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Maintenance Of The Lubrication System Of Modern Cars

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Abstract. The operation of internal combustion engines in hot and dusty climates presents challenges that impact engine performance, reliability, and longevity. This paper examines the effects of high temperatures and dust-laden air on the electrolyte levels in batteries, oil degradation, and the formation of carbon deposits in the lubrication system. Key maintenance procedures, including oil filtration, crankcase ventilation, and flushing techniques, are explored to mitigate these challenges. The study highlights the importance of using advanced oil filtration systems and scheduled maintenance to ensure optimal engine performance. Recommendations for maintaining lubrication system efficiency in extreme environments are provided.

Keywords: Engine lubrication system, high-temperature operation, oil degradation, filtration system, crankcase ventilation, engine maintenance.

Introduction.

Operating vehicles in hot and dusty climates requires special attention to engine lubrication systems. Elevated ambient temperatures accelerate oil aging, increase mechanical impurities, and promote the formation of carbon deposits in critical engine components. Additionally, dust particles infiltrating the lubrication system contribute to wear and contamination. This paper discusses the necessary precautions and maintenance strategies to ensure engine longevity and efficiency under extreme environmental conditions.

During prolonged operation of vehicles at elevated temperatures, the amount of carbon deposits and resinous substances in the cylinder-piston group of the engine, in the oil lines and on the lubrication system devices increases sharply. When preparing the engine lubrication system for operation in high temperature conditions, it is necessary to check the serviceability of the instruments and mechanisms of the lubrication system and thoroughly clean the internal cavity of the engine from resin deposits. The instruments are checked on a running engine preheated to 70°C, and the lubrication system is flushed with clean industrial oil, heated to 80°C, intended for this type of engine.

Before pouring flushing oil into the crankcase, the used oil is removed from the crankcase and the oil filters are replaced with new ones. In case of increased gumming of the internal cavity of the engine, it is necessary to remove the crankcase pan and remove gum deposits and



dirt accumulations from the walls with kerosene, after which all channels of the lubrication system are blown out with compressed air.

The minimum pressure in the lubrication system for carburetor engines should be at least 1.0 N/cm², and for diesel engines 1.3-2.0 N/cm². Under operating conditions, a drop in pressure in the lubrication system may occur as a result of excessive oil dilution, a malfunction of the pressure-reducing valve or pump, severe contamination of the pump oil receiver mesh, oil leakage from the line, significant wear of the connecting rod and crank group, and other reasons.

An increase in pressure in the lubrication system beyond the permissible limit may be the result of clogging of the oil line or channels, as well as a significant increase in oil viscosity.

When the engine is running, as a result of dust particles getting into the lubrication system, the rubbing surfaces of the parts wear out in a shorter time, while small dust-like metal particles get into the oil and worsen its quality. In addition, when changing the oil, mechanical impurities in the form of dust and sand may get into the crankcase. The high-quality operation of devices for cleaning oil from contaminants when operating cars in desert-sandy areas is of paramount importance.

Cleaning of oil from contaminants and resin formations in modern cars is carried out in coarse filters with subsequent filtration of oil particles in replaceable elements of fine filters, in coarse filters with simultaneous filtration of part of the oil in partial-flow filters (centrifuges), in full-flow filters or by centrifugal cleaning in cavities of the connecting rod journals of the crankshaft in combination with one or more other methods indicated above.

Solid particles measuring 0.5 x 0.5 mm are captured by mesh filters installed on oil inlet pipes. Smaller impurities are captured by coarse and fine filters using plate or belt elements. It is necessary to periodically clean the working surface of the elements with a special 0.06 mm thick scraper that fits into the gaps between adjacent elements. The gaps are cleaned by turning the scraper. Belt filters for coarse cleaning are capable of retaining particles larger than 0.08 mm. To prevent coarse filters from becoming dirty, it is recommended to periodically wash the filters in diesel fuel or kerosene every 50-60 hours. Fine filters are designed to capture impurities up to 0.005 mm in size and are divided into two categories: with replaceable and permanently operating elements. Replaceable elements of fine filters are designed for a certain service life, after which they are replaced with new ones. This category of filters includes: thread, cardboard, paper and absorbent.

Permanent fine filters also include jet filters for centrifugal oil cleaning, full-flow and partial-flow. These mechanisms are designed for a long service life. During operation, they require periodic maintenance and repair. For reliable operation of the engine lubrication system

when operating in desert-sandy terrain, it is necessary to periodically wash the coarse filter elements in diesel fuel after 120 hours, replace the packing of the fine thread filters with a new one after 240 hours of engine operation. Cardboard filters are mainly used on all automobile engines. They come in two brands: automobile superfilter-sedimentation tank (ASFO) and two-section automobile superfilter-sedimentation tank (DASFO).

The ASFO oil filter element is replaceable and is a set of thin cardboard plates and gaskets, in the center of which a hole is formed. The ASFO filter element has a high degree of oil purification, it is 4-5 times more effective than a belt filter.

DASFO filters differ from ASFO filters mainly in the design of the plates and gaskets. In the DASFO filter, the gaskets are made in the form of cardboard strips with narrow longitudinal notches. ASFO filter elements No. DASFO are produced in three standards, differing in the number and size of the plates and gaskets. The characteristics of the filters are given in **Table 1**.

Most modern automobile engines have a device for forced ventilation of the crankcase. In this case, air filters are connected to the internal cavity of the engine, sucking out the air, fuel vapors and oil. When operating cars in sandy desert conditions, abundant deposits of resinous and mud formations are observed in the ventilation ducts and lines of the system. As a result of deterioration of crankcase ventilation, the temperature of engine parts increases sharply, the process of preparing the working mixture is disrupted, power indicators deteriorate and fuel consumption increases.

When preparing vehicles for operation under the specified conditions, as well as when performing the next first maintenance (TO-1), the engine crankcase ventilation system must be opened, cleaned of resin and dirt deposits from the air ducts and channels, and blown out with compressed air. When assembling the system, ensure the tightness of the connections in order to eliminate the possibility of air being sucked in from the atmosphere and disruption of the forced crankcase ventilation.

Table 1. Carboard Filter Data

Filter element	Diameter, mm	Diameter, mm
ASFO-1 and DASFO-1	116	206
ASFO-2 and DASFO-2	116	128
ASFO-3 and DASFO-3	86	134

Maintenance of oil filters during operation consists of the following periodic draining of sediment from coarse and fine filters, flushing of coarse filter elements, flushing or replacing



fine filter elements, and, in the case of increased contamination of the lubrication system with resin deposits, flushing the internal cavity of the engine with clean, heated oil.

Conclusion

The operation of internal combustion engines in high-temperature and dusty environments necessitates rigorous maintenance of the lubrication system. Regular monitoring of oil quality, systematic cleaning of filtration elements, and proper ventilation of the crankcase significantly enhance engine reliability. The implementation of advanced oil filtration technologies, including centrifugal and fine filtration methods, reduces the accumulation of impurities and resinous deposits. Adhering to scheduled maintenance protocols ensures optimal performance, prolongs engine life, and enhances overall operational efficiency.

Thus, modern and high-quality maintenance of the engine lubrication system, the use of high-quality oil filters allows to increase the resources, improve engine operation and increase the reliability and durability of the engine.

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The Role Of Personal (Individual) Mobility In Improving The Quality Of Road Traffic

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Annotation. The issues of terminology and classification of mobility aids for pedestrians participating in road traffic are considered.

Key words: Traffic rules, means of individual (personal) mobility, means of increased danger.

Introduction

From the moment of his awareness as a pedestrian, man sought to move across the surface of the earth faster than on foot. This is inherent in human nature: the speed of movement greatly influenced the survival of humans as a species. For this reason, man rode an animal, created a wheel, a cart, and a car. In fairy tales, with the help of magical power, without the strain of human effort, a stove, sleigh and other objects, such as running boots, move.

The need for a compact mobile device, with the help of which a pedestrian who has it, with the expenditure of almost the same physical strength, can move faster than other pedestrians participating in road traffic, led to the appearance of skis and skates, including roller skates, scooters and other sports equipment. The speed of movement was determined by the success of the design and the physical characteristics of the pedestrian who moved on them. A completely logical continuation of the development of the design of vehicles on which pedestrians moved was the integration of small engines, both internal combustion and electric motors, into their wheeled and other propellers. The internal combustion engine used in certain propulsion designs for moving pedestrians was not widely used and was inferior to the electric motor, which was powered by a compact energy source. We can say that progress in the design of the battery as a source of electricity has predetermined the widespread use of electric scooters and other means of pedestrian transportation.



The increase in the number of pedestrians on mechanical vehicles (hereinafter referred to as MPV), who became road users, quite naturally led to their conflict with other road users. The appearance of a “semi-finished product” (no longer a pedestrian in terms of speed of movement, and not yet a vehicle in terms of the means of transportation) on the roadway led to a conflict with vehicle drivers, and on the sidewalk - with pedestrians.

Without dwelling in detail on the designs of MSPP, it should be noted that, for example, an electric scooter can transport an individual weighing up to 100 kg and reach speeds of up to 40 km/h. The natural question is how dangerous it is for an individual who is traveling on it both in the flow of pedestrians and in the flow of vehicles.

It is convenient to characterize a moving object by an impulse of force, the modulus of which is equal to the product of the mass of the body and its speed or the product of the force and the time of its action. If the body is at rest, the momentum is zero. Any moving body, including a motor vehicle controlled by a pedestrian, has a non-zero impulse. Force impulse is a measure of how great the force must be, acting over a certain time, to stop or accelerate a pedestrian from a place to a given speed. We are interested in the impulse of force now of collision. So, a pedestrian weighing 60 kg when moving at a speed:

- 5 km/h (walking) when colliding with a stationary object, is exposed to a force impulse of 83.3 kg*m/s;
- 12 km/h (running) when colliding with a stationary object, it is exposed to a force impulse of 200.0 kg*m/s;
- 25 km/h (driving on a motor vehicle) when colliding with a stationary object, it is exposed to a force impulse of 416.0 kg*m/s.

The impact of an impulse on the human body at a speed of more than 12 km/h will lead to a combined injury. With combined trauma, the patient receives numerous injuries to different parts of the body: head, chest, abdomen, sprains and ruptures of limb ligaments, hematomas, dislocations of joints, damage to knee joints [1, 2].

Experienced pedestrians on MSPPs most often suffer serious injuries because they have long felt like fish in water on this vehicle. Experienced riders love speed, brake sharply, and perform various pirouettes, which can result in a fall. Most hoverboards or motorcycles can reach speeds of up to 15 km per hour, and some even more. The risk of injury greatly increases self-confidence. Often a person: drives at maximum speed; does not pay attention to pedestrians or vehicles, and as a result may collide with them; turns while driving fast; takes an incorrect, insufficiently stable position on the board; drives while intoxicated (even a small dose of alcohol,



which is not subjectively felt, significantly impairs coordination of movements and the ability to maintain balance); moves on a slippery surface[3].

The question is natural: - a pedestrian moving on a MCPP controls a source of increased danger or not, and MCPP a vehicle or not. Since the appearance of MCPPs, they have been outside the legal field for a relatively long time, causing harm to the health of both pedestrians moving on them and pedestrians with whom a collision occurred. Isolated cases of collisions were considered in the plane of hooliganism. However, in the second half of 2022, almost simultaneously in Russia and the Republic of Belarus, the terms “personal mobility device (hereinafter referred to as PMD)” appeared in the legal field. This is a device or appliance that is not a vehicle (hereinafter referred to as a TS), driven by an engine and intended for individual or joint (in the case of the presence of specially equipped seats) use by pedestrians (electric scooter, gyro scooter, segway, unicycle, etc.) clause 2.601 of the Traffic Regulations [4] and “individual mobility device (hereinafter referred to as SIM)” is a vehicle with one or more wheels (rollers), intended for individual human movement using an engine (engines) (electric scooters, electric skateboards, gyro scooters, segways, unicycles and other similar means) [5]. It should be noted that "other" in the term SPM includes any device or appliance driven by an engine, which a pedestrian uses individually or jointly for his/her movement. At the same time, a pedestrian operating a SPM is not a driver, and the person moving together with him/her is not a passenger. This follows from the thesis that a SPM is not a vehicle. At the same time, a vehicle is a device intended for movement on the road and for the transportation of passengers, cargo or equipment installed on it, paragraph 2.69 of the Traffic Regulations.

If, to reveal the meaning of the term, we substitute the definition of a vehicle into the term SPM, we get: SPM - a device or device that is not (a device intended for driving on the road and for transporting passengers, cargo or equipment installed on it), driven by an engine and intended for individual or joint (in the case of specially equipped seating) use by pedestrians (electric scooter, hoverboard, Segway, unicycle, etc.).

The construction of the definition of the term SPM as a device or device, through the exclusion of the term vehicle, led to the emergence of a contradiction (in the case of substituting the concept of vehicle into the term SPM): at the same time it is a device or device and not a device intended for ... transporting passengers and, at the same time, this is a device ... intended for individual or joint (in the case of specially equipped seating) use by pedestrians. At the same time, the use of SPM involves its movement with the help of an engine, and the presence of specially equipped seating areas so that the pedestrians who sit on them are passengers. At the same time, the pedestrian who drives the SPM is not vested with legal responsibility as a driver.



The construction of the definition of SIM in the traffic rules of the Russian Federation through the term TS is also not without drawbacks, for the following formal reasons. Thus, a vehicle in the traffic rules of the Russian Federation is a device intended for transporting people, goods or equipment installed on it along the roads. If we substitute the definition of a vehicle into the term SIM, we get: SIM is a device designed for transporting people, cargo or equipment installed on it on roads, having one or more wheels (rollers), intended for individual movement of a person using an engine (motors)) (electric scooters, electric skateboards, hoverboards, Segways, unicycles and other similar means) A person riding on a SIM is not a road user because “road participant” is a person directly involved in the process of movement as a driver, pedestrian, passenger of a vehicle, and not a person. If:

- a person driving a SIM driver, then the responsibilities of the driver are fully extended to him, including legal liability;

- A SIM is a vehicle, then it is subject to a list of malfunctions and conditions under which operation of the vehicle is prohibited (annex to the basic provisions for the admission of a vehicle to operation and the responsibilities of officials to ensure road safety) as far as it concerns.

The presence of additional requirements in Section 24 of the Traffic Regulations of the Russian Federation does not mean that a person traveling on a SIM should be guided only by these provisions. It is subject to all the requirements of the Russian Federation Traffic Regulations, as far as they are concerned, but there is ambiguity in the application of a number of points. For example, in the section “traffic controller signals” ... Persons using personal mobility devices for movement must be guided by traffic controller signals for pedestrians. At the same time, clause 24.2 allows the SIM to move along the right edge of the roadway. When driving on a SIM along the edge of the roadway, a pedestrian, as a vehicle driver, must be guided by the traffic controller’s signals for the vehicle, and at the same time, persons using the SIM for movement “must be guided by the traffic controller’s signals for pedestrians.” Note that not all traffic controller permitting signals for the pedestrian and the driver are the same.

The key factor in determining the means of mobility of a pedestrian, as an individual participating in road traffic, is the concept of a vehicle. In one case (traffic regulations of the Russian Federation) the mobility device is classified as a vehicle, and in the other (traffic regulations) it is not, but in both cases there are problematic issues. The way out of the current situation is seen in preserving the essence of the term TS as a device for movement with the exclusion of its features for SIM-SPM as MSPP. Electric scooters, electric skateboards, gyro scooters, segways, unicycles and other similar means of pedestrian mobility do not exclude other



means and devices that, using any engine operating on any physical principle, will allow a pedestrian to move (participate in road traffic) at a speed greater than when walking. For example, back in 1976, "seven-league boots" with an internal combustion engine were developed and manufactured at the Ufa Aviation Institute [6]. The described design has neither rollers nor wheels for movement. Thus, it is quite possible to implement a design when a pedestrian participates in road traffic and does not even touch or minimally touches the road surface. The author believes that a careful study of existing patents will provide a wide range of devices that can be classified as SIM-SPM. Tomorrow they may appear on the road and make their negative contribution to the state of road safety.

Taking into account the above, the term SIM-SPM should include the following:

- it is a controlled self-propelled object, specially designed, adapted or used for moving a pedestrian;
- a pedestrian on a SIM-SPM participates in road traffic;
- at the maximum speed of the SIM-SPM, in a collision with a pedestrian, the resulting bodily injuries will not go beyond minor injuries.

The issue of the permitted maximum speed of the SIM-SPM should be considered in the plane of the speed of the pedestrian. Thus, when walking quickly, the average pedestrian takes 120-140 steps per minute, which corresponds to a speed range of 5.6 - 6.5 km / h. The speed advantage of a pedestrian moving on a SIM-SPM, taking into account safety requirements in a collision, should not exceed 1.5-1.75 times. Thus, it is advisable to set the speed limit at about 10 - 12 km / h.

As for SIM-SPM that are used by pedestrians together (in the case of specially equipped places for sitting), it is necessary to consider such a parameter as the power of the drive electric motor. Currently, the power of the electric motor installed on the SIM-SPM fluctuates in a wide range: from several hundred to a thousand watts or more. At the same time, the minimum power in the long-term load mode (more than 0.25 kW) is defined only for a moped, paragraph 2.27 of the Traffic Regulations. A power of 250 W can be defined as the upper limit for vehicles equipped with an electric motor. This category will include bicycles with an electric motor and SIM-SPM. Taking into account the proposed upper speed limit for SIM-SPM of 12 km/h, a speed range for bicycles equipped with an electric motor can be justified as 12-25 km/h.

Thus, the term SIM-SPM can be stated in the following wording: - this is a controlled self-propelled (using any engine) object, specially designed, adapted or used to move a pedestrian



participating in road traffic at a speed of no more than 12 km/h. If equipped with an electric motor, the rated maximum power in continuous load mode is up to 250 W.

As for vehicles that go beyond the speed limits established in the definition of the term for SIM-SPM, including electric bicycles, their classification is necessary by analogy with the classification of vehicles. Depending on the degree of harm caused and the severity of the consequences when participating in SIM-SPM traffic, a certain part of them can be classified as vehicles with all the ensuing consequences for their design. So, if the maximum speed is:

- up to 12 km/h and the rated maximum power in continuous load mode up to 250 W should be classified as SIM-SPM;
- up to 25 km/h and rated maximum power in continuous load mode up to 250 W should be classified as bicycles;
- up to 50 km/h – for mopeds, clause 2.27 of the SDA, regardless of the type of engine;
- 50 km/h and above – for motorcycles, clause 2.28 of the Traffic Regulations, regardless of the type of engine.

SIM-SPM for sports and other special purposes, which should not participate in road traffic, can be classified into a separate class.

Decisions

As for the classification of SIM-SPM as a source of increased danger, by default the driver of the vehicle is considered and treated as a person managing a source of increased danger. However, the current legislation does not define the term “source of increased danger.” There is only a “source of increased danger to the environment” [7]. Analysis of this term allows us to identify key points in its definition: these are objects of activity; objects carrying out activities; objects with a high level of potential danger.

In the legislation of the Russian Federation [8], a source of increased danger is recognized as any activity, the implementation of which creates an increased likelihood of causing harm due to the impossibility of full control over it by a person, as well as activities for the use, ... and other objects of production, economic or other purposes, having the same properties. From the definition of the owner of a source of increased danger, which is understood as a legal entity or citizen who uses it (a source of increased danger) by virtue of their property rights, the right of economic management, operational management or on other legal grounds (for example, under a lease, rental agreement, by proxy for the right to drive a vehicle, by virtue of an order from the relevant authority to transfer to him a source of increased danger)” [9] it follows that: the vehicle is a source of increased danger.



Conclusion

The term “harm” means injury or damage to human health, equipment or the environment [10,11], and probability is a quantitative measure of the possibility that a certain random event will occur. Trauma is traumatic damage: wounds, bruises, sprains, broken bones, dislocated joints.

The analysis shows that the source of increased danger is an object that creates an increased likelihood of causing harm due to the impossibility of complete human control over it, and this is not only the vehicle. SIM-SPM, as a MSPP, undoubtedly fully meets the stated criteria: there is no complete control on the part of the pedestrian; Even at speeds up to 12 km/h, damage is caused. A pedestrian does not undergo a medical examination to participate in road traffic and does not receive (after training) the right to drive a SIM-SPM. The amount of harm depends on the object with which the collision occurred (a child pedestrian, an elderly pedestrian, or other objects) and the mechanism of the collision itself.

In relation to road traffic, a source of increased danger should be understood as: an object (not only a vehicle) that creates an increased likelihood (the possibility of what will happen) of causing injury (wounds, bruises, sprains, broken bones, dislocated joints), due to the impossibility full control over it by the road user [12-14].

To summarize the above, we note that: in the legal field, it is advisable to consider SIM-SPM as a controlled self-propelled object (if equipped with an electric motor with a rated maximum power in continuous load mode of no more than 250 W), specially designed, adapted or used to move a pedestrian participating in road traffic at a speed of no more than 12 km/h, while it creates an increased likelihood of causing injury due to the inability of the pedestrian to fully control it.

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Influence Of Physical Properties Of Gas Condensates (Gc) On Fuel Supply Parameters And Diesel Performance

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Abstract: The article presents an analysis of the use of GC with unchanged fuel supply control bodies, which leads to some reduction in energy indicators. To obtain the calculated (nominal) indicators of diesel, it is necessary to adjust the fuel supply and set the optimal injection advance angle. It is established that, firstly, there is a certain relationship between the injection parameters and the physical properties of heavy gas condensates, and secondly, dependencies are proposed for predicting the energy and economic indicators of diesel taking into account the physical properties of heavy gas condensates.

Keywords: Gas condensate (GC), fuel supply, diesel, fuel, fuel equipment, density, kinematic and dynamic viscosity, compressibility, compressibility coefficients, correlation relationship, pressure, temperature, fuel supply advance angle, cyclic supply, two-position stop, injection, rotation frequency, surface tension, load, mixture formation, combustion, rigidity of the working process, average indicator pressure, hourly fuel consumption, exponents, rack, physical properties, energy indicators, mechanical losses.

The limited experimental data and mathematical relationships on the influence of the physical and chemical properties of GC on the fuel supply process do not allow a full assessment of the efficiency of GC of various deposits and make it difficult to establish patterns of change in the main indicators of the diesel engine operating process. Studies of fuel equipment when operating on various fuels have shown [1,3] that when switching from diesel fuel to lighter fuel, significant changes are observed in the fuel supply process, due to a decrease in density and viscosity, as well as an increase in compressibility.

Studies of the properties of various fuels have shown that their main physical parameters: density ρ_f , viscosity ν_f , surface tension σ_f and compressibility β_f are in a correlation relationship. For diesel fuels, dependencies of the type $\nu_f = f(\rho_f)$ and $\beta_f = f(\rho_{f0})$ are known.

As is known, during diesel operation, the fuel, flowing through the fuel supply system, is exposed to high variable pressures and temperatures.

The density and viscosity of the fuel decreases when heated, and its compressibility increases. Increasing the pressure has the opposite effect: viscosity and density increase, and the compressibility coefficient decreases.

There is currently virtually no data on the effect of fuel temperature on the true compressibility coefficient. The effect of temperature on density can be expressed by the formula:

$$\rho_p = \rho_o - 10^{-4}(18-13v_o) (t - t_o). \quad (1)$$

It is practically impossible to estimate the influence of pressure p on the change in density experimentally, but it can be estimated theoretically using the equation:

$$\rho_p = \rho_o e^{\int_0^p \beta dp} \text{ or } \rho_p = \rho_o + \frac{40}{10^6 \rho_o^3} \cdot P. \quad (2)$$

The influence of fuel temperature on its viscosity is assessed using the expression:

$$v_t = v_o + (1,1v_o - 0,3) (1,3 - \lg t), \quad (3)$$

where v_o - kinematic viscosity of fuel at 20°C, sSt.

In the work of A.A. Abdurakhmanov [2], the dependence of viscosity change on pressure is given for various GCs of Central Asia at different fuel temperature values (see Fig. 1).

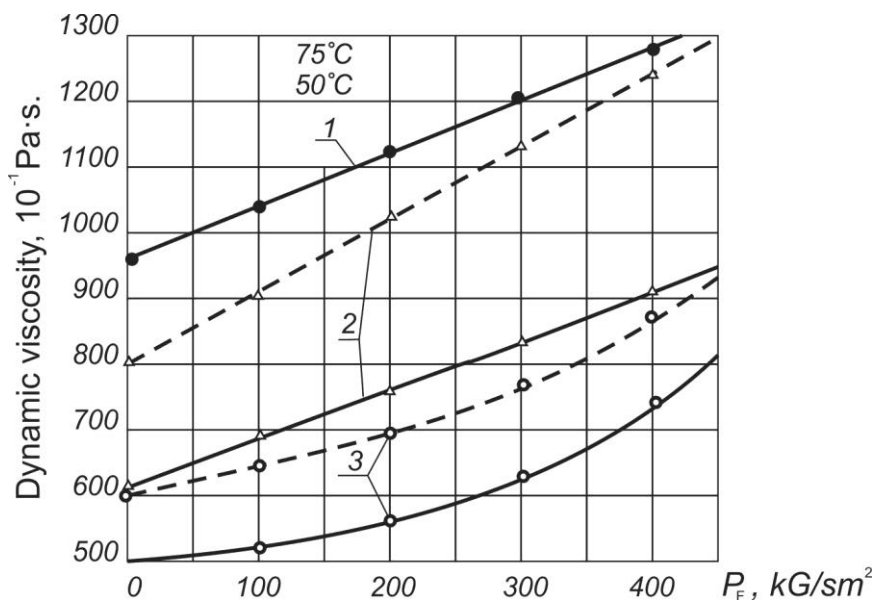


Fig.1. Effect of pressure and temperature on dynamic viscosity of fuels: 1 - diesel fuel; 2 - Shatlyk gas condensate; 3 - Achak gas condensate



At present, in order to recommend GC of a new field as diesel fuel (or a mixture of GC with diesel fuel), it is necessary to conduct deep and long-term studies in laboratory conditions, on non-motorized and motorized installations. At the same time, the development of a method for calculating the parameters of fuel supply for local types of fuel would significantly reduce the time for non-motorized studies or eliminate them altogether.

As a rule, the combustion process in diesel engines is largely determined by the fuel supply parameters (maximum p_{inj} , average p_{avr} injection pressures and injection duration ϕ_{inj}) and the nature of the air charge movement. In turn, the fuel supply parameters with the existing design of the fuel system depend on the viscosity, density, surface tension and compressibility of the fuels, as well as the speed and load mode of diesel operation.

Adaptation of the fuel system to operation on different types of fuel is mainly determined by the difference in their physical constants (density, compressibility, surface tension and viscosity).

To ensure satisfactory operation on gas condensate and diesel fuel, it is necessary to:

- a) select the optimal fuel feed advance angle;
- b) have a two-position feed stop in order to ensure the same cyclic feed;
- c) increase the fuel pressure in the suction line.

At the same time, theoretical analysis showed that the method for calculating the fuel feed parameters for different types of fuel is identical.

For the existing design of the injection molding machine, when using different fuels, the injection parameters mainly depend on the dynamic viscosity, which takes into account both the viscosity itself and the density of the fuel.

According to our data [3], the difference in the values of the maximum injection pressure between Shatlyk (GC 2) and Achak (GC 1) fuels reaches 4-4.5 MPa, and in the injection duration - 2 degrees, i.e. 14%. However, the difference in kinematic viscosity is $5 \cdot 10^{-6} \text{ m}^2/\text{s}$, i.e. 46% (see Fig. 2), and in density the difference does not exceed 2% (see Fig. 3). Therefore, it is necessary to find a more informative parameter, the influence of which on the fuel supply parameters would be indisputable. In our opinion (at $q_{cf} = \text{const}$), it is dynamic viscosity, i.e. its functions of temperature and pressure [$\mu = f(T, p)$], and compressibility affects mainly the cyclic fuel supply.

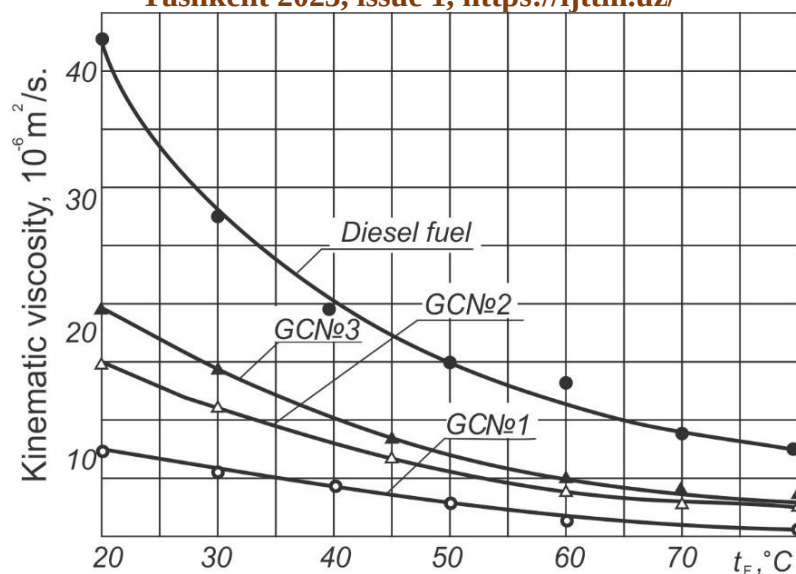


Fig.2. Effect of temperature on the kinematic viscosity of diesel fuel and gas condensates

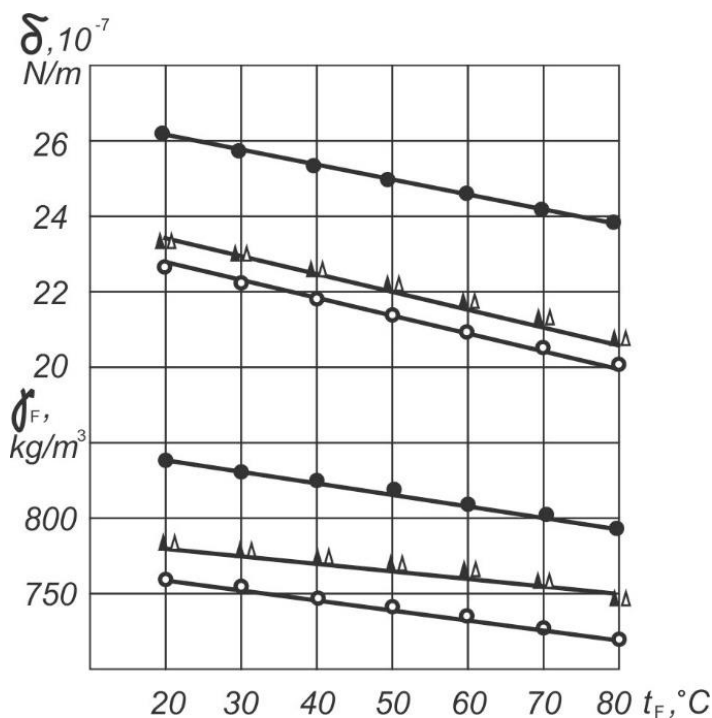


Fig. 3. The influence of temperature of different fuels on their density and surface tension (the designations are the same as in Fig. 2)

The process of fuel supply and combustion of GC depends on many factors, among which we can distinguish adjustable and non-adjustable factors. The first group includes injection pressure and duration, rotation frequency, etc., and the second group includes physical properties of GC (viscosity, compressibility, surface tension, etc.).

Tests conducted with three types of fuel showed that the kinematic viscosities of GC1 and GC2, respectively, are equal to $11,6 \cdot 10^{-6}$ and $17,4 \cdot 10^{-6} \text{ m}^2/\text{s}$, while the viscosity of diesel fuel is significantly higher and equals $43,0 \cdot 10^{-6} \text{ m}^2/\text{s}$. Table 1 below shows the results of measuring the viscosity, density and surface tension for the fuels studied.

Table 1.

Physical properties of the studied fuels

Fuel type	Viscosity $\nu_f, 10^{-6} \text{ m}^2/\text{s}$	Density $\rho_f, \text{ kg/m}^3$	Surface tension $\sigma_f,$ $\text{N/m } 10^{-7}$
DF	43,0	834	26,35
GC 1	11,6	768	23,21
GC 2	17,4	773	23,47
GC 3	20,9	776	23,52

Our experimental data at fixed values of rotation speed n_c and fuel dose q_{fc} show that changing the kinematic viscosity of GC I and GC 2 by 46% (from $11,6 \cdot 10^{-6}$ to $17,4 \cdot 10^{-6}$) causes an insignificant change in the output functions.

Thus, the kinematic viscosity was not informative. On the other hand, the task at hand requires taking into account not the kinematic, but the dynamic viscosity μ_f , which changes depending on the fuel temperature and injection pressure. The studies in this paper have established that the fuel temperature in the pump reaches $75-80^\circ\text{C}$. Therefore, the data from [3] at $t = 75^\circ\text{C}$ were used for the calculation (see Fig. 1).

The purpose of this study is to establish the relationship between the dynamic viscosity μ_f and the pressure p at $t = \text{const}$. It is necessary to find the exact relationship in the form of first- and second-order regression plans:

$$\mu_f = \beta_0 + \beta_1 P + \beta_2 P^2 \quad (4)$$

Finding the unknown coefficients in these equations is carried out using the least squares method.

The final equation for diesel fuel has the following form:

where p - fuel pressure, MPa.

When establishing the relationship between dynamic viscosity and pressure for gas condensate of the Achak field, the approximation of experimental data to the linear plan turned out to be unsatisfactory, and to the second-order regression plan - very good.

The equation for the dynamic viscosity of gas condensate GC1 has the form:

$$\mu_f = 0,04908 + 1,5789 \cdot 10^{-4} p + 1,2084 \cdot 10^{-5} p^2. \quad (6)$$

The relationship between the dynamic viscosity of GC2 and pressure is as follows:

$$\mu_f = 0,06017 + 8,0257 \cdot 10^{-4} p \quad (7)$$

Equations (5-6-7) allow replacing kinematic viscosity with a more informative parameter, i.e. dynamic viscosity μ_f .

Thus, regression equations are derived for determining dynamic viscosity at $t=const$ for various fuels.

Performance of the diesel engine operating cycle using GC

Indicator values. The average indicator pressure of a diesel cycle when using a GC depends on:

- the cyclic fuel supply, i.e. on the load;
- organization of the process of mixture formation and combustion, since the air consumption G_{air} , its density ρ_o and filling coefficient η_v for a specific engine design remain unchanged. Therefore, the average effective pressure is a function:

$$p_i^{GC} = f(\eta_i^{GC} H_u^{GC} G_f^{GC}). \quad (8)$$

Research shows that GCs have 2-3% higher H_u values compared to DF. In addition, due to improved fineness of atomization, mixture formation and combustion are improved, and this provides some increase in the η_i value. However, this is achieved with increased rigidity of the diesel engine operating process, since when using GCs, the ignition delay period increases. To

achieve softer operation, it is advisable to change the injection advance angle, and in this case, the η_i value is somewhat reduced. Therefore, for engineering calculations, the average indicator pressure (when using GCs) can be estimated with sufficient accuracy using the following expression:

$$p_i^{GC} = p_i^{df} \cdot \frac{\eta_i^{GC} H_u^{GC} G_F^{GC}}{\eta_i^{df} H_u^{df} G_f^{df}}. \quad (9)$$

The change in hourly fuel consumption or cyclic supply when using GC, taking into account their physical properties, can be written as:

$$G_f^{GC} = G_f^{df} \sqrt{\left(\frac{\beta^{df}}{\beta^{GC}} \cdot \frac{v_f^{df}}{v_f^{GC}}\right)^y} \sqrt{\frac{\rho_f^{GC}}{\rho_f^{df}} \cdot \left(\frac{v_f^{df}}{v_f^{GC}}\right)^x}, \quad (10)$$

where v_f^{GC}, v_f^{df} и ρ_f^{GC}, ρ_f^{df} - kinematic viscosities and densities of GC and DF;

x, y - exponents;

β^{df}, β^{GC} - compressibility coefficients of diesel fuel (df) and GC.

Formula (10) shows that when using the GC, the constant position of the rack ($h_r = const$) significantly affects the change in hourly fuel consumption due to their physical properties

It should be noted that when the same cyclic fuel supply is provided to the df and GC, the diesel engine energy indicators remain virtually unchanged. In the final form, for the case of using GC, the average indicator pressure can be estimated using the formula:

$$p_i^{GC} \simeq p_i^{df} \frac{G_f^{GC}}{G_f^{df}}. \quad (11)$$

Effective indicators. It should be noted that the use of GC does not affect the power of mechanical losses N_m . Therefore, all the reasoning that was given for indicator indicators is also valid for effective indicators.



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