more machine time to process the model. It is also believed that TIN is better suited for displaying the relief of mountainous areas, while GRID is more suitable for presenting flat areas.

The widespread use of three-dimensional modeling is explained by providing greater visibility of such models, making it possible to most fully convey information about changes in relief over time.

Thus, we tested the integrated use of the Easy Trace vectorizer and the ArcScene module of ArcGIS software. The result shows that terrain modeling should provide not only prompt receipt of the necessary numerical data, but also visualization of the terrain in the form of a three-dimensional map.

References

1. Burshtynska, H., Dorozhynsky, O., Zozulyak, P., & Zayets, O., (2013). Digital modeling of relief using the Surfer package and the ArcGis geographic information system. *Geodesy, cartography and aerial photography.* (63), 196–200.

Mishchenko S. V.

REVIEW OF RESEARCH ON BRAKE SYSTEMS WITH A HYDRAULIC DRIVE

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Hydraulic drives are used in various fields of technology. They are widely employed in aviation, machine building, construction, road and other types of vehicles, agricultural machinery, and automobiles.

Road traffic safety largely depends on the quality of brake systems used in cars. More than 40% of traffic accidents caused by technical malfunctions in cars occur due to defects in the brake systems.

In this regard, in recent years, the requirements for car brake systems have significantly increased. The strictness of these requirements has led to the search for new design solutions that ensure compliance with current and future standards.

Modern pneumatic brake actuators in cars are characterized by complex design, significant dimensions, and weight. Expanding the working mechanism helps address issues related to reducing mass, dimensions, and activation time of the drive.

In this context, hydraulic actuators emerge as the most promising type. Their working mechanism can be easily compressed to pressures of about 20 MPa.

Hydraulic drives can be classified into two groups based on the energy source used to actuate brake actuators: a hydraulic drive utilizing the driver's energy (simple drive) and a hydraulic drive utilizing an external energy source (automated).

The use of a simple hydraulic drive is restricted by the inability to achieve decelerations mandated for heavy vehicles due to regulatory constraints on the force applied to the control body (or pedal lever). In recent years, automated drives have become widespread, where the driver's muscular strength is either reinforced by an external source or entirely replaced by it.

Hydraulic drives with a third-party energy source are categorized into two groups: partially automated and fully automated. Partially automated drives achieve servo drive through the utilization of vacuum energy (hydro vacuum drive), compressed air (hydro pneumatic drive), and fluid pressure (servo hydraulic drive).

A fully automated hydraulic drive that harnesses fluid pressure energy is known as the hydraulic power brake drive. This type of drive is characterized by the driver's primary function being control, directing the braking action using fluid pressure energy.

Comparing hydraulic brake drives with their pneumatic counterparts reveals their undeniable advantages: short activation time, reduced dimensions and mass, high efficiency, and simple design, requiring minimal maintenance.

However, drawbacks include reduced drive efficiency at low ambient air temperatures and challenges in ensuring compatibility between the tractor and trailers.

According to foreign studies (Halderman, 2017), the hydraulic power drive of brakes, operating at a pressure of approximately 15 MPa, exhibits the shortest activation time.

Hydraulic power brake drives can be categorized into three types: a drive with the accumulation of fluid pressure energy, a drive with liquid bypass, and a combined drive with two circuits (power and simple).

The fluid energy storage drive holds a significant advantage over the fluid bypass drive; it remains operational even when the engine is stopped. This is due to the presence of a reserve of fluid pressure in hydraulic accumulators, sufficient to perform the proposed amount of braking. Brake actuators of this type are manufactured by Lockheed (Great Britain), Clayton-Dewandre (USA), Westinghouse (Germany), and others.

The combined drive from Automotive Products (Great Britain) and Teyes (Germany) effectively integrates the benefits of power and simple hydraulic drives. However, in the event of a power circuit failure, the driver's effort may prove insufficient to attain the prescribed braking efficiency, especially when dealing with heavy vehicles.

The hydraulic brake drive boasts several noteworthy advantages that set it apart favorably from other types of brake drives.

The use of high pressure in hydraulic drives significantly enhances their dynamics. According to Westinghouse, the time required to actuate such a drive – from pressing the brake pedal until reaching 9% of the maximum pressure in the actuator – is 20-30% less compared to the corresponding time for a pneumatic brake actuator (Halderman, 2017).

The working fluid, subjected to high pressure, occupies a smaller volume compared to compressed air in pneumatic drives. This characteristic aids in reducing the inertia of the drive.

For a crucial component of modern cars such as the brake drive, reliability is of paramount importance. The reliability of drive operation, along with its activation, constitutes a crucial element for the active safety of the car.

In the event of a disruption in one of the circuits of a simple or hydraulic drive and a malfunction in the vacuum amplifier of the hydraulic drive, the relationship between pedal force, its stroke, and the deceleration of the car undergoes significant changes. The hydraulic drive ensures the preservation of the «effort-stroke-deceleration» relationship even in the case of a partial failure in its performance.

In this scenario, the effort required on the brake pedal increases slightly, serving as a signal of a malfunction. Additionally, the hydraulic power drive exhibits an increased level of reliability in the presence of damage or leakage in the brake mechanism, leading to a substantial increase in the volume of the corresponding working cylinder.

The components used in the hydraulic drive are small and compact. A comparison of this drive with an equivalent pneumatic drive, as conducted by Lockheed, indicates that for a car with a gross weight of 16 tons, the total weight reduction attributed to the brake drive is 20–25 kg. The application of high pressure enables the shortening of the working stroke of the brake pedal.

The durability of hydraulic drive parts and assemblies, unlike pneumatic and others, is ensured by the constant presence of lubrication, which serves as the working fluid for the drive itself. This lubrication allows the use of spool valves, reducing the reliance on seals made of polymers. Additionally, the working fluid acts as a protective layer, guarding internal drive parts against corrosion, particularly crucial for moving components.

Due to the costs associated with gas compression, energy expenses for liquid compression are significantly lower. The notably higher efficiency of hydraulic pumps and brake drive hydraulic components leads to lower energy consumption compared to an equivalent pneumatic drive, resulting in higher overall efficiency.

The cost of a hydraulic brake actuator for a 10-ton car does not exceed that of an equivalent pneumatic actuator.

It is important to note that the hydraulic brake actuator possesses several specific features that set it apart from other hydraulic actuators.

Hence, hydraulic brake systems are widely used in automobiles and other vehicles, as well as in various industrial applications. Here are some advantages and disadvantages of these systems (Burennikov et al., 2009).

Advantages. Braking efficiency: hydraulic systems provide effective and fast braking by transmitting hydraulic pressure through fluid.

Even distribution of force: the systems can provide an even distribution of braking force to all wheels of the vehicle, which improves stability and controllability.

Ability to integrate with anti-lock braking system (ABS): hydraulic braking systems are often combined with ABS technology, which helps maintain vehicle control during braking.

Less wear and longer life: reduced friction between brake parts can result in less wear and longer system life compared to mechanical brakes.

Disadvantages. There is a tendency to trap air in the system: hydraulic systems can accumulate air, impacting braking performance. Besides, compared to mechanical brakes, hydraulic systems may require more attention and maintenance.

There is also a need for hydraulic fluid: The hydraulic system requires a special fluid to operate, and its level must be regularly checked and topped up.

In addition, hydraulic brakes can be more expensive to repair compared to mechanical brakes due to the complexity and cost of parts.

References

1. Halderman, J. D. (2017). *Automotive Brake Systems*, Pearson.
2. Бурєнніков, Ю. А., Кашканов, А. А., & Ребедайло, В. М. (2009). *Рухомий склад автомобільного транспорту: робочі процеси та елементи розрахунку*. ВНТУ.

Misnichenko S. O.

ADSORPTIONSKAPAZITÄT DES LUXUS-VERJÜNGUNGSMITTELS “ED-L“

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Asphaltbeton ist das weltweit am häufigsten verwendete Material für Straßenbeläge. Der Grund dafür sind die bedeutenden Vorteile dieses Materials: hohe physikalische und mechanische Eigenschaften, Beständigkeit gegen elastische und plastische Verformungen, Herstellbarkeit von Asphaltbetonbelägen und die Möglichkeit, Asphaltbeton wiederzuverwenden. Leider gibt es neben den Vorteilen von Asphaltbeton auch einige Nachteile: eine erhebliche Abhängigkeit der Eigenschaften von den Witterungs- und Klimabedingungen; eine Tendenz zur Alterung, die sich in einer Veränderung der physikalischen und mechanischen Eigenschaften von Asphaltbeton mit zunehmender Nutzungsdauer im Straßenbelag äußert. Gleichzeitig ist der Hauptgrund für die Veränderung der Eigenschaften von Asphaltbeton im Laufe der Zeit die Alterung des bituminösen Bindemittels, das Bestandteil des Asphaltbetons ist, und die sich in einer Abnahme der Plastizität des Bindemittels und einer Zunahme seiner Steifigkeit äußert, was wiederum zu einer Abnahme der Rissfestigkeit der Asphaltbetondecke führt.

Eine der Möglichkeiten, die Auswirkungen der Alterung von Asphaltbelägen zu verringern und ihre physikalischen, mechanischen und betrieblichen Eigenschaften zu verbessern, ist die Verwendung von Verjüngungsmitteln. Chemische Additive dieser Klasse wurden in den 60er Jahren des letzten Jahrhunderts in den USA eingeführt (Rostler & White,1970; Boyer, 2000). Aufgrund ihrer einfachen Anwendung und ihrer Wirksamkeit bei der Verbesserung der Leistungseigenschaften von Asphaltbelägen haben sich Zusatzstoffe dieser Klasse in der Straßenbauindustrie auf der ganzen Welt durchgesetzt. Derzeit gibt es zwei Hauptverfahren für den Einsatz dieser Zusatzstoffe: das erste ist die Behandlung von altem Asphaltschrott, der in einem Asphaltwerk einem neuen Asphaltmischgut zugesetzt wird, und das zweite ist die Behandlung bestehender Asphaltbeläge (Rostler & White,1970; Boyer, 2000; Petersen, C. J. (1984).

Die erste Methode der Verwendung von Verjüngungsmitteln ist die gängigste und hat sich in letzter Zeit in der heimischen Straßenbauindustrie weit verbreitet. In diesem Fall kann das Additiv sowohl dem Bitumen während der Aufbereitung des Bindemittels im Werk als auch direkt der Oberfläche des alten Asphaltbetons zugesetzt werden, wodurch eine Verbesserung der Eigenschaften des alten Asphaltbetons aufgrund der Plastifizierung des Bitumens, das Teil dieses Asphaltbetons ist, eintritt.

Bei der zweiten Methode der Verwendung von Verjüngungsmitteln werden diese in Form von Wasseremulsionen auf der Oberfläche des bestehenden Asphaltbelags verteilt, und aufgrund der Adsorption des Zusatzstoffs in der oberen Schicht des Asphaltbetons wird eine Plastifizierung des Bitumens und eine Versiegelung der Oberflächenschicht des Belags beobachtet.

Rostler F.S. und White R.M. (Rostler & White,1970; Boyer, 2000) entwickelten in den 60er Jahren des letzten Jahrhunderts die theoretischen Voraussetzungen für den Einsatz von Rejuvenationsmitteln und schlugen die ersten Methoden zu deren Bewertung vor. Boyer R.E. (Boyer, 2000) stellte auf der Grundlage seiner Forschungen fest, dass die Wirksamkeit der Sanierung von Asphaltbelägen mit Hilfe von Verjüngungsmitteln durch deren Adsorptionsfähigkeit bestimmt wird, durch die das Additiv bis zu einer bestimmten Dicke der Asphaltschicht eindringt und das Verhältnis zwischen der Menge an Asphaltenen und Maltenen im Bitumen korrigiert.

Gegenwärtig wird weltweit eine beträchtliche Anzahl verschiedener Verjüngungsmittel verwendet, die sich in ihrer chemischen Zusammensetzung unterscheiden und sowohl für das erste als auch für das zweite Anwendungsschema eingesetzt werden. Zahlreiche Studien, die in verschiedenen Ländern der Welt durchgeführt wurden, bestätigen ihre Wirksamkeit (Al-Saffar et al., 2021; Loise, Caputo, Porto, Calandra, Angelico, & Oliviero Rossi, (2019).

Das erste einheimische Verjüngungsmittel Lux "ED-L", das von der ukrainischen Firma SPE "Lux-X" (LLC) synthetisiert wurde, wurde als Forschungsobjekt ausgewählt. Dieses Verjüngungsmittel ist für die Anwendung nach dem zweiten Schema vorgesehen (Behandlung der Oberfläche eines bestehenden Asphaltbelags in Form einer Wasseremulsion).

Die Ergebnisse der Studie über die Wirkung des Verjüngungsmittels Lux "ED-L" sind in (Pyrig, Galkin, Oksak, Ilin, & Shyika, 2022) dargestellt. Die zuvor gewonnenen Daten zeigen, dass durch die Zugabe dieses Additivs zum Bitumen die Eigenschaften des ursprünglichen Bindemittels wiederhergestellt werden, was durch die Werte der Standardeigenschaften (Penetration, Erweichungspunkt und Sprödigkeit) bestätigt wird. Darüber hinaus verbessert der Zusatzstoff Lux ED-L die Klebeeigenschaften des Bindemittels erheblich.

Aufgrund der erhaltenen Daten kann eine Methode empfohlen werden, die auf der Veränderung des Haftindexes an der Glasoberfläche basiert, um die Adsorption des Verjüngungsmittels durch die Bitumenschicht zu bestätigen.

Literatur

1. Rostler, F. S., & White, R. M. (1970). Rejuvenation of Asphalt Pavements. *Materials research and development INC.* Oakland CA. United States.

2. Boyer, R. E. (2000). Asphalt rejuvenators “fact, or fable”. *Transportation systems*. 58, 1-17.

3. Petersen, C. J. (1984). Chemical composition of asphalt as related to asphalt durability: State of the Art. *Transportation Research Record*. 999, 13-30.

4. Al-Saffar, Z. H. et al. (2021). A review on rejuvenating materials used with reclaimed hot mix asphalt. *Canadian Journal of Civil Engineering*. 48(3), 233-249.

5. Loise, V., Caputo, P., Porto, M., Calandra, P., Angelico, R., & Oliviero Rossi, C. (2019). A review on Bitumen Rejuvenation: Mechanisms, materials, methods and perspectives. *Applied Sciences*. 9(20), 4316. https://doi:10.3390/app9204316

6. Pyrig, Y., Galkin, A., Oksak, S., Ilin, I., & Shyika, Y. (2022). Influence of Rejuvenator on the Properties of Bitumen and Asphalt Concrete. Key *Engineering Materials*. 938, Chapter 6: Building Materials, 225-233.

7. ДСТУ 9169:2021 Бітум та бітумні в’яжучі. Визначення зчеплюваності з мінеральним матеріалом (2021). [Чинний з 2022-08-01]. Вид. офіц. УкрНДНЦ.

Mokhonko R. O.

RECOVERY BRAKE SYSTEM IN ELECTRIC VEHICLES

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Electric vehicles have undeniably gained traction on the roads, offering a sustainable alternative to traditional combustion engine vehicles. However, the challenge of optimizing range remains a focal point of innovation in the electric vehicle industry. Among the array of solutions, the regenerative braking system emerges as a key system.

To stop a car you need to remove kinetic energy. During normal braking, the car brakes using the force of friction. Using usually disc brakes or drum brakes. In this case, kinetic energy is converted into heat.

Regenerative braking's core principle lies in harnessing the kinetic energy dissipated during braking and converting it into a valuable resource for EVs. By engaging the electric motor in generator mode, regenerative braking complements, and in some cases, substitutes traditional friction braking systems. Electric vehicles today typically feature both disc brakes for emergency situations and regenerative brakes for regular deceleration, creating a dual braking system that optimizes energy usage.

On modern electric vehicles, you need to release the accelerator pedal to activate the regenerative braking system. In this case, wheels rotate the electric motor in the opposite direction. This energy flow allows the motor to act as a generator, resisting the rotation of the wheels and creating electricity to recharge the vehicle's battery. The system generates energy. he amount of energy depends on the braking distance and speed of the electric vehicle. That means the battery is charged and the electric vehicles slows down. This mode is called "e-Pedal". You can also disable this mode (e-Pedal). As a result when releasing the accelerator pedal, the car will coast for longer. Regenerative mode will be activated when you press the brake pedal.

Currently, regenerative braking systems are reclaiming around 60% of energy during deceleration, a remarkable achievement but not the final frontier. Anticipated technological advancements promise even greater efficiency gains. Engineers are working to overcome challenges associated with low-speed effectiveness, ensuring that regenerative braking continues to contribute significantly in various driving conditions.

Regenerative braking has its drawbacks. **It is clear that** is a decrease in effectiveness at low speeds. In slow-moving stop-and-go traffic, regenerative braking cannot capture much energy and feed it back to the battery, significantly reducing system benefits during rush hour. Furthermore recovery brakes are less effective compared to disc brakes.

Another disadvantage is the negative impact of regenerative brakes on the battery. This process introduces an additional thermal load to the battery. The rapid cycling of charging and discharging during regenerative braking events can elevate the temperature of the battery pack, potentially leading to increased thermal stress. Elevated temperatures can accelerate chemical reactions within the battery cells, contributing to a faster rate of capacity degradation over time. During regenerative braking, the electric motor operates in generator mode, producing voltage spikes as it feeds energy back to the battery. These voltage spikes can induce stress on the battery's internal components, impacting its overall health. Battery management systems (BMS) are employed to mitigate such spikes, but challenges may arise in scenarios where the battery is subjected to frequent and abrupt regenerative braking events. Regenerative braking inherently involves frequent charge and discharge cycles as the battery alternates between storing and releasing energy. The cumulative effect of these cycles can contribute to capacity fade over time, diminishing the battery's ability to hold a charge. Battery degradation is a natural process in any energy storage system, and regenerative braking, with its cyclical nature, may expedite this degradation to some extent. Effective implementation of regenerative braking necessitates sophisticated battery management systems. Ensuring optimal performance and longevity requires constant fine-tuning of these systems to balance the benefits of regenerative braking with the need to preserve battery health. Striking this balance poses a challenge for manufacturers in their quest for maximizing both energy efficiency and battery lifespan.

Looking ahead, advancements in regenerative braking technology are expected to contribute to the overall efficiency and sustainability of electric vehicles.

With ongoing research and development, it is likely that future electric vehicles will feature more sophisticated and efficient regenerative braking systems, further extending their range. As the automotive industry continues its transition toward electrification, regenerative braking remains a crucial innovation in addressing the challenges associated with electric vehicle range and efficiency.

While regenerative braking offers a host of benefits, it is essential to acknowledge its environmental implications. The reduction of emissions of metal particles and the extended lifespan of traditional friction braking components contribute to making electric vehicles more eco-friendly. As regenerative braking technology matures, its holistic impact on the environment is likely to become even more pronounced.

All in all the recovery brakes system is very effective. You will never recover all of the energy consumed in driving the car forwards, harvesting some of it will increase your range. Secondly recovery brakes reduce emissions of metal particles and increase the resource friction braking system. This makes the electric car more environmentally friendly.

References

1. Choksey, J. S. (2021). *What is Regenerative Braking?* https://www.jdpower.com/cars/shopping-guides/what-is-regenerative-braking
2. Braithwaite-Smith, G. (2023). *How can regenerative braking improve your electric car's range?* https://www.motoringelectric.com/driving/what-is-regenerative-braking/

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BRIDGE CONSTRUCTION: STAGES, TYPES OF BRIDGES

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Bridge construction is a complex work that requires long-term training of engineers and builders. Previously, for the construction of supports, a shallow place in the river or the sea was sought and an artificial embankment was made, but today technologies allow the construction of large structures directly in the sea.

The installation of any bridge includes four stages of construction: the first stage – the area is developed, temporary structures are erected, communications are laid; at this stage, the work of surveyors and engineers plays a major role; the second stage – supports are erected, for this purpose various technologies are used, for example, special structures – cofferdams – are installed in the sea; the third stage – a metal span structure is installed, the road is laid; the fourth stage – tests of the new bridge are carried out.

This scheme works both for a small river crossing and for large structures across the straits.

Supports are a key part of any bridge. To build a support, cofferdams are constructed. This is a special round dam that is being built around the future pile. Using the cofferdam, the water can be dried and construction work can be done normally.

Construction such a dam is a complex process. First, piles are installed, then a metal frame is created, which is filled with a concrete mixture. All this work takes place on land. Usually, cofferdams are divided into several parts, which are then lowered into the water one by one. When the structure is placed on the bottom, water is pumped out from the inside. A temporary bridge to the cofferdam is also being pierced so that equipment and people can reach it. Now erecting the supports can be started. By the way, a similar technology for creating a mini dam is used not only in the construction of bridges, but also during repair work.

Further construction technology is similar to installing a conventional foundation: a frame of reinforcement is assembled on the bank and placed inside the cofferdam, then filled with concrete.

Another technology is also used without draining the river. The assembled frame is lowered to the bottom and filled with a special cement mortar that is not afraid of water. In some cases, construction workers lean on the bank. Then a small embankment is created at the bottom, where the structure is installed. Such methods are used when it is necessary to make a bridge of short length.

Spans are structures attached between supports. They consist of trusses – large rod structures produced on the bank, in some cases the factories for their production are built right next to the bridge. Finished reinforced concrete structures are lifted using cranes and installed on supports. When the crane cannot be used, the trusses are pushed on mobile scaffolding. If the truss weighs little, it is lowered onto a barge and transported to the right place. Then it is lifted and fixed using a crane. Rivets, bolts or welding are used as fasteners. Slings are also used.

There are many bridges, but only five main ones. They differ in the type of design and construction technology.

Block. Small bridges are built from the blocks, the length of which does not exceed 40 meters. Most often, they are used as a crossing over a small river or road. The design of such bridges is quite simple. A concrete beam is installed as a support and is used for spans. Block bridges are divided into several separate categories: simple – several beams are used, usually one span – one beam; continuous – a long beam is produced that covers the entire bridge or several spans at once; cantilever – two types of beams are used (cantilever and suspension) in the construction of this bridge; thermal – the special arrangement of the beams allows this bridge to combine the advantages of a simple and continuous bridge.

Truss. This type of bridge uses trusses instead of blocks. Such bridges have good strength and are suitable for long distances. Just like the block structure, the truss structure has two types: simple and continuous.

Pontoon. When a rigid structure is not required, pontoon bridges are used. Floating spans and supports allow the quick creation a crossing. The pontoon is used for the construction of other bridges and works.

Arch bridge. Some bridges have an arch structure. This makes it possible to completely eliminate deformation forces and resist only compression. Also, ships with high masts can sail under the upward-curved structure.

Spacer. This type of bridge is similar to a block bridge, but unlike it, the supports of this bridge feel two forces at once: horizontal and vertical. It turns out that the supports expand. There are several types of this bridge: frame – large frames are used for supports, and crossbars are used for spans, the frame bridge looks like the letter "T" or "П", since the structure uses one or two supports and a flat span (used for overpasses); suspension – it is installed in those places where supports cannot be installed or it is too expensive. On each bank, opposite each other, pylons are installed, to which cables are attached. For additional rigidity, trusses or blocks are added; cable-stayed – generally similar to suspension one, but instead of cables, cable-stayed trusses are used, obtained by twisting steel ropes (applied for highways); combined – these bridges combine block and arch types and are built in cities where wide rivers flow, blocks can withstand heavy loads, and arches give a beautiful and aesthetic appearance.

There are also moveable bridges. The most common is a design in which the left and right parts rise by 90 degrees (in production areas and ports, bridges with a lifting middle part are installed that are less aesthetic, but easier to build). This design is divided into three parts: two fixed spans that are attached to the bank and a movable middle.

References

1. Страхова, Н. Є., Голубєв, В. О., Ковальов, П. М., & Тодіріка, В. В. (2002). *Експлуатація і реконструкція мостів.*
2. *Будівництво мостів: етапи, типи мостів.* https://virakran.com/budivnytstvo-mostiv-etapy-typy-mostiv/

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CONSTRUCTION OF QUALITY ROADS IN UKRAINE: A STEP TOWARDS CHANGE AND MODERNIZATION

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The construction of quality roads in contemporary Ukraine has evolved into not just a pragmatic but a strategically crucial stride in the recovery and reform strategy post the economic crisis period between 2014 and 2016. Defining innovation directions, implementing the ProZorro system for transport procurements, ensuring quality guarantees for road works, initiating a road fund, and a substantial increase in funding for road construction and maintenance stand out as key components and promising future prospects for this strategically vital sector, even in the aftermath of the war in Ukraine.

The implementation of the ProZorro system is just one facet of the significant changes in transportation infrastructure. Ensuring quality guarantees for road works, the establishment of a road fund, and increased funding represent a call for a comprehensive and systematic approach to the modernization and development of the country's transportation hubs.

Further expansion of the sector's prospects may become feasible through a favourable financial fund that will gradually be filled. This includes an increase in funds from excise taxes and import duties. The road fund is poised to reflect ambitious plans for the repair and construction of roads, seen as a substantial step toward enhancing infrastructure in the future. Plans for the volume of repaired, restored, and newly built roads are expected to be extensive and increase annually.

Projects like GO Highway not only bear witness to Ukraine's ambitions in strengthening its transport and transit potential but also serve as mechanisms for integration into the international transport arena. Discussions on the European plan for Ukraine, attracting new investors for development projects, can open new perspectives and demand effective management of these funds.

The implementation of quality roads leads to realized transportation and transit potential, resulting in significant economic benefits. This creates job opportunities, fosters the development of related industries, and enhances the country's infrastructural attractiveness to foreign investors.

Quality roads reduce distances and bring people closer. This can help overcome social and economic disparities between regions, promote the exchange of ideas, and contribute to the development of national identity.

Massive road construction can become a national project that unites citizens and politicians. Infrastructure development becomes a unifying factor, ensuring a positive national sentiment.

With the onset of full-scale war, the Cabinet of Ministers of Ukraine made decisions regarding certain aspects of road management during a state of war. In 2022, for this period, an exception was made for budgetary fund managers who can enter into agreements for the construction and repair of roads, provided it aligns with budgetary constraints and is funded through a special fund.

Changes have been introduced to the funding of the road development program, specifying the volumes and sources of funding. Payment terms for contracts may be postponed until the restoration of tax rates and the cancellation of tax incentives introduced by laws from March 15, 2022.

The necessity of publishing comprehensive information about agreements and urging contractors to disclose contracts without delay is a step toward creating an effective control system. This will contribute to combating corruption in road construction and the management of funds allocated to infrastructure projects. The public, media, and anti-corruption agencies will be able to monitor, analyze, and identify possible violations. All these measures will contribute to the creation of a control system that will help overcome corruption challenges and ensure the efficient use of financial resources in road construction.

The abovesaid can help make the following conclusion.

The construction of quality roads has the potential to become not only an economic backbone but also a national symbol of success and development. This will give Ukraine a new image in the global community and serve as motivation for political leaders, similar to the example of Poland, where success in road construction proved to be a key element in community support and political victories.

Finally, quality roads are a factor of civilizational identity. The myth of brotherhood between the Ukrainian and russian peoples is being imposed on us. Of course, we differ, but in the grand scheme of things, how are we better, at least we were until recently? Didn't we have the same rotten state? Didn't we have the same two biggest problems: expensive and stupid? Building good highways is an incredible chance to prove, first of all to ourselves, that we are different, that we are not rotten. There, "beyond the ledge", the roads will never be good, because there is neither a sufficient population density that would justify their expediency, nor the depth of the economy (developed small and medium-sized businesses, the middle class, which are most in need of highways), but corruption flourishes, one of the largest centres and mainstays of which in every country is the road industry. By building high-quality highways, we will show that all this does not concern us, that we are different. And then the need to fight will disappear, because fundamentally there will be nothing to share.

As Slawomir Novak said, in Poland, politicians won elections by building roads. Apparently, this is also possible in Ukraine. This should motivate politicians to support the processes that have started. Of course, no one is safe from the victory of populists in the next election, who will want to get into the pockets of road users and all of us in order to get rich in a long-known, proven way. But it will not be so easy to do, because the industry is gradually gaining momentum and turning from an outsider into a leader.

References

1. Шавалюк, Л. Будівництво доріг як національний проект. https://tyzhden.ua/budivnytstvo-dorih-iak-natsionalnyj-proekt/
2. *Постанова КМУ від 15 липня 2022 р. № 803 «Деякі питання дорожнього господарства».* https://zakon.rada.gov.ua/laws/show/803-2022-%D0%BF#Text
3. *«Велике будівництво» під час великої війни. Хто заробляє найбільше.* https://glavcom.ua/publications/velike-budivnitstvo-pid-chas-velikoji-vijni-khto-zarobljaje-najbilshe-905864.html
4. Володимир Зеленський: За два роки в межах програми «Велике будівництво» оновлено й побудовано понад 40% основної мережі доріг України. https://www.president.gov.ua/news/volodimir-zelenskij-za-dva-roki-v-mezhah-programi-velike-bud-72245

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APPLICATION OF FRACTALS IN METROLOGY

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Metrology encompasses all procedures necessary for establishing the significance of a particular quantity and also ensures the uniformity of measurements, which is essential for ensuring the reliability of the entire conformity assessment system. All aspects of metrology - legal, scientific, and practical - must be shaped in a way that provides the necessary resources to provide accurate and verified information in the conditions of a market economy.

Over the past decades, there has been a qualitative and quantitative shift in the scientific and practical tasks facing experts working in the field of ensuring measurement uniformity. The structure of individual measurement equipment has become more complex, leading to the transformation of individual measurement constructions into technical and metrological complexes that require a new scientific approach to their design, maintenance, and management. There has been an increased overall need to provide samples for basic metrological centers, large industrial companies, interconnected by scientific and technical relationships, and their geographical location.

The significance lies not only in the formation of individual measuring equipment that meets progressive conditions in terms of accuracy, durability, aesthetics, cost, energy and labor consumption, but also in shaping the concepts of their development. The activities of these concepts directly address the task of preserving and transmitting the dimensions of units and the performance of the state's reference base as a whole. New conditions for the national measurement unity assurance system (NMUAS) are also associated with the introduction of metrological traceability of measurement results. In this context, fractal qualities began to manifest themselves in the NMUAS.

Fractals are geometric objects characterized by a highly intricate configuration and possess the quality of self-similarity. Self-similarity, as the primary attribute of a fractal, means that it is organized in a more or less identical manner across a wide range of scales. Therefore, upon magnification, small parts of the fractal resemble the larger parts. One classical example of a geometric fractal is the Koch snowflake (Figure 1).

The zeroth iteration considers an equilateral triangle. Subsequently, each side of this triangle is divided into three equal parts, and the middle part is removed. In its place, an equilateral triangle is constructed (see Figure 2). In the next stage of this division procedure into three parts, along with the construction of an equilateral triangle, each side of the resulting shape undergoes the same process, and this continues infinitely. The property of exact self-similarity is only true for certain fractals, including the Koch snowflake. Essentially, regular fractals are a mathematical abstraction and allow for an infinite number of iterations. For a real fractal, there is a certain minimum size, lmin, such that at distances $l \leq$ lmin, its main quality—self-similarity—is excluded.

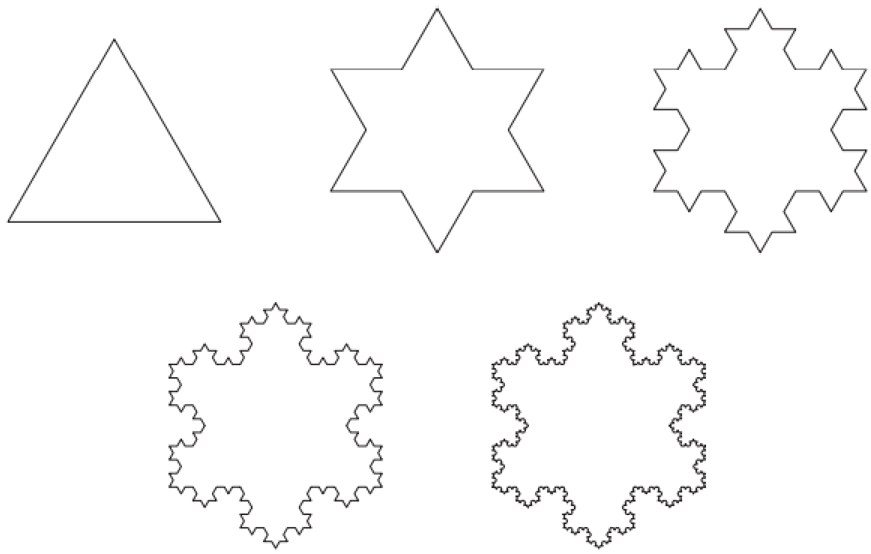

Figure 1. – Koch Snowflake

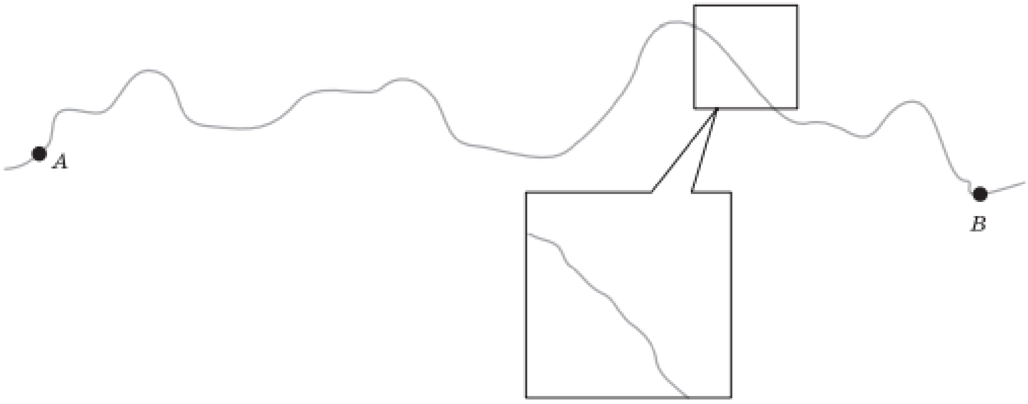

Figure 2. – Fractality of a Coastline

Furthermore, at sufficiently large scales, $l \geq lmax$, the property of self-similarity is also violated. The exact analogy disappears, and the number of iterations becomes limited. Such fractals are often referred to as irregular, considered as a result of the influence of natural forces or human activities. The concept of a fractal in physics initially arose in connection with the problem of determining the length of a coastline. When measured according to an existing map of the area, it was found that the more extensive the map considered, the longer the coastline appeared. To determine the length of the coastline between points A and B, one can place stakes connected to each other at a uniform distance of $l = 10$ kilometers. The length of the coastline between points A and B in kilometers equals the number of stakes minus 1, multiplied by 10. If the distance between adjacent stakes is reduced to $l = 1$ km, then the distance becomes greater. With further reduction in the distance between the stakes, the length of the coastline will increase. The smaller the scale used, the finer the elements of the shore will be refined, contributing to the measured length. In a straight section of the coastline, at the smallest scale, a jagged section appears at an increased scale. Clearly, unlike a geometric regular fractal, the level of intricacy will vary, despite it being a fractal as well (Figure 2).

The concept of a fractal has long transcended geometric figures and is applied in various fields of activity. H. J. Varnke used a fractal approach to the structure and management of enterprises. He proposed analyzing the enterprise as a set of subsystems that improve themselves in terms of implementing the production process and ways of achieving goals. Vitality and dynamics were among the main indicators of the fractal. Vitality was suggested to be understood as the ability to operate successfully in rapidly changing situations based on constant consideration of internal and external conditions, while dynamics expressed the potential of internal and external relationships to change and readjust in the shortest terms. The action of fractals is characterized by constant autonomous optimization and further formation of internal processes.

Regarding the electrical supply of industrial enterprises as a management object, B. I. Kudrin applied a fractal approach. In his work, he observed that the analysis of workshops and organizations at different levels of upward inclusion, as well as possible fragmentation, is limited to a few steps. The expression of fractal qualities of technical systems in metrology was noted during the analysis of ensuring measurement unity in the field of measuring electrical resistance.

Let's try to assess the number of steps in the fragmentation of the Measurement Unity Assurance System (MUAS), starting from the international level. In 1999, at a meeting of national metrology institutes (NMI), the Agreement on the Mutual Recognition of National Standards and Calibration Certificates Issued by NMIs (CIPM MRA) was signed. NMIs that signed the MRA participate in the formation of a worldwide database on measurement and calibration capabilities. For this purpose, under the auspices of the International Committee for Weights and Measures and the International Bureau of Weights and Measures, key comparisons are conducted. The next level involves regional comparisons conducted by associations of national metrology institutes. The third level consists of metrological activities at the national level. The fourth level involves metrological work at the level of regions within a specific country. The fifth level comprises directly metrological centers. For large metrological centers, another level of fragmentation is possible.

Before moving on to further discuss the qualities of metrological concepts, let's try to find the answer to the question of the number of standards in a specific type of measurement. Suppose there are 100 reference standards in 100 metrological organizations. Among them: secondary standards - 5 (in 5 organizations), working standards of the 1st grade - 15 (in 15 organizations), working standards of the 2nd grade - 25 (in 25 organizations), working standards of the 3rd grade - 55 (in 55 organizations). But how many standards of all grades are there in total?

In accordance with the terms and definitions adopted in metrology: a reference standard is a sample that possesses the highest metrological qualities (in a country or group of states, in a region, department, organization, enterprise, or laboratory) and transfers the unit of measurement or scale to subordinate standards and available measuring instruments. In this context, standards that are part of the control scheme (calibration hierarchy) and are subordinate to the reference standard are typically referred to as subordinate standards.

Let's start the analysis with organizations that have primary standards of the secondary level. The primary standard, like any other, undergoes changes in its basic metrological characteristics. This change is more noticeable, the more intensively the standard is used. Therefore, the use of measuring instruments from the main set of secondary-level standards will be limited. Instruments of low accuracy will be calibrated using a complex of measuring equipment that belongs, in terms of its metrological characteristics, to working standards of the 3rd category. Ideally, the organization will have its own internal calibration hierarchy, including working standards of the 1st category, working standards of the 2nd category, and working standards of the 3rd category.

Drawing an analogy for an organization with a primary working standard of the 1st category, we get two more levels: working standards of the 2nd category and working standards of the 3rd category. In an organization where a working standard of the 2nd category is used as a primary standard, we get one additional level. Let's assume that in the presence of an initial working standard of the 3rd category, no 4th level is formed within the framework of its own local calibration hierarchy.

If we now sum up the number of all standards in all organizations, we get 170 standards of different accuracy levels. I would like to emphasize that this is an abstract number, and the actual number of levels in each organization may be more or less. Each organization, in this sense, is unique but similar in its own structure.

In a simplified form, the transfer of the unit of measurement at the national level can be represented as a combination of both the national and local levels, taking into account the embedding example of a secondary-level standard.

In the development of the local system for the transfer of measurement units, it is necessary for the organization itself to ensure viability and dynamics based on continuous analysis of internal and external conditions. There are two main tasks. The first is to ensure participation as an element of the national measurement standards system at its level of accuracy. The second is continuous independent optimization and further development of internal processes that ensure the performance of metrological work at the required level of quality.

Regarding metrological centers of local subordination, this means ensuring the transfer of measurement units to subordinate standards and providing the necessary measurement information on the activities of all center departments. In the example of the standard for the unit of alternating current voltage, the primary tasks can be formulated as follows:

- Increasing the range of nominal values;
- Expanding the frequency range;
- Increasing the accuracy of metrological work;
- Increasing the level of automation during metrological work.

It should be noted that the number and content of measurement tasks facing a specific metrological center cannot be predicted even in the foreseeable future. Additionally, in the improvement of measuring equipment, manufactured, delivered, and installed means of measurement are used, which have undergone an informational selection.

References

1. Warnecke, H.-J. (1993). *Revolution Unternehmenskultur: Das Fractale Unternehmen.* Heidelberg, Springer Publ.
2. Russ, J. (2001). Fractal geometry in engineering metrology. *Metrology and Properties of Engineering Surfaces.*
3. *International equivalence of measurements: the CIPM MRA.* Bureau International des Poids et Mesures. https://www.bipm.org/en/cipm-mra/

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RESEARCH OF STIFFNESS PARAMETERS OF AUTOMOBILE TIRES

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Recently, the tire, as one of the main components of a car that is in direct contact with the bearing surface, has developed quite significantly, and current trends point to further improvements. As a rule, tire manufacturers provide recommendations on the optimal values of their main characteristics that should be maintained to ensure the efficiency of their use and road safety. However, these recommendations are correct for tire operation only in certain environmental conditions and under certain bearing surface conditions, i.e. they are not “universal”. Of course, most of the time, the operating conditions are almost constant and predictable, but there is still a possibility of “unfavorable” environmental conditions (temperature and humidity) for the operation of automobile tires. There are also certain regions where the ambient air temperature can fluctuate in quite wide ranges, from $-40°C$ to $+50°C$. Operation of tires in such conditions requires additional attention, as their behavior is somewhat unpredictable.

Stiffness is one of the main performance characteristics of a car tire. It largely determines the behavior of the tire during operation. In turn, the stiffness is significantly affected by such basic tire characteristics as internal pressure and temperature, which can vary over a wide range during operation, especially when the vehicle is driven in the starting mode. Accordingly, the stiffness will also not be constant and may differ slightly from the optimal values for safe and efficient operation.

The analysis of the main performance characteristics of car tires is presented in the works of many scientists. It is worth noting that most of the reviewed works do not study the starting period of driving, i.e., do not take into account the peculiarities of the behavior and condition of the tire. In previous scientific studies by the authors (Karpenko, Voropay, & Neskreba, 2022), the concept of “starting period of movement was first introduced and the results of experimental studies of some tire characteristics were briefly presented. The presented dependences of the internal pressure and temperature of the tire filler indicate their rather significant change during the period of operation at the beginning of driving. An indirect assessment of the tire's rolling resistance was also performed, which showed that the rolling resistance coefficient can vary by 20-25%, i.e., it may differ from the standard value. In this work, the main parameter for assessing the condition of the tire will be its stiffness, namely such indicators as the stiffness coefficient and the damping coefficient.

Various methods are known for determining the radial stiffness of a tire k and damping factor c when the tire is radially loaded. These parameters are most easily determined under static loading of the tire. When conducting such an experiment, it should be borne in mind that the total resistance force of the deformed pneumatic is composed of elastic and inelastic resistance forces. Since the inelastic resistance force of the pneumatic depends on the strain rate, the loading and unloading processes should be carried out slowly. In the inelastic drag force, in addition to the strain rate-dependent component, there is also a component such as “dry” friction. When the tire is loaded and unloaded very slowly, it is the “dry” friction that determines the width of the hysteresis loop, which is used to determine c. Radial stiffness k determines the elastic drag force.

Under operating conditions, the tire rolls and can make vertical oscillations. Therefore, the value of the coefficient c depends on the deformation speed of the pneumatic. In this case it is necessary to determine the dynamic coefficients k and c .

It is known that the frequency of damped free oscillations determines k, and the damping decrement determines the coefficient c.

The change of damping factor c as a function of velocity V_k and frequency of radial oscillations f is approximated with sufficient accuracy by dependence (1).

$$c = c_0 \Big/ \left(1 + \frac{V_k}{f}\right) \tag{1}$$

where c_0 is the damping factor of the non-rotating tire.

Tire stiffness, its main characteristics, and methods for determining them are described by Peregon et al. (2017). The authors (Rostami et al, 2023).) presented the results of studies of the effect of tire stiffness on the car suspension system. In addition, they analyzed the effect of tire pressure, camber angle, and vehicle speed on tire stiffness and damping coefficient.

We will perform a study to determine the stiffness of a car tire and its dependence on operating conditions and the environment. At the initial stage, the car-mobile wheel can be simplified as a two-mass system “mass-spring-damper” (Fig. 1).

Using the results of experimental studies obtained by Karpenko and Neskreba (2022) as the initial data, it is possible to solve equations (2) and (3) with respect to the stiffness and damping coefficients, i.e., to evaluate the tire stiffness characteristics. However, it is necessary to set initial conditions.

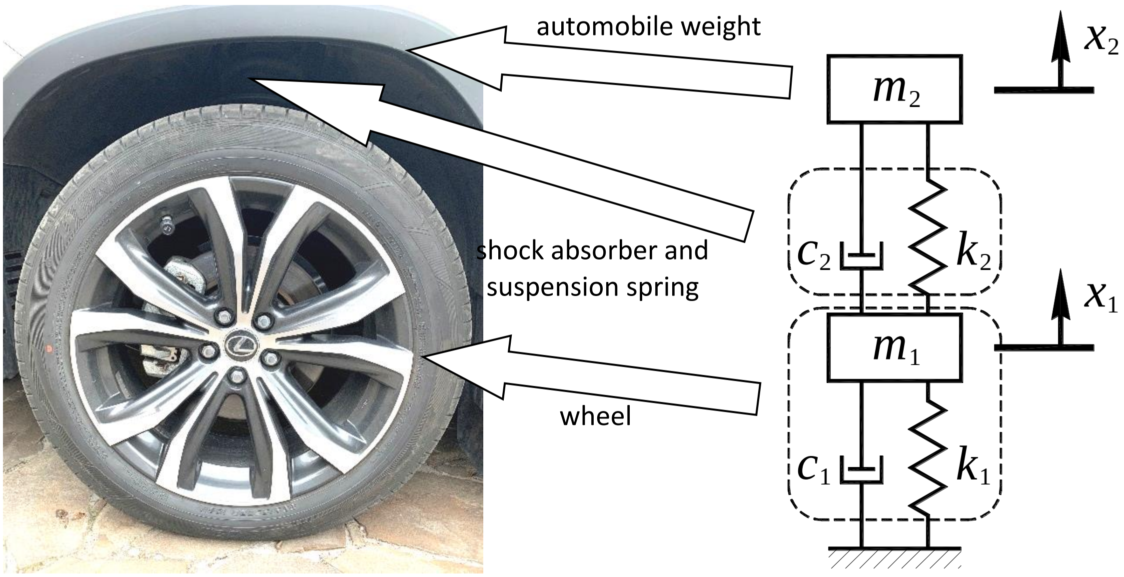
The application of the described analytical method makes it possible to determine the values of the tire stiffness parameters “c” and “k” with high accuracy, depending on the operating conditions and the environment. In other words, the stiffness and thus the behavior and condition of the tire during the initial driving period can be evaluated.

The equations of motion of the system (Fig. 1, b) are as follows:

$$m_1\ddot{x}_1 + (c_1 + c_2)\dot{x}_1 - c_2\dot{x}_2 + (k_1 + k_2)x_1 - k_2x_2 = 0. \qquad (2)$$

$$m_2\ddot{x}_2 + c_2\dot{x}_2 - c_2\dot{x}_1 + k_2x_2 - k_2x_1 = 0. \qquad (3)$$

where m_1 is the weight of the car wheel (unsprung weight), m_2 is the part of the vehicle weight that falls on the car wheel under test (sprung weight), c_1 is the damping coefficient of a car tire, c_2 is the combined damping coefficient of the shock absorber and suspension spring, k_1 is the stiffness coefficient of an automobile tire, k_2 is the combined stiffness coefficient of the shock absorber and suspension spring.



a b

Figure 1. – Car wheel (a) and its mass-spring-damper model (b)

References

1. Karpenko, V. O, Voropay, O. V., Neskreba, E. Ye. (2022). Indirect assessment of the rolling resistance of a car tire in the starting mode of motion. *Avtomobil'nyy transport*. (50), 5-13. https://doi.org/10.1115/1.2936925

2. Peregon, V. A., Karpenko, V. A., Pozdnyakova, E. I., Levchenko, A. N., Zagorodnij, A. A., Barannik, I. M., & Koryak, A. A. (2017). *Kolebaniya i vibroakustika avtomobil'noj shiny'* [Vibrations and vibroacoustics of a car tire].

3. Rostami, H. T., Najafabadi, M. F., Ganji, D. D. (2023). Investigation of tire stiffness and damping coefficients effects on automobile suspension system. *Journal of Automobile Engineering*, 1–8. DOI: 10.1177/09544070231151860

4. Karpenko, V. O., Neskreba, E. Ye. (2022). Refined assessment of tire rolling resistance in the starting mode. *Avtomobil'nyy transport*, (51), 5-13. https://doi.org/10.30977/AT.2219-8342.2022.51.0.01

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VEHICLES WITH A PNEUMATIC POWER UNIT

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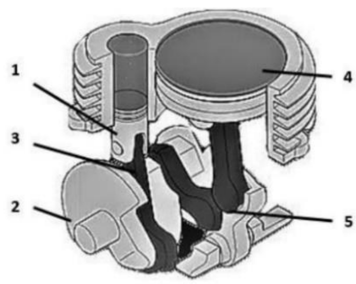
The main problem of modern internal combustion engines and electric motors is that in city traffic jams, the energy produced by the engine is wasted. The problem could be solved by using additional engines that would store this energy.

An alternative to such a solution could be the application of engines that use ordinary compressed air as a working body, which can be pumped in at any moment.

The *purpose* of the study is to outline the prospects for the further development of pneumatic cars, their position in the market of vehicles.

Guy Negre engine. One of the most advanced pneumatic motors is Guy Negre's piston pneumatic motor, which is called Compressed Air Technology (CAT). The principle of its operation is quite simple. First, a little volume of air from the cylinders is fed into a small cylinder. A small piston compresses the air to 20 atm., due to which the temperature rises to 400 degrees. Then it passes into a large cylinder and is combined with a large portion of cold compressed air from cylinders, heating it. The pressure begins to rise even more. Negre founded his company Motor Development International (MDI), which uses this engine to this day, upgrading it and installing it on their pneumatic cars.



1 – small piston, 2 – crankshaft, 3 – conventional connecting rod, 4 – large piston, 5 – intermediate link

Figure 1. – Structural diagram of a hydromechanical PA of two-stage injection

MDI Airpod Second Generation. The company presented many pneumatic cars until 2023, but only the AirPod series, which is represented by three-wheeled vehicles, went into mass production (MDI, Technology, 2023).

Figure 2. – MDI Airpod Second Generation

The car has a power of 10.2 hp, at which a maximum speed of 70-80 km/h is reached. The cylinders have a volume of 250 l at a pressure of 248 bar. The range is 120 km, and, according to the manufacturer, 360 km on the battery. The trunk has a volume of 400 l. The vehicle weighs only 360 kg and is capable of carrying 500 l of cargo Such indicators make it possible to transfer AirPod to the category of compact city cars.

MDI Air'Volution. On June 22, 2019, the MDI company presented the Air'Volution car, created by the order of the Veolia company. This is the first industrial vehicle on compressed air in the 21st century (MDI, Applications, 2023).

Figure 3. – MDI Air'Volution

The car runs on compressed air, which is compressed at 248 bar and stored in carbon fiber tanks.

The Air'Volution garbage truck itself seems interesting not as much as due to its industrial purposes, but as a base for further development. Dimensions make it possible to develop other industrial vehicles on this basis: flatbed trucks, delivery vans/refrigerators.

The car travels at a speed of 30 km/h, but the speed can be neglected due to the significant increase in carrying capacity. At the end of the 19^{th} century, pneumatic cars were known, capable of moving loads up to 10 tons at a low speed, which worked in places with increased fire risk. In this design, Air'Volution can be used as an inexpensive intra-factory freight transport.

Air'Volution is also interesting as a base for passenger transport. The dimensions allow to use it as a small bus or van.

In terms of flatbed trucks, it is possible to achieve a high carrying capacity, which does not allow to drive the car at high speeds. An example can be the boom in compressed air transport that occurred at the end of the 19^{th} century. It started with the railway and moved to motor vehicles. At the same time, France, England and the USA began to produce in-plant equipment, which was especially in demand at enterprises where there was a high fire hazard. In the USA, special pneumatic trucks were produced, which were extremely slow, but whose carrying capacity allowed transporting cargo up to 10 tons.

Air'Volution is also interesting as a base for passenger transport. The dimensions allow to use it as a small bus or a van: the load capacity and the choice of pneumatic engine remain the decisive indicator. If such a car is quite cheap, with a market value much lower than that of modern passenger vans/campers, then for many European families with a very low income, such cars will be more financially attractive than the expensive Volkswagen Crafter, Volkswagen Transporter T6. For such families, the speed characteristics of the car may not be as decisive for the purchase of a vehicle as its cost.

Figure 3. – MDI Airone

Conclusions

1. Perhaps the main advantages of a pneumatic car are its small dimensions and cheapness. The car may have a price comparable to an expensive two-wheeled motorcycle, but at the same time it is a full-fledged car: an airtight interior, great safety and the ability to carry a large payload. The AirPods 2.0 could become an alternative car for low-income families which cannot afford more expensive full-size cars and even compact cars. A similar role was played by the Isetta and Zundapp Janus cars, which were widely used throughout Europe during the economic and social crisis following the devastation of World War II. These cars may become in demand after similar crises that humanity faces in the 21st century.

2. If such a car as Air'Volution is quite cheap, with a market value much lower than that of modern passenger vans, then for many European families with a very low income, such cars will be more financially attractive than the new Volkswagen Crafter, Volkswagen Transporter T6. For such families, the speed characteristics of the car may not be as decisive for the purchase of a vehicle as its cost. Cars that run on compressed air do not emit harmful elements and are environmentally friendly.

They cannot compete with gasoline/electric commercial vehicles, but offer a low-cost alternative for low-income families. They are actually creating their own new niche.

References

1. *Motor Development International. Technology. Discover our products.* (2023). https://www.mdi.lu/
2. Motor Development International. Applications. Discover what can compressed air technology offer to the world. (2023). https://www.mdi.lu/copy-of-technology

Pavlenko O. V.

METROLOGY IN SPORTS

Language Advisor – Asst. Prof. Beztsinna Zh. P.

Sports metrology is the science of measurement in physical education and sports. It should be considered as a specific application of general metrology, the main task of which is to ensure the accuracy and uniformity of measurements. At the same time, as an academic discipline, CM goes beyond general metrology. This is due to the following circumstances.

Specialists in metrology focus on the problems of unity and accuracy of measurements of physical quantities. These include: length, mass, time, temperature, electric current, light intensity, and amount of substance. In physical education and sports, some of these quantities (time, mass, length, force) are also measured. But most of all, specialists in our field are interested in pedagogical, psychological, social, and biological indicators that cannot be called physical in their content. General metrology practically does not deal with the methodology of their measurement, and therefore it became necessary to develop special measurements, the results of which comprehensively characterize the fitness of physical educators and athletes. The subject of SM is comprehensive control (CC) in physical education and sports, the use of its results in planning the training of athletes and physical educators. In the practice of physical education and sports, it is commonly believed that comprehensive control can be called such control, which uses pedagogical, psychological, sociological and other indicators. Such an approach does not allow to realize the ultimate goal of control - to obtain reliable and accurate information for managing the process of physical education and sports training. It is possible, for example, to use all existing control methods, assessing only competitive (or only training) activity, and not to obtain a comprehensive assessment. Therefore, only such control can be called comprehensive, in the course of which various indicators of competitive and training activities, as well as the state of athletes, are recorded. Only in this case can their values be compared, and cause-and-effect relationships between loads and results in competitions and tests be established. Only after such a comparison and analysis can we start developing training programs and plans.

There are three types of CC: stage, current and operational. A measurement of any physical quantity is an operation that determines how many times this quantity is greater (or less) than another quantity that is taken as a standard (for example, a meter is taken as a standard for length, and by measuring it in a competition or test, we will know how many meters the result will be, which was shown by an athlete in long jump, shot put, etc.) However, in many sports, there are no legalized standards. For example, it is often necessary to evaluate the expressiveness of figure skating or rhythmic gymnastics, the complexity of diving movements, the fatigue of marathon runners, and the tactical skills of football players and fencers. In this case, measurement is the establishment of a correspondence between the phenomena under study, on the one hand, and numbers, on the other. The introduction of scientific and technological progress into physical education and sports begins with the CC. The information obtained serves as the basis for all subsequent actions of coaches and scientists. The evaluation of any indicator (for example, the endurance of sprinters or the effectiveness of boxers' technique) should be carried out in the same way. For this purpose, there are measurement standards.

A standard is a regulatory and technical document that establishes a set of norms, rules, requirements for the object of standardization (in our case, up to 6 sports measurements) and is approved by a competent authority. The use of a standard increases the accuracy, efficiency and uniformity of measurements.

Metrological support is the use of scientific and organizational foundations, technical means, rules and regulations necessary to achieve uniformity and accuracy of measurements in physical education and sports. The scientific basis of this support is metrology. Metrological support is aimed at ensuring the uniformity and accuracy of measurements. Uniformity of measurements is achieved by the fact that their results should be presented in legalized units and with a known probability of errors. Currently, the international system of units SI is used. The main units of physical quantities in the SI are the units of length - meter (m); mass - kilogram (kg); time - second (s), electric current - ampere (A), etc.

There are four basic measurement scales:

1. Scale of names.
2. Order scale.
3. Scale of intervals.
4. The scale of relations.

The naming scale (nominal scale) is the simplest of all scales. In this scale, numbers are used to represent and recognize the objects being studied (for example, the numbering of players on a football team). The designations assigned to objects are numbers. When using the naming scale, only some mathematical operations can be performed. In nominal measurements, the introduced symbols mean that object 1 only differs from objects 2, 3, 4. However, it is impossible to measure how different and in what way this scale is different. 7 Order scale. If any objects have a certain quality, then ordinal measurements allow us to determine the differences in this quality. For example, there are sports where the result of an athlete is determined only by the place he or she took in the competition (single combat). The places occupied in the ordinal scale are called ranks, and the scale itself is called rank or non-metric. In such a scale, the numbers that make up the scale are ordered by ranks (i.e., places taken), but the intervals between them cannot be measured accurately. With the help of order scales, you can measure qualitative indicators that do not have a strict quantitative measure. Interval scale. Measurements in such a scale are not only ordered by ranks, but also divided by certain intervals. The interval scale has set units of measurement (degree, second, etc.). The feature that distinguishes it from the ratio scale (which will be discussed below) is that the zero point is chosen arbitrarily. An example is calendar time (the beginning of chronology in different calendars was set by random causes). The processing of measurement results in the interval scale is carried out by all mathematical methods, except for the calculation of ratios, and allows you to determine "how much more" one object is compared to another (for example, 0.50 if the body temperature of one athlete during the exercise was 39.00 C, and the other - 39.50 C. Ratio scale. This scale differs from the interval scale only in that it has a strictly defined zero point position, so at some point in time the measured quality may be zero. In this regard, when evaluating the results of measurements in this scale, it is possible to determine "how many times" one object is larger than another. In this scale, one of the units of measurement is taken as a standard, and the measured value contains as many of these units as it is many times larger than the standard. For example, when measuring the length of a jump, we find out how many times this length is greater than the length of another body taken as a unit of 8 length (a meter ruler, in particular), when weighing a barbell, we determine the ratio of its mass to the mass of another body - a unit weight "kilogram", and so on. The results of measurements in this scale can be processed by any methods of mathematical statistics.

References

1. Ashmarin, B. A. (1978). Theory and methods of pedagogical research in physical education. *Fizkultura i sport*, 1(2), Article 2.
2. Godik, M. A. (1999). Sports metrology. *Fizkultura i sport.* 2(3), Article 35.
3. Zatsiorsky, V. M. (2003). Fundamentals of sports metrology. *Fizkultura i sport.* 23(2), Article 56.

Plakhotniuk O. M.

MODERN REALITIES OF TRACKING AND RECOVERING GEODESIC POINTS IN UKRAINE

Language Advisor – Asst. Prof. Ponikarovska S. V.

The State Geodetic Network of Ukraine is a framework for conducting geodetic works on the territory of the state. An important process is monitoring its condition. The modern geodetic network in Ukraine is, in fact, inherited from the USSR, so many of the points have been around for decades. State Geodetic Network (SGN) of Ukraine has 5933 points of 1 and 2 classes of accuracy, 108 bases, 256 astronomical points of Laplace, with the coordinates and azimuths defined on them. Geodetic points are established for long-term use, but various factors sometimes lead to their destruction. One of the main problems is human activity. Sometimes, in order to track the location of a geodetic point, specialists in this field face obstacles that block people from accessing the points. This causes many difficulties. The issue of regulating the relations of citizens with specialists of geodetic, land management and other land services is still unresolved.

Restoration and modernization of SGN points are not currently carried out to the required extent. There are many different reasons for this. Among them are the cost of work, the complexity of tracking and reconstruction of points. At present, the war has become a serious obstacle, which makes work very difficult. Territories that are now under occupation or have been occupied before remain dangerous due to explosive devices. It covers an area of more than 82,000 km^2 and is currently explosive.

That is why the process of restoring geodetic points in part of the territory is impossible in the near future. The approximate number of SGN points on it is 15% of the total, which is about 1000 units. Currently, the issue of tracking and restoration of geodetic points is relegated to the background, which means complicating the situation with the state of SGN of Ukraine as a whole. It is necessary to determine the phasing of geodetic work to restore the signs, analyzing the situation at the end of hostilities in our country. First of all, it is necessary to determine the economic and scientific component. Currently, the method of application of GNSS technologies is quite common, so it is necessary to find the optimal solution to the step-by-step stage of restoration of the SGN of Ukraine, taking into account the actual number of necessary items. In modern conditions, in order to begin to restore the existing geodetic signs, a lot of work should be done to find and test their stability.

As technical and scientific advances have made a great leap forward, the issue of modernization of each industry becomes acute. An important step is to attract modern scientific and technical achievements, because working with obsolete equipment and networks today is one of the inhibiting factors of development. The complex of scientific and applied works related to the modernization of the state topographic and geodetic network will allow in a short time to improve the system of geodetic support of Ukraine on the basis of modern satellite and computer technologies and solve the problem of creating and presenting digital cartographic information on modern scientific and technical levels. These actions should be based on modern technologies for determining coordinates by GNSS (Satellite Navigation System), which will allow the use of new schemes for the construction of geodetic networks of higher order. With the beginning of the use of satellite technologies that allow real-time reading of coordinates with high accuracy, the use of data on SGN points is a process too resource-intensive and time-consuming.

In 2017–2018, the territorial bodies of the State Geocadaster conducted a full-scale survey of geodetic points of the SGN on the territory of Ukraine. This full-scale survey exceeded the allowable survey period of geodetic points by almost three times. According to the provisions of the legislative act "Some issues of implementation of the first part of Article 12 of the Law of Ukraine "On topographical, geodetic and cartographic activity" 2013 "Periodic survey and updating of geodetic, gravimetric points and leveling benchmarks is carried out depending on the needs, but not less than once in 10 years"

The introduction of the concept of "protection zone of a geodetic point" into the practice of topographical and geodetic work (On the Procedure for the Protection of Geodetic Points, 1999), involves only the preservation of the point on the site as a physical point, and not its functioning. Functional preservation means the absence of obstacles for receiving radio signals from artificial satellites of the Earth, optical visibility to adjacent points, transition points during leveling, etc. All this involves the restriction of rights to land plots near the geodetic point, in particular, the problem of the legislative implementation of various servitudes in field topographic and geodetic works arises. Theoretical studies of scientists show that for each type of geodetic network, it is necessary to introduce not only the right of passage, but also the right to perform radio or optical measurements, the right to carry out surveys and updates, control of works on areas of different sizes and the appropriate technology of implementation on the ground. Considering the age of the points and the nationwide importance of topographical and geodetic works, such restrictions should be long-lasting and constant over time and, accordingly, be reflected in legislative and regulatory documents.

Having approached the problem of using the existing network of geodetic points comprehensively, it is necessary to find the optimal way to use modern geodetic equipment without losing the quality of results and maintaining updated data on important key parameters of the SGN.

References

1. Тревого, І., Ільків, Є., & Галярник, М. (2019). Аналіз сучасного стану державної геодезичної мережі України. *Сучасні досягнення геодезичної науки та промисловості.* 2(38), 54–60.
2. Анісенко, О., & Рощенко, В. (2018). Сучасний стан державної топографо-геодезичної мережі України. *Агросвіт*, 21, 22–27.
3. Бурак, К. О., Лисько, Б. О. (2017). Результати дослідження точності RTN методів GNSS вимірювань єдиним базовим рішенням. Їх використання для розмічувальних робіт при будівництві. *Науковий вісник УНФУ*, 27(6), 145-149.
4. Савчук, С. Г., Задемленюк, А. В., & Піскоровський, А. Я. (2009). Експериментальні дослідження точності RTK з використанням GPRS INTERNET з'єднання. *Сучасні досягнення геодезичної науки і виробництва*, 1(17).

Podorozhnia A. K.

TRENDS IN THE DEVELOPMENT OF AERIAL PHOTOGRAPHY IN MODERN GEODESY

Language Advisor – Asst. Prof. Ponikarovska S. V.

Modern geodesy is characterized by the rapid development of technologies that influence all aspects of measurements and cartography. One of the key areas that has undergone significant expansion is the use of aerial photography. Aerial photography has become an efficient tool in geodetic research, cartography, and urban planning.

Initially, aerial photographs were captured using aerial cameras mounted on airplanes. However, with the advancement of drone technologies and the improvement of purpose-built cameras, significant progress has become possible. Modern drones provide flexibility in selecting flight paths and altitude, facilitating the capture of images in hard-to-reach areas, making aerial photographs widely applicable across various fields of human activity.

Contemporary digital technologies enable the acquisition of images in ultra-high resolution, crucial for detailed mapping and the precise determination of object coordinates. One of the leading trends in the world of aerial photography is the development of technologies that allow real-time data acquisition. This is made possible by employing state-of-the-art data transmission systems and high-speed connections, allowing for the retrieval of up-to-date images almost instantly. This trend provides geodesists and engineers with an essential tool for the instantaneous tracking of changes in natural and geographical conditions.

Another promising trend in the use of aerial photography is the integration of artificial intelligence and machine learning systems. Algorithms of artificial intelligence and machine learning automate processes such as the processing and analysis of large volumes of data. For example, they can identify and classify objects in images, simplifying tasks for geodesists and cartographers.

The future of aerial photography in geodesy promises a range of innovations. One of them is the development of hyperspectral imaging technologies, allowing data acquisition across a broader spectrum of light. This is beneficial for analyzing vegetation and developing new methods for environmental monitoring. The application of aerial photographs in addressing ecological issues is becoming increasingly relevant, with uses including monitoring changes in vegetation, detecting erosion processes, and assessing the state of water resources. This provides the opportunity to respond promptly to environmental challenges and develop effective preventive measures.

The evolution of global navigation systems, such as GPS, contributes to improving the accuracy of geolocation on aerial photographs. This is crucial for large-scale mapping and measurements, where the precision of georeferencing is decisive. Global positioning systems also enable the creation of unified and compatible spatial databases, fostering collaborative geodetic projects.

An additional intriguing aspect in modern geodesy is the use of aerial photographs to create and enhance Geographic Information Systems (GIS). GIS integrates geodetic data, aerial photographs, and other geospatial information to create comprehensive cartographic models. This is particularly crucial for the development of modern "smart" cities and regions, where the collection and analysis of geospatial data play a key role in making strategic decisions regarding development and territorial planning.

In addition to other perspectives, the application of aerial photography in the field of transportation infrastructure is gaining popularity. They can be used for monitoring road networks, ensuring traffic safety, and analyzing and planning the development of transportation arteries.

Furthermore, aerial photography is becoming an increasingly important tool in studying climate change. Data collection through aerial photographs allows for the examination of the impact of changes in natural conditions on the landscape and the identification of areas most susceptible to climate changes. This information can be valuable for developing strategies for adaptation and minimizing negative environmental impacts.

Entering the realm of aerospace technologies, aerial photographs are integral to space missions and research. They are used for mapping planetary surfaces and studying the geology and geodesy of other astronomical objects.

Finally, it is crucial to consider the ethical aspects of using aerial photographs, such as ensuring confidentiality and protecting personal data. As the volume of collected information grows, improving security and privacy protection systems is essential to ensure the ethical and legal use of the acquired data.

In conclusion, collaboration among geodesists, scientists, and other stakeholders in the field of aerial photography is gaining popularity. This creates opportunities for data exchange, resource pooling, and collaborative problem-solving. Open data and freely accessible resources contribute to the overall development of the field, allowing more efficient use of aerial photographs to address diverse tasks. In summary, aerial photography in modern geodesy is an integral part of measurements and research. The trends in its development indicate ongoing improvement in technical tools used for image acquisition, as well as an expansion of its application areas. Alongside the growth in data processing and analysis capabilities, aerial photography continues to play a key role in studying and documenting the geospatial environment, making it accessible and understandable across various disciplines.

References

1. Дорожинський, О. Л., & Тукай, Р. (2008). *Фотограмметрія.*
2. *Аерофотознімання.* https://magneticonemt.com/aerofotozjomka/

Prykolotin S. A.

INVESTIGATION OF THE RELATIONSHIP BETWEEN WEAR-FRICTION PROPERTIES AND ENERGY-LOAD OF FRICTION COUPLES OF BRAKE DEVICES

Language Advisor – Asst. Prof. Beztsinna Z. P.

Brake devices are essential components in various mechanical systems, serving to convert kinetic energy into thermal energy through frictional contact. The performance and longevity of brake systems are inherently dependent on the wear, friction, and energy-load characteristics of the friction couples involved. Understanding the intricate relationship between these properties is crucial for enhancing the design, efficiency, and safety of brake devices in diverse applications, ranging from automotive vehicles to industrial machinery.

The wear behavior of friction materials within brake devices is a critical consideration, as it directly affects the material loss and surface degradation over time. Additionally, the friction properties, characterized by the coefficient of friction, play a pivotal role in determining the braking performance and stability under different operating conditions. Furthermore, the energy-load characteristics of the friction couples significantly influence the energy conversion efficiency and thermal management of brake systems, with implications for heat dissipation and overall reliability.

While previous studies have individually explored aspects of wear, friction, and energy-load in brake systems, there is a notable gap in understanding the interdependencies and relationships between these properties. A comprehensive investigation into the complex interplay between wear-friction properties and energy-load of brake system friction couples is needed to advance the fundamental knowledge in this field and provide valuable insights for the development of enhanced brake systems.

In this context, this scientific article presents the results of a detailed investigation into the relationship between wear-friction properties and energy-load of friction couples in brake devices. Through a series of experiments conducted under varying operating conditions, the study aims to elucidate the complex dynamics governing the wear, friction, and energy-load behavior of different friction materials, providing valuable insights for the design and optimization of brake systems. The findings have the potential to catalyze advancements in brake technology, leading to improved performance, enhanced durability, and increased safety across a range of applications.

By elucidating the intricate relationship between wear-friction properties and energy-load of friction couples in brake devices, this study seeks to address an important knowledge gap in the field, offering valuable guidance for researchers, engineers, and industry professionals engaged in the development and optimization of brake systems.

Previous studies have investigated various aspects of wear, friction, and energy-load in the context of brake systems, providing valuable insights into the individual behaviors of these properties. This literature review surveys the relevant body of research to elucidate the current understanding of the wear-friction properties and energy-load characteristics of friction couples in brake devices, highlighting the existing knowledge gaps and informing the rationale for the present investigation.

Wear Behavior of Friction Materials. The wear behavior of friction materials within brake systems has been a subject of extensive research. Studies have focused on understanding the mechanisms of material removal and surface degradation under different operating conditions, including varying loads, temperatures, and sliding speeds. Notably, the investigation by Smith et al. (2020) provided detailed insights into the wear characteristics of friction materials, highlighting the influence of load and temperature on material loss and surface topography.

Friction Characteristics under Varying Conditions. The frictional behavior of brake materials has been another focal point of research, with a particular emphasis on the coefficient of friction and its response to different parameters such as temperature, pressure, and surface roughness. The work (Jones et al., 2018) contributed significantly to this area by examining the friction characteristics of brake materials under varying operating conditions, shedding light on the complex interplay between friction coefficients and environmental factors.

Energy-Load Analysis and Thermal Management. Understanding the energy-load characteristics of friction couples in brake devices is critical for managing thermal effects and optimizing the efficiency of energy conversion. Prior studies, such as the work (Wang et al., 2019), have delved into the energy-load analysis of brake systems, focusing on thermal management, heat dissipation, and energy conversion efficiency. This research has underscored the importance of considering the energy-load characteristics in the design and performance evaluation of brake devices.

Despite these individual contributions, there exists a notable gap in the literature regarding the comprehensive investigation of the interrelationships between wear-friction properties and energy-load of friction couples in brake devices. Few studies have sought to integrate these facets into a cohesive understanding of the complex dynamics governing brake system performance. As such, this review emphasizes the need for a holistic approach to the study of wear, friction, and energy-load, which forms the basis for the current investigation.

In light of the existing research landscape, this work presents a comprehensive study that addresses the aforementioned knowledge gaps, aiming to deepen the understanding of the intricate relationship between wear, friction, and energy-load characteristics of friction couples in brake devices. The integration of these components is essential for advancing the design and optimization of brake systems, and the findings of this study are poised to contribute significantly to the advancement of brake technology and safety engineering.

Conclusion

In conclusion, the comprehensive investigation conducted in this study has provided valuable insights into the relationship between wear-friction properties and energy-load characteristics of friction couples in brake devices. The experimental findings have revealed complex interdependencies and dynamic interactions among wear, friction, and energy-load, contributing to a deeper understanding of the underlying mechanisms governing the performance and reliability of brake systems.

The observed direct correlation between energy-load and both wear and friction coefficients underscores the critical influence of energy dissipation on material degradation and braking efficiency. Moreover, the varying effects of operating conditions on wear-friction properties highlight the importance of considering a holistic approach to brake system design and optimization. By integrating these findings, it is evident that advancements in brake technology can be achieved through the development of advanced friction materials, optimized geometric designs, and improved thermal management strategies.

As the field of brake system engineering continues to evolve, the insights gained from this study offer a foundation for the ongoing pursuit of enhanced performance, durability, and safety in diverse applications, including automotive, aerospace, and industrial sectors. The implications of this research extend beyond fundamental understanding, providing actionable guidance for the design and development of next-generation brake devices that are capable of meeting the increasingly stringent performance requirements and safety standards.

Moving forward, further research and innovation in this area can leverage the findings of this study to drive the development of advanced friction materials with tailored wear-friction properties, as well as the optimization of energy-load characteristics for improved thermal management and energy conversion efficiency in brake systems. It is our hope that the knowledge and insights generated by this investigation will inspire collaborative efforts within the scientific and engineering communities to propel the advancement of brake technology, ultimately leading to safer, more efficient, and more reliable brake devices for a wide range of applications.

In summary, the investigation of the relationship between wear-friction properties and energy-load of friction couples in brake devices has not only enriched our understanding of the intricate dynamics underlying braking systems but has also set the stage for transformative advancements in the field of brake technology, with far-reaching implications for the future of transportation, machinery, and safety engineering.

References

1. Smith, J. et al. (2020). Wear behavior of friction materials under varying loads and temperatures. *Tribology International*, 102, 287-295.
2. Jones, R. et al. (2018). *Friction characteristics of brake materials at different operating conditions. Wear*, 376-377, 339-348.
3. Wang, S. et al. (2019). *Energy-load analysis of brake systems for improved thermal management.* SAE Technical Paper 2019-01-0995.

Rebryk B. D.

THE IMPORTANCE OF METROLOGY IN INDUSTRY

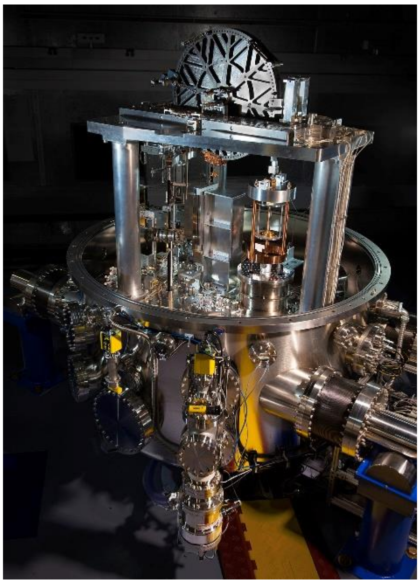
Language Advisor – Asst. Prof. Beztsinna Zh. P.

In today's world, where accuracy and quality are the defining characteristics of products, metrology plays an important role for industry. Metrology, the science of measurement, has become a necessary component to ensure reliable results and achieve maximum accuracy. This article will discuss the basic principles of metrology and its importance to industry. Definition of metrology and its basic principles. Metrology is the science of measurement, which studies methods and means of measurement, and establishes metrological activities to achieve accuracy and uniformity between measurement results. The basic principles of metrology include standardization, metrological support, metrological conformity and metrological control.

The importance of accurate measurements for industry. Accurate measurements in industry are vital. Incorrect or inaccurate measurements can lead to a loss of product quality, wastage of materials and resources, and safety hazards for workers. Accurate measurements are the basis for quality control and production processes. Explanation of the purpose of the article and its relevance.

The purpose of this article is to discuss the importance of metrology for industry and show how it affects the quality and safety of products, as well as quality control processes. This topic is relevant because in today's world, accurate measurements are a necessary element for success in industry.

Development of metrology in industry. A historical overview of metrological standards shows the continuous development of metrology in industry. Important steps in the development of measurement technology include the creation of new instruments, the improvement of standards, and the discovery of new measurement methods.



Impact of metrology on product quality and safety. Metrology has a direct impact on product quality and safety. Accurate measurements help to identify defects and inconsistencies, which ensures reliable product quality. In addition, measurements are important to ensure the safety of workers and personnel in the workplace. The role of metrology laboratories in industry. Metrology laboratories play a key role in industry. They measure, calibrate, and test a variety of devices and measuring instruments to ensure the accuracy and reliability of results.

Types of metrology laboratories and their functions. There are several types of metrology laboratories, such as governmental, industrial, and research laboratories. All of them have their own specific functions, but the main goal is to ensure the accuracy and reliability of industrial measurements. The impact of measurements on quality control processes.

Measurements are a key component of quality control processes. Accurate measurements help identify and correct errors in production. They also influence decision-making on product quality. The importance of certification and accreditation of laboratories. The certification and accreditation of metrology laboratories is essential for industry. It guarantees the measurability of results and affects the interchangeability of results between different laboratories.

Modern challenges of metrology in industry. Automation and digital measurement technologies are among the current challenges of metrology in industry. The requirements for metrological systems in modern production are becoming increasingly complex. Global standards and harmonization of metrology. Global metrology standards and harmonization play an important role for industry.

They provide measurements that are recognized around the world and help improve product quality and safety.

Conclusion.

Metrology is essential for industry. Accurate measurements ensure the quality and safety of products, influence quality control processes and the development of production. Certification and accreditation of laboratories, as well as automation and harmonization, are key aspects of modern metrology in industry.

References

1. *Міжнародний метрологічний словник (International Vocabulary of Metrology, VIM).* 3-е видання. 2008 р. Міжнародна організація зі стандартизації (ISO). Стандарти ISO 9000, ISO 17025, ISO 14001.
2. *Нормативно-правові документи з метрології, стандартизації та сертифікації.* Український державний метрологічний інститут (УДМІ).

Savvon S. O.

ANALYZING THE ELEMENTAL COMPOSITION OF STEEL METHOD OF MASS SPECTROMETRY

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To examine the elemental composition of steels used in the engineering enterprise, and determine the deviations in the composition of the examined steels from DSTU (State Standard of Ukraine). The research object are steel 20Х13Л.

Table 1. – Chemical composition of the material (%)

C	i	Mn	P	S	Cr	Cu	Mo	N
0,16-0,25		1	0,03	0,025	12-14	0,6	0,8	0,3

Mass spectrometry is a sensitive method for determining the chemical composition and molecular structure of substances. This method is based on registering the mass spectrum of ions formed as a result of ionization of atoms from the sample being studied.

The principle of mass spectrometry involves the deflection of charged particles (ionized atoms) by a magnetic field. From the physics of magnetism (Фізика, 2019), it is known that if a particle with a charge passes through a homogeneous magnetic field, it experiences the Lorentz force, which is perpendicular to the direction of the velocity of the charge and the vector of the magnetic field induction.

Under the influence of centrifugal force and magnetic field, the particle will move along a curved trajectory.

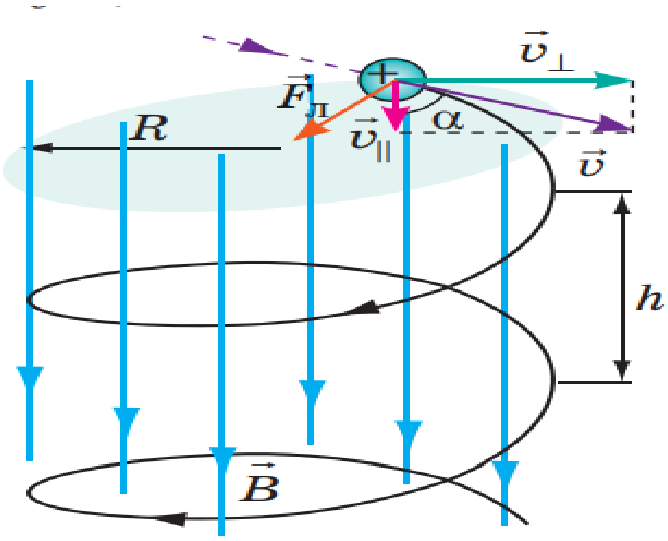

Figure 1

The first step to obtain a mass spectrum is to convert neutral molecules and atoms that constitute any substance into charged particles - ions. The ionization process differs for organic and inorganic substances.

The second essential requirement is to transfer ions into the gas phase within the vacuum chamber of the mass spectrometer. All mass spectrometers necessitate creating a vacuum because ions are highly unstable in the presence of foreign molecules. The vacuum system consists of forevacuum and diffusion (or turbomolecular) high vacuum pumps, along with a so-called "trap" filled with liquid nitrogen at a temperature of -195.75°C to freeze out residual gases in the mass spectrometer chamber. A deep vacuum ensures unobstructed movement of ions inside the mass spectrometer; in its absence, ions scatter and recombine (transform back into neutral particles) (Кучеренко, 1991).

In this study mass spectrometric analysis was conducted using photoplates as detectors. Detection of charged particles was achieved by measuring electric ion currents, which resulted in darkening of the photoemulsion. To obtain highly precise results regarding the elemental composition of steels, various factors had to be taken into account: the transmission and sensitivity of the photoemulsion, the exposure of ion current, and the isotopic distribution of the analyzed element. Mass spectra were obtained at numerous different exposures.

The schematic diagram of the experimental setup for the laser energy mass analyzer EMA-2 (TU 25-05, 2680-80) (Енерго-мас аналізатор ЕМАЛ-2, 1990). The mass spectrometer is structurally assembled in a metal chamber. The chamber is evacuated by a zeolite adsorption pump to a preliminary vacuum (10^{-2}–10^{-3} mm Hg) and a magnetron-discharge pump (NORD-100) to achieve working vacuum (3–5)10^{-6} mm Hg. The value of the working pressure is determined by the ion free path length, which should exceed the drift distance for the device, amounting to 1.5–2 meters.

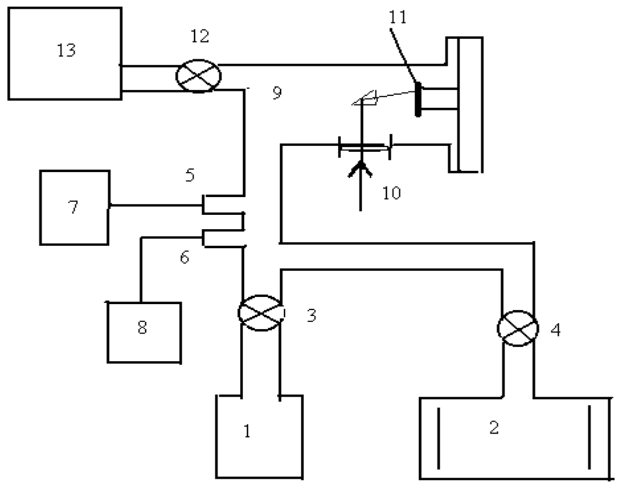

Figure 2

1 – zeolite pump; 2 – magnetron-discharge pump; 3, 4 – vacuum valves; 5 – thermocouple sensor; 6 – ionization sensor; 7 – thermocouple vacuum gauge; 8 – ionization vacuum gauge; 9 – working chamber; 10 – flange for laser beam input; 11 – sample; 12 – angle valve; 13 – mass analyzer

For steel 20Х13Л, the amount of iron is 85.7192%, and chromium is 13.63%, shown on the diagram with a broken scale.

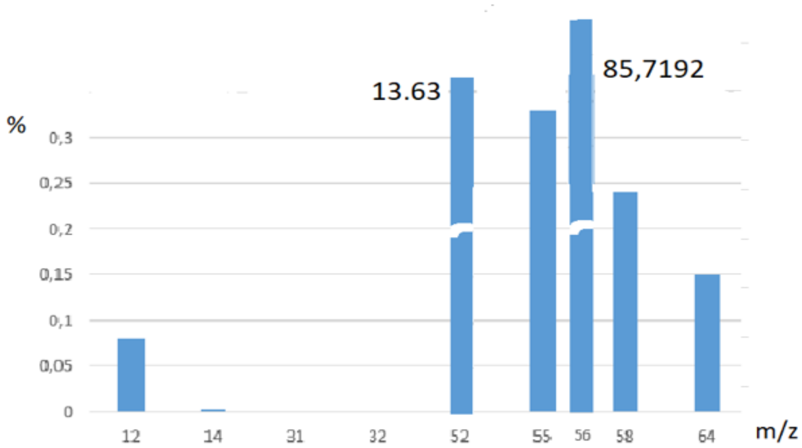

Figure 3. – The obtained data after conducting the analysis

Table 2. – Chemical composition of the material after analysis (%)

C	N	Cr	Mn	Ni
0.08	0.0008	13.63	0.33	0.24

Thus, mass spectrometric studies of the composition of steel 20Х13Л allowed for the detection of base elements as well as impurities with an accuracy of up to 10^{-4}% (with a method sensitivity of 10^{-7} atomic %).

The elemental composition of steel samples after mass spectrometric analysis.

Table 3. – Elemental composition by mass fraction (%)

C	N	P	Si	S	Cr	Mn	Ni	Cu	W
0.08	0.0008	-	-	-	13.63	0.33	0.24	-	-

Steel 20Х13Л generally complies with the standards for the quantity of alloying elements but has a reduced amount of carbon (0.8 instead of 0.16 - 0.25), due to the high sensitivity of the laser mass spectrometry method, traces of nitrogen at 0.0008% were detected.

Presence of an unexpectedly high amount of nitrogen impurities may suggest that they were introduced through a process like nitriding for strengthening purposes.

Therefore, the conducted mass spectrometric analysis of the chemical composition of the 20Х13Л steel sample revealed some discrepancies from the standard. Deviations in the elemental composition of the investigated steels should be considered in production when addressing practical tasks.

References

1. *Фізика.* (2019). Бар`яхтар. https://shkola.in.ua

2. Кучеренко Е. Т. (1991). *Довідник з фізичних основ вакуумної техніки.* Вища школа.

3. *Енерго-мас аналізатор ЕМАЛ-2* (1990). Технічний опис та посібник до експлуатації.

Shabalin T. D.

DEVELOPMENT OF A MONITORING AND MEASUREMENT PROCEDURE AT A FOOD ENTERPRISE

Language Advisor – Asst. Prof. Beztsinna Zh. P.

Ensuring food safety is very important for society and concerns the activities of all food businesses. Every food market operator is responsible because its activities are closely related to ensuring the health and safety of food consumption. Therefore, food businesses are those enterprises whose activities are regulated by a number of legislative acts. Laws and other regulations govern the relationship between food producers and consumers, set requirements for food businesses, and define the legal and organizational framework for state control to verify compliance with the established requirements.

At the same time, metrology is the basis on which food safety is built. Measurements and verification of the compliance of the values obtained at critical control points with the established requirements allow us to make the necessary decisions regarding food safety. The same data is used to monitor the compliance of a food company with the established legal requirements.

According to the Law of Ukraine "On Metrology and Metrological Activities," food quality and safety control falls within the scope of legally regulated metrology.

However, almost all legislative documents do not take this requirement into account. At the same time, during metrological supervision, state inspectors make comments and impose fines on food companies.

Thus, measurements at critical control points in food processing plants should be carried out taking into account that they fall within the scope of legally regulated metrology.

Therefore, the development of a monitoring and measurement procedure for a food company is an urgent task.

The legal requirements for food businesses are regulated by various documents at the state and local government levels. The main legislative acts related to the food industry are listed below:

The Law of Ukraine "On Basic Principles and Requirements for Food Safety and Quality";

The Law of Ukraine "On State Control over Compliance with Legislation on Food, Feed, Animal By-products, Veterinary Medicine and Animal Welfare";

Law of Ukraine "On Consumer Information on Food Products".

Requirements for measurements in the field of legally regulated metrology are established in accordance with the Law of Ukraine "On Metrology and Metrological Activities" and include requirements for accuracy, reliability and reliability of measurements. Metrological activity is mandatory in many areas where it is required to determine the exact values of physical quantities. Legally regulated metrology provides for the fulfillment of requirements aimed at ensuring uniformity of measurements and traceability, and is carried out through state regulation in the field of measurements, units of measurement and measuring instruments. Measurement requirements in legal metrology depend on the specific application, as different industries require different levels of accuracy and reliability. For example, measurements in the food industry have their own peculiarities, as they are related to the determination of the mass, volume and chemical composition of food. In this case, the requirements for the accuracy of the measurement results are of great importance, as incorrect determination of mass or chemical composition can lead to product quality issues and even endanger consumer health.

Ensuring the uniformity of measurements at the enterprise means that all measurements carried out at the enterprise meet the requirements established by the Law of Ukraine. In addition, the characteristics of measurement errors or uncertainties are known with a certain probability and do not exceed the established limit values. This process guarantees the accuracy and reliability of the measurements carried out at the enterprise and ensures that their results meet the requirements of measurement activities.

The importance of ensuring uniformity of measurement is that it ensures the accuracy and reliability of measurements, which is essential in business. For example, if measurement is used to control product quality, non-compliance with measurement standards can lead to the manufacture of low-quality products and a negative impact on the company's reputation. In addition to ensuring a certain accuracy of measurements, there are several other components of ensuring the uniformity of measurements at the enterprise (Figure 2.1).

Thus, to ensure consistency of measurement across an enterprise, several steps need to be taken. First, it is necessary to establish measurement standards that will be applied throughout the enterprise. These can be standardized measurement protocols, procedures, or other documents that regulate measurements.

Secondly, it is necessary to ensure that all employees who make measurements are experienced and trained through education and training. They must be aware of the importance of measurement accuracy and adherence to established standards.

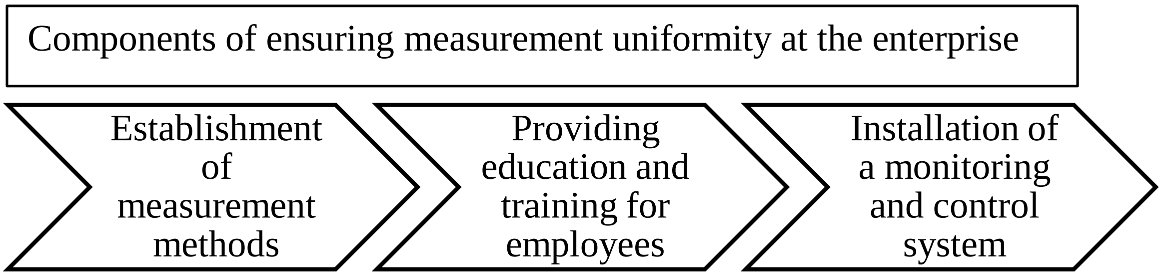

Figure 1. - Components of ensuring measurement uniformity at the enterprise.

Thirdly, a monitoring and control system can be established at the enterprise to ensure that all measurements are made in accordance with established standards. This system can include verification, checking the metrological characteristics and calibration of measuring instruments, checking the implementation of measurement procedures, and evaluating measurement results.

It is also important to have a documentation system in place to keep records of measurements, results, and any deviations from standards. This will allow for future verification and analysis of the data and identify any measurement issues that may arise.

Also, it is important that all employees involved in measurements are properly trained and understand the requirements of the standards to avoid any errors or shortcomings in measurements. In addition, regular reviews and updates of the measurement uniformity system will help businesses stay compliant with changing standards and technologies.

Ultimately, ensuring measurement uniformity in an enterprise is an important element in achieving measurement quality and reliability, which can have a positive impact on product quality and business reputation.

References

1. Про основні принципи та вимоги до безпечності та якості харчових продуктів: Закон України від 23.12.1997 р. № 771/97-ВР (Дата оновлення: 31.03.2023).

2. Про державний контроль за дотриманням законодавства про харчові продукти, корми, побічні продукти тваринного походження, ветеринарну медицину та благополуччя тварин: Закон України від 18.05.2017 р. № 2042-VIII. (Дата оновлення: 20.11.2022).

3. Про інформацію для споживачів щодо харчових продуктів: Закон України від 6 грудня 2018 року № 2639-VIII. (Дата оновлення: 20.11.2022.)

4. Про метрологію та метрологічну діяльність: Закон України від 05.06.2014 № 1314-VII. (Дата оновлення: 01.01.2022).

Shtonda Y. O.

TOPCON POSITIONING SYSTEMS EQUIPMENT AS A TOOL FOR SAVING MONEY AND IMPROVING THE QUALITY OF ROAD CONSTRUCTION

Language Advisor – Asst. Prof. Ponikarovska S. V.

In European countries, no company receives an order if its machines are not equipped with automatic leveling devices. Automatic leveling systems help to avoid mistakes when forming pavement layers, etc.

There are two technological methods of automatic leveling.

The first one is two-dimensional. It is used to prepare the field first. Using levels and other geodetic equipment, the work area is covered with a network of surveying strings. Then, technological machines (bulldozers, asphalt pavers, rollers, etc.) with 2D equipment enter the site. Ultrasonic sensors are placed above the compass strings. They are used to bind the working bodies of construction equipment. Also, the curb or the boundary of the base from the previous pass can be used for binding. In the absence of obstacles (trees, uneven ground), rotary laser levels can be used. It is advisable to use it in areas where the surface is flat (horizontal or inclined).

The second is three-dimensional. 3D systems use satellite navigation and total stations. To work in 3D, a digital surface model is created. This further reduces the need for the services of surveyors and other workers. The system automatically controls the working body of the equipment and forms the projected surface. It also generates a report on the work performed and sends it to the server. The main thing is to properly prepare a digital surface model and a reference plan-height base.

3D systems bring qualitative changes to the construction process, and are not just additional equipment.

It is not easy to choose the equipment that best suits the specific needs of production among the existing variety of offers.

Among the most technologically advanced innovations for precise positioning is the Japanese corporation Topcon Positioning Systems. Its technology for global positioning using satellite systems (GNSS) is called VANGUARD.

VANGUARD technology provides powerful filtering and high-speed processing of GNSS signals in Topcon and Sokkia receivers, and thus productivity.

In receivers of other companies, the number of channels is limited and preference is given to one or another satellite system. The Topcon Universal Tracing component of the Vanguard supports 226 communication channels. Therefore, it tracks signals from all available satellite systems: GNSS-GPS, GLONASS, Galileo, BEIDOU, SBAS.

It should be noted that not all GNSS systems interact equally well with satellites, especially in areas with obstacles. The unique Fence Antenna solution on Topcon and Sokkia devices ensures interference-free operation and excellent communication in difficult conditions. Signals from the best combination of satellites are automatically selected by Topcon patented Intelligent Tracking Optimization technology. Topcon channels are universal. They are not tied to a specific system. Any channel can track any signal. So far, only Topcon technology is capable of this. In addition, the innovative Quartz Lock Loop method ensures high-quality communication even when the construction equipment is vibrating during operation. This set of characteristics gives you the best possible positioning anywhere, anytime.

Topcon 2D and 3D automatic control systems can be installed on all major types of special equipment: bulldozers, excavators, graders, rollers, asphalt pavers, concrete pavers, scrapers, and road milling.

To develop a high-quality road repair plan, you need to have detailed information about the surface. The RD-M1 mobile scanner will help with this. When using it, no traffic is required, it is enough to install the equipment on the car and drive along the relevant section of the road. The equipment surveys and measures 25 thousand points every second. The data will become the basis for project preparation and the work of other road machines.

For asphalt paving, it is best to pave on a flat, well-prepared surface. The 3D LPS (Local Positioning System) system is capable of providing millimeter-accurate surface formation. Thanks to the use of a robotic total station, it does not require satellite positioning. Therefore, it is equally effective in open areas, dense urban areas and even in tunnels.

The robotic total station included in the 3D LPS can also be used for other tasks on the construction site.

The Topcon mmGPS 3D system combines rotary laser levels with satellite positioning. Satellite receivers on the milling cutter receive corrections from the GNSS base station and determine the planned coordinates. And the elevation is calculated using a laser zone builder. Laser sensors correct the readings to an accuracy of several millimeters. The system can be equipped with one or two masts. The second mast is needed when using wide milling cutters to orient the machine.

The mmGPS system does not lose its functionality even if the line of sight between the LZ-T5 rotary level and the PZS-MC laser zone sensor is lost.

The RD-MC 3D leveling system relies on satellite positioning and uses ultrasonic sensors to determine the vertical position of the drum.

The P32 2D system efficiently guides the leveling plate, controlling one or both sides. It can be used on new and used pavers. It has ultrasonic sensors for height control. Additionally, it has a two-sided slope sensor. Most often, the system is equipped with the Smoothtrac ultrasonic averaging system - the so-called "ultrasonic ski", mounted on beams with a length of 8-14 meters.

3D mmGPS for asphalt pavers combine the accuracy obtained from a rotary level with the coordinates obtained from satellite positioning systems. It ensures compliance with the thickness of asphalt concrete to millimeters. When the width of the slab is small, a single-mast system is used. In this case, the height of one side of the slab is determined by a laser, and the other side is calculated from the tilt sensor. If the paving width is more than 7-8 meters, a two-mast system is used. Thanks to the satellite coordinate measurements, the machine is able to accurately pave asphalt concrete even when there is no visual connection between the prism and the total station.

The 3D LPS for the asphalt paver uses Topcon robotic technology. It uses a robotic total station to accurately position the paver's working body in plan and height. Most often, a single-mast version is used in combination with a slab tilt sensor. For large paving widths, a two-mast system in combination with GPS is used. The same as on milling machines. The 3D LPS system on asphalt pavers is suitable for open areas, tight spaces and tunnels.

Asphalt pavers are also equipped with the RD-MC 3D leveling system, similar to the one used on milling machines. It precisely adjusts the height of the smoothing plate. It automatically calculates the thickness of the asphalt concrete layer with a compaction margin.

Topcon 3D technology provides a unique opportunity to automatically control the paver's course. This option is available on Volvo machines as well as Vogele machines equipped with the Navitronic Plus system. An asphalt paver with autopilot and 3D leveling greatly facilitates the work of the driver and the entire crew.

For concrete base pavers and concrete profile pavers, Topcon offers the 3D mmGPS product. Just like the asphalt pavers, it has satellite positioning and laser receivers. Information about the surface shape, layers, points, centerline, boundaries, and other spatial parameters of the base or profile are entered into the digital model. The system monitors the height with millimeter accuracy and ensures that the machine moves along the trajectory specified by the project. The technical complex can operate even if the optical connection between the laser level and the laser zone sensor is lost. The staff does not have to be distracted by operating the paver itself. This means more time is available for the production process, such as mix delivery, profile quality control, etc. The system works with Gomaco, Wirtgen, and Power Curbers machines.

For the strength and durability of the pavement, it is of great importance to adhere to the specified number of passes of the roller. During long monotonous work, the operator may make a mistake about where to start the pass and lose track of the number of passes.

The Topcon C 53 system displays information about the passage in any section of the road and warns against mistakes. When purchasing the product, you can customize the type of corrections for a specific job and not pay extra. For example, you can control only the position of the roller to evenly compact the surface. If you need to know the height of the surface after compaction, order a different configuration. In the basic version, the system controls the number of passes, direction of movement, and compaction speed. It is also possible to use temperature sensors to accurately select the moment when the mixture should be compacted. If the surface temperature deviates from the norm, the system will notify the operator and record it in a log.

The use of Topcon automatic leveling systems at every stage of road construction helps to improve quality, reduce fuel costs and outsourcing services.

References

1. *Website Fillers*. https://mcet.com.ua/
2. *Website of the manufacturer Topcon Co.* https://www.topconpositioning.com/

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DEFINITIONS FOR METROLOGY AND NANOMETROLOGY

Language Advisor – Asst. Prof. Bezcinna Zh. P.

Definitions for Metrology and Nanometrology

Metrology is "the science of measurement, embracing both experimental and theoretical determinations at any level of uncertainty in any field of science and technology," as defined by the International Bureau of Weights and Measures (BIPM, 2004). Metrology can be divided into three subfields: scientific metrology, applied metrology, and legal metrology. Legal metrology is the end of the line, concerning regulatory requirements of well-established measurements and measuring instruments for the protection of consumers and fair trade. In applied metrology, the measurement science is developed toward manufacturing and other processes, ensuring the suitability of measurement instruments, their calibration, and quality control. Scientific metrology is the basis of all subfields, and concerns the development of new measurement methods, the realization of measurement standards, and the transfer of these standards to users. The metrology activity is coordinated by national laboratories, such as the National Institute of Standards and Technology (NIST, USA) and the National Institute of Metrology, Quality and Technology (Inmetro, Brazil), which are internationally coordinated by the BIPM. In parallel, standardization is coordinated by the International Organization for Standardization (ISO), together with other organizations like the Versailles Project on Advanced Materials and Standards (VAMAS), whose main objective is to support trade in high-technology products, through international collaborative projects aimed at providing the technical basis for drafting codes of practice and specifications for advanced materials.

The growing interest in applying nanomaterials to societal needs is now urging that increasing attention be given to the development of scientific and applied metrology to address nanomaterials as the newly developing field of nanometrology. This multidisciplinary field spans many disciplinary fields, such as chemistry, physics, materials science, biology, engineering, and nanoscience. Nanomaterials embrace the full range of traditional materials classes. The distinction between metrology in general and metrology on the nanoscale stems from the different properties of materials on the nanoscale as compared to their bulk counterparts. The Technical Committee for Nanotechnologies Standardization (TC-229) of ISO defines the field of nanotechnologies as the application of scientific knowledge to (1) understanding and control of matter and processes at the nanoscale, typically, but not exclusively, below 100 nanometers in one or more dimensions where the onset of size-dependent phenomena usually enables novel applications; (2) utilizing the properties of nanoscale materials that differ from the properties of individual atoms, molecules, and bulk matter, to create improved materials, devices, and systems that exploit these new properties. Specific tasks include developing standards for terminology and nomenclature; metrology and instrumentation, including specifications for standard reference materials; test methodologies; modeling and simulations; and science-based health, safety, and environmental practices.

However, the fundamental aspects for the development of protocols and standards in nanomaterials, i.e., for building the basis for nanometrology, are still under construction.

The International System of Units (SI from the French Système International) is an evolving system, related to the physical understanding of nature, changing in accordance with advances in science and technology. Today's SI is based on seven units: length (m), mass (kg), time (s), electric current (A), thermodynamic temperature (K), amount of substance (mol), and luminous intensity (cd), all the other units being derived from these. A fundamental goal of metrology is that different institutions should be able to calibrate these basic units, obtaining the same values within the same uncertainty. The historical way of doing that has been by using standard materials. The methodology today is trying to define the SI units based on fundamental constants. The meter convention was signed in 1875 as the distance between two lines made on a platinum–iridium prototype. The present definition dates from 1983: "The meter is the length of the path traveled by light in vacuum during a time interval of 1/299,792,458 of a second." This definition actually fixes the speed of light in vacuum. The ampere is defined as "the constant current, which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 meter apart in vacuum, would produce between these conductors a force equal to 2×10–7 N." This definition sets the permeability of vacuum at 4p×10–7 Hm-1. The definition of mass, however, still remains as the one adopted in 1901: "The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram." The platinum–iridium international prototype is maintained at the BIPM (Paris). Considerable efforts are being made to define the kilogram in terms of fundamental constants, linking the kilogram to the Planck constant, the Avogadro constant, or the mass of an atom of 12C. The definition of the mole dates from 1971: "The mole is the amount of substance of a system that contains as many elementary entities as there are atoms in 0.012 kilogram of 12C." This definition refers to unbound atoms. As a consequence of the differences in binding energy, 0.012 kg of graphite has about 4×1014 more 12C atoms than the same mass in the gas phase. A given mass of diamond at room temperature contains about 1012 fewer atoms than the same mass of graphite.

In this article we focus on scientific metrology to indicate some conceptual pathways for constructing the basis for applied and legal metrologies.

References

1. *What is metrology? Celebration of the signing of the Metre Convention, World Metrology Day 2004.* BIPM. 2004.
2. Jorio, A., & Dresselhaus, M. S. (2016). *Nanostructured Materials: Metrology.*
3. Moriarty, P. (2001). Nanostructured materials. *Reports on Progress in Physics*, *64*(3), 297–381. https://doi.org/10.1088/0034-4885/64/3/201

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HYBRID CAR TYPES: EASY WALK-THROUGH FOR BEGINNERS

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Hybrid cars have gained in popularity as an environmentally friendly alternative to traditional gasoline-powered vehicles, offering a mix of electric power and gasoline. With options such as hybrid electric vehicles, plug-in hybrid electric vehicles and more, it can be difficult for potential buyers to navigate the hybrid market. A hybrid car is a type of vehicle that combines a gasoline engine with one or more electric motors to propel the car. This combination improves fuel efficiency and reduces emissions compared with conventional gasoline-powered vehicles. There are different types of hybrid car: mild hybrids, full hybrids, plug-in hybrids and range-extender hybrids.

Full hybrids, like the famous Toyota Prius, are capable of running solely on electricity for short distances. This type of hybrid features a larger electric motor and battery, enabling the car to run exclusively on electricity at low speeds or when starting. When the car needs more power, the gasoline engine kicks in, and the electric motor and gasoline engine work together to provide the necessary propulsion. Like light hybrids, full hybrids also use regenerative braking to capture and store energy.

Plug-in hybrids take the full-hybrid concept a step further by allowing the owner to charge the vehicle's battery at home thus significantly increasing the range of electric driving. PHEVs generally feature larger batteries and can offer a range of 50 miles or more in all-electric mode. Once the battery is depleted, the gasoline engine operates in the same way as that of a full hybrid. Range-extender hybrids, sometimes called electric range-extender vehicles, have the same basic design as electric vehicles, but also feature a small gasoline engine. This engine acts as a generator to recharge the battery, rather than powering the vehicle directly. This configuration offers the advantages of an electric car while eliminating the problems associated with limited range. Different hybrid cars cater for different needs and driving preferences. Each type offers different levels of fuel efficiency, electric range and performance, giving drivers many options when it comes to choosing an environmentally friendly, cost-effective car for their lifestyle.

The Toyota Prius and Honda Insight are popular examples of parallel hybrid vehicles. In series hybrids, the internal combustion engine does not directly drive the wheels. Instead, the engine functions as a generator, charging the vehicle's battery, which in turn powers the electric motor that drives the wheels. This configuration is generally found in range-extending electric vehicles such as the BMW i3 REx. Regenerative braking is a technology used in hybrid vehicles to capture and store the energy usually lost during braking. When the driver applies the brakes, the electric motor works in the opposite direction to slow the vehicle down. This process generates electricity, which is then stored in the battery for later use. This technology not only improves fuel efficiency, but also reduces wear and tear on the braking system.

Hybrid cars use electric motor assistance to enhance performance and efficiency. The electric motor works in tandem with the conventional engine, providing extra power during acceleration, overtaking or hill climbing, enabling a smaller, more efficient gasoline engine to be put to work. This technology not only reduces fuel consumption, but also delivers a smoother, more responsive driving experience. Continuously variable transmissions are widely found in hybrid vehicles to optimize fuel efficiency and enhance performance. Unlike traditional transmissions with a fixed number of gears, the CVT uses a system of belts and pulleys to offer a virtually infinite range of gear ratios.

This enables the hybrid system to select the most efficient gear ratio for any given driving situation, improving fuel economy and ensuring a smoother ride. Fuel efficiency and environmental friendliness are the two main advantages of hybrid vehicles, made possible by the integration of various cutting-edge technologies such as regenerative braking, electric motor assistance, start-stop system and continuously variable transmission. These features combine to make hybrid cars a popular choice for environmentally conscious drivers seeking a driving experience that is both efficient and powerful. Hybrid cars are renowned for their energy efficiency. They combine a traditional internal combustion engine with an electric motor to reduce fuel consumption. As a result, they consume less gasoline, which saves money at the pump. However, their efficiency is highly dependent on factors such as driving style and traffic conditions. One of the main advantages of a hybrid car is that it produces fewer emissions. Thanks to the use of an internal combustion engine and an electric motor, hybrids emit fewer greenhouse gases and other pollutants than conventional gasoline-powered cars. Nevertheless, they still produce emissions, and are therefore not very environmentally friendly.

When it comes to performance, hybrid cars offer a quiet, smooth driving experience, especially when operating in electric mode. The electric motor delivers instant torque, enabling impressive acceleration. On the other hand, some hybrid vehicles may have less power than their gasoline-powered counterparts, which can translate into reduced performance in certain situations.

In summary, these popular hybrid car models offer car buyers different options to suit their needs. Each vehicle offers unique features and benefits, whether it is superior fuel economy, stylish design or advanced technology. By researching and familiarizing themselves with these models, buyers can make an informed decision when purchasing their next eco-friendly vehicle.

References

1. Bagloee, S A., Tavana, M., Asadi, M. , & Oliver, T. (2016). Autonomous vehicles: Challenges, opportunities, and future implications for transportation policies. Journal of Modern Transportation 24 (4), 284–303.
2. https://christiansautomotive.com/2022/01/05/5-common-hybrid-car-problems-and-what-to-do-about-them/
3. https://motorandwheels.com/problems-with-hybrid-cars

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PROCESSING THE RESULTS OF ENGINEERING AND GEODETIC SURVEYS IN AUTOCAD SOFTWARE

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Camera work is an important part of surveying and engineering projects. These tasks can be performed in an office environment using software such as AutoCAD. In this article, we'll look at how AutoCAD helps with fieldwork and what specific tasks can be accomplished with its help.

Using blocks and templates in AutoCAD

One of the key features of AutoCAD is the ability to create and use blocks and templates. Blocks allow you to group objects together so that they can be easily moved, copied, or reused. Templates help you create standard settings for new drawings, making your workflow much easier.

Creating blocks

Blocks in AutoCAD can be created from any combination of graphic objects, including lines, circles, arcs, text, and more. This can be useful, for example, when creating standard elements such as doors or windows in architectural drawings, or components in mechanical engineering.

Using templates

Templates in AutoCAD allow you to set standard settings for new drawings, such as page sizes, scales, text styles, layers, and more. This can be useful for ensuring consistency between different projects or parts of the same project.

Importing and exporting data in AutoCAD

AutoCAD lets you import and export data from other sources. This can be useful, for example, when sharing data with other CAD or GIS programs, or when using data from databases or spreadsheets. AutoCAD supports a wide range of file formats, including DWG, DXF, DWF, PDF, JPG, and others.

Using layers in AutoCAD

Layers in AutoCAD let you organize and manage objects in your drawing. You can create different layers for different types of objects (for example, one layer for lines and another for text), and then easily switch between them or show/hide them as needed.

Using blocks for efficiency

Blocks in AutoCAD are groups of objects that are combined into a single object. They are very useful for reusing standard elements such as doors, windows, or machine parts. You can create a block once and then insert it into a drawing as many times as you need, which greatly improves your work efficiency.

Standards support in AutoCAD

AutoCAD supports many industry standards, allowing you to work according to specific protocols and regulations. This can be especially useful when performing fieldwork for large projects or projects that require adherence to certain standards.

The main tasks of drafting in AutoCAD.

In AutoCAD, desktop publishing covers a wide range of tasks that do not require direct access to the workplace. They include checking, processing, analyzing, and modifying graphic data, creating plans, reports, and other technical documents. The main tasks include:

1. Editing and modifying drawings: AutoCAD allows you to conveniently make changes to existing drawings, as well as modify them to meet new project requirements.
2. Creating new drawings: Based on existing data, you can easily create new drawings that meet the needs of the project.
3. Abstracting and labeling objects: AutoCAD lets you add abstracts and labels to help you better understand graphical objects.
4. Creating sections, perspective views, and three-dimensional models: The program provides tools for working with three-dimensional space, which is important for some projects.
5. Creating technical documentation: AutoCAD simplifies the process of creating technical documentation required for projects.

The process of performing desk work in AutoCAD

To start working in AutoCAD, it is important to load the reference points correctly. You can do this by using the Insert External File command in the Insert panel of the top menu. It is important to customize the insertion options to meet the requirements of your fieldwork.

After loading the control points into AutoCAD, the next step is to connect them to create a graphical representation of the road infrastructure elements. This includes traffic lanes, shoulder, roundabouts, safety islands, forest belt, etc.

Steps to follow:

1. Using the "Polyline" command, create lines between the control points.
2. After creating each connected line, press "Enter" to save the line.
3. The rest of the anchor points are processed in the same way.

As a result of these steps, we get a graphical representation of the infrastructure.

Adding explanatory labels and dimension lines

To improve the understanding of the project, we add explanatory labels and dimensional lines that provide information about the dimensions and characteristics of various elements.

Steps to follow:

1. Using the Text command, add explanatory labels that indicate symbols and situational objects.
2. Use the Polyline command to add lines that indicate the locations to which the explanatory text refers.
3. Use the Dimension command to measure the distance between two points on the project and automatically add a dimension line.

After repeating these steps for all the necessary elements, we get informative explanatory labels and dimensional lines of the project.

The result of processing the field work in AutoCAD is shown in Figure 1.

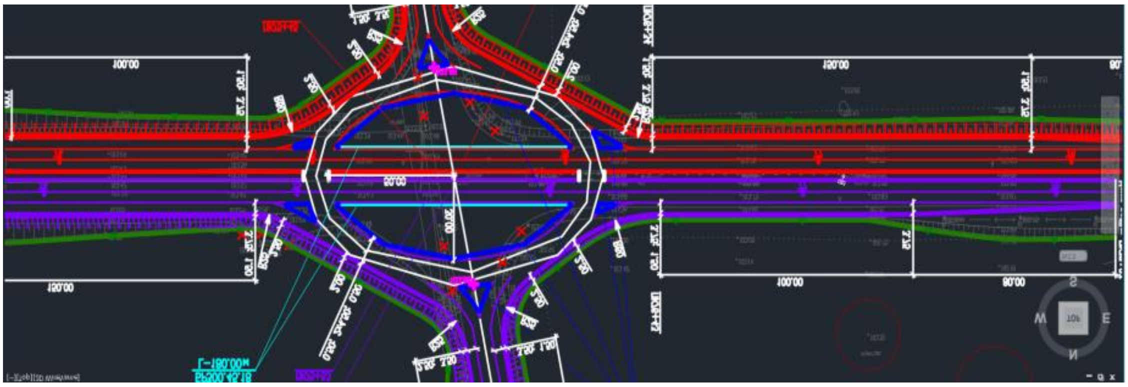

Figure 1. – The result of processing of camera work in AutoCAD software

Thus, AutoCAD is an important tool for performing desktop work in geodesy and engineering. It provides a wide range of functionality that allows you to effectively solve tasks such as creating and editing drawings, annotating objects, generating technical documentation, and importing and exporting data. AutoCAD is an indispensable tool for surveyors and engineers, simplifying and improving the design and analysis process.

References

1. *What is chamber work.* StudFiles. https://studfile.net/preview/7076440/page:4/
2. *AutoCAD system. What it is and what it is capable of. Vidpoviday.com. Useful tips for every day*. https://vidpoviday.com/sistema-autocad-shho-ce-take-i-na-shho-vona-zdatna

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STATE OF THE BRIDGE ECONOMY OF UKRAINE

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Ukraine has a developed network of highways on which many bridges function (Боднар, 2022). More than 80% of them are older than 58 years. The design service life of reinforced concrete bridges is 70-100 years, if the structure was built with high quality, was constantly under the supervision of the operating organization and timely repair work was carried out. Reinforced concrete bridges make up 94% (Table 1) of the total number.

Table 1 – Number of bridges in Ukraine by material

Material	%
Reinforced concrete	93.95
Metal	2.14
Steel concrete	1.9
Stone	1.68
Wooden	0.33
Total	100

Distribution of bridges according to operating conditions (Настанова з оцінювання і прогнозування технічного стану автодорожніх мостів, 2012): condition 1 – serviceable; condition 2 – limited serviceability; condition 3 – workable; condition 4 – limited workable; condition 5 – unworkable. According to (Боднар, 2022), among the examined bridges, more than 53% are in the 3rd condition, 27.3% are in the 4th condition, and 5.7% are in the 5th condition. That is, in total, a third of the country's bridges are in condition that can lead to emergency situations and threaten the safety of road infrastructure users.

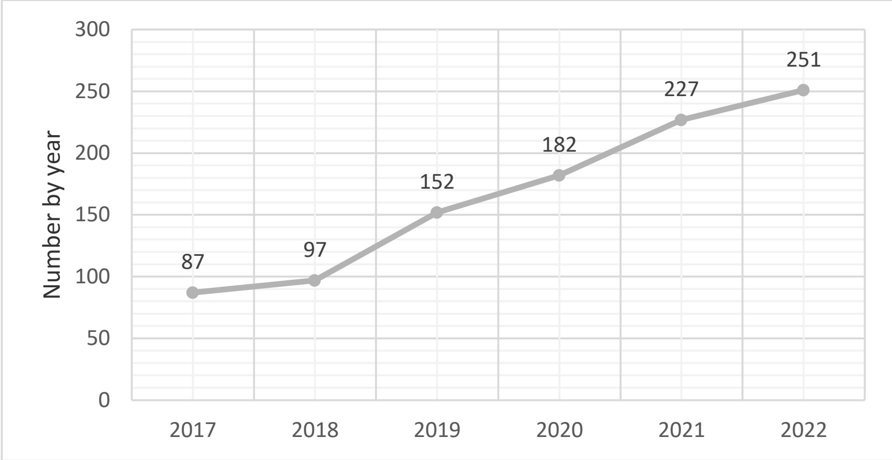

Figure 1. – The diagram for the increase of bridges on public roads that are in an unworkable condition

The accumulation of problems in the national bridge economy took place for many years. Some of the main reasons are:

– lack of necessary funding;

– lack of constant control and systematic maintenance of operating organizations;

– low quality materials for waterproofing;

– low work performance culture, etc.

W.R. de Sitter from the Eindhoven University of Technology created a theory called "The Law of Fives" (de Sitter, 1984). The author of the theory divided the life process of concrete structures into four stages: creation of the structure, the appearance of a minor defect, the spread of the defect, and structural damage to the structure. That is, ignoring the problem at each previous stage leads to a fivefold increase in the cost of eliminating defects at the next stage.

During 2020-2021, an attempt was made in Ukraine to change the state of affairs in the bridge economy. The large-scale government program "Great Construction" restored 560 bridges and planned to restore another 810 during 2022-

2023. But as a result of Russian military aggression against Ukraine in 2022-2023, many bridges were damaged and destroyed (Агентство відновлення продовжує активно відбудовувати мости в Україні). In the Kharkiv region alone, according to the head of the Infrastructure Restoration and Development Service, it is necessary to spend about 4.5 billion hryvnias to restore destroyed bridges (Ульянова & Гребінник, 2023).

Restoration of bridges must be carried out constantly. It is necessary to find opportunities for financing, to carry out regular maintenance and monitoring of bridge structures, especially those in the 4th and 5th stages. If necessary, carry out overhaul or reconstruction. It is necessary to accumulate temporary collapsible bridges in the warehouses of operating organizations for the quick restoration of interrupted traffic. It is necessary to replenish the information on the inspection of bridges, which will allow for a more optimal allocation of funds. The restoration of the transport infrastructure is undoubtedly the key to the development of the State.

References

1. Боднар, Л. (2022). Аналітична інформація з програмного комплексу АЕСУМ щодо мостів станом на 2022 рік. *Дороги і мости*, 26, 155-171.
2. Настанова з оцінювання і прогнозування технічного стану автодорожніх мостів. (2012). *ДСТУ-Н Б.В.2.3-23:2012*.
3. de Sitter, W. R. (1984). Costs of service life optimization "The Law of Fives". *CEB-RILEM Workshop on Durability of Concrete Structures: CEB Bulletin d'Information*, 152, 131-134.
4. Агентство відновлення продовжує активно відбудовувати мости в Україні. https://restoration.gov.ua/press/news/55516.html

5. Ульянова, О., & Гребінник, Д. (2023, 10 травня). Відновлення мостів на Харківщині: на відбудову необхідно 4,5 мільярди гривень. https://suspilne.media/472097-vidnovlenna-mostiv-na-harkivsini-na-vidbudovu-neobhidno-45-milardi-griven/

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USING THE TWO-STAGE FUEL INJECTION INTO THE CYLINDER AS A MEASURE FOR IMPROVING DIESELS ENVIRONMENTAL FRIENDLINESS

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Introduction

As is already well known, in modern diesel engines, an effective means of reducing the noise of their operation and NOx emissions with exhaust gases (GHG) without worsening the economy is the use of the two-stage fuel injection (Mollenhauer & Tschoeke, 2010; Shehovtsov, 1992).). Such a law of fuel supply leads to a two-stage, portioned, time-spaced fuel combustion process in the cylinder.

At the same time, the preliminary or pilot portion of fuel serves to additionally “warm up” the air during the compression stroke, which significantly reduces the period of ignition delay of the main fuel portion (and, therefore, the amount of fuel that evaporates during this period). This has a beneficial effect on reducing the level of combustion noise (the maximum rate of increase of pressure in the cylinder is reduced) and fuel consumption, and even on the reduction of NOx and CH emissions. Multistage fuel injection is used in modern diesels with a Common-Rail type fuel system.

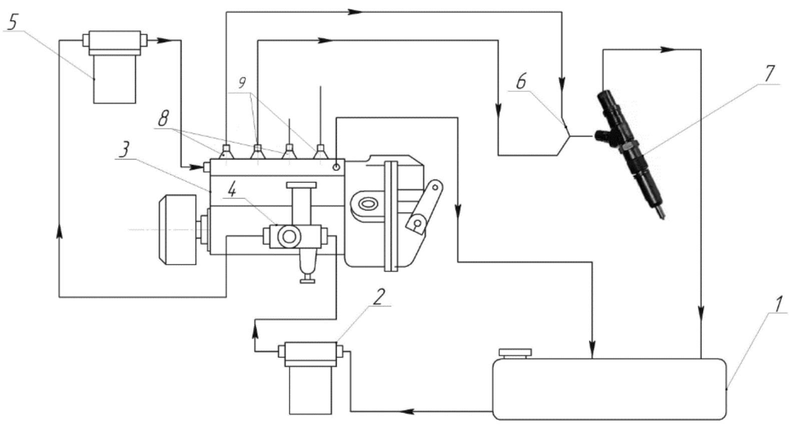
However, the conducted analysis shows that the vast majority of diesel engines operated in Ukraine use traditional hydro-mechanical fuel supply systems, which do not implement the two-stage injection, and the adaptation of modern CR-type fuel systems for such engines is quite a difficult task, since the algorithms of their management are commercial secrets (know-how) of firms.

The *purpose* of the study is to improve the environmental performance of transport diesels with a hydromechanical fuel supply system by providing the possibility of the two-stage fuel supply.

The development of a hydromechanical two-stage fuel injection system. The basis of the development of the method is the task of improving the hydromechanical fuel supply system of diesel vehicles by providing the possibility of the two-stage fuel supply with limited intervention in the design of the diesel engine, which will allow a significant improvement in the environmental performance of the diesel engine.

This problem can be solved by additional equipment of the high-pressure fuel pump with high-pressure sections that work to inject fuel for pilot injection. The drive shaft cams of these sections are ahead of the shaft cams of the main sections.

The structural diagram of such a two-stage fuel injection system is shown in Fig. 1. The high-pressure fuel pump 3 has a number of high-pressure sections twice as many as the number of engine cylinders. At the same time, half of the high-pressure sections are adjusted and operate for pilot injection, and the other half for main injection, providing the necessary cyclic supply. As a result, two high-pressure sections of the fuel pump work for one cylinder. Tee 6 connects the high pressure lines of the pilot (preliminary) and main injection sections.



1 – fuel tank, 2, 5 – coarse and fine fuel cleaning filter, 3 – high-pressure fuel pump with an increased number of high-pressure sections, 4 – fuel injection pump, 6 – high-pressure fuel line tee, 7 – hydromechanical injectors

Figure 1. – Structural diagram of a hydromechanical PA of the two-stage injection

This organization of the two-stage fuel injection with hydromechanical fuel equipment, in our opinion, will make it possible to achieve a reduction in nitrogen oxide emissions from a diesel engine and the noise of its operation while maintaining the level of indicator and effective parameters.

In order to check the performance of the proposed two-stage fuel supply system and to confirm the possibility of achieving its stated parameters, calculation studies were performed based on mathematical modelling of hydromechanical processes in this system. As a research tool, a mathematical model of the high-pressure fuel system of the Ч 12/14 research single-cylinder diesel engine was used (Prohorenko et al., 2017).

Results of mathematical modelling. The test results of calculations according to this mathematical model for the operating mode of the system at a camshaft rotation frequency of 650 min^{-1} and full fuel supply are shown in Fig. 2–4. These figures illustrate the main operating parameters of the high-pressure injection system:

the change in fuel pressure in the over-plunger cavities of the main and pilot sections; change in fuel pressure in the injector; laws of displacement of injection valves (NC) of the main and pilot sections; the law of movement of the injector needle; differential and integral injection characteristics.

As can be seen from the above results, with the adopted setting and mode of operation, the high-pressure system provides the two-stage injection with the following indicators: total cyclic fuel supply 64 mm^3/cycle, the pilot dose – 9 mm^3/cycle (which is 16% of the total cyclic supply); the maximum injection pressure is 49 MPa with a maximum pressure of 58 MPa in the over-plunger cavity; the maximum injection pressure of the pilot dose is 16.5 MPa, while the pressure reached in the over-plunger cavity is 26.5 MPa; the duration of the injection of the pilot dose is about 2 degrees rotation of the camshaft, the main one is 4.7 degrees of rotation of the camshaft (Prohorenko et al., 2006).

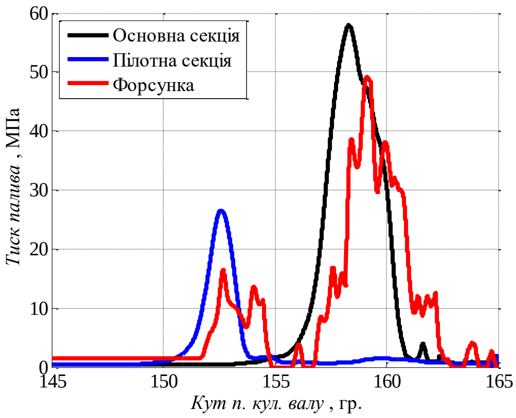


Figure 2. – Fuel pressure in the over-plunger cavities and in the nozzle atomizer pocket

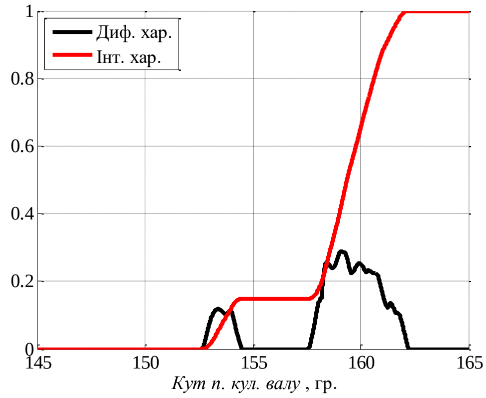


Figure 3. – Relative differential and integral injection characteristics

When performing the calculations, the angle of the geometric start of injection was set to 157 degrees of rotation of the camshaft for both high pressure sections relative to their own cams. The angle between the geometric start of injection of the pilot and main sections (angle of the cams) is taken as 5 degrees of rotation of the camshaft.

Conclusions

Based on the results of the research, the following conclusions can be drawn.

1. For the hydromechanical high-pressure fuel supply system of a diesel engine, the implementation of a method of the two-stage fuel injection into the cylinder is proposed.

2. At a camshaft rotation frequency of 650 min^{-1} and full fuel supply, the high-pressure system provides the two-stage injection with the following indicators: total cyclic fuel supply 64 mm^3/cycle, the pilot dose – 9 mm^3/cycle (which is 16% of the total cyclic supply); the maximum injection pressure is 49 MPa with a maximum pressure of 58 MPa in the over-plunger cavity; the maximum injection pressure of the pilot dose is 16.5 MPa, while the pressure reached in the over-plunger cavity is 26.5 MPa; the duration of the injection of the pilot dose is about 2 degrees of rotation of the camshaft, the main one is 4.7 degrees of rotation of the camshaft.

3. The application of the proposed modification of the fuel system of transport diesels has a favourable effect on reducing the noise level and decreasing the emission of NOx and CH with exhaust gases.

References

1. Mollenhauer, K., Tschoeke, H. (2010). Handbook of Diesel Engines. *Springer*.

2. Прохоренко, А. О., Кравченко, С. С., Солодкий, Є. І., Кожушко, А. П., & Шуба, І. В.; власник Прохоренко, А. О. (2006). Пат. 150726 Україна, МПК (2022.01) F02D 41/10, F02D 1/00 (2006.01), F02M 45/02 (2006.01). Система двостадійного впорскування палива за допомогою

гідромеханічної паливної апаратури. № u 2021 06729; заявл. 29.11.2021; опубл. 30.03.2022, Бюл. 13, 3

3. Прохоренко, А. О., Кравченко, С. С., Карягін, І. М., Вовк, Є. Г., & Думенко, П. І. (2017). Розробка універсального електронного регулятора частоти обертання колінчастого валу дизеля. *Двигуни внутрішнього згоряння.* 2, 35-39.

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BRIDGES AS ENGINEERING MASTERPIECES. THE USE OF WOOD IN BRIDGES

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Bridges are engineering structures that allow people and vehicles to cross obstacles such as rivers, valleys and roads. They are an important element of infrastructure in any society.

Bridges are among the oldest engineering structures. The first bridges were built in prehistoric times from wood, stone, and other natural materials. With the development of technology, bridges have become stronger, more stable, and more elegant.

But despite this, people continue to use the first materials, such as wood, but with new methods and technologies.

Reasons, advantages and disadvantages of using wood in bridge construction.

The reasons can be different and depend on where the bridge is being built, what the construction conditions are, and what the economic savings are. But the main reasons for using this particular material include:

1. Strength: Wood is a strong material that can withstand heavy loads.
2. Durability: This material can last for hundreds of years if it is properly treated. The next point comes from the same point.

3. Ease of processing: Wood is easy to process, which allows you to create bridges of complex shapes and sizes.

4. Environmental friendliness: Wood is an environmentally friendly material that is renewable. Especially now, when people are gradually realizing the importance of ecology and its impact on our lives.

Thus, we can name the advantages of this material, namely:

It is strong, durable, and relatively easy to obtain. Wood is also a good insulator, which can be an important factor in cold climates.

Wooden bridges are also relatively inexpensive to build and maintain. They can also be easily repaired or replaced if necessary.

But, like any other material, wood can have disadvantages, and these are:

1. They are less durable than bridges made of other materials
2. They can be difficult to maintain in good condition.
3. Wooden bridges are also more prone to fire than bridges made of other materials.

It is because of the last point that new technologies and new ways of processing this material are emerging. The desire is to increase its fire resistance, strength and durability. Such modern materials include:

1. Fire retardant treatments. These treatments can be applied to wood to make it more resistant to fire. They work by forming a layer on the surface of the wood that makes it difficult for flames to spread.

2. Composite materials. Composite materials, such as fiberglass, can be used to reinforce wooden beams and other bridge elements. They make bridges stronger and more resistant to deformation.

Figure 1. – The Gau system bridge over the Sava River where such material was used.

3. New types of wood. New types of wood, such as larch and acacia, have natural fire resistance and durability. They can be used for the construction of bridges that do not require additional fire protection or treatment.

Figure 2. – European larch.

4. Use of new technologies. New technologies, such as laser cutting and 3D printing, can be used to create more complex and durable wooden bridges.

The future of wooden bridges

Wooden bridges continue to be built in the modern world. They are an attractive option for engineers looking for a strong, durable and inexpensive material for bridge construction.

Some modern wooden bridges use advanced technologies to make them more durable and long-lasting. Therefore, the future of wooden bridges looks bright. These bridges are a reliable and durable option for engineers looking for an alternative to traditional concrete and metal bridges.

References

1. Ilgin, H. E, Seppälä, M., Karjalainen, M., & Pajunen, S. (2023). An Analysis on Finnish Wooden Bridge Practices. https://www.researchgate.net/publication/369595044_An_Analysis_on_Finnish_Wooden_Bridge_Practices
2. Українська вікіпедія. https://uk.wikipedia.org/wiki/Мости_системи_Гау
3. Matras, J., Pãques, L. E. (2008). Larix decidua – Technical guidelines for genetic conservation and use for European larch. https://www.euforgen.org/species/larix-decidua/

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ANALYSIS OF STRUCTURAL SCHEMES AND FUNCTIONAL CHARACTERISTICS OF HYBRID VEHICLES

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Today, the main direction of automobile development is increasing fuel efficiency and reducing emissions of toxic components in the exhaust gases of internal combustion engines (ICE). The fundamental solution to this issue is the creation of hybrid vehicles.

A significant innovation in the world of hybrid technologies is the merging of the positive attributes of a diesel power system with an electric one in order to create a line of vehicles with a wider mileage potential.

There is no single concept for creating hybrid vehicles in the world. Each hybrid vehicle manufacturer has its own opinion regarding the design of the hybrid power unit (HPU) for it. All design solutions can be conventionally divided into four fundamental structural variations (Тімков, 2010):

1. Use of a low-power electric machine (from 2 to 4 kW), performing the functions of a starter-generator. Such vehicles are equipped with a Stop/Start system, which automatically turns off the ICE when stopping, and provides a charge to the accumulator acid battery (ACB) when braking or coasting, using the recuperation of the vehicle's kinetic energy. The key component of the HPU is the "smart" generator. In this case, a more powerful traction battery is used.

2. Use of an electric motor less than 25 kW, which generates mechanical energy in parallel with the ICE, so the powers are added up. This scheme (electric machine) replaces the starter-generator and allows operation in Stop/Start mode.

3. Use of an electric motor with a power of 30 kW or more. The vehicle can work in combined modes: only ICE; only with an electric motor; ICE plus an electric motor. There are equipped with 1, 2 or 4 valve electric motors. Energy

distribution is carried out by a planetary mechanism or electrically. Coordination of operating modes is carried out by the computer and the inverter.

4. The ICE has no kinematic connection with the driving wheels. The mechanical energy from the ICE is converted through the generator into electrical energy, which enters the traction electromechanical drive of the vehicle's driving wheels.

The classification of transmissions is based on the following structural principles (Бажинов, Смирнов, Серіков, Гнатов, & Колесніков, 2008):

Series scheme – the ICE has no kinematic connection with the vehicle's driving wheels. It represents a chain: ICE – an electric generator and a traction electric motor. The advantages are the absence of a mechanical transmission, a reduction in fuel consumption and toxic components in the exhaust gases of the ICE. The disadvantage is a decrease in the efficiency factor (EF) due to the double energy conversion;

Parallel scheme – in the case of an ICE and the electric motor, which receives energy from the ACB, transmits torque to the driving wheels. The advantages are the simplification of the transmission and higher EF compared to the series scheme. The disadvantage is the complication of the electric transmission for energy recuperation;

Series-parallel scheme (Toyota cars) – this scheme combines series and parallel systems to obtain the maximum advantages of both schemes. Depending on the operating conditions, it operates in the following modes: electric engine, ICE, electric engine plus ICE. This scheme provides energy recuperation in the ACB.

The benefits of hybrid vehicles go far beyond the usual gasoline fuel savings:

Increased mileage, fast refueling. Hybrid vehicles can drive much more due to the successful combination of ICE and electric motor. As a rule, gasoline is used in hybrids only for the purpose of additional energy supply of batteries, facilitating the start of the vehicle and increasing the speed of movement. At low speeds, the electric motors do the main work, but when the car picks up speed, the gasoline engines take over some of the effort;

Reduction of fuel and maintenance costs. Low operating costs are one of the main advantages of hybrid drive vehicles. Traveling in a vehicle that doesn't always need fuel to start you can save a lot. Hybrid vehicles require less maintenance, if only because their propulsion system is much less subject to wear and tear. Moreover, most components of hybrid vehicles do not require regular maintenance;

Excellent performance. A hybrid vehicle performs at the same level of performance as any other vehicle, and, moreover, can be even more efficient on steep inclines and at high speeds.

The number of hybrid vehicles on the road is increasing due to the fact that they have a number of advantages over purely electric or gasoline models, however, like any type of transport, vehicles with hybrid technology are not without disadvantages: worse properties in cold weather. Accumulator batteries, which are an integral part of the transmission, as a rule, reduce their capacity at sub-zero temperatures. Operation of batteries in the cold season significantly shortens their life. In addition, adding extra weight to the vehicle with bulky batteries does not always have a positive effect on their maneuverability.

High cost. Hybrids cost about 20% more than vehicles of the same brands and models with gasoline or only one electric drive. Such a discrepancy in cost is explained by the use of transmission components that are more expensive to manufacture and assemble.

Difficulties with maintenance and finding new components. Hybrid drive parts for vehicles are usually more expensive and exclusive than other vehicles. In addition, due to some novelty of these vehicles, it is quite difficult to find a real mechanical specialist who would be able to engage in the maintenance of hybrids.

The development of hybrid vehicles is a response to the need for more efficient use of fuel and reduced emissions. Technology innovations include new power electronics, batteries, electric motors, and software to deliver extended mileage, lower fuel consumption and improved performance. However, hybrid vehicles are expensive, require specialized maintenance, and may perform worse in cold weather. Despite this, the advantages of such vehicles contribute to their spread and popularity.

References

1. Тімков, О. М. (2010). Аналіз конструктивних схем гібридних автомобілів. *Вісник СНУ ім. Володимира Даля*, 7 (149), 14.
2. Бажинов, О. В., Смирнов, О. П., Серіков, С. А., Гнатов, А. В., & Колесніков, А. В. (2008). *Гібридні автомобілі.* ХНАДУ.

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DEVELOPMENT OF ROAD TRANSPORT

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Road transport is one of the most important modes of transport in the world. It plays a key role in the economy by transporting passengers and cargo, and in social life – by providing people with the opportunity for personal mobility.

The history of road transport development goes back more than 100 years. The first cars appeared in the late 19th century, but they became widespread only in the early 20th century. This was facilitated by the development of technology, which made it possible to create more perfect and affordable cars, as well as by the construction of motorways (Bey, 2017).

Beginning of the road transport development (1885–1910)

The first car was invented in 1885 by German engineer Karl Benz. It was a three-wheeled car with a petrol engine. Other cars appeared in the following years, but they were expensive and difficult to operate.

Rapid growth (1910–1945)

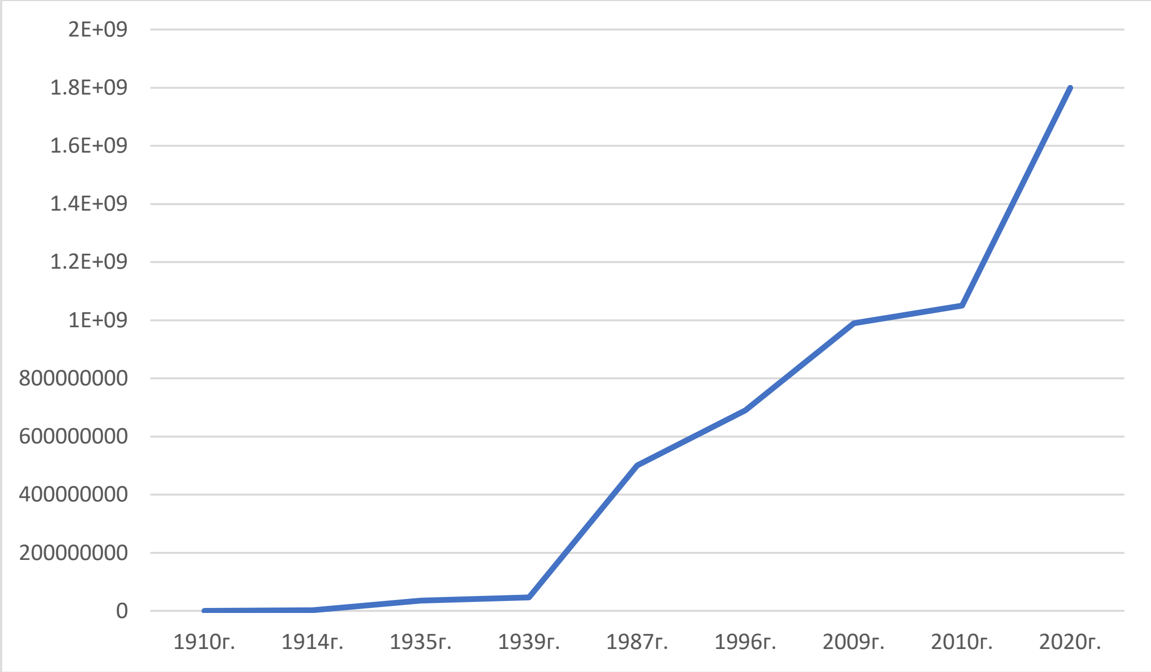
The early 20th century saw the rapid development of road transport. This was fuelled by advances in technology that allowed for more advanced and affordable cars. This period saw innovations such as the four-stroke engine, electric starter, gearbox and pneumatic tyres. The construction of motorways also contributed to the development of road transport. During this period, the first trunk roads were built, which allowed cars to reach high speeds.

Expansion of the road transport use (1945–1970)

After World War II, the development of road transport continued. During this period, road transport became the main mode of transport in developed countries. A number of factors contributed to this, including: increase in the standard of living of the population, improved road quality, reduction of car prices, trends in road transport development.

Currently, the development of road transport is characterised by the following trends described below (Redziuk, 2005).

Decrease in the growth rate of the car fleet: in recent decades, the growth rate of the global car fleet has somewhat slowed down. This is due to a number of factors, including rising fuel prices and environmental concerns.



Changes in the structure of the car fleet: in recent years, there has been an increase in the share of fuel-efficient and environmentally friendly cars in the structure of the car fleet. This is due to rising fuel prices and concern for the environment.

Development of new technologies: new technologies such as electric vehicles, unmanned vehicles and artificial intelligence are actively developing in road transport. These technologies may lead to significant changes in road transport in the future.

Impact of road transport on the economy: road transport plays an important role in the economy by transporting passengers and goods. In developed countries, road transport is the main mode of transport for passengers and is also an important mode of transport for short distance transport of goods. Road transport contributes to economic development by creating jobs, increasing mobility and facilitating trade.

Impact of road transport on social life: road transport provides people with personal mobility, which improves their ability to move and quality of life. Road transport also promotes tourism and leisure activities.

Prospects for road transport development: the future development of road transport will be determined by a number of factors, such as rising fuel prices, environmental pollution and the development of alternative modes of transport. Rising fuel prices is one of the main factors constraining the growth of road transport. Rising fuel prices result in lower profitability of road transport, which may lead to fleet reduction and lower transport volumes. Environmental pollution is another important factor that can affect the growth of road transport. Increasing public awareness regarding environmental issues may lead to a decrease in demand for fossil fuel vehicles.

Emergence of alternative modes of transport can also influence the role and place of road transport. The development of electric vehicles, unmanned vehicles and other alternative modes of transport may lead to a decrease in the share of cars in total transport.

Road transport is an important mode of transport that has both positive and negative effects. The future development of road transport will be determined by such factors as rising fuel prices, environmental pollution and the development of alternative modes of transport.

References

1. Бей, Н. О. (2017). Історія розвитку виробництва автомобільного транспорту в Україні. *Історія науки і біографістика*, 1. http://nbuv.gov.ua/UJRN/INB_Title_2017_1_5
2. Редзюк, А. М. (2005). *Автомобільний транспорт України*: стан, проблеми, перспективи *розвитку*: монографія. ДП ДержавтотрансНДіпроект.

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PROBLEMS OF RECOVERING LOST POINTS OF GEODESIC NETWORKS

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Over the past decade, the issue of the loss of points in the State Geodetic Network (SGN) and densification networks has become more acute. The prerequisites for this negative phenomenon include a significant time gap between periodic inspections of geodetic points in Ukraine, as well as socio-economic manifestations of regional economic development. Today, the solution to the main tasks of land management, cartography, and cadaster should be based on modern geodetic support. Modern means, methods, and techniques of geodetic work are gradually being applied more widely. At the same time, existing regulations define specific indicators for the density of points in the SGN and densification networks. Therefore, in the context of ensuring the necessary density of geodetic points, the issue of restoring lost geodetic points is relevant.

One of the fundamental conditions for the functioning of any geodetic network is to ensure direct optical visibility between adjacent points of this network. The absence of visibility can be caused by the loss of geodetic points. Accordingly, to eliminate this reason, it is possible to restore lost geodetic points. The procedure for constructing the SGN of Ukraine involves the need for inspection, restoration of geodetic points, and monitoring of the SGN. However, there is still no clear concept of geodetic point restoration. The procedure for monitoring the condition of the SGN is not normatively provided.

Periodic inspection and updating of geodetic, gravimetric points, and leveling benchmarks should be carried out no less than once every 10 years, and in urban areas and zones of active economic activity, no less than once every five years. Systematic inspections are carried out by subjects of topographic-geodetic activity directly during cadastral surveys or topographic-geodetic works.

The search for geodetic points is carried out based on their external features using large-scale topographic maps, plans, GPS receivers (navigators), and sketches of the locations of geodetic points. A geodetic point of the SGN is considered lost if the monoliths of its center are not preserved, and all possible measures to locate the geodetic point do not allow finding its designed location on the terrain.

The causes of complete or partial destruction of geodetic points in the SGN and densification networks in Ukraine include:

– agricultural work using agricultural equipment on agricultural lands;

– unawareness of land users and owners about the existence of geodetic points on the territory of their land use;

– use of external geodetic signs and point centers not for their intended purpose due to irresponsible storage;

– various construction works (construction of buildings, structures, and constructions of various purposes on the site of a geodetic point, demolition of buildings with wall geodetic signs, construction and repair of road coverings, laying of underground communications, earthworks, etc.);

– mining operations in active quarries;

– vandalism, illegal constructions, and other crimes;

– obsolescence of centers of geodetic points built using technologies of the second half of the 20th century, which under certain conditions may not ensure long-term and reliable preservation of the design location of the centers' marks;

– erosion phenomena.

In case of loss of a point, the Instructions for the Inspection and Updating of Points of the SGN of Ukraine [2] provide for the search for such a point using linear-angular methods or GNSS observations. The choice of a specific method is determined by the conditions of visibility, the number and peculiarities of the location of available geodetic points or reference marks, the advantages, and disadvantages of the applied methods.

In all cases, an approximate location of the center of the point is determined first, after which the center of the point is searched using a probe or excavation. For the search of ground metal centers of points, engineering-geophysical methods (electro reconnaissance, magnet reconnaissance) are also used.

From the information provided above, it can be concluded that the territory of Ukraine is currently insufficiently equipped with geodetic points for topographic surveys, and the process of restoring lost geodetic points remains insufficiently normatively regulated.

The main problems associated with the loss of SGN points include:

– increased time spent searching for geodetic points;

– increased distance of initial geodetic points from objects of topographic survey;

In our opinion, the following ways to solve the problems associated with the loss of geodetic points are advisable:

– Determination of indicators of admissibility of losses of geodetic points based on the analysis of the density of points in the SGN and densification networks in the territories of administrative-territorial units.

– Improvement of normative support for the construction and operation of the SGN of Ukraine in matters of the mandatory restoration of geodetic points.

References

1 Порядок побудови Державної геодезичної мережі: Постанова Кабінету Міністрів України від 7.08.2013 р., 646.

2 Інструкція з обстеження та оновлення пунктів Державної геодезичної мережі України: наказ Головного управління геодезії, картографії та кадастру України від 28.02.2000 р., 23.

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IMPROVEMENT OF CONDITIONS FOR FILLING TRANSPORT DIESEL ENGINE CYLINDERS

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The power, economic and environmental indicators of internal combustion piston engines are largely determined by the perfection of the functioning of the internal combustion engine gas systems. These systems primarily include intake (intake tract and gas distribution system) and exhaust systems, exhaust gas recirculation, etc.

The intake tract of the engine is intended to supply fresh charge (of air) to the cylinders. The intake tract includes an intake of atmospheric air, intake pipelines, an air filter, a supercharging unit (if available), an intake manifold, intake nozzles and intake channels of the cylinder head.

As Chintala et al. (2013) claim the parameters of the intake tract affect the indicators of engine cylinder filling. Due to the correct determination of the dimensions of the pipelines and the adjustment of the intake tract, it is possible to achieve a significantly greater filling of the cylinders, for example, by improving the shape of the bends of the exhaust system pipelines.

When designing gas-air tracts (GAT), a set of contradictory requirements is presented by Cameretti et al. (2022) which consist in maximizing the filling ratio, minimizing the coefficient of residual gases, the noise level, as well as creating the proper swirling of the charge in the cylinder and combustion chamber.

Gas-air tracts of internal combustion engines have, as a rule, a complex geometric shape and possess certain hydraulic resistance, which determines the presence of a pressure difference between the cylinder and the environment (Abdelhameed et al., 2022). The amount of energy spent on gas exchange, the amount of fresh charge that entered the cylinder, and the amount of combustion products remaining in the cylinder at the end of the release depend on the size of this difference. In addition, the flow of fresh charge and spent gases is accompanied by heat exchange with the walls of the channels and the cylinder.

Ensuring the minimum resistance at the inlet is achieved by eliminating the roughness of the internal walls of the pipelines, as well as sharp changes in the flow direction and sudden narrowing and expansion of the tract.

Reducing the inlet resistance due to reducing the flow rate by increasing the cross sections of the pipelines is not always possible for several reasons. Firstly, the dimensions and mass of the engine increase when the cross-sections of the pipelines increase; secondly, the decrease in the flow rate reduces the turbulence of the fresh charge when it enters the cylinders, as a result of which the quality of mixture formation deteriorates, especially in diesel engines.

The six-cylinder V-shaped engine 6Ч 15/15 has a block opening angle of 120^{o}. The intake manifolds are located outside and on the side of the first cylinder.

The intake manifolds are connected to the air filter, which combines the two rows of cylinders.

The geometry of the intake manifold was formed in a three-dimensional setting in Cartesian coordinates. The general view of the geometry is shown in Figure 1, and the casting (flowing part) – in Figure 2.

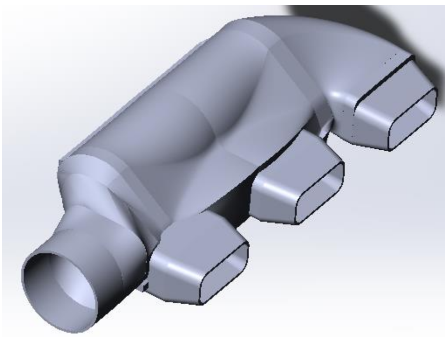


Figure 1. – General view of the intake manifold geometry

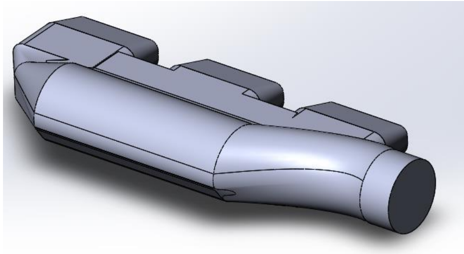


Figure 2. – The flowing part of the intake manifold

Next, the geometry of the two manifolds (right and left), the connection elements with the air filter and the air filter hopper were formed.

The general view of the geometry for two manifolds is shown in Figure 3.

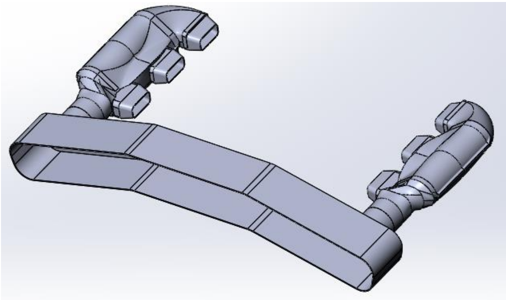


Figure 3. – General view of the geometry for two manifolds

The results of the calculation of the air flow process in the standard and modernized intake manifolds of the diesel engine are shown in Figures 4 – 7.

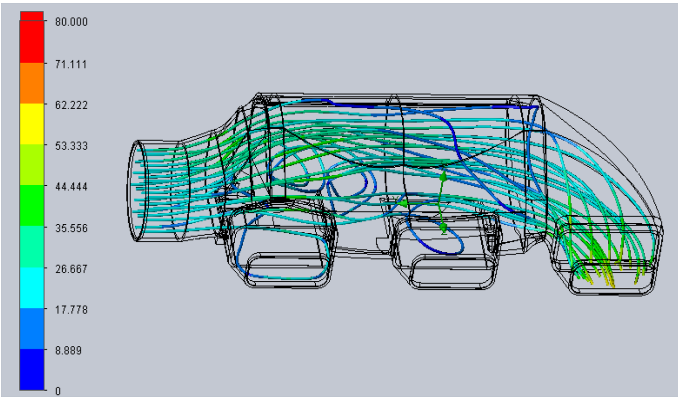


Figure 4. – Visualization of the air flow rate distribution, m/s (in the form of streamlines)

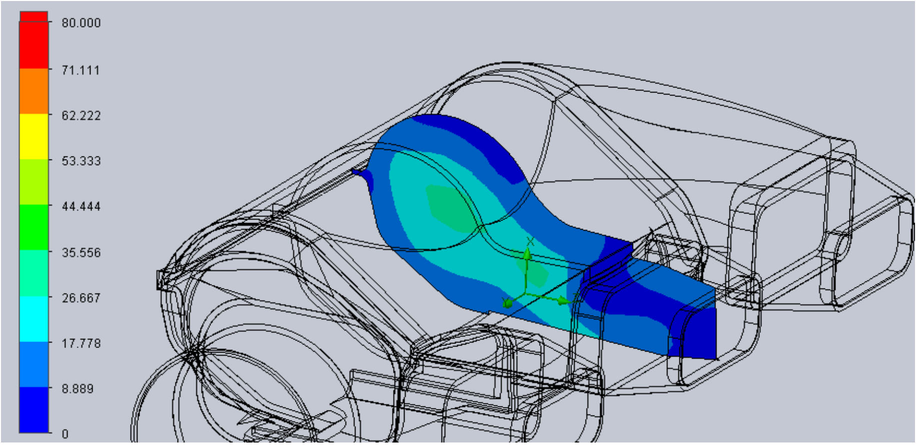


Figure 5. – Visualization of the air flow rate distribution, m/s (in the form of a cross-section diagram)

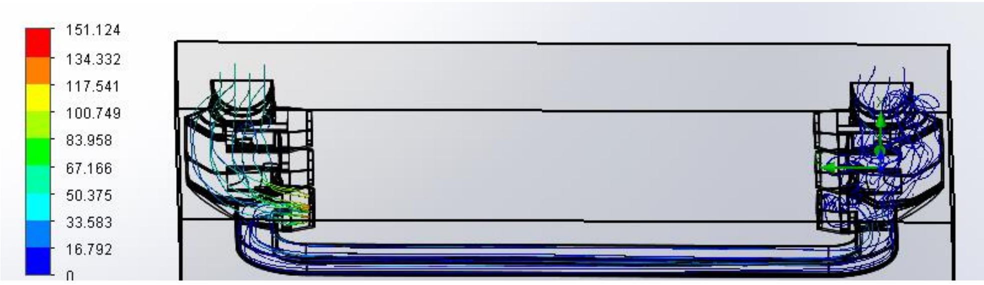
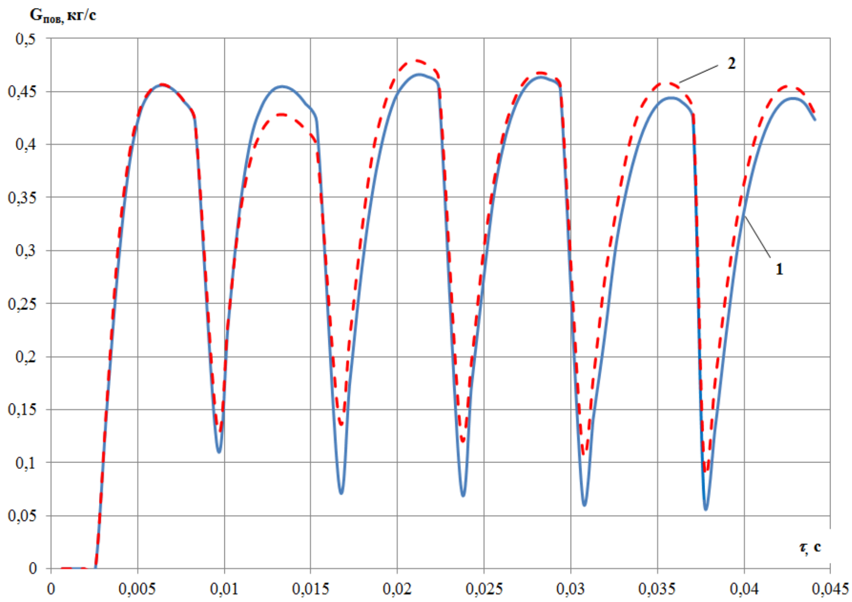


Figure 6. – Visualization of the air flow rate distribution, m/s (in the form of streamlines)



1 – basic design; 2 – modernized design

Figure 7. – Pulsation of the air volume discharge in the intake manifolds of the 6 Ч 15/15 diesel engine at nominal power mode

A calculation study was carried out in order to choose rational parameters of the intake tract, which ensure the best filling of the cylinders. Based on the results of the calculation study, the change in air flow rates and pressure in the flowing part of the intake manifolds with the standard and modernized design and the pressure pulsation at the inlet to the intake manifolds during the operation of the engine at the nominal power mode were evaluated.

It is shown that the use of a connecting pipe between the sections of the intake manifolds is the most effective and allows to increase air flow by an average of 5–9%.

References

1. Chintala, V., & Subramanian, K. A. (2013). A CFD (computational fluid dynamics) study for optimization of gas injector orientation for performance improvement of a dual-fuel diesel engine. *Energy*, 57, 709–721. https://doi.org/10.1016/j.energy.2013.06.009
2. Cameretti, M. C., De Robbio, R., Mancaruso, E., & Palomba, M. (2022). CFD Study of Dual Fuel Combustion in a Research Diesel Engine Fueled by Hydrogen. *Energies*, 15(15), 5521. https://doi.org/10.3390/en15155521
3. Abdelhameed, E., & Tashima, H. (2022). EGR and Emulsified Fuel Combination Effects on the Combustion, Performance, and NOx Emissions in Marine Diesel Engines. *Energies*, 16(1), 336. https://doi.org/10.3390/en16010336

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CURRENT STATE OF UKRAINIAN AEROSPACE INDUSTRY

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JSC "FED" is one of the leading enterprises in Ukraine that specializes in developing, manufacturing, maintenance and repair of aviation, space, and general-purpose units. Flight control systems manufactured by the FED company are of crucial importance for ensuring safety of aircraft and helicopters.

The FED company possesses a modern fleet of high-precision metal-processing equipment enabling the manufacture of products that meet the highest global standards and allowing it to compete successfully in the world aviation market.

The FED company is one of the leaders in the export of aerospace engineering products. Over 60% of the company's products are exported. Its products are supplied to the EU, China, South Korea, India, and the United Arab Emirates. Additionally, the company collaborates closely with the United States, Canada, and Brazil on joint projects in the aircraft engineering industry.

The FED company is the holder of patents for a series of innovative technologies in the field of machine-building that are used in the manufacture of aviation and space equipment. In many countries, the FED company's innovative solutions are used in civilian transport aircraft, helicopter engineering and spacecraft. In 2016, the FED company (JSC "FED") successfully completed the certification audit and received the certificate of compliance of the quality management system in accordance with international standards (AS/EN 9100: 2009 No.6186490-Rev1) for design, development, production and repair of aerospace engineering products. The FED company is the only Ukrainian company in the aerospace industry to hold such a certificate.

The FED company was awarded the State Prize of Ukraine in the field of Science and Technology for its achievements in the development, construction and putting into operation of the An-148-100/An-158 aircraft family. JSC "FED" is equipped with modern precision production equipment from leading global brands.

The consistent high quality and safety of products manufactured by the FED company are ensured by a modern quality management system. The system, implemented in the company in 2014, has become an integral part of both the strategic and operational management of the enterprise at all levels. The quality management system is designed to meet customers' requirements unconditionally and prevent any inconsistencies.

A distinctive feature of the FED company is its unique approach to working with its customers. The company allows customers to monitor the progress of their orders and make adjustments to align with the demands of the modern aerospace market. The seamless interaction of processes within the FED company's system and its structural units, coupled with a modern material base, advanced technology, qualified and motivated staff, and adherence to aviation legislation requirements, ensures the production of high-quality products that meet customers' needs.

The FED company keeps its customers informed about all stages of product manufacturing, enhancing their satisfaction and minimizing their risks. This ensures the company's competitive edge in the aerospace market. The Deputy Chairman of the Board for Quality Management and Certification oversees the continued development, management, and enhancement of the FED company's quality control system and supervises the operation of the following:

– Department of Internal Audits;
– Engineering Supervision Board;
– Quality Control and Certification Service;
– Office of the Chief Metrologist.

The system of internal audits, monitoring and risk assessment ensure a timely response to potential deviations at all the stages of manufacturing the products in order to prevent them.

The primary objective of the Engineering Supervision Board is to prevent the production and release of products that do not comply with customer requirements and technical documentation. The board aims to enhance production discipline and increase accountability across all production stages to ensure product quality.

The Quality Control and Certification Service is responsible for maintaining and continuously improving the quality management system in line with national, European, and international standards, as well as Ukrainian aviation regulations. This effort aims to enhance overall management efficiency, ensuring competitiveness in the aerospace industry. The service collaborates with relevant certification authorities on all aspects of product approval developed by the company and monitors compliance with airworthiness standards and environmental protection requirements in the design and specifications of the products.

The Office of the Chief Metrologist is responsible for ensuring measurement uniformity in the design, manufacture, maintenance, and testing of products manufactured by the company. The laboratory responsible for the calibration of measuring equipment within the company conducts metrological confirmation (calibration/verification). This laboratory is authorized by the Central Agency for Standardization and Metrology of the Armed Forces of Ukraine for verifying measuring instruments, encompassing metrological activities in the defense sector.

The operation of the quality management system ensures the company's capability to meet all customer requirements, maintain consistent design, development, manufacture and supply of products, and offer maintenance services for those products while adhering to legal and regulatory requirements.

The company employs state-of-the-art measuring equipment. The production of parts undergoes checks at every stage, beginning with testing of materials upon their delivery to the company and concluding with the quality control of the packaged finished products.

Considering the aforementioned points, it can be stated that the FED company is a modern production facility that adheres to international quality standards and offers European working conditions. Currently, the labor market exhibits an imbalance: there is a surplus of economists and lawyers, whereas there is a pronounced shortage of qualified engineers. Without sufficient engineers, the growth rate of industrial production could be significantly hindered. Therefore, one of the FED company's objectives is to encourage young individuals to pursue engineering education.

References

1. Irvine, T. B. (2021). *Emerging Technologies, Societal Trends and the Aerospace Industry*. https://doi.org/10.2514/6.2022-0398

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MATERIALS SCIENCE

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The status of a state in the modern world is determined by two most important integration indicators: the scientific and technological level and the ability to develop technologically. The winner in the competitive struggle is the one who, combining the work of scientists and specialists through the use of innovative technologies, quickly realizes material and sectoral resources.

Materials science is one of the main disciplines for mechanical engineering transport specialties. This is due to the fact that obtaining, developing new materials and methods of their processing are the basis of modern production and largely determine the level of development of the country's scientific, technical and economic potential.

Designing efficient, competitive products and organizing their production is impossible without a sufficient level of knowledge in the field of materials science.

Materials science is the basis for studying many specialty disciplines. It prepares a bachelor's degree student for mastering these disciplines by studying basic production technologies and processes. Modern directions in the development of materials science are characterized by the accumulation of a significant amount of quantitative information about the structure and properties of both traditional materials and new ones obtained by science and industry: organic and inorganic polymeric materials, ceramics and composite materials based on them.

Modern engineering and industry involve the design and creation of new generation materials with a range of properties that meet increasingly stringent requirements for physical, chemical, mechanical, operational and environmental characteristics.

The purpose of the discipline "Materials Science and Technology of Materials" is to ensure that the future bachelor of transport is familiarized with the capabilities of modern technologies for obtaining and processing materials for transport purposes; with the physical essence of the phenomena that occur in materials when they are exposed to various factors in operation, as well as acquire knowledge of the structure and properties of basic structural materials and the use of various materials in transport.

Therefore, it will be extremely important and useful for bachelors studying this course to learn about the areas of improvement and the formation of new modern materials used in transportation. With the development of science and technology, the list of materials used is supplemented by new materials with optimal properties - magnetic, thermophysical, refractory, semiconductor, polymer, etc.

Materials technology introduces the laws of technological processes, ways to optimize them, and allows you to navigate the main directions of scientific and technological progress.

Materials science and materials technology is one of the first engineering disciplines studied by bachelors of engineering. Knowledge of materials science is essential for a future railway engineer, as it allows them to assess the suitability of a particular material for a particular product and helps them solve problems of ensuring the durability and reliability of machines.

This discipline provides bachelors with knowledge about the structure and properties of basic structural materials, their composition, labeling, means of manufacturing and processing products depending on their operating conditions, and methods of their production.

Masters must master the theory and practice of heat treatment and other methods of strengthening materials that provide high reliability and durability of machine parts, tools, and other equipment.

The course is aimed at forming a set of knowledge, skills and concepts that are necessary for solving practical problems of material selection and processing for a specific vehicle part.

In the course of studying the discipline, bachelors get acquainted with the development of the latest materials and methods of protecting parts and assemblies from wear and corrosion in extreme operating conditions.

Given the complexity of the course, a significant role in the in-depth study of the discipline is played by the purposeful independent work of students.

Taking into account the interconnectedness of independent study of theoretical materials with the implementation of calculation work, it became necessary to develop these methodological instructions, which contain tasks, guidelines and auxiliary reference materials for performing calculation work.

References

1. Ashby, M., Shercliff, H., Cebon, D. (2007). *Materials: engineering, science, processing and design* (1st ed.). Butterworth-Heinemann.

2. Askeland, D. R., Pradeep, P. P. (2005). *The Science & Engineering of Materials* (5th ed.). Thomson-Engineering.

3. Callister, Jr., William, D. (2000). *Materials Science and Engineering – An Introduction* (5th ed.). John Wiley and Sons.

4. Eberhart, M. (2003). *Why Things Break: Understanding the World by the Way It Comes Apart*. Harmony.

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THE IMPORTANCE OF METROLOGY FOR ENVIRONMENTAL PROTECTION

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Metrology is the science of measurements, their organization and uniformity. It is the basis for the development of science, technology, production and other areas of human activity, including environmental protection.

It is difficult to overestimate the importance of metrology for environmental protection. Without metrology it is impossible: Understand the state of the environment. Develop environmental protection measures. Ensure compliance with environmental legislation. Metrology is used in various areas of environmental protection, in particular: In environmental research. In environmental control. In environmental expertise. Metrology is an important tool for environmental protection. It allows for accurate and reliable measurements that are necessary to understand the state of the environment, develop measures to protect it and ensure compliance with environmental legislation.

Thus, metrology is a key factor for successful environmental protection. Metrology in environmental research Metrology is used in environmental research to measure such physical quantities as temperature, pressure, concentration of substances, noise level, air, water, soil pollution, etc. These measurements are necessary for understanding the state of the environment and developing measures to protect it. For example, to study air pollution, the concentration of harmful substances in the air is measured. To study water pollution, the concentration of harmful substances in water is measured. To study soil pollution, the concentration of harmful substances in the soil is measured. Metrology in environmental control Metrology is used in environmental control to measure the compliance of emissions, discharges, waste, etc. with established standards. These measurements are necessary to ensure compliance with environmental laws and ensure a safe environment. For example, to control air emissions from enterprises, the concentration of harmful substances in emissions is measured. To control the discharges of enterprises into the water, the concentration of harmful substances in the discharges is measured. To control the waste of enterprises, the amount and composition of waste is measured. Metrology in environmental expertise Metrology is used in environmental assessment to measure the impact of economic activity on the environment. These measurements are necessary to assess environmental risks and develop measures to reduce them. For example, to assess the environmental impact of building a new enterprise, noise,

air, water, and soil pollution in the construction area is measured. To assess the environmental impact of farming, the level of pesticide and fertilizer contamination in the soil is measured. All of these measurements must be made using accurate and reliable measuring instruments that meet international standards. This ensures the reliability of the results obtained and allows for informed decisions on environmental protection. In the future, metrology will evolve to meet new requirements arising from the development of science, technology and production. The main directions of metrology development are: Development of new methods and means of measurement that will be more accurate and reliable. Integration of metrology with other sciences, such as computer science, cybernetics and artificial intelligence. Expanding the scope of metrology, for example, in the field of biotechnology and nanotechnology. These directions of metrology development will ensure its compliance with new requirements and allow it to continue to play an important role in the development of science, technology and production. Additional arguments in support of the prospects for the development of metrology: The growth of global trade and international cooperation requires uniform measurement standards. The development of new technologies, such as artificial intelligence and quantum technologies, requires the development of new methods and means of measurement. Growing attention to environmental protection requires more accurate measurements.

References

1. Бондаренко, В. О., Мірошниченко, О. А., Коваленко, О. В. (2017). *Метрологія та метрологічне забезпечення в охороні навколишнього середовища*.

2. Коваленко, О. В. (2021). *Метрологічне забезпечення екологічного контролю*.

3. Дробязко, С. А. (2022). *Метрологічні аспекти екологічної експертизи*.

TRANSPORT TECHNOLOGIES

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ANALYSIS OF METHODS FOR DETERMINING TRAFFIC FLOW INTENSITY

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Determining the intensity of traffic flow over time is a critical issue as it directly influences the effective management of transportation infrastructure and the overall development of transportation systems. The relevance of this topic continues to grow due to the expansion of urban areas, the increase in the number of vehicles, and shifts in people's daily routines and work schedules. The intensity of traffic flow over time is determined by the volume of vehicles, their movement, and concentration on roads within specific periods. This aspect becomes pivotal for managing transportation infrastructure for several key reasons:

– Efficiency of Movement: Understanding and analysing the intensity of traffic flow aids in planning optimal routes, avoiding congestion, and minimizing travel time for users.

– Safety: Increased traffic flow intensity can lead to compromised road safety due to a higher risk of accidents.

– Environmental Aspects: High traffic flow intensity can contribute to increased emissions of harmful substances into the air, negatively influencing the environment and human health.

– Urban Planning Needs: Understanding the intensity of traffic flow over time helps in planning and developing cities, determining the need for constructing new roads, public transportation facilities, and infrastructure.

Solving the problem of determining traffic flow intensity over time involves employing various technologies, analysing data, and developing strategies for managing transportation systems. It is a crucial element in ensuring stable and efficient transportation, reducing the negative environmental impact, and enhancing the quality of life for citizens.

The problem of traffic management on highways, as well as the problem of automatic accounting of cars moving on the roads led to the need to develop and create special measuring devices and those that register other traffic flow parameters. These devices are usually called transport detectors.

Numerous and conflicting requirements for transport detectors have led to the creation of a large number of methods for collecting information about parameters of traffic flow, which, in turn, gave rise to many different traffic detectors and their modifications. To determine the traffic flow parameters using technical means, we can distinguish the following methods:

- contact-mechanical method;
- magnetic-inductive method;
- method of probing pulses;
- method using car radiation;
- photographic method;
- television method;
- method of using a special leader car.

For the first four methods, different traffic detectors are used. The principle of operation of detectors related to this method is based on the direct action of a moving car on the road surface. Therefore, in order to perceive this action, elements sensitive to the loads created by the wheels of passing cars should be located on the coating or in its upper layer.

Weighing detectors are the most attractive from the point of obtaining information about both the number of passing cars and the composition of the traffic flow.

The speed of the car affects the accuracy of its weighing. It was established that the difference between dynamic and static load does not exceed 100%. This discrepancy largely depends on the amplitude and frequency of the vertical oscillations of the car, therefore, in front of the weighing detector, the evenness of the coverage area must be ensured.

If you place two sensitive elements in sequence along the course of the car, then knowing the distance between them and the time interval between the two signals, you can determine the speed of the car.

The disadvantages of weighing detectors include the difficulty of installing them in the road surface, the destruction of the coating in the locations of the beams, the difficulty of protecting moving units from dirt, moisture, snow, freezing and other actions, and the difficult conditions of operation of sensitive elements. These shortcomings have led to the limited use of these detectors.

A large group consists of contact pressure detectors that respond directly to the pressure of a car wheel. The most common of this group are pneumatic detectors, which is explained by the ease of their installation and operation.

Pneumatic detectors allow you to count only the number of axles; they cannot accurately determine the number of cars. To determine the speed and direction of movement, it is necessary to install two detectors next to each other.

Electric contact detectors are also based on the principle of closing contacts in the counter circuit. At the same time, sensitive elements can be various types of spring-loaded plates or beams installed in the coating and protected by rubber mats or metal plates. The number of contacts of these detectors can be different. Several contacts placed along the width of the carriageway allow you to receive a signal about the place of passage of the car and the number of wheels on the rear axle, which to some extent characterizes the carrying capacity of the car. Two rows of contacts laid along the road allow you to determine the speed and direction of the car.

Electric contact detectors have the same disadvantages as pneumatic ones. In addition, electrical contacts located in the road surface do not provide the necessary reliability of operation due to oxidation of the contact surface, changes in the gap between them, or breakdowns. Given the fact that the replacement of contact groups is associated with construction works and traffic closures, non-contact detectors that are triggered by passing cars are used. This group includes magnetic and capacitive detectors.

In addition to direct pressure on the surface, the wheels of passing cars cause vibration of the surface layer of the road. Using this effect, vibration detectors have been developed: electric contact and triboelectric.

Roller detectors can be distinguished as a separate type. The sensitive elements of these detectors are freely rotating rollers installed across the road in such a way that the outer parts of the rollers almost coincide with the road surface. The complexity of the design and installation, as well as the need for constant cleaning and lubrication of rotating parts, led to a very limited use of roller detectors.

Inconveniences in the operation of detectors of contact-mechanical methods, caused primarily by moving elements embedded in the road surface, led to the development of other types of detectors that do not have moving elements. Among them, the largest group consists of detectors implementing magnetic-inductive methods, based on the interaction of the metal mass of the car with a magnetic or electromagnetic field.

The analysis of various methods used to determine the intensity of traffic flow over time revealed distinct advantages and limitations for each approach. Vehicle counters provide precise data on the number of vehicles but lack information regarding their types or speeds. Video surveillance offers visual insights into traffic movement but it might face limitations in coverage and data processing. Surveys and interviews offer subjective yet valuable information about routes and travel times.

Road sensors provide continuous data but may be challenging in installation and maintenance.

The prospects for further research in this field involve exploring more precise and efficient data collection methods for traffic flow. Advancements in technologies like artificial intelligence, machine learning, and next-generation sensors could significantly enhance the accuracy and speed of gathering transportation data.

Additionally, potential directions for improving analysis methods include developing integrated systems that combine various approaches for comprehensive data acquisition. These systems could leverage the strengths of different methods, providing a more holistic understanding of traffic flow and assisting in addressing complex tasks related to transportation infrastructure management and planning.

References

1. Бакуліч, О. О., Дзюба, О. П., Єресов, В. І. et al. (2012). *Організація та регулювання дорожнього руху.* Поліщук, В. П. (Ред.). Знання України.

2. Єресов В. І., Григор'єва О. В. (2017). *Технічні засоби організації дорожнього руху.* НТУ.

3. Лановий, О. Т. (2014). Системологія на транспорті. *Організація дорожнього руху.* Знання України.

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WHAT IS A TRANSPORT & LOGISTICS CENTRE?

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Transport is one of the basic elements of the state economy. The National Transport Strategy of Ukraine 2030 states that the transport system of Ukraine has a low level of development of transport and logistics technologies, which reduces its competitiveness and limits the access of Ukrainian products to the world transport market (Про схвалення Національної транспортної стратегії України на період до 2030 року, 2018).

As it is known from the general theory, the component of logistics in the structure of the product produced in the country is an important characteristic of the development of the country's economy, a kind of macroeconomic indicator. If in developed countries, the logistics component in the gross domestic product (GDP) is equal to 10-15% (in EU and the USA it is 12-16 % of GDP, 26 % in China, 6 % in Japan). As for Ukraine, this indicator varies between 30-35 %. At the same time, 70 % of logistics costs fall on transport ($7 billion), 25 % on warehousing ($ 2.5 billion) and about 5 % on logistics flow management ($ 0.5 billion) (Особливості ринку логістичних послуг в Україні, 2017).

As world experience shows, the most effective direction of development of the transport sector can be implemented by forming transport and logistics centres. However, it is worth noting that there is no unanimity in the world regarding the interpretation of the concept of “transport and logistics centre” (TLC), its functions and classification. In European countries, transport and logistics centres are quite common and can be organized in the form of cargo circulation centres, activity centres, logistics platforms; logistics hubs; intermodal terminals and other forms. According to the study conducted by McMaster University (Canada) on behalf of the Ministry of Transportation of Ontario (MITL. An Exploration of the Freight Village

Concept and its Applicability to Ontario, 2011), there are more than 20 terms in the world, that are close in nature and describe such a phenomenon as a transport and logistics centre (Ярошенко, 2016).

A wide variety of logistics concepts in foreign literature has led to the appearance of many definitions similar to the concept of "transport and logistics center", these are:

– freight villages – in the USA, the EU;

– logistics centres (centre de logistique), transport platforms (plates-formes logistiques / multimodales) – France;

– interport (interporti) – in Italy;

– goods movement centre (Guterverkehrszentren (GVZ)) – in Germany;

– logistics park (logistics park), cargo platform (platform freight terminal) – in some European and American countries;

– cargo coordination centres (sentro integrado de mercancias), transport centres (sentro de transporte), logistics square (plaza logistica) – in Spain;

– rail service centre (rail service centre (RSC)) – in the Netherlands;

– transport centre – in Denmark (FV-2000, 2000).

However, transport and logistics centres can differ not only by name, but also by the purpose of creation and operation. The most comprehensive is the interpretation of the concept of "transport and logistics centre", which takes into account the peculiarities of its structure, management and functioning, formed by EUROPLATFORMS (European Association of Transport & Logistics Centres): "Centre in a defined area within which all activities relating to the transport, logistics and distribution of goods, both for national and international transit, are carried out by various operators on a commercial basis" (FV-2000, 2000).

Some of its key characteristics are listed below:

- It must comply with European standards and quality performance to provide the framework for commercial and sustainable transport solutions.

- It is important that it is managed in a single and neutral legal body (preferably by a Public-Private-Partnership), in order to ensure synergy and commercial cooperation.
- It must allow access to all companies involved in the activities set out above.
- The operators can be either owners or tenants of buildings and facilities.
- It must provide the required facilities, equipment and services to the users, as well as public services for the staff.
- It should preferably be served by a multiplicity of transport modes (road, rail, sea, inland waterways, and air) (FV-2000, 2000).

The transport and logistics centre coordinates the use of various types of transport, carries out loading and unloading operations and transhipment of goods, provides short-term and long-term storage of goods, cargo processing, fulfilment of necessary customs procedures, stock inventory, forwarding, provides a full range of service and commercial and business services, including banking, information, consulting and analytical services, a full complex of ensuring the delivery of goods to the client using modern technologies.

The main task of the TLC is to expand the range of transport and logistics services and reduce their cost because of concentration, while the overall result is more important than the sum of its components, which makes it expedient to create joint ventures on a corporate basis.

The experience of countries with developed economies shows that the creation of a network of transport and logistics infrastructure facilities is currently a strategic task for the development of Ukraine's economy. Successful implementation of the task requires the availability of scientific research on issues of delivery technology management in transport and logistics centres.

References

1. Про схвалення Національної транспортної стратегії України на період до 2030 року: розпорядження Кабінету Міністрів України від 30.05.2018. 430. (2018). *Офіційний вісник України*. 52, 533. http://zakon.rada.gov.ua/laws/show/430-2018-%D1%80

2. Особливості ринку логістичних послуг в Україні. (2017). *Pro-Consalting. Аналітика ринків. Фінансовий консалтинг.* https://pro-consulting.ua/ua/pressroom/osobennosti-rynka-logisticheskih-uslug-v-ukraine

3. *MITL. An Exploration of the Freight Village Concept and its Applicability to Ontario.* (2011). McMaster Institute for Transportation&Logistics. https://mitl.mcmaster.ca/a-exploration-of-the-freight-village-concept-and-its-applicability-to-ontario/

4. *FV-2000.* (2000). Quality of Freight Villages Structure and Operations. European Commission. https://trimis.ec.europa.eu/project/quality-freight-village-structure-and-operations

5. Ярошенко, Л. Л. (2016). Міжнародний досвід розбудови транспортно-логістичних центрів як спосіб розвитку транспортно-логістичної інфраструктури. *Причорноморські економічні студії*. 8, 201-204.

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STUDY OF PROBLEMS OF PROCESSES QUALITY MANAGEMENT IN MODERN CONDITIONS

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One of the modern and effective methods of quality management (including processes) at enterprises is the development and implementation of a quality system based on the ISO 9000 series standards, the main tool of which is the process approach.

Quality Management System (QMS) is a management system for guiding and managing an organization regarding quality, QMS is based on eight principles of quality management.

Customer Orientation: Organizations depend on their customers, so they must understand the current and future needs of customers, meet their requirements and strive to exceed expectations.

Manager's leadership: managers ensure unity of purpose and direction of the company's activities. They create and maintain an internal environment in which employees can be fully involved in solving the company's tasks.

Employee Engagement: employees at all levels are the backbone of the company, and their full engagement enables the company to leverage their strengths.

The basis for the implementation of this principle in the QMS is a correctly constructed system of motivating people, which includes both material stimulation and moral aspects, the psychological climate in the team. It affects all the needs of the company's employees: material, communication needs, respect, recognition and self-expression.

The advantage of the process approach lies in the continuity of management, which it provides at the junction of individual processes within their system, as well as in their combination and interaction.

A systematic approach to management: identification, understanding and management of interconnected processes as a system contribute to the effectiveness and efficiency of the Company's work in achieving its goals.

This principle is implemented in the QMS in the form of systematic development of knowledge, experience and motivation of the company's employees in the organization of work and management in inseparable connection with consumers and suppliers (internal and external).

Continuous improvement of the company's activities as a whole should be considered as its constant goal. A process of continuous improvement has been implemented at QMS.

Evidence-based decision-making: effective decisions are based on data and information analysis.

There are two aspects to the QMS: internal and external. The internal aspect is the application in the company's own QMS of a rich arsenal of control and analysis methods, information visualization techniques that allow all employees to see their own problems equally, and therefore areas for improvement.

Mutually beneficial relations with suppliers. A company and its suppliers are interdependent, and a mutually beneficial relationship enhances the ability of both parties to create value. The implementation of this principle in the company's activities implies mutual and mutually beneficial cooperation based on the principle of “winning together”.

Process management is the main tool of the quality management system, which is necessary for the implementation of the principle of quality management under the process approach.

Existing approaches to modelling business processes and logistic information processes, in particular, can be divided into three groups: functional modelling (BPwin, Erwin, Design/IDEF, etc.); object-oriented modelling (CASE/4.0, Designer 2000, Silverran, etc.); complex modelling (ARIS Toolset, Modsim, ProModel, etc.).

Functional modelling consists in the sequential construction of a business process scheme in the form of a sequence of functions with decomposition into indivisible operations, the input and output of which are displayed: material and information objects, used resources, organizational units.

Complex modelling is based on the complex use of: functional and object-oriented approaches. Depending on the goals of modelling, you can choose adequate tools for analysing and designing business processes. Its disadvantage is its focus exclusively on specialists in the field of information technologies.

Functional modelling is based on the method of structural analysis or SADT-methodology (Structured Analysis and Design Technique), developed by D.Ross. Initially, the SADT method was intended for modelling technological processes, but for more than twenty years it has been successfully used all over the world by hundreds of companies in various fields of activity. In the early 1970s, the US military applied a subset of SADT for process modelling to implement projects within the framework of 1CAM programs (Integrated Computer-Aided Manufacturing). Later, this subset of SADT was adopted as a US federal standard under the name IDEF (Integrated computer Aided manufacturing Definition).

The functional model of business processes consists of diagrams, text fragments and a glossary, which have links to each other. Diagrams are the main components of the model, which reflect sequences of functions (operations, actions, activities) of the business process interconnected through common objects.

The advantage of the functional model is its graphic simplicity, in which only two structural elements are used:

– functional unit – description of functions, operations, actions, work;

– interface arc connecting two functional blocks - a description of an object, a flow of objects.

A functional model begins with the construction of a general description of the process, which is presented in a zero-level diagram or context diagram. At this level, the entire process is considered as one functional unit with all associated processed and control objects.

This diagram also reflects the purpose of the structural analysis (for example, reducing the duration of the process or reducing costs while improving the quality of service, etc.) and the point of view from which the model is considered (director of the organization, director of quality, IT manager, department logistics, etc.).

Diagrams of subsequent levels detail the process functions of each previous level. Thus, functional block A_0 is decomposed into a set of interconnected sub functions Al, A2, A3.... In turn, each functional block of the first level can be decomposed into a set of sub functions, for example, A2 into A21, A22, A23, A24 and so on, until at the next level elementary actions will result. It is recommended to place no more functional blocks on each level. The number of levels of decomposition is not limited.

Process quality management can be divided into four stages: Plan-Do-Check-Act. These stages are known as the Deming cycle.

Process quality management can be divided into three phases: planning, control and quality improvement, which are known as Juran's trilogy.

The quality planning process includes the planning of the following stages:

– use of process output;

– user requirements for the purpose of the process (with acceptable deviations);

– supplier and entry specifications;

– global goals for process efficiency (costs and time);

– process development: sequence of work, personnel, equipment and work procedures;

– control system development:

– quality indicators for input, output and the process itself;

– performance indicators;

– feedback chains and responsible, owners of the process.

The process of quality improvement, unlike the processes of planning and control, does not have a clearly defined phase in the life cycle of any process. For example, suggestions for process improvement may arise at the end of the planning phase because of pilot testing or at any time during process execution because of operational control.

The improvement process is sometimes held back by the lack of opportunities in the process itself to ensure user-specified tolerances for its output. In addition, here the process manager, who must optimally correlate the capabilities of the process and the tolerances at its output in order to improve the results and cost of the process, plays an important role.

Classic quality management methods were developed in the last millennium, they do not take into account the peculiarities of production and operation of products, and therefore they are not applicable to customer service processes.

References

1. FIPS 183 (IDEF/0). (1993). Integrated Definition for Process Modeling.
2. Sullivan, L. P. (1984). Reducing Variability: A New Approach to Quality. *Quality Progress*, 17, 15-21.
3. ДСТУ 50.1.028-2001 Методологія функціонального моделювання.
4. ДСТУ ISO 9001-2001 Системи управління якістю. Вимоги затверджені.
5. Шостак, Л. В., Близнюк, А. Л., & Богдан, М. А. (2019). Управління бізнес-процесами: вітчизняний і зарубіжний досвід. *Економіка і суспільство.* 20, 433-440.

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CURRENT STATE AND DEVELOPMENT PROSPECTS OF THE UKRAINIAN LOGISTICS MARKET

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Recently, apart from technological and scientific development, the COVID-19 pandemic and the Russian-Ukrainian war has altered dramatically the overall situation. Transformation of a logistics sector with redistribution of supply chains is one of the main global changes. A process of transformation in the logistics sector started at the time of the COVID-19 pandemic, and today it is still in progress. The war causes new challenges for the world logistics sector and especially for Ukraine. The challenges are making us adapt quickly to new circumstances. The war in Ukraine influences negatively the world economy. Moreover, it is impossible to have long-terms prognoses due to unpredictable course of war.

On the one hand, invasion of Russia into Ukraine has ruined a part of imperfect transport infrastructure. On the other hand, the invasion has made it impossible to use important transport routes, and that has resulted in the threat of global food crisis.

According to the report of the World Bank *Rapid Damage and Needs Assessment*, direct damages to the transport industry accounted for USD 35.7 bln as of February 2023; in comparison to other ones, the industry has the highest needs for restoration, being USD 92.1 bln (World Bank, 2023).

The transport infrastructure damages are not even over the country; they depend on the war intensity. Vinnytska, Volynska, Zakarpatska, Ivano-Frankivska, Lvivska, Poltavska, Ternopilska, Khmelnytska, Chenivetska, Kirovohradska, Rivnenska, Cherkaska, and Odeska oblasts experienced the least damages (damages – up to USD 130.3 mln; losses – up to USD 1584.7 mln; restoration needs – up to USD 402.3 mln). The highest damages are found in the oblasts where long stationary combat actions took place: Donetska (USD 9254.5 mln), Luhanska (USD 5358.7 mln), Khersonska (USD 5363 mln), and Zaporizka (USD 5076.9 mln) ones (World

Bank, 2023). It should be emphasized that the course of war is difficult to predict; consequently, the volume of damages for transport infrastructure will grow.

A structure of the distribution of direct damages and reconstruction needs is not proportional. The following requires reconstruction the most: railway infrastructure and rolling stocks (30%); motorways, highways, and other national roads (29%); local regional, village, and communal roads (16%) (World Bank, 2023).

A process of transformation in the sphere of logistics has started during the pandemic period; it has resulted in the following:

1. Localization of the supply chains (Мельнікова, Клименко, & Весела, 2021). While planning the supply chains, one should consider geographical proximity of the production area and sales markets as well as geopolitical interests of the country, through which the material flows pass;

China has strived much to establish the best connection with Europe, Near East, Africa, and Asia by the *Belt and Road Initiative* (Rojanaleekul, Pungchompoo, Sirivongpaisal, 2022). Because of the war and China's attitude to it, the circle of opponents to commercial globalization has expanded. New order has resulted in concerns as for significant influence of China on the economy of other countries. This fact will result in the intensified trend of logistics localization despite the need in considerable investments.

2. Flexibility of logistics. As far back as during the pandemic, the companies started searching for new ways for growing flexibility and sustainability of the supply systems. To increase the stock of critical products and attract several suppliers for cargo delivery have become the most widespread methods.

Geopolitical processes during the war have pointed out at the necessity of forming partnership relations with the companies located in the neighbouring countries, which share the norms and values of modern economy.

3. Digitalization of logistics. Automation of business-processes provides transparency of supply chains. The process is one of the main directions of logistics development.

The war in Ukraine has added certain trends that are intensifying challenges in the logistics market. They can include the following:

– Intensification of food crisis. Logistic problem of grain delivery is stipulated by the fact that there are no equal-ranking alternatives of sea transportation. The problem cannot be solved due to incompatibility of the rail width of Ukrainian railroad transport with the EU countries and insufficient number of crossing points for motor vehicles;

– Global recession. Production activity is being decreasing all over the worlds; and it is especially seen in Ukraine. Destruction of production facilities, occupation of the country's part, lack of skilled staff, limited access to electrocarriers, high fuel prices etc. are the reasons here. Reduced demand for transport services is inevitable (Офіційний сайт Державної служби статистики України).

Due to blocking of traditional transport routes through the Black Sea by the country-aggressor, a necessity has arisen to organize operating re-orientation, simplify bureaucratic procedures, and cancel the necessity to obtain a permit for cargo transportation. Implementation of the specified tasks was complicated considerably without support of the EU countries. The signed agreements have helped Ukrainian trucks cross the borders with the EU countries without additional limitations as for the number of entrances and duration of stay (Україна та ЄС підписали угоду про транспортний безвіз. *Вісті України*, 2022).

In 2022-2023, the measures were implemented to eliminate negative effects in the sphere of motor logistics as the motor vehicles took the highest load during the war. A problem of long queues can be solved with the help of electronic system *eCherha* for cargo transport (Система онлайн-бронювання місця в черзі для перетину кордону для міжнародних вантажних перевізників. «єЧерга»). This application can be used to get message about the status in a queue, its progress, time of entering a crossing point. Joint efforts of the Customs and customs services have made it possible to improve greatly the capacity of the available crossing points and open the new ones.

The war in Ukraine has changed the views on certain aspects of safety. With the course of time, it has become clear that the globalization process is not only a tool to improve economy and social welfare of the country but a threat to the national safety. In terms of the worldwide transition to a new logistics model and possessing damaged transport infrastructure, Ukraine is getting ready for a long-term and costly process of restoration of its logistics sphere.

Transport industry is critically important in the strategic space of Ukraine. Nevertheless, the war has changed the priorities. Earlier, to unlock its trade potential, Ukraine placed its stakes on trade expansion of China and strengthening of cooperation for joint implementation of the idea for the development of economic belt *Great Silk Road*. However, now the focus is on integration into the EU though the probability of restoring the *Great Silk Road* is not excluded at all.

Thus, it should be noted that the primary concern is restoration of infrastructure as the platform for the development of logistics market. The restoration process is influenced by following factors: numerous scenarios of war development; financial deficit; readiness of the international partners to help while restoring; considerable dependence of the restoration process upon slow demining of the liberated territories; high level of technical and engineering complexity while designing the reconstruction process for a transport industry; consideration of the environmental component; high level of corruption. The majority of the mentioned factors are negative.

As a result of the analysis, a pessimistic picture of the development of Ukraine's logistics market during the post-war period is drawn; though, it should be stressed that despite all the obstacles, the country has great transit potential. The prospect of localizing supply chains and support of the EU countries gives certain hope for the crisis overcoming.

References

1. Rojanaleekul, V., Pungchompoo, S., Sirivongpaisal, N. (2022). Trade values predictive model of Southeast Asia under the Belt-Road Initiative. *The Asian Journal of Shipping and Logistics*, 38 (2), 162-172.
2. *World Bank.* (2023). Ukraine Rapid Damage and Needs Assessment: February 2022 – February 2023. Washington [online cit.: 2023-05-01]. http://documents.worldbank.org/curated/en/099184503212328877/P1801740d1177f03c0ab180057556615497
3. Мельнікова, Ю. І., Клименко, І. Ю., & Весела,_М. А. (2021). Проблеми розвитку транспортної логістики Україні в умовах пандемії. *Сучасні технології в машинобудуванні та транспорті*, 2, 110-116.
4. Офіційний сайт Державної служби статистики України. http://www.ukrstat.gov.ua/
5. Система онлайн-бронювання місця в черзі для перетину кордону для міжнародних вантажних перевізників. «єЧерга». https://echerha.gov.ua/
6. Україна та ЄС підписали угоду про транспортний безвіз. *Вісті України.* (2022). https://visitukraine.today/blog/555/ukraine-and-the-eu-have-signed-an-agreement-on-liberalization-of-road-transport/

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INCREASING THE EFFICIENCY OF TRAFFIC MANAGEMENT

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Over the past decade, the world has witnessed a rapid increase in the number of vehicles and the intensity of road traffic, leading to a rise in the number of road traffic accidents (hereinafter referred to as RTAs) and their negative consequences. According to the World Health Organization, road traffic injuries are currently one of the major health care challenges, and it is predicted that by 2030, RTAs may become one of the top five causes of death worldwide.

Ensuring road safety and traffic organization requires significant attention due to the substantial casualties and material costs associated with road traffic events.

The growth in the number of vehicles, traffic intensity, and speed necessitates the creation of necessary conditions to ensure the convenience and safety of the transportation process. Primarily, the road network should be optimal in length and meet the requirements of transportation and operational characteristics. However, experience shows that it is not enough to build roads, it is necessary to carry out purposeful and continuous engineering activities on them, including planning and equipping them with special technical means for traffic organization.

Ensuring safety and traffic organization on roads is crucial due to significant casualties and material losses in road traffic accidents.

Substantial improvement in traffic safety involves refining road design methods, enhancing the technology of road construction works, namely ensuring the necessary evenness and roughness of the pavement and preserving these conditions throughout the road service.

To ensure road safety, the following tasks need to be addressed:

– Ensuring the unimpeded flow of traffic on the road with a calculated intensity and specified speed through road planning and longitudinal profile design.

– Traffic management, including the establishment of optimal speeds.

– Timely information to drivers about constant changes in road conditions (fog, icy conditions) by installing warning road signs with updated information.

– Maintenance by the repair service of the transportation and operational quality of roads (evenness, strength, tire traction coefficient with the pavement), and timely removal of the impact of external factors on traffic conditions, primarily weather-climatic factors.

Main measures to improve traffic safety on public roads include:

– Widening the roadway, constructing additional lanes on inclines for slow-moving vehicles.

– Strengthening and widening roadsides.

– Equipping bus stops with expanded road sections.

– Creating gentle slopes on the sides of the road.

– Reconstructing curves in the plan and longitudinal profile to improve visibility.

– Expanding narrow bridges.

– Installing signals at railway crossings, constructing overpasses over railway tracks, and at intersections of roads at different levels.

– Marking the roadway to improve traffic organization.

– Reconstructing intersections at the same level with the construction of directional islands or roundabouts.

– Installing barriers and guideposts in hazardous areas.

– Providing lighting on sections with a high number of road traffic accidents at night.

– Installing underground and aboveground pedestrian crossings, erecting barriers to prevent pedestrians from entering the road.

– Constructing parallel roads for local traffic and transition-speed lanes, equipping approaches, entrances, and exits.

– Building sidewalks in populated areas and bicycle lanes.

– Installing signals and directional signs; introducing traffic light control in specific areas.

Each road consists of individual sections that differ in plan and longitudinal profile curve radii, visibility provision, longitudinal slopes, and other route characteristics. Various methods, based on adapting coefficients characterizing the impact of individual factors, are proposed to assess the combined influence of these factors.

The primary factors include evaluating the safety of linear graphs using accident coefficients and assessing road safety based on the safety coefficient schedule. The first method is used to solve the following tasks:

– Identifying sections of designed or reconstructable roads where plan elements, profile, or roadside situations contribute to conditions that increase the risk of road accidents.

– Comparatively assessing parallel roads and their individual sections in terms of traffic safety.

– Comparatively evaluating the effectiveness of measures to improve traffic safety on specific sections.

The second method is based on assessing the smoothness of the route and various options for design lines from the perspective of improving traffic safety based on the speed curve epicycles of a single car, representing the ratio of speeds on lane segments.

Given the current significant growth in automobile transport, which implies a decrease in safety levels due to many road networks not adapted to such a volume of vehicles, a variety of methods is necessary for accurate and comprehensive evaluation of the research object.

The third method that will be overviewed is Optimizing speed regimes one. Optimizing traffic speed involves influencing the traffic flow speed to enhance traffic safety, its capacity, or the speed of communication. Depending on specific conditions, the optimization task may involve reducing or increasing the existing speed regime.

Considering that the highest road capacity is achieved at speeds of around 50 km/h, it is probable that the road condition does not allow for such speed (e.g., deteriorated road surface). The optimization measure, in this case, would be the elimination of this deficiency. Alternatively, on a road with a normal speed of 90 km/h, during rush hours when the desired capacity cannot be achieved, a temporary speed limit of 60-70 km/h may be necessary to increase noticeably capacity by safely increasing traffic density.

After analysing the given method, the following drawbacks were identified:

– When using speed regime optimization, the season and time of day are not fully taken into account. For example, when installing a speed limit sign, there is a situation where its effect is justified (poor road conditions, dark hours), and conversely, when the road is in excellent condition, the sign may be unnecessary or significantly lowers the speed, leading to driver frustration.

– This method of traffic organization has a relatively small impact on traffic safety because it only considers speed and does not have a connection with other traffic indicators.

Among the advantages of this method, the following can be named:

– It allows achieving uniform speed for both individual vehicles and the entire traffic flow, reducing internal disturbances.

– The method, when controlling traffic, does not require significant expenses.

Equalization of traffic composition: Creating homogeneous traffic flows contributes to smoothing the speed of movement and increasing road capacity. One example of addressing this issue is differentiating lanes for passenger and freight vehicles on multi-lane roads. However, manoeuvres before intersections for changing direction and stopping, as well as the undisciplined behaviour of some drivers who do not follow lane discipline, prevent achieving complete uniformity in traffic flows. Therefore, on the busiest routes, it is advisable to provide road differentiation.

Road conditions significantly influence traffic safety. Poor road surface condition reduces their capacity; potholes and irregularities lead to hazardous situations; insufficient width of the roadway (bridges with a width less than or equal to the roadway width), poor visibility in plan and longitudinal profile, sharp changes in road direction, intersections with unregulated traffic flow, lack of acceleration and deceleration lanes, steep inclines, and hills are the main reasons leading to reduced safety and the occurrence of road traffic accidents.

Currently, the road has a solid surface with a roadway width of 7-9 meters along its entire length.

In general, improving the efficiency of traffic organization requires a comprehensive approach that combines technological innovations, urban planning solutions, and public involvement. Only such an approach will allow achieving a high level of safety, convenience, and efficiency on the roads.

References

1. *Безпека дорожнього руху. Автомобільні дороги загального користування. Загальні технічні вимоги. ДСТУ 218-03449261-106-2003.(2003).* [Чинний від 2003-08-01]. Державна служба автомобільних доріг України. (Галузевий стандарт України).

2. *ДБН Б.1–2–95 Склад, зміст, порядок розроблення, погодження і затвердження комплексних схем транспорту для міст України.* (1996).

3. Редзюк, А. М., & Штанов, В. Ф. (1998). Актуальні питання державного регулювання на автомобільному транспорті. *Автошляховик України*. 4, 5-6.

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ASSESSMENT OF THE CITY PUBLIC TRANSPORT FUNCTIONING EFFICIENCY

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The issue of assessing the effectiveness of measures in public passenger transport is complicated by the inability to determine the ultimate results of its operation – the satisfaction of passengers' mobility needs. Existing methodologies for calculating cost assessments of transport quality currently rely, ultimately, on conversion coefficients that somehow relate indicators of travel distance to passenger productivity indicators. Such an approach has one significant drawback – it does not consider the ultimate goal of any individual, namely, the satisfaction of their needs. Any attempts to measure the result of a process or phenomenon by the costs incurred in achieving it cannot capture all its advantages and, therefore, do not provide sufficient grounds for decision-making regarding its effectiveness.

Furthermore, the use of exclusively cost-based metrics cannot provide a comprehensive assessment of the effectiveness of specific measures, that is, indicate the possible consequences of implementing measures for all economic entities, as they determine only the nature of resource distribution. The way out of this situation, particularly acute in passenger transport, lies in evaluating the degree of satisfaction of people's needs in specific products or services. The property of a product or service to be beneficial, i.e., to satisfy needs, is called utility. Current methodologies for assessing utility are primarily aimed at examining specific situations of human behaviour in conditions of uncertainty and are purely prognostic in nature. Evaluation aspects in this case take a back seat, and determining the result of consumption, including transportation products, is not yet feasible.

To address this issue, it is necessary to describe the utility of the product or service (hereinafter referred to as the commodity) using mathematical models and determine the corresponding coefficients of these models. The utility model of the object may depend on the consumer's relation to it and the volume of consumption over a certain period.

$$U_i = c_i * f(Q_i), \tag{1}$$

where U_i is the utility of the i-commodity, c_i is the utility of consuming the first unit of the commodity, which defines the consumer's relation to it; $f(Q_i)$ is the function representing the change in utility, and Q_i is the volume of commodity consumption over a certain period.

To represent $f(Q_i)$, the following functions are the most convenient, differentiable at least once, relatively simple, and provide a wide range of rates of change in the utility function:

$$\begin{cases} f(Q_i) = q_i \cdot (1 - \frac{\Delta_i}{2}) + q_i^2 \cdot \frac{\Delta_i}{2} & (2.1) \\ f(Q_i) = \frac{\Delta_i^{q_i} - 1}{\Delta_i - 1} & (2.2) \\ f(Q_i) = q_i^{\Delta_i} & (2.3) \end{cases} \tag{2}$$

where $q_i = Q_i/t$ is the specific volume of commodity consumption for the period t in the corresponding units of measurement,

(2.1) – the sum of q_i elements of an arithmetic progression.

(2.2) – the sum of q_i elements of a geometric progression.

(2.3) – the exponential function.

Δ_i – indices for the respective functions determining the direction of utility change with an increase in consumption volume.

For function (2.1), a value of $\Delta_i>0$ means that each subsequent unit of consumption more effectively satisfies the consumer than the previous one (an increasing utility function). Conversely, $\Delta_i<0$ implies that each subsequent unit of consumption satisfies the consumer less than the previous one (a diminishing utility function). Finally, when $\Delta_i=0$, the utility does not depend on the consumption volume (a constant utility function). Corresponding values for functions (2.2) and (2.3) take the form $\Delta_i>1, \Delta_i<1, \Delta_i=1$, except for the case $\Delta_i=1$ for function (2.2), where it is undefined.

If values c_i and Δ_i are determined, this will not only allow obtaining an estimated criterion for assessing the effectiveness of systems in the consumption of products but also comparing various development options for systems producing entirely different products. These values can be determined by considering the consumer as a rational subject who maximizes consumption utility under budgetary constraints and fixed product prices (*condition 1*). These assumptions will enable the use of the Lagrange function to search for a constrained extremum. With known values of c_i and Δ_i, this method can be used to predict consumption volume. However, the inverse problem is of greater interest – finding the values of c_i and Δ_i for known consumption volume in a certain period with a given budget constraint.

For these purposes, the following system of equations can be used, provided for the case of a geometric progression.

$$\begin{cases} q_{t1} \cdot Ld_1 + 1 \cdot Lc_1 - 1 \cdot L_1 = Lp_1 \\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \\ q_{ti} \cdot Ld_i + 1 \cdot Lc_i - 1 \cdot L_1 = Lp_i \\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \\ q_{tn} \cdot Ld_n + 1 \cdot Lc_n - 1 \cdot L_1 = Lp_n \end{cases} \quad (3)$$

where $q_{ti}=Q_i/t$ is the consumption volume of commodity i in period t; $Lp_i=Ln(P_i)$ is the natural logarithm of the price P_i of commodity i; n is the number of available groups of commodities.

The unknowns in this system of equations are:

$$Ld_i = Ln(\Delta_i) \Rightarrow \Delta_i = Exp(Ld_i);$$

$$Lc_i = Ln\frac{c_i \cdot Ln\Delta_i}{\Delta_i - 1} \Rightarrow c_i = \frac{Exp(Lc_i)\cdot(\Delta_i - 1)}{Ln\Delta_i};$$

$$L_1 = Ln(-\lambda_1) \Rightarrow \lambda_1 = -Exp(L_1).$$

The number of unknowns in this system is $2n+1$, and the number of equations is n, meaning the system has an infinite set of solutions. However, introducing an additional condition that the consumer's preferences remain unchanged in subsequent periods $t_1, t_2 \ldots t_k$, (*condition 2*), this system can be supplemented with sets of similar equations. In this case, the number of unknowns in the new system is $2n+k$, and the number of equations is nk, where k denotes the number of considered consumption periods. To obtain a particular solution, it is sufficient to consider $k = 2\cdot n/(n-1)$ consumption variants.

However, in the general case in the system (3), when $k>1$, linearly dependent columns exist, and it is necessary to specify parameters for the base commodity to determine the utility c_i and the rate of its change Δ_i for other commodities. Their values have a relative nature corresponding to the method of obtaining them since the overall volume of consumed utility for different periods is not explicitly defined here. Only the consumption results are described with the corresponding assumptions about consumer behaviour. The consumption volume within this model for a geometric progression is determined by the equation:

$$q_i = \frac{\dfrac{\Pi}{Ld_i} + \sum\limits_{j \neq i}^{n} \dfrac{P_i}{Ld_i \cdot Ld_j}\cdot(Ls_i - Ls_j)}{\sum\limits_{j}^{n} \dfrac{P_j}{Ld_j}}, \tag{4}$$

where Π is the budget constraint, i.e., the amount of funds available in the considered period; $Ls_i = Lp_i - Lc_i$.

As consumption indicators are considered given in determining the consumption volume, conclusions can be drawn about the direction of consumption volume change with an increase in Π. All other quantities here are constant. If $\forall Ld>0$ or $\forall Ld<0$ (correspondingly $\Delta_i > 1$ or $\Delta_i < 1$), an increase in Π will lead to an increase in the consumption q of all commodities. This result is confirmed by the results of natural surveys and is intuitively plausible, given condition 2. Otherwise, an increase in Π will lead to an increase in the consumption of some commodities and a decrease in the consumption of others, with the direction of the change in consumption volume determined both by the nature of the function (diminishing or increasing) and by the sign of the denominator, which can be either positive or negative.

A special case arises when one or several commodities are described by constant utility. With the increase in Π, the consumption volume changes only due to one commodity with constant and maximum specific utility, while the consumption of other commodities with constant utility remains at 0, with the variable being *const*, which clearly does not correspond to reality.

Therefore, determining the direction of utility change for the base commodity is crucial. The peculiarities of the system (3) are such that setting an increasing (diminishing) function as the base leads to obtaining increasing (diminishing) functions for other commodities. It is necessary to determine the direction of utility modification that corresponds to the real situation. The general opinion on this matter is that utility functions are usually considered diminishing. However, there seem to be objective reasons to determine how utility should actually change with an increase in consumption volume.

Another conclusion can be drawn when determining utility based on consumption data, the entire spectrum of consumption should be considered, even when studying the utility of a specific type of consumption, in this case, the consumption of transportation services.

Similar results are obtained when studying arithmetic progression and an exponential function. After determining the utility of each commodity, functional dependencies between the utility value and the indicators of passenger movement in public transport (as well as any other) can be found using known mathematical methods. The obtained dependencies can be used to assess the effectiveness of management decisions in passenger transport.

References

1. Burinskiene, M. (2005). *Urban transport planning*. Technika.
2. Горбачов, П. Ф., Колій, О. С., & Курочка, Л. О. (2008). Модель маршрутної мережі пасажирського транспорту міста Харкова в середовище PTV VISION® VISUM. *Новий колегіум*, 2 (45), 60 – 64.
3. Доля, В. К. (2011). *Пасажирські перевезення*. Форт.

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ADAPTABILITY OF TRACTORS TO ENERGY TECHNOLOGIES

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General-purpose tractors are used during energy-intensive agrotechnological processes such as primary tillage, cultivation, sowing, etc., particularly as part of combined and transport-technological units. According to the degree of adaptability of the energy parameters of the tractor to the performed agrotechnological process is assessed as its energy-technological adaptation. The problematic situation is due to the contradiction between the energy saturation of tractors and the need to reduce energy consumption for the production of agricultural crops. The particular relevance of solving this problem is determined by the saturation of Ukraine's agricultural sector with powerful general-purpose tractors, mostly of foreign production.

Saturation of the agricultural sector of Ukraine with general-purpose tractors of the increased energy density of foreign companies John Deere, Case IH, and New Holland (Лебедєв, 2014) ensured an increase in the working speeds of machine-tractor units (MTA) from 4-8 to 8-15 km/h, which reached the technological limit. However, many years of experience in testing tractors at the Kharkiv branch of UkrNDIPVT named after L. Pohorilo (Лебедєв, Лебедєв, & Коробко, 2018) showed that the weighted average degree of useful utilization of the operating power of the engine of general-purpose tractors during the year is 50-80%. Therefore, a question arises regarding the feasibility of increasing the power of engines of new tractors, if their effective use in operation is not ensured (Лебедєв, Лебедєв, 2021). The underutilization of engine power during MTA technological operation is caused by many factors, the most important of which are: non-uniformity of MTA energy consumption during operation, in particular due to the oscillating nature of external resistances and dynamic loads; reserving power for an acceleration of the unit, especially the transport one; the impossibility of rational staffing of MTA.

Due to the instability of the MTA energy consumption, the task of ensuring the operation of the tractor with the highest indicators of energy efficiency during technological tillage is solved. The research was conducted on the John Deere 8335R tractor, which is the most popular general-purpose tractor on the Ukrainian market (Figure 1).

Figure 1. – General view of the tillage unit: John Deere 8335R tractor + Vaderstad Top Down 500 cultivator

When determining the traction and energy indicators of the John Deere 8335R tractor, the requirements for different groups of technological operations of the main tillage were taken into account according to the operating speed of the unit $V_н$:

1 – plowing and deep loosening with nominal value and interval $V_{н1}$ = 2.2±0.25 m/s;

2 – post-harvest no-till combined processing (continuous cultivation), disking, and chiseling $V_{н2}$ = 2.7±0.3 m/s;

3 – surface post-harvest treatment (hulling of stubble), pre-sowing treatment, and sowing $V_{н3}$ = 3.3±0.5 m/s.

The method of evaluating the traction characteristics of the tractor in terms of energy saving under variable external load takes into account the simultaneous influence of two criteria - traction power and hourly fuel consumption - on the performance indicators of the MTA. This method allows you to evaluate the rational modes of operation of the engine and tractor using a generalized criterion - the minimum energy consumption of the technological process lambda $\lambda^*_{E_{MTA}}$. This criterion takes into account the minimum value of energy losses with a decrease in MTA productivity and an increase in fuel consumption. It is calculated as the ratio of energy consumption at the basic value of the tractor loading mode (λ_p = 1.0) and total energy consumption when the tractor is operating in the optimal mode (λ_p^*) for the current value of the traction force $P_{кр}$ on single 1K and double wheels (2K) (table 1).

Table 1. – Traction and energy modes of the John Deere 8335R tractor for the main groups of tillage operations

Operations group	V_p^*, m/s	υ_p	Complete set	$G_т$, kg/h.	$N_{кр}$ at $P_{кр}^*$, kW	$P_{кр}^o$, кN	m_e^*, kg	λ_p^*	V_{po}^*, m/s
1	2.2±0.25	0.15	1K	48.4	208	65	13820	1.0	2.28
			2K	51.2	213	70	15470	1.03	2.26
2	2.7±0.3	0.10	1K	53.1	214	69	13820	1.03	2.70
			2K	53.3	221	73	14370	1.05	2.65
3	3.3±0.5	0.06	1K	53.4	216	44	11680	1.04	3.61
			2K	53.5	225	47	12950	1.07	3.63

Note. V_p^*, V_{po}^* – speed of movement of MTA working, optimal; υ_p – coefficient of load variation; m_e^* – operating mass; λ_p^* – degree of loading of the tractor; $N_{кр}$ – traction power of the tractor with unstable traction indicators; $P_{кр}^o$ – the optimal value of the traction force; $G_т$ – fuel consumption with unstable traction load.

A comparison of the materials in this table showed that the energy indicators of the tractor on single and double wheels at different values of the load variation coefficient are insignificantly different for the same amount of operating mass m_e^*. The installation of double wheels allows for improving the parameters of the traction characteristics of the tractor, which provides an increase in the traction power of the tractor by an average of 6%. Losses of power $N_{кр}$, caused by the influence of variable factors on the unit and tractor, amounting to 5% at the maximum value of the load variation coefficient υ_p, which is 1% lower than with the 1K configuration. Optimal loading modes for different tractor configurations υ_p = 0.06-0.15 are in the zone of the degree of loading of the tractor λ_p^* = 1.0-1.07. Fuel consumption $G_т$ increases when the coefficient of variation decreases υ_p. It should be noted that due to the increased torque reserve of the John Deere 8335R tractor engine (torque adaptation factor K_n = 1.41), the fluctuation of the external load does not have a significant effect on the energy performance of the tractor. Installing double wheels on the tractor allows you to increase its traction power by an average of 5 %.

For the operation of the first (V_p^* = 2.2 m/s) and the second (V_p^* = 2.7 m/s) loading modes of tillage groups $\lambda_p^* \geq 1,0$ are located in the section of the traction characteristic of the tractor between the values of the nominal $P_{кр.н}$ and the limit $P_{кр.г}$ of the traction force. For operations of the third group, effective equipping of the tractor with double wheels, provides an increase in traction power by 5 %. The implementation of traction and energy indicators of the tractor is effective in the biotechnological processing of various agricultural crops.

A comparison of the materials in this table showed that the energy indicators of the tractor on single and double wheels at different values of the load variation coefficient are insignificantly different for the same amount of operating mass m_e^* . The installation of double wheels allows for improving the parameters of the traction characteristics of the tractor, which provides an increase in the traction power of the tractor by an average of 6%. Losses of power $N_{кр}$, caused by the influence of variable factors on the unit and tractor, amounting to 5 % at the maximum value of the load variation coefficient υ_p, which is 1% lower than with the 1K configuration.

The issue of assessing the relationship between fuel consumption by the tractor engine and the biopotential of crop cultivation remains open. It is necessary to carry out theoretical and experimental research in this direction, especially combined agricultural units.

References

1. Лебедєв, С. (2014). Технічній рівень тракторів сільськогосподарського призначення на ринку України. *Техніка і технології АПК*. 11 (52), 8-12.

2. Лебедєв, А. Т., Лебедєв, С. А., & Коробко, А. І. (2018). *Кваліметрія та метрологічне забезпечення випробувань тракторів*. «Міськдрук».

3. Лебедєв, А., Лебедєв, С. (2021). Технологічна адаптація тракторів загального призначення. *Техніка і технології АПК*. 4 (121), 17-21.

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APPLICATION OF GRID AT LOCAL AND REGIONAL LEVELS PROBLEMS OF MODERN TRANSPORT

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In my opinion, the main problems of modern transport are:

1) Traffic jams during peak hours
2) Many people at peak times
3) High prices for public transport
4) Air pollution
5) Potholes on the roads
6) Obsolete rolling stock
7) Fuel prices
8) Fuel quality
9) Bad weather

Application of grid at local and regional levels

We define the modern transport infrastructure of cities and regions as a set of intelligent systems for planning and modeling transport networks, traffic management, and telepathic complexes that provide operational information about the state of the road environment and allow interaction with all road users. The development and operation of transport infrastructure require powerful computer resources. However, the current state and the possibilities of their improvement are hindered by a lack of funds, which is characteristic of almost all local self-government bodies. The solution to the problem is possible by obtaining additional computer resources based on existing large computer systems, and corporate networks due to using the latest GRID technologies (Alekseev, 2002; Volkov, Alekseev, et al., 2006).).

Historically, in large cities, the computer networks of any stably existing enterprises and organizations of various profiles were built according to the financing and improvement of the possibilities of purchasing computer equipment. The practice of introducing new technologies preceded scientific and technical substantiation, evaluation of the effectiveness of project solutions, and generalization of the results that were achieved. Gradually, such networks were transformed from relatively simple computing complexes to interconnected systems at the corporate level. Let's consider how to get additional computer resources for the development of transport infrastructure due to access to such computer systems.

The use of computer resources of existing large computing complexes (more than 1,000 computers) depends on the rational organization of subsystems and links that differ in their technical characteristics, application features, and terms of existence. The reliability and performance of individual systems may be relatively small, but the user of such a distributed system receives a single reliable and productive platform for computing, and gaining access to databases and knowledge. The development of computing networks takes place at the following levels: Intragrid (internal Grid); Extragrid (external Grid that already unites several organizations); the highest level of the scale of the size of Grid systems is Intergrid (global systems that already unite many organizations, partners, cluster solutions).

The application of GRID technologies is a logical continuation of the development of modern information systems and computer networks. The main advantage of such systems is the management of distributed resources that are provided for use by a wide range of consumers.

By implementing GRID technology in maintenance, we get a kind of intelligent regulator that combines the advantages of software control systems with flexible systems.

Software modules are executed in parallel in IT maintenance departments. GRID - the maintenance system should have the properties of a unified hardware and software complex. Therefore, the creation of a computing network in transport applications is based on the experience of using distributed systems. To solve problems, they must be provided both with hardware implementation and with the right choice of software platform.

The GRID computer environment enables the existence of each person in the information space, uses computer resources from individual computers and local computer networks to global distributed network systems. Almost all computer users have access to the global Internet. But a situation has arisen in which, in parallel with the development of information capabilities, contradictions in the use of computer resources are defined. This is explained by the physical and psychological isolation of the user's perception of the computer working environment by the participant of the movement along with the compatible use of resources of global networks and the opportunities provided by the information space of the Internet.

It is the GRID technology that can resolve this contradiction, ensure the unification of heterogeneous computer resources. Such a union provides a kind of recovery of computer capacity reserves, which consists in the simultaneous use of computers to solve the tasks of different users, parallel processing of information, synergistic self-organization of LAN nodes.

In the absence of virtualization of computing resources, IT departments allocate separate physical machines for each application. As a result, a significant amount of excess resources is formed on each of the machines. With the help of virtualization, you can run several applications on the same machine, while maintaining the required level of application isolation.

Therefore, the creation of GRID systems in maintenance for the simultaneous performance of complex transport tasks should be carried out considering transparency, virtualization, interoperability, and scaling.

The development of GRID technologies consists of the further use of Cloud Computing - a virtual environment. It consists of heterogeneous distributed systems and performs the distribution of necessary resources for the user community at the level: of "software + services". Transport organizations, virtual communities, and individuals act as users.

It would be logical to highlight several key components of the management of the information part of the transport infrastructure. Decision-makers (DPOs) on the organization of transport processes will provide instructions and receive information directly from the IT department, which will have a help center for communication with users. The user must also be provided with clear information about the operation of the system and its services. A direct connection should be created between the OPR and the support group of the GRID-portal IT - department of the transport organization.

Thus, a relatively decentralized system will be obtained, where, on the one hand, the work of the GRID portal will be influenced by users, and on the other, by the OPR.

References

1. Alekseev, V. O. (2002). Mobile computing complex for monitoring the traffic environment. *Automobile transport: Collection of scientific works,* 9, 101–104.

2. Volkov, V. P., Alekseev, V. O. et al. (2006). *Stability of wheeled vehicles against skidding during braking and ways to improve it.* Podrihalo, M. A. (Eds). KhNADU.

3. Aleksiev, V. O. (2006). X-by-WIRE technology and mechatronization of motor vehicles. *Bulletin of KhNADU: Collection of scientific works*, 32.

4. Aleksiev, V. O., Neronov, S. N., Khabarov, V. O. (2005). Mechatronic system for continuous monitoring of highways. *Automobile transport: collection of scientific works,* 16. KhNADU.

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TRANSPORT GRAVITY FUNCTION FOR TRANSPORT CORRESPONDENCES IN TRANSIT TO THE CENTRAL PART OF THE CITY

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Origin-destination trip matrices (O-D matrices) are important part of city transport network modelling because they represent traffic needs in transport system. There are many scientific articles about OD-matrix calculation, increasing its fidelity and correctness. (Abdel-Aal, 2014; Alexander, Jiang, Murga, González, 2015; Schnabel, Lohse, Latzsch, 1997; Thompson, Saxberg, Lega, Tong, & Brown, 2019; Гецович, & Засядько, 2014). However, in our task of transit traffic volume and route calculation for city centres the calculation of O-D matrices have some particularities. The hardest task is how to get O-D matrix. Practically, the most accurate method is direct questionnaire of drivers (automobile owners). However, this method is very hard to implement. Other methods are simpler, but less accurate. You can calculate O-D matrix if you know volumes of arriving and volumes of departure for every transport zone and distances between them using “gravity” model of trip distribution. There are some disadvantages of this approach: first, you need to know traffic arriving and traffic departure volumes for every transport zone; second, the “gravity” model is not accurate (we are talking about so called “gravity function”). The first disadvantage may be reduced using author’s method of transport zoning, so called “method of enlarged zones” (Lovelace & Ellison, 2018). The second problem is finding the appropriate kind of “gravity” function and taking into accounts all factors, influencing on traffic attraction between zones.

The attraction function reflects the dependence of the amount of correspondence on the distance of travel, the cost of transport time or money. Different researchers propose different types of transport gravity function (Alexander, Jiang, Murga, González, 2015; Schnabel, Lohse, Latzsch, 1997; Thompson, Saxberg, Lega, Tong, & Brown, 2019; Гецович, & Засядько, 2014). In particular, it is believed that transport attraction is inversely dependent on the distance between transport areas or the time for movement between areas, or the monetary costs of movement. In addition, different forms of dependence of transport gravity on these parameters are proposed, in particular, inverse dependence, inverse quadratic and inverse exponential dependence.

The lack of unanimity among researchers regarding the type of transport attraction function and the need for a calibration procedure for some types of this function prompts further research in this direction. Moreover, the type of transport attraction function affects the calculation of the matrix of correspondences and, ultimately, the results of calculations of the required carrying capacity of conditional ring sections for diverting transit for downtown traffic flows.

The work (Thompson, Saxberg, Lega, Tong, & Brown, 2019) mentions such a general form of the transport attraction function:

$$d_{ij} = \frac{a}{t_{ij}^{k}}, \qquad (1)$$

where a and k – calibration coefficients;

i, j – transport zones of departure and arriving;

t – travel time.

Simple forms of such a model are usually used in the practice of modelling city transport systems (Zheng, Fan, Wang, Qi, & Gman, 2020; Гецович, & Засядько, 2014),

$$d_{ij} = \frac{1}{t_{ij}}, \qquad (2)$$

$$d_{ij} = \frac{1}{t_{ij}^{2}}, \qquad (3)$$

where n – quantity of transport zones;

h_{ij}^{f} - O-D trip, calculated using “gravity” model (attraction function f) h_{ij}, vehicles/hour;

$N_{âèõi}$ - traffic volume at the entrance of mega-zone i, vehicle/hour.

Some authors propose “gravity” (or attraction) functions of an exponential form (Abdel-Aal, 2014; Гецович, & Засядько, 2014)

$$d_{ij} = a \cdot e^{-bt_{ij}}, \qquad (4)$$

$$d_{ij} = a \cdot e^{bt_{ij}^{c}}, \tag{5}$$

where b, c – calibration coefficients.

German researchers propose (Thompson, Saxberg, Lega, Tong, & Brown, 2019) this kind of function under the conventional name EVA

$$d_{ij} = \frac{1}{\left(1 + t_{ij}\right)^{\varphi\left(t_{ij}\right)}}, \tag{6}$$

where

$$\varphi\left(t_{ij}\right) = \frac{E}{1 + e^{\left(F - G \cdot t_{ij}\right)}}, \tag{7}$$

where E, F, G – calibration coefficients.

The next task of our research is definition of traffic attraction function between peripheral transport mega-zones and central transport mega-zone to get volumes of trips going through the city centre as a transit traffic and volumes of trips whose origin or destination is city centre.

In the article (Lovelace & Ellison, 2018) showed that EVA-function is most suitable for business O-D trips calculation, which is suitable for our task, because the percentage of business O-D trips is more bigger than other types of O-D trips during morning and evening "peak" time periods.

We made the experiment trying to evaluate O-D trip matrix of cross-centre transit O-D trips for Kharkiv city using this approach (Zheng, Fan, Wang, Qi, & Gman, 2020). The territory of the city of Kharkiv was divided into 14 peripheral transport mega-zones and the central part of city as a mega-zone too. There was designated several checkpoints at the main streets at the border of city centre for traffic volume measuring (arriving and departure traffic from and to city centre). There was also video surveillance made to monitor traffic volumes at that checkpoints during different hours, different days of week. Therefore, we was able to calculate traffic capacity of peripheral traffic mega-zones and for city centre for transit traffic calculation (Table 1).

Table 1. – Traffic volume data for 8:00-9:00 Monday

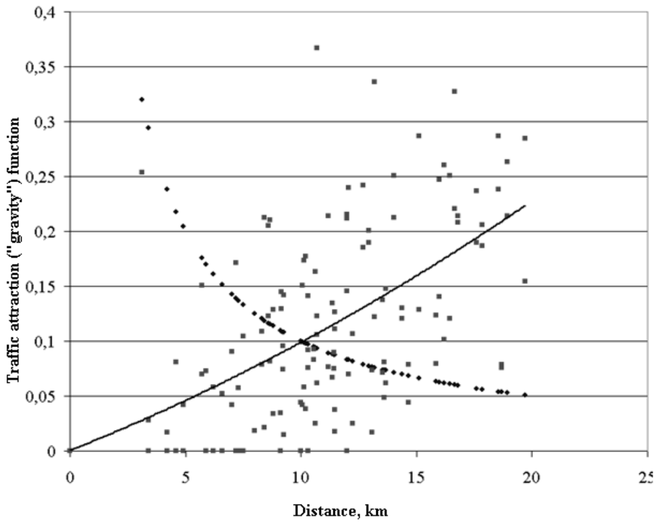
Mega-zone	1	2	3	4	5	6	7	8
Arriving volume, veh./h.	989	1480	1100	690	750	720	640	1420
Departure volume, veh./h.	1780	1810	1920	1010	1100	1070	650	1220
Mega-zone	9	0	11	12	13	14	City centre	
Arriving volume, veh./h.	1210	1740	470	370	750	790	5608	
Departure volume, veh./h.	2026	2120	420	360	1260	1980	-	

Next, several variants of the transport correspondence matrix were calculated according to the gravity model using the above-mentioned types of the transport gravity function.

In the process of calculating the matrix, we must keep the condition of equality of the sum of the values of O-D trips heading to a certain mega-zone and the specified transport capacity upon arrival for this mega-zone. We used Shatskyi-Sheleyhovskyi calculating procedure for this (Моделювання в транспортних технологіях, 2022; Поліщук, Красильнікова, & Дзюба, 2014). However, after calculations according to this procedure, the values of the correspondences change and cease to correspond to the given function of transport gravity. An example of such changes for the variant in which the gravity function is inverse to the distance travelled is shown in Fig. 1. In this graph, each point corresponds to the O-D trips between certain mega-zones before and after balancing (taking into account the calibration coefficients). In Figure 1, it can be seen that after the adjustment, the relationship between the distance of the trip and the transport gravity becomes not inverse, but direct. Similar dependences were obtained for other types of the transport gravity function, where also after balancing the matrix, the dependence changed from inverse to direct. A similar situation is observed for both morning and evening "peak" periods.

In our opinion, the obtained inversed dependence of the value of O-D trips on the distance of travel indicates that the distance of travel from home to the workplace is not such an important criterion for choice of place of work for city residents who own personal cars (and the share of such cars is the largest in the traffic flow), as for those residents who travel to work by public transport, on foot or by bicycle.

The results of calculations and calibrations of the matrix of correspondences show that the previously known types of attraction function are not suitable for calculating matrices of transit correspondences for the city centre when using transport macro-zoning. After adjusting the matrix according to the Shatskyi-Sheleykhovskiy procedure, it turns out that the gravity function is not decreasing, but increases with increasing distance.



■ - the value of transport “gravity” as the inverse of the distance;

◆ - the value of transport gravity after adjustment according to the Shatsky-Sheleykhovsky procedure;

▬ - the trend of changes in transport gravity depending on the distance after adjustment.

Figure 1. – Dependence of transport “gravity” on the distance of the trip

This can be explained by the characteristics of those traffic flows moving through the city centre. Most of these transport correspondences take place over considerable distances (more than half of the "diameter" of the city) or even to diametrically opposite areas of the city. Therefore, the introduction of the appropriate type of attraction function, which takes into account the above circumstances, will allow increasing the accuracy of calculations of the matrix of transit for the city centre of transport correspondences.

References

1. Abdel-Aal, M. M. M. (2014). Calibrating a trip distribution gravity model stratified by the trip purposes for the city of Alexandria. *Alexandria Engineering Journal*, 53(3), 677–689. https://doi:10.1016/j.aej.2014.04.006

2. Alexander, L., Jiang, S., Murga, M., González, M. C. (2015). Origin–destination trips by purpose and time of day inferred from mobile phone data. *Transp. Res. Part C Emerg. Technol.* 58, 240–250. https://doi.org/10.1016/j.trc.2015.02.018

3. Lovelace, R., & Ellison, R. (2018). Stplanr: A Package for Transport Planning. *The R Journal*. 10 (2), 7–23. https://doi.org/10.32614/RJ-2018-053

4. Schnabel, W., Lohse, D., Latzsch, L. (1997). Grundlagen der Straenverkehrstechnik und der Verkehrsplanung. Band 2: Verkehrsplanung 2. neu bearbeitete Auflage.: Berlin.

5. Thompson, C. A., Saxberg, K., Lega, J., Tong, D., & Brown, H. E. (2019). A cumulative gravity model for inter-urban spatial interaction at different scales. *Journal of Transport Geography*, 79.

6. Zheng, C., Fan, X., Wang, C., Qi, J., & Gman. (2020). A graph multi-attention network for traffic prediction. *Proceedings of the AAAI Conference on Artificial Intelligence*, 34 (1), 1234–1241.

7. Гецович, Є. М., & Засядько, Д. В. (2014). Побудова матриці транспортних кореспонденцій, транзитних для центральної ділової частини мегаполіса. *Автомобільний транспорт*. ХНАДУ, 34, 60–67.

8. Моделювання в транспортних технологіях. (2022). Ч. І. Сохацький, А. В. (Ред.) Дніпро : УМСФ.

9. Поліщук, В. П, Красильнікова, В. П., & Дзюба, О. П. (2014). Транспортне планування міст. Знання України.

Наукове видання СТУДЕНТСТВО. НАУКА. ІНОЗЕМНА МОВА

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Засновник – Харківський національний автомобільно-дорожній університет

Свідоцтво про державну реєстраціюСерія ХК № 1495-236Р
від 29 грудня 2008 року

Адреса редакції: 61002, м. Харків, вул. Ярослава Мудрого, 25, тел. 752-88-87