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Methodological instructions to laboratory work from the discipline  
«Exploitative materials» full-time students in the specialty 274 «Motor  
vehicle transport» by educational and qualification level – bachelor.

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Methodological instructions are intended for the methodological support of laboratory classes of applicants when studying the discipline «Exploitative materials» for bachelors of specialty 274 «Motor vehicle transport» of all forms of study.

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## **GENERAL INSTRUCTIONS**

Methodical instructions are intended for methodical provision of laboratory classes for students of existing forms of education in areas 6.070106, 6.050503, 6.010104.

Conducting classes is aimed at ensuring consolidation of theoretical knowledge obtained within the course of lectures "Operational materials".

The works are performed by students of all forms of education according to the work plans and the volume of the study load in the laboratory of the department of technical operation and service of cars. The labor intensity of completing each work in its entirety is 2 study hours, the amount of laboratory work can be adjusted by the teacher who conducts the class.

Each work is performed by a group of 5-6 students. The completed work is protected by each student individually.

## **Laboratory work No. 1**

### **DIAGNOSING FUEL QUALITY AND DETERMINING OCTANE NUMBERS**

#### **The purpose of the work**

Consolidate the acquired theoretical knowledge about the detonation resistance of automobile gasoline; familiarize yourself with the methods of determining the octane numbers of gasoline on the UIT-65 installation and give a quantitative assessment of their application for engines with the appropriate compression ratio.

#### **Equipment and materials**

1. Installation of UIT-65 with a set of tools.
2. Barometer.
3. Measuring flasks with a capacity of 250, 500 and 1000 ml.
4. Gasoline B-70.
5. Control fuel.
6. Reference fuels.
7. Tested gasoline.
8. Wiping materials.

The content of the work



11-oil temperature indicator; 12-regulator for heating the mixture; 13-mixture heating switch; 14-button "Start"; 15-button "Stop"; 16-oil heating switch; 17, 18, 19, 20 - power-on indication lamps; 21, 22-diagnostic connectors; 23-knob of rough adjustment; 24-knob of fine adjustment; 25-switch "Time constant"; 26-switch "Range", 27-tumbler "Network"; 28-tumbler "Oud"

Before performing the work, prepare control fuel (Table 1.1) with a nominal octane number close to the expected octane number of the fuel intended for testing in the fume hood. Prepare two reference fuels by direct mixing of n-heptane (GOST 25828) and isooctane (GOST 12433), differing by two octane units. For example, if the expected octane number of the tested fuel by the motor method is equal to 82, the control fuel should be chosen with  $OЧ = 81.7$ , and two reference mixtures with  $OЧ = 82$  and  $OЧ = 84$ .

### **1. Inspection of the UIT-65 installation on control fuel**

Check the installation using the control fuel prepared according to Table 1.1. Drain B-70 gasoline from the fuel tank, which is used to warm up the engine, and fill in control fuel.

Move the carburetor needle to each of the "1, 2, 3" positions and adjust the fuel level in fuel tanks 1, 2, and 3 using the measuring glass of the float chamber.

Having set the control fuel level to the maximum intensity of detonation, by changing the compression ratio, bring the detonation indicator reading to  $55 \pm 3$  divisions, recording the compression ratio indicator indicators. The resulting compression ratio remains unchanged during the entire subsequent test of the control fuel.

In order to check the correct setting of the compression ratio to the standard intensity of detonation, the ignition must be turned off. If the engine stops immediately, then the installation is prepared for the fuel test.

After warming up and adjusting the fuel level, start determining the degree of detonation during the operation of the installation on control and reference fuels. By turning the handwheel, set the carburetor tap to the appropriate position: "1" - control fuel; "2" - reference fuel #1; "3" - reference fuel No. 2 and turning on the "UD sensor" toggle switch, fix the maximum deviation of the arrow.

Based on the obtained value of detonation levels on the corresponding fuels, calculate the octane number of the control fuel according to formula 1.

The installation is capable of further testing if the obtained octane number of the control fuel corresponds to that indicated in table 1.2.

If the deviation of the octane number of the control fuel exceeds  $\pm 0.5$  octane unit, it is necessary to check the condition and mode of adjustment of the engine, equipment and check the composition of the reference mixtures.

## 2. Determination of the octane number of the tested gasoline

Pour the tested gasoline into tank No. 1, having previously disposed of the control fuel.

Adjust the composition of the fuel-air mixture to the maximum intensity of detonation. Having set the level of the tested gasoline and changing the degree of compression, bring the value of the detonation indicator to 55 divisions. The degree of compression obtained at the same time remains unchanged throughout the cycle of further testing of gasoline.

Compare the gasoline under study with mixtures of reference fuels. By switching the carburetor valve sequentially to the second and third tanks, similarly to the method described above, determine the level of detonation on the corresponding fuels.

If the value of the detonation index on the sample is not between the readings of the reference mixtures or is not equal to the level of one of them, drain the first reference mixture from the carburetor, and instead pour a third reference mixture that differs from the second by no more than two octane units.

Table 1.1 – Methods of determining octane numbers

Test mode	Motor method	Research method
1	2	3
Crankshaft rotation frequency, min-1	900 $\pm$ 9	600 $\pm$ 6
Ignition advance angle, degrees	variable 26° under Art. compression 5	constant 13°
The gap between the electrodes of the candle, mm	19° under Art. compression 7 0.5 $\pm$ 0.1	0,5 $\pm$ 0,1

Continuation of the table. 1.1

1	2	3
The gap between the circuit breaker contacts, mm	0,30±0,05	0,30±0,05
Oil pressure, MPa	0,196±0,03	0,196±0,03
Gap between valve rods and rocker arms, mm	0,20±0,05	0,20±0,05
Oil temperature in the crankcase, oC	333±10	333±10
Coolant temperature, °C	100±2	100±2
The temperature of the air entering the carburetor, oC	50±5	50±5
Temperature of the fuel-air mixture, oC	149±1	does not heat up

Table 1.2 – Control fuels

Control fuel number	Volume fraction of components, %			Nominal octane number (deviation ±0.5)
	Toluene	N-heptane	Isooctane	
1	58	42	0	67,1
2	62	38	0	71,1
3	68	32	0	76,9
4	74	26	0	81,7
5	74	21	5	85,4
6	74	14	12	90,5
7	74	8	18	95,6
8	74	4	22	99,1
9	74	0	26	100,9

If the values of the detonation index on the sample are between the values of the reference fuels, calculate the value of the octane number of the sample using the obtained detonation indicators according to formula 1.

When switching the engine from one fuel to another, wait at least 1 minute to ensure stable engine operation.

### 3. Processing of research results

Based on the obtained value of detonation levels on the corresponding fuels, determine the arithmetic average value of detonation of each fuel. Based on the average value, calculate the octane numbers of the control and tested fuels according to the formula

where  $O_{\text{com}}$  is the octane number of the tested fuel;

$O_1$  – octane number of reference fuel No. 1, which detonates more strongly than the tested fuel;

$O_2$  – octane number of reference fuel No. 2, which detonates weaker than the tested fuel;

$a$  - average arithmetic value of the detonation level of the tested fuel;

$a_1$  is the average arithmetic value of the detonation level of reference fuel No. 1;

$a_2$  is the average arithmetic value of the detonation level of reference fuel No. 2.

An example of calculating the octane number of fuel.

Let's assume that control fuel KP No. 3 from table 1.2 with  $O_{\text{C}} = 81.7$  was taken. Reference fuel mixtures were composed of SEP No. 1 with  $O_{\text{C}} = 81$  and SEP No. 2 with  $O_{\text{C}} = 83$ . The following levels of detonation were obtained:

KP #3	SEP #1	SEP #2
55	61	41
56	61	41
54	61	41
56	61	41

54            61            41

average 55    average 61    average 41

Then the octane number of control fuel No. 3 according to the test results is:

$$O\check{C}_{K\Pi N_3} = 81 + (83 - 81) \cdot \frac{61 - 55}{61 - 41} = 81 + 0,6 = 81,6.$$

Comparing the obtained value of the octane number of control fuel No. 3 with the nominal octane number according to Table 1.2, we come to the conclusion that the deviation from the nominal value is 0.1 units ( $81.7 - 81.6 = 0.1$ ), and this indicates that the installation is operating normally.

Similarly, formula 1 determines the octane number of the tested gasoline, taken directly from the tank or fuel tank of the car.

### **Control questions**

1. What is the octane number of gasoline and what does it depend on?
2. What are the ways to increase the detonation resistance of gasoline?
3. What is the essence of motor and research methods for determining octane numbers of gasoline?
4. In what cases is it advisable to use motor or research methods for determining the octane number of gasoline?
5. Which groups of hydrocarbons have high detonation resistance?
6. How is the sensitivity of gasoline to the operating mode of the engine determined?
7. What characterizes the hardness of gasoline?
8. How does the actual octane number differ from the road octane number?
9. Does the octane number change during long-term storage of gasoline?
10. Does the value of the octane number affect the reliability, durability and economy of the engine?

Literature [18, 19]

## **Laboratory work 2**

### **DETERMINATION OF THE FRACTIONAL COMPOSITION OF GASOLINE**

The purpose of the work

Familiarize yourself with the method of determining the fractional composition of fuel according to GOST 2177 (ISO 3405), providing an assessment of the influence of individual fractions of gasoline on the operation of the engine.

#### **Equipment, reagents and materials**

1. A device for dispersing petroleum products.
2. Flask heater with rheostat.
3. Measuring cylinder with a capacity of 100 ml.
4. Measuring cylinder with a capacity of 10 ml.
5. TYN4-2 type thermometer with a measurement scale from 0 to 360°C.
6. Asbestos gasket.
7. Kolodius.
8. Fuel sample (100 ml).

#### **General Information**

Before performing the laboratory work, it is necessary to familiarize yourself with the recommended literature, paying special attention to the fuel properties that affect the trouble-free operation of the engine.

Tasks of work: carry out acceleration of gasoline; determine the characteristic points of the fractional composition, type and brand of fuel, comparing the obtained results with the requirements of DSTU 4839:2007; to give an operational assessment by fuel fractions; give a

conclusion about its use in the engine and about the influence of the fractional composition on fuel consumption and engine wear.

Gasoline is a mixture of hydrocarbons, which are characterized by different volatilities. Evaporation characterizes the speed and completeness of the transition of gasoline from a liquid to a vapor state and is determined by its chemical composition. Gasoline, as a complex mixture of various hydrocarbons, boils not at one constant temperature, but in a wide range of temperatures (30...215 °C). The volatility of gasoline is estimated according to the temperature limits of its boiling points and the boiling points of its individual parts - fractions.

Fractional composition is the main indicator of volatilization of automobile gasoline, the most important characteristic of its quality. The ease of starting the engine, its warm-up time, fuel efficiency and other performance indicators depend on the fractional composition of gasoline.

In fig. 2.1 shows the acceleration curve of gasoline and indicates its main fractions - starting, working and final. The starting fraction of gasoline consists of the lowest boiling hydrocarbons (the first 10% of the distillate volume). The working fraction includes distillates from 10 to 90% of the volume, and the final fraction - from 90% of the volume to the end of gasoline boiling. According to DSTU 4063-2001, the fractional composition of gasoline is standardized by five characteristic temperatures: the beginning of distillation, the distillation of 10%, 50 and 90% of the volume and the end of boiling.

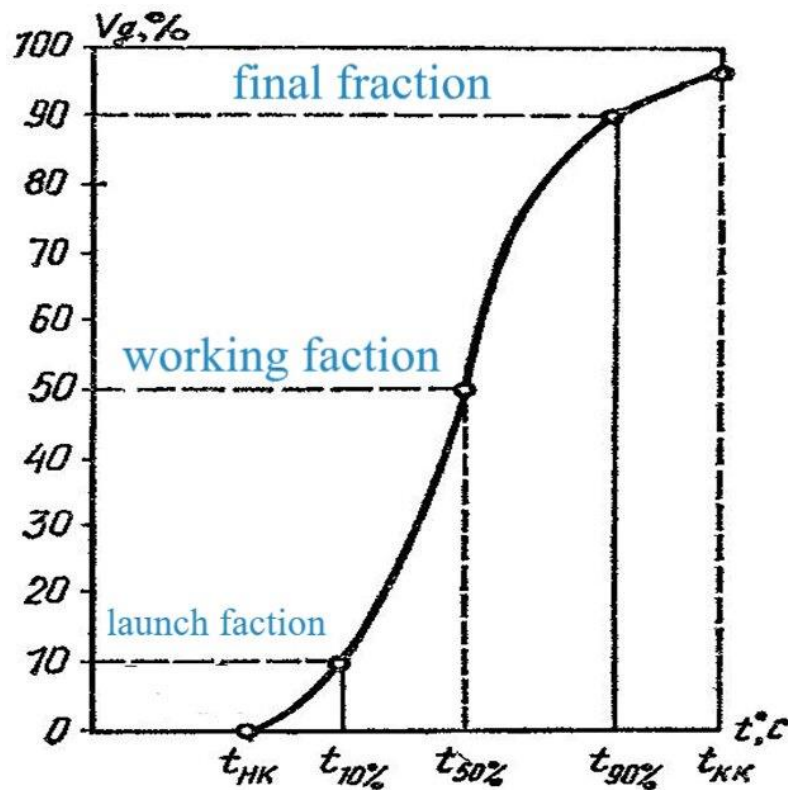


Figure 2.1 – Gasoline acceleration curve

The fractional composition of gasoline should be such as to ensure a good start of the engine and quick acceleration of the car, low specific fuel consumption, uniform qualitative and quantitative distribution of the combustible mixture in the engine cylinders, minimal wear of pistons and cylinders.

The temperatures of the start of distillation and the distillation of 10% gasoline characterize the starting properties of the fuel. If there are not enough low-boiling fractions in the gasoline, then when starting a cold engine, part of the gasoline does not have time to evaporate and enters the cylinders in a liquid state. The combustible mixture turns out to be too lean, it does not ignite from an electric spark and the engine cannot be started. Liquid gasoline in the cylinders washes away the lubrication, and in the engine crankcase it dilutes the engine oil. Therefore, at the moment of start-up and during the subsequent warm-up, friction of the parts of the cylinder-piston group without a sufficient amount of lubricant is observed. The lubricant is not enough to form a strong film on the surfaces of the parts. In this case, the frictional parts of the engine, the so-called starters, wear out, the extent of which

depends on the amount of gasoline that has not evaporated, the duration of the start-up, engine warm-up and the speed of recovery of the oil film on the cylinders. The shorter the evaporation time of gasoline in the engine intake system, the longer the start-up and the worse the supply of lubricant to the friction parts, the greater the start-up wear.

The content of low-boiling hydrocarbons in modern automobile gasoline is controlled by three indicators: the temperature of the start of distillation, the distillation temperature of 10% gasoline, and the pressure of saturated vapors.

According to the current standard DSTU 4839:2007, the temperature at which the distillation of automobile gasoline begins is not regulated (but it should not be lower than 30 °C), and at a temperature of 70 °C, gasoline must be distilled within 20-50%. Thanks to this, the start of a cold engine is ensured on gasoline at an ambient air temperature above -10 °C. The appearance of steam plugs under these conditions is practically impossible.

Warming up of the engine lasts from the time of starting to the time of establishing a stable operating mode. At the end of the warm-up in idle mode, almost complete evaporation of gasoline in the intake pipeline is achieved. The lighter the fractional composition and the lower the distillation temperature of 50% gasoline, the faster the engine warms up. Gasoline with a low distillation temperature evaporates 50% faster in the intake pipeline, filling the cylinder with a combustible mixture improves, and engine power increases. At a low temperature of the surrounding air, it is necessary to use gasoline with a low distillation temperature of 50% of the fuel.

Capacitance is the property of the engine in a warm state under load to quickly go from a low rotation frequency to a higher one when the throttle is suddenly opened. To ensure good engine reception, it is necessary that the engine cylinders be filled with an enriched fuel mixture at the moment of throttling. When the throttle valve is suddenly opened, a larger portion of cold air and liquid gasoline enters the intake pipeline, which leads to a sharp deterioration in the conditions of vaporization due to a lack of heat for complete vaporization of the fuel.

If gasoline has a high distillation temperature of 50% of the fuel, then some part of the high-boiling hydrocarbons that make up the working fraction of the fuel does not have time to evaporate in the power system. In this case, the fuel mixture is too lean, and the engine is unable to reach a high rotational speed of the crankshaft and may even stop.

It takes some time to restore the thermal regime of the engine power system. Thermal equilibrium is established faster, the better the process of evaporation and mixture formation, the more low-boiling hydrocarbons in gasoline. Therefore, the efficiency of the engine largely depends on the temperature of distillation of 50% of gasoline. As this temperature decreases, handling improves and the car's acceleration time decreases. The optimal acceleration of the car is observed under the condition of such evaporation of gasoline, which creates a combustible mixture of air and fuel vapor in the ratio of 12:1.

If the evaporation of gasoline is worse, and therefore the distillation temperature of 50% of the fuel is higher, then a lean mixture will be formed and the acceleration time of the car will increase.

The distillation temperature of 50% gasoline should not exceed 120°C. At such temperatures, a quick warm-up and good engine reception are ensured during the operation of the car.

The temperatures of distillation of 90% and the end of boiling of gasoline characterize the completeness of its vaporization. If the gasoline contains a lot of high-boiling hydrocarbons, then the engine operating conditions are similar to the conditions of starting a cold engine on gasoline with a low distillation start temperature. High-boiling hydrocarbons do not evaporate in the intake pipe of the engine and enter the cylinders as a liquid. Some of it evaporates and burns, and the remaining part flows down the walls of the cylinder and washes the lubricant from them. Getting into the engine crankcase, heavy fractions of gasoline dilute the oil and reduce its viscosity. In those places where the grease has been washed away, there is friction without lubricant and increased wear of parts

When using gasoline with a high boiling point, engine wear increases, the amount of deposits on its parts increases, and fuel consumption increases.

The distillation temperature of 90% of fuel for automobile gasoline should not be higher than 190 °C. The boiling point of gasoline must not be higher than 210 C.

According to DSTU 4839:2007, depending on the conditions of use, the volatility classes are established: summer classes - A, B; winter classes - C, D, E, F; transitional classes - C1, D1, E1 F1. The diagram for determining the volatility class of gasoline due to saturated vapor pressure is given in Appendix A (DSTU 4839:2007).

### **The order of work**

Before conducting research, the refrigerator should be filled with water with snow or ice. In the absence of snow or ice, run tap water through the refrigerator at such a speed that its temperature at the outlet of the refrigerator does not exceed 30 °C. Measure the temperature with a TN2 type thermometer.

Having determined with the measuring cylinder 100 ml of the tested fuel, pour it into the flask, keeping the latter in such a position that the outlet tube is directed upwards. Throw 2-3 pieces of porous material (porcelain, fireclay) inside the flask.

After filling flask 1 with gasoline (100 ml), insert a TYN4-2 thermometer into the neck of the flask so that the axis of the thermometer coincides with the axis of the flask, and the top of the mercury ball is at the level of the lower edge of the outlet tube in the place of its solder. After that, put the flask on an asbestos pad and fix the outlet tube in the refrigerator with a cork.

Cover the flask with a protective cover, and place the measuring cylinder under the lower end of the outlet tube of the refrigerator in such a way that the tube enters the cylinder at least 25 mm, but not below the 100 mm mark. After carrying out the specified preparatory operations, proceed directly to the distillation process.

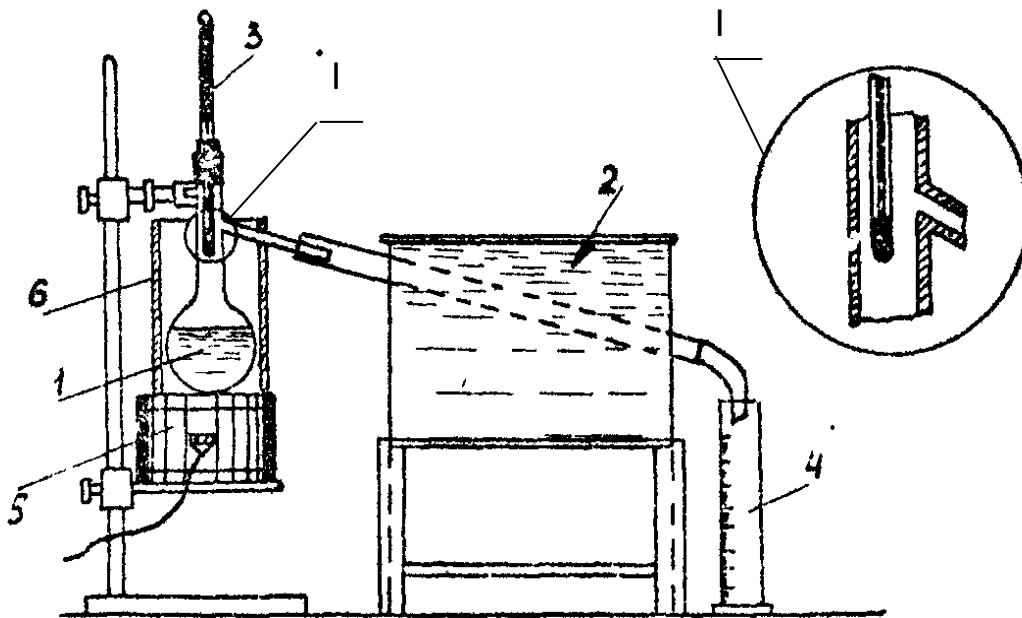


Figure 2.2 – Device for determining the fractional composition of gasoline: 1 - flask with fuel; 2 - refrigerator; 3 - thermometer; 4 - measuring cylinder; 5 - heating device; 6 - protective cover

Distillation should be carried out in the following order:

1. Turn on the heating device. The intensity of heating should be such that the first drop of distillate falls from the refrigerator tube no earlier than after 5...10 minutes.

2. The temperature recorded by the thermometer at the moment of the first drop should be conditionally taken as the temperature at the start of distillation.

3. Carry out further distillation at a speed of 4...5 ml/min, which corresponds to 20...25 drops in 10 seconds. Record readings of the amount of distilled distillate at specified temperatures (70, 100, 150 °C).

4. After distilling 90% of the distillate, adjust the heating of the flask so that 3-5 minutes remain until the end of the distillation. End the race when the mercury column stops. At this point, record the temperature at the end of the distillation, turn off the heating, remove the protective cover and allow the flask to cool for 5 min.

5. After cooling the flask, remove the thermometer and remove the flask from the device. Pour the residue left in the flask into a 10 ml measuring cylinder and measure to the nearest 0.1 ml.

6. Fill in the report based on the distillation results (table 2.1).

7. Compare the obtained results with the indicators of DSTU 4839:2007 and draw a conclusion about the compliance of the fuel sample according to this indicator with the norms of the standard.

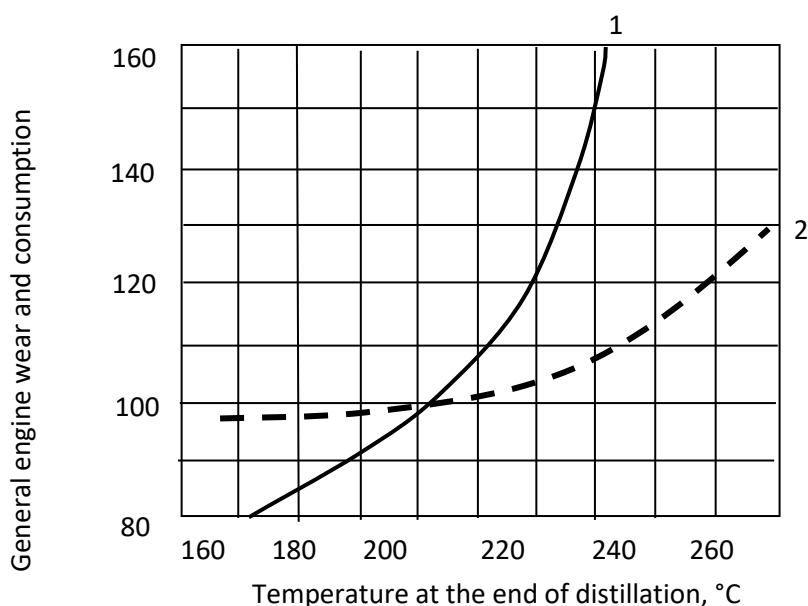


Figure 2.3 – Graph of dependence of engine wear and fuel consumption on temperature at the end of distillation: 1 – engine wear curve; 2 – fuel consumption curve

8. To give an operational assessment of the tested fuel, assessing the dependence of the starting qualities of gasoline, its ability to ensure sufficient engine receptivity, to form steam plugs and to thin the oil in the crankcase, on the values of the characteristic points of the fractional composition.

According to the graph (Fig. 2.3), which determines the dependence of engine wear and fuel consumption on the temperature of the end of gasoline distillation, analyze the operation of the engine on the tested fuel.

Give an assessment of the quality of gasoline, noting what consequences the use of this fuel will lead to in practice.

Table 2.1 – Test protocol

Indexes	The value of the indicator for classes volatility						Sample
	A	B	C/C <sub>1</sub>	D/D <sub>1</sub>	E/E <sub>1</sub>	F/F <sub>1</sub>	
volume of evaporated gasoline, %, at the temperature:							
70 °C	20-48	20-48	22-50	22-50	22-50	22-50	
100 °C	46-71	46-71	46-71	46-71	46-71	46-71	
150 °C, no less than	75	75	75	75	75	75	
the end of gasoline boiling, °C, not higher	210						
the remainder in the flask, %, no more	2,0						

### Control questions

1. What is the purpose of determining the fractional composition of fuel?
2. What points of the fractional composition of gasoline are standardized according to DSTU 4839:2007?
3. How does the fractional composition of the fuel affect the engine's operating mode?
4. Why do different types of gasoline differ in their fractional composition?
5. How does the fractional composition of the fuel change during storage and how does it affect the operation of the engine?
6. How does the fractional composition affect the efficiency of the engine?

Literature [20, 21, 22, 23]

## **Laboratory work 3**

### **MEASUREMENT OF CONCENTRATION LEVEL OF ACTUAL RESINS IN FUEL**

#### **The purpose of the work**

Familiarize yourself with the method of controlling the presence of tarry compounds in fuel according to GOST 1567 and give an estimate of the effect of tarring of fuel on the condition and performance of the engine.

#### **Equipment, reagents and materials**

1. Device for determining the actual POS-77 resins.
2. Analytical scales.
3. Measuring cylinder with a capacity of 25 ml.
4. Desiccator.
5. A thermometer with a measuring scale from 0 °C to 250 °C.
6. Crucible tongs.
7. Vomiting glass.
8. Filter paper according to GOST 12026.
9. Distilled water.
10. Acetone according to GOST 2603 or an alcohol-benzene mixture (1:4).
11. Sodium sulfuric acid according to GOST 4166 is freshly calcined.
12. Fuel sample (100 ml).

## **Content and order of work**

1. Before performing the work, familiarize yourself with the recommended literature, paying special attention to the properties that affect the preservation of the original qualities of the fuel. Familiarize yourself with the principle of operation of the POS-77 device.

Job tasks:

- determine the content of actual resins in the fuel;
- to compare the obtained research results with the normative data of DSTU 4839:2007;
- to determine the type and brand of fuel, making a conclusion about the quality of the fuel, the shelf life and the expediency of its use in the engine.

2. Place the POS-77 device (Fig. 3.1) on a specially equipped place, attach a rubber tube for draining condensate to the refrigerator 8, check the grounding of the device. Connect the device to the network with a voltage of 220 V using the switch 5. Depending on the type of fuel being tested, using the button switch 4 temperature sensors, set the following temperature mode: for gasoline 160 °C, for kerosene 180 °C, for diesel fuel 225 °C. Place the thermometer in the socket when the thermostat is heated to no more than 60 °C. The start time of the test should be considered when the device reaches the specified temperature mode (at this moment the light bulb goes out).

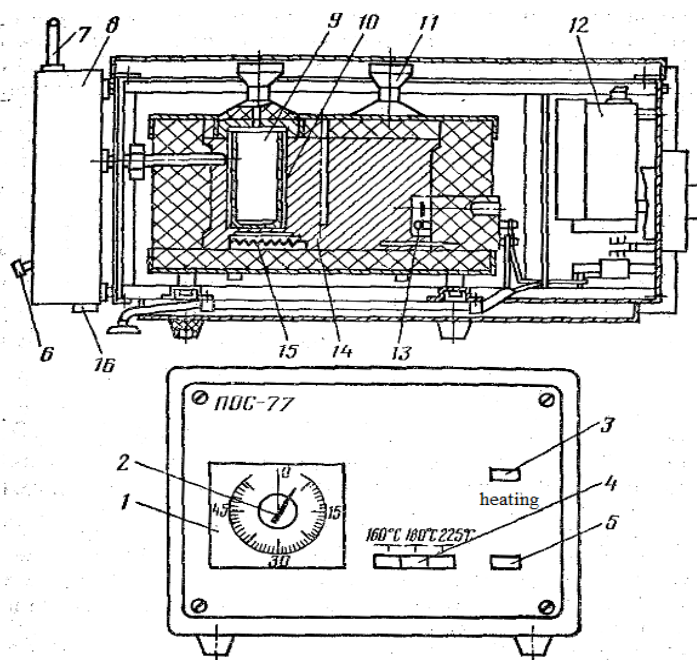


Figure 3.1 – Device for determining actual POS-77 resins: 1 - alarm clock; 2 - alarm clock start handle; 3 - indicator; 4 - temperature sensor switch; 5 - power supply switch; 6 - tube; 7 - tube of the cooler; 8 - refrigerator; 9 - glass for fuel; 10 - pocket; 11 - pocket cover; 12 - electronic thermostat; 13 - temperature sensor; 14 - thermostat; 15 - heater; 16 - cork

Before the test, the glasses 9, designed to determine the actual resins, as well as the lower ends of the tubes supplying steam to the glasses, located on the lids, are thoroughly washed both externally and internally with acetone or an alcohol-benzene mixture. Put the washed glasses 9 in the pocket of the device heated to the test temperature, close with lids 11 and leave for 20 minutes. Then remove the lids and, after 2 minutes, remove the glasses from the pockets with tongs, cool them in the flow for 30...40 minutes in a desiccator, and then weigh them on an analytical balance (with an error of no more than 0.0002 r).

Thoroughly mix and filter the fuel intended for testing. Why install a hole with a paper filter in the measuring cylinder and pour the tested fuel. If there are obvious traces of water in the fuel, it should be mixed with freshly prepared sodium sulfate, shaken for 10-15 minutes and filtered.

After filtering, use a measuring cylinder to measure the fuel into 25 ml glasses of the device. Using a measuring cylinder, measure 25 ml of distilled water and pour into the glasses of the device intended for water.

Put the glasses 9 with fuel and water in the corresponding pockets of the device preheated to a temperature of 160 °C at the same time, close tightly with the lids 11 so that the nipples enter the channels of the lids, and the polished cavities of the lids and pockets hermetically touch each other with one, without passing fuel and water vapors.

Then check the output of the device at the set temperature mode  $t = 160$  °C (the indicator light goes out), start the alarm clock 1 by turning the clock start knob to the right for the time of the three-valve test, which must correspond to the set thermal mode.

Control the maintenance of the thermal regime visually (in the period of a stable temperature regime, the indicator light burns dimly).

After the end of the test time (after the alarm time), unlock the device. Carefully remove the covers of the pockets and, after 2 minutes, use tongs to remove the glasses into which the fuel was poured from the pockets of the device. Cool them in a desiccator for 30...40 minutes, and then weigh them on an analytical balance with an accuracy of 0.0002 g.

After weighing, determine the amount of actual resins present in the fuel both in a dissolved and suspended state (mg per 100 ml of fuel in each cup) according to the formula

$$X_1 = \frac{m_2 - m_1}{V} \cdot 100$$

where  $X_1$  is the amount of actual resins per 100 ml of fuel in the first glass, mg;

$m_1$  – mass of clean, dry first glass, mg;

$m_2$  – mass of the first glass with resins after experience, mg;

$V$  is the volume of fuel poured into the glass during the test, ml.

Carry out a similar calculation for the second resin glass. The content of actual resins in the tested fuel is calculated as the arithmetic mean of parallel tests.

The difference between the results of parallel tests of the content of actual resins should not exceed the values given in table 3.1.

Table 3.1 - Permissible variation in the content of actual resins

Content of actual resins in 100 mol of fuel, mg	Acceptable discrepancy
until 15	2 mg
over 15 to 40	3 mg
over 40 to 100	8% of the lower result
more than 100	15% of the lower result

If as a result of the test, no more than 2 mg of actual resins are obtained in 100 ml of fuel, then it should be assumed that they are absent in the fuel. Compare the obtained results with the requirements of the standard, determine the compliance of the fuel according to these indicators with the requirements of technical standards and evaluate the suitability for use in the engine, as well as for further storage.

Estimate the amount of deposits in the intake system of a car engine depending on the content of actual resins in the fuel (Fig. 3.2).

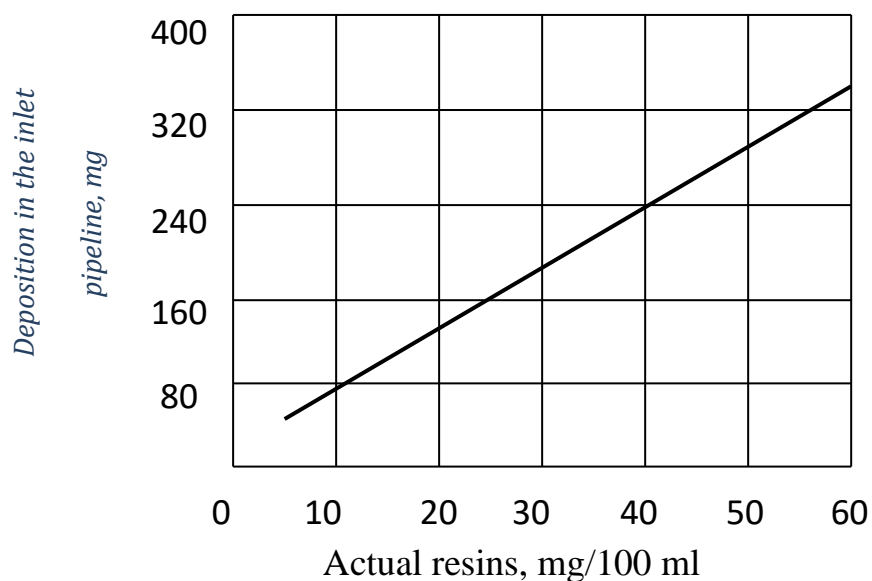


Figure 3.2 – Dependence of the amount of deposits in the engine intake system on the content of actual resins in the fuel

An approximate estimate of the condition of the engine by the number of deposits and the duration of its normal operation, depending on the content of actual resins in the fuel, can be given on the basis of the table. 3.2.

Table 3.2 – Condition and performance of the engine depending on the content of resinous substances in the full.

Content of actual resins, mg per 100 ml	Engine condition after 50 hours of work	Possible mileage of the car before the appearance of malfunctions in the engine due to resins, km
1	2	3
until 10	No deposits are observed in the intake system	Unlimited

Continuation of table 3.2

1	2	3
11 - 15	Faint traces of deposits on the valves and walls of the intake pipeline	not more than 25,000
15 - 20	Small deposits on the walls of the pipeline and on the valves	no more than 16,000
20 - 25	Visible deposits in the power system	no more than 8,000
25 - 30	Significant deposits on the walls of the intake pipeline, as well as on the valves. Reduction of the intake pipeline by 20-25%.	no more than 5,000
50 - 120	Significant deposits on the walls of the power supply system and on the valves. Jets, diffuser and throttle are coated with sticky resin.	no more than 2,000

Give an assessment of the quality of the fuel, assessing the possibility of its use and likely consequences.

### Control questions

1. What chemical processes occur in fuel during its storage?
2. What are the factors of the formation of resin compounds in the engine?
3. How does the group composition of the fuel affect the formation of actual resins?
4. What characterizes the fuel induction period and how is it determined?
5. What factors affect the chemical stability of fuel?
6. How to improve the chemical stability of fuel?
7. What effect do tarry deposits have on engine operation?
8. What is the acceptable value of discrepancies of parallel fuel tests when determining the content of actual resins?
9. What is the maximum content of actual resins permissible in gasoline of different grades?

### Literature [20, 21]

**Laboratory work 4**  
**MEASUREMENT OF KINEMATIC VISCOSITY**  
**OIL PRODUCTS**

**The purpose of the work**

Get acquainted with the methods of determining the viscosity of liquid petroleum products and give an assessment of the influence of viscosity-temperature properties on engine operation.

**Equipment, reagents and materials**

1. Capillary viscometers made of glass with a small coefficient of temperature expansion (for example, borosilicate), which ensure the required accuracy.
2. Viscometers of the types VPZHT-1, VPZHT-2, VPZHT-4, VNZHT according to GOST 10028-81. It is possible to use viscometers of types VZH-1, VZH-2, VZH-4, VZH.
3. Paper filter.
4. Thermometer.
5. Thermostat.
6. Stopwatch.
7. Funnel.
8. Rubber tube.
9. Rubber pear.
10. Glycerin (3 l).
11. Sample of oil product (50 ml).

## Content and order of work

### 1. General provisions

Before carrying out the laboratory work, it is necessary to analyze the influence of engine oil viscosity on the operation and service life of the engine based on the recommended training manuals.

The property of a liquid to resist flow (the movement of one liquid layer relative to another) under the action of an external force is called viscosity (internal friction). Interfere with the movement of layers of liquid molecular adhesion forces.

Viscosity is determined for liquid petroleum products, the shear stress of which is proportional to the rate of deformation, so-called Newtonian liquids. Their viscosity does not depend on the tangential stress and the velocity gradient. Dynamic and kinematic viscosity are distinguished.

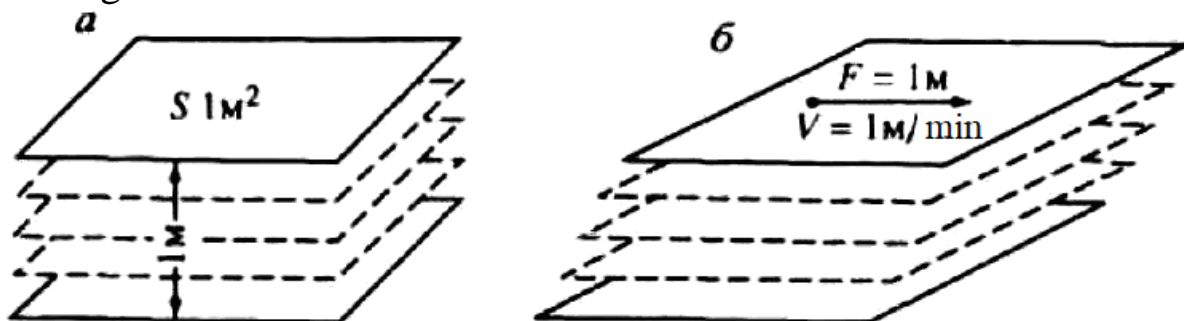


Figure 4.1 – Scheme of mutual movement of liquid layers: a - state of rest; b - the beginning of movement

Dynamic viscosity is a measure of fluid flow resistance. The coefficient of dynamic viscosity is the ratio of the applied tangential stress to the velocity gradient.

The unit of dynamic viscosity in the SI system is the viscosity of a liquid that resists the mutual movement of 1 N of two layers of liquid with an area of 1 m<sup>2</sup> that are 1 m from each other and move at a relative speed of 1 m/ with.

The scheme of mutual movement of liquid layers is shown in fig. 4.1. The unit of dynamic viscosity in the SI system is the pascal-second (Pa\*s). In practice, mPa\*s = 10<sup>-3</sup> Pa\*s, as well as centipoise (cP = mPa\*s) are used.

The dynamic viscosity  $\eta$  is found as the product of the kinematic viscosity of the liquid  $\nu$  by its density  $\rho$  at the same temperature,

$$\eta = \nu \cdot \rho.$$

i.e. kinematic viscosity  $\nu$  is the ratio of dynamic viscosity  $\eta$  of liquid to density  $\rho$  at the same temperature

Kinematic viscosity serves as a measure of fluid resistance to flow under the influence of gravitational forces.

The method of determining kinematic viscosity consists in measuring the time it takes for a certain volume of the tested liquid to flow out under the influence of gravity. The kinematic viscosity is found as the product of the measured flow time and the viscosity constant. In the SI system, the unit of kinematic viscosity is m<sup>2</sup>/s. In practice, another unit is used - mm<sup>2</sup>/s = 10<sup>-6</sup> m<sup>2</sup>/s, as well as centistokes (cSt = mm<sup>2</sup>/s).

Linkevich's viscometer, shown in fig. 4.2, is a V-shaped tube 1, in one leg of which there are two calibrated balls 4, which pass into a capillary tube, and in the other leg - an expanded capacity 5, a wide tube 2 and a diverting process 3.

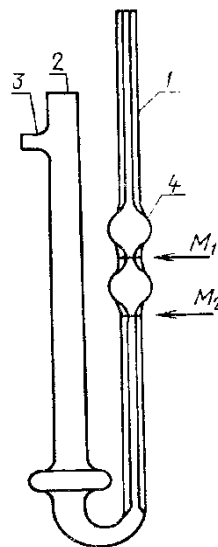


Figure 4.2 - Linkevich viscometer (VPZHT-2, VPZHT-4): 1-V-shaped tube; 2-wide tube; 3-abducted process; 4-calibrated balls; 5-extended capacity; M1 and M2 are the labels of the measuring volume.

Viscometers are produced with different capillary diameters. The higher the viscosity of petroleum products, the larger the diameter of the capillary used.

A passport is attached to each viscometer, which indicates the number of the viscometer, its diameter, constant value  $C$ , expressed in  $\text{mm}^2/\text{s}^2$  (CT). The diameter of the viscometer is chosen so that the time of movement of the liquid is not less than 200 and not more than 600 s. If the constant of the viscometer  $C$  is multiplied by the time  $\tau$  in seconds of the outflow of liquid in the volume, balls, then we have the value of the kinematic viscosity  $\nu$  at the temperature of determination.

A transparent vessel is used as a viscometer thermostat (Fig. 4.3). The oil product in the viscometer is immersed at least 20 mm below the liquid level in the bath and 20 mm above the bottom.

## **2. Conducting research**

2.1 First of all, you should choose a viscometer with measurement limits corresponding to the expected viscosity of the tested oil product. The viscometer must be dry and clean, so between measurements it should be washed with solvents (gasoline solvent for the rubber industry, neutral ether, acetone, toluene, etc. Periodically, the viscometer is washed with a chromium mixture, and then with distilled water, acetone and dried by air

2.2 The oil product sample is filtered through a sieve, glass or paper filter. Sometimes the oil product is dried with anhydrous sodium sulfonate or roasted table salt, and only then filtered through a paper filter. The viscometer is filled with the studied oil product and placed in the thermostat 6 (Fig. 4.3), setting the required temperature.

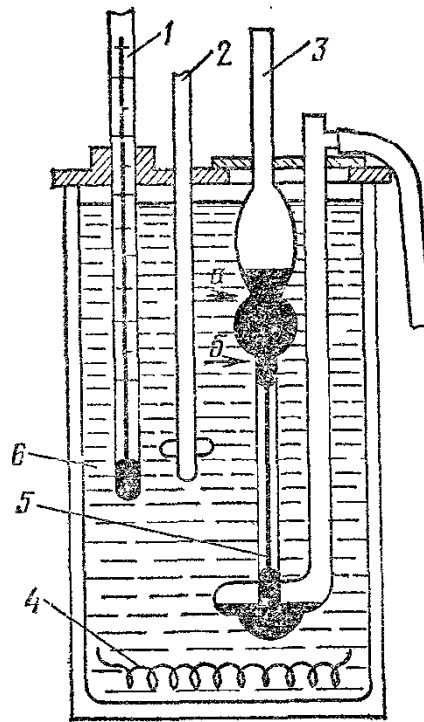


Figure 4.3 – Device for measuring the kinematic viscosity of an oil product:  
 1 – thermometer; 2 – stirrer; 3 – viscometer; 4 – electric heater; 5 – viscometer  
 capillary; 6 – thermostat (bath)

2.3 Filling the thermostat with liquid. The following liquids will be used to fill the thermostat: technical ethyl alcohol for temperatures from -60 to +15 °C; distilled water - for temperatures from 15 to 60 °C; glycerin or a solution of glycerin with water 1:1 or light petroleum oil - for temperatures above 60 °C.

### 3. Measurement of the viscosity of oil products

NOTE. In this work, the viscosity measurement should be carried out for diesel fuel or motor oil according to the instructions of the teacher

3.1 Pour the tested petroleum product (without water or mechanical impurities) into a glass in the amount of 30-40 ml. Fill a dry and clean viscometer with the selected petroleum product, for which a rubber tube should be put on the outlet tube 3 (Fig. 4.3). Next, by pinching elbow 2 with your finger and turning the viscometer over, immerse elbow 1 in a vessel with petroleum product and suck it (with the help of a rubber bulb, a water jet pump, or another method) to the M2 mark, making sure that the liquid does not air bubbles formed.

Remove the viscometer from the vessel, quickly returning it to its normal position. Remove excess liquid from the outside of the end of knee 1 by putting a rubber tube on its end.

3.2 Place the viscometer in the thermostat so that expansion 4 (Fig. 4.3) is below the liquid level.

**WARNING!** When working with a viscometer, you should be careful not to break it. For this, the following rules should be followed:

- when filling and placing the viscometer, it should be held by one knee; on which a rubber tube is put on or taken off;
- prevent air from entering the viscometer;
- when fixing the viscometer in the tripod, tighten the clamp excessively strongly.

3.3 In the thermostat, set and all the time maintain the temperature necessary for the test.

3.4 Keep the viscometer and the studied petroleum product in the thermostat at the specified temperature for 15 minutes.

3.5 Through the rubber tube put on the narrow part of the viscometer, use a pear to inject petroleum product into ball 4 slightly above mark a, making sure that there are no oil product breaks and air bubbles.

3.6 Observing the flow of the petroleum product through capillary 1 into extension 3 (Fig. 4.3), turn on the stopwatch when the liquid level reaches the mark a. Stop the stopwatch when the fuel level reaches the mark b, which is located below the two balls.

3.7 After recording the time of leakage (determined by a stopwatch, with an accuracy of 0.2 seconds), repeat the experience at least twice, that is, get three measurements that should differ by no more than 0.5%.

3.8 On the basis of the three readings obtained, find the arithmetic mean and calculate the kinematic viscosity of the studied petroleum product ( $\nu$ ) in mm<sup>2</sup>/s according to the formula.

$$\nu = C \cdot \tau,$$

where C is a constant viscometer, mm<sup>2</sup>/s<sup>2</sup>;

$\tau$  – the average arithmetic time of the flow of the oil product in the viscometer, p.

3.9 Calculate the value of  $v$  (to the nearest thousandth) and enter the results in the table. 4.1.

Table 4.1 – Results of viscosity measurements of the tested sample

Sample name	Expiry time, s			Average flow time, s	Viscosity, mm <sup>2</sup> /s	Oil product brand according to DSTU
	1	2	3			

3.10 Compare the obtained measurement results with DSTU (Table 4.2, 4.3 depending on the type of oil product), drawing conclusions about its suitability.

Table 4.2 – Indicators of kinematic viscosity of diesel fuel

Indicator	Fuel brand (DSTU 4840:2007)
Kinematic viscosity at 40°C, mm <sup>2</sup> /s	2,0-4,5

Table 4.3 – Viscosity indicators of motor oils

Indexes	Motor oil brands according to SAE J300													
	AZMOL 20W40	AZMOL Super	AZMOL Turbo 2	AZMOL Leader	AZMOL M-2042	AZMOL M-3042	ESSO ULTRA	ESSO ULTRA	ESSO ULTRA	ESSO ULTRA	ESSO ULTRA	ESSO ULTRA	ESSO ULTRA	ESSO ULTRA

Kinematic viscosity, mm <sup>2</sup> /s at 100°C	12,5-16,3	13,5-14,5	14,0-16,3	13,0-16,3	7,5-8,5	10,5-11,5	10,1	14,5
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### Control questions

1. On what factors does the coefficient of liquid friction depend?
2. What is the difference between dynamic, kinematic and conditional viscosity? In what units are they measured?
3. What operational and technical requirements must motor oils and diesel fuels meet?
4. Why should diesel fuel have a certain viscosity?
5. How does the viscosity-temperature characteristic affect the operating properties of petroleum products?
6. How does temperature affect the viscosity of petroleum products?
7. What operational and technical properties of diesel fuel depend on the reliability of its supply to the engine cylinders?
8. By what characteristics are automobile oils classified?

**Literature [20, 21, 22]**

## **Laboratory work No. 5**

### **QUALITATIVE AND QUANTITATIVE CONTROL**

#### **ADDITURE OF WATER IN OIL**

##### **The purpose of the work**

Familiarize yourself with methods of controlling water impurities in oil; provide an estimate of the impact of mechanical impurities on the life of the engine.

##### **Equipment, reagents and materials**

1. Device for determining water in oil (qualitative method).
2. Thermometer up to 200 °C.
3. Chemical test tubes.
4. Heating device.
5. A round-bottomed metal or glass flask with a diameter of 100 mm.
6. Trap receiver.
7. Reverse refrigerator.
8. Heating device.
9. Tripod.
10. Technical and chemical scales.
11. Measuring cylinder 100 ml.
12. Solvent.
13. Kolodius.

##### **The content of the work**

Before performing the laboratory work, it is necessary to familiarize yourself with the recommended literature, paying attention to

the corrosive properties of oils that affect the wear of engine parts, the costs of repair and maintenance of cars. The purpose of the work: to determine the presence of water impurities in the oil, providing a conclusion on the possibility of its use in the engine, on the influence of water on stability, the processes of hydrocarbon oxidation and oil foaming, and on the starting characteristics of the engine.

## 1. Quality control of water in oil

The device (Fig. 5.1) consists of a cylindrical vessel (oil bath) with a lid 1, to the lower part of which a metal circle 2 is attached to the rack. There are two holes in the lid: one of which slightly exceeds the diameter of the test tube, and the other has a smaller diameter (for a thermometer).

The metal circle has holes to ensure stability of the test tube and thermometer. The vessel is filled with any mineral oil that functions as a thermostating medium.

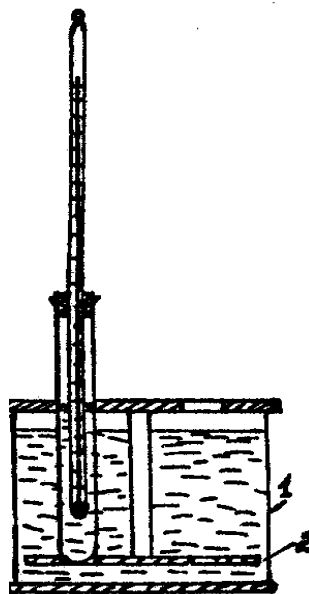


Figure 5.1 – Device for controlling water in oil: 1 - cylindrical vessel; 2 - rack with a metal circle

The thermostatic medium should be heated to a temperature of 175 °C. Pour the tested oil into a dry test tube up to a height of 80-90 mm,

close the test tube with a plug in which a thermometer is inserted. The ball of mercury should stand 20-30 mm from the bottom of the test tube.

Place the tube with the tested oil vertically in the heating bath and wait a few minutes until the temperature of the oil in the tube reaches 150°C.

Signs of the presence of moisture in the oil are cracking and foaming of the oil.

## 2. Quantitative control of water in oil

Weigh about 100 g of the tested oil into a dry flask 2, pre-weighed on technical and chemical balances, add 100 ml of solvent and several pieces of pumice stone. Insert the trap 3 connected to the refrigerator 4 into the flask. All plugs of the device should be filled with collodion, and the upper opening of the refrigerator should be closed with cotton wool (Fig. 5.2).

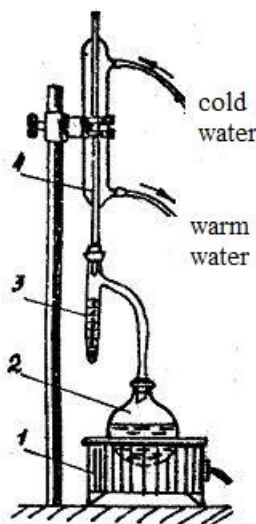


Figure 5.2 – Device for quantitative determination of water in oil:  
1 - heating device; 2 - bulb; 3 - trap; 4 – refrigerator

Turn on the heating device 1, and conduct heating at such a speed that no more than 5 drops per second fall from the refrigerator into the receiver-trap. Stop the distillation when the volume of liquid in the trap stops increasing and the top layer of the solvent becomes transparent.

The duration of distillation should not exceed one hour. The device should be disassembled only after the flask has completely cooled.

Calculate the water content in the oil according to the formula:

$$W = \frac{V \cdot 100}{G},$$

where W is the water content in the oil, %;

V – volume of water in the receiver-trap, ml;

G - mass of oil, g.

The difference between two parallel determinations should not exceed one division near the upper level in the trap receiver.

The amount of water less than 0.03 ml (half of the lower distribution) is considered traces according to the State Standard.

### **Control questions**

1. How does air humidity and temperature affect the solubility of water in oil?
2. Why is the presence of water in oil harmful?
3. In what quantities is the acceptable water content in motor oils?
4. Does humidity and air temperature affect the corrosive properties of oils?
5. What is the component composition of precipitation deposited on the walls of the crankcase tray during engine operation?
6. Does the presence of water affect the service life of engine cylinders?
7. In which zone of the engine cylinders is there increased wear with an increase in the content of water condensate in the oil?
8. What determines the protective properties of oils?
9. How its component composition affects the solubility of water in oil

### **Literature [22]**

## Laboratory work No. 6

### DETERMINATION OF THE DROPLET TEMPERATURE PLASTIC LUBRICATION

#### The purpose of the work

Familiarize yourself with the method of determining the droplet temperature of lubrication according to DST 6793-74 and give an estimate of the influence of this parameter on the operation of the friction unit.

#### Equipment, reagents and materials

1. A special thermometer complete with a capsule.

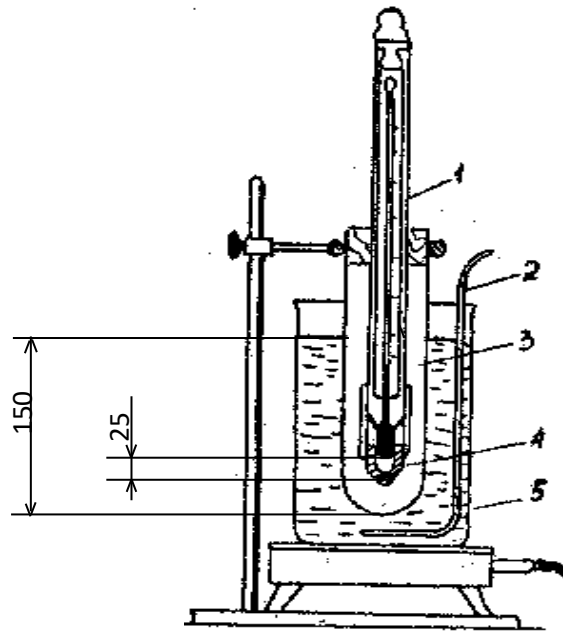


Figure 6.1 – Special thermometer: 1 - thermometer sleeve; 2 - stirrer; 3 - test tube; 4 - capsule; 5 - a glass

2. A glass tube with a diameter of 40-45 mm and a length of 180-200 mm.

3. A glass (chemical) glass with a capacity of 300-500 ml.

4. Spatula.

5. Stopwatch.
6. Tripod.
7. Heating device.
8. Lubrication test.

### **Content and order of work**

Before carrying out laboratory work, it is necessary, on the basis of the recommended literature, to consider the heat resistance of plastic lubrication, which characterizes its performance in friction nodes. The task of the work: to determine the droplet temperature of the lubricant and its brand, to give a conclusion about the quality of the lubricant and the features of its use in friction nodes that ensure reliable lubrication of friction parts.

Remove the capsule 4 from the sleeve of the thermometer 1 and, using a spatula, fill it with the tested lubricant, making sure that no air bubbles get into it. Cut off excess lubrication from the upper part of the capsule with a spatula, insert the capsule into the thermometer sleeve up to the stop on the inner edge. Cut off the excess grease squeezed out by the thermometer ball with a spatula. Place a circle of paper on the bottom of test tube 3, which must be replaced after each measurement (Fig. 6.1). Insert the thermometer with the capsule into the tube so that the lower edge of the capsule is at a distance of 25 mm from the bottom of the tube. Vertically place the test tube in a glass 5 filled with water or glycerin, fix it in a tripod at an immersion depth of about 150 mm.

The liquid in the glass should be heated in two stages. At the first stage, where the heating rate has not yet been standardized, the temperature range is from room temperature to 20 °C for low-melting, up to 60 °C for medium-melting, up to 130 °C for sodium and up to 150 °C for lithium lubricants; at the second stage, the rate of temperature increase in the device should be 1 °C per minute. At both

stages, the liquid in the glass should be periodically stirred with a special stirrer 2.

The temperature at which the first drop of the tested lubricant falls from the lower opening of the capsule during the heating process is the drop temperature. If the lubricant does not form drops, but is drawn out of the capsule in the form of a cylinder, then the temperature at which the output column of the lubricant touches the bottom of the test tube is taken as the droplet temperature. Enter the obtained data in table 6.1 and compare with the requirements of the DST (table 6.2). Give an operational assessment of the tested lubricant.

Table 6.1 – Test protocol

The name of the lubricant	Droplet temperature, °C	The temperature of the friction unit for applying lubrication, °C	Compliance with ISO 6743

Table 6.2 – Standard indicators of brands

<i>Indexes</i>	Lubrication of graphite Zh	Litol-24	AZMOL No. 158	CYATIM 201	ИИРБ-4	ShRB-4	Fiol-2U	AZMOL LIKA (P)
Droplet temperature °C, not lower	76	185	150	175	200	190	185	230
Operating temperature limits, °C	-20... +60	-40... +130	-40... +120	-60... +90	-40... +130	-40... +120	-40... +130	-40... +150

## **Control questions**

1. What characterizes the droplet temperature of a plastic lubricant?
2. According to what criteria are used to classify lubricants.
3. What is the syneresis of plastic lubricants? What properties of lubricants affect it and how are these properties evaluated?
4. What properties of plastic lubricants are called thixotropic? What do they characterize?

## **Literature [21, 22]**

## **Laboratory work No. 7**

### **MEASUREMENT OF THE IGNITION TEMPERATURE OF MOTOR OILS IN AN OPEN crucible**

#### **The purpose of the work**

Get acquainted with the method of measuring the flash point of oil according to GOST 4333, providing an estimate of the influence of the flash point on the operational properties of motor oils.

#### **Equipment, reagents and materials**

1. Metal crucible.
2. Sand bath.
3. Thermometer.
4. Template.
5. Motor oil.

#### **Content and order of work**

Before carrying out laboratory work on the basis of the recommended literature, analyze the influence of the flash point of the oil on its consumption. The task of the work: control the flash point of the oil, determine the type and brand of oil, compare the obtained data with the requirements of the standards, give a conclusion about the possibilities of using the selected oil in a car engine.

Place the device (Fig. 7.1), consisting of a tripod 1, a sand bath 2, and a crucible 3 in a fume hood. Place the template on the crucible and pour the tested fuel to the appropriate level. Place the crucible in a sand bath so that the sand is at the same level as the oil in the crucible. Place a thermometer in the oil. 4. Heat the sand bath at a rate of rise of the oil temperature up to 10°C per minute.

40 °C before the expected flash temperature, reduce the heating rate to 4 °C per minute; at 10 °C, every 2 °C, conduct along the edges of the crucible (parallel to the surface of the oil) with the flame of the ignition device. The moment of flash should be considered the appearance of a blue flame above the surface of the tested product. The error of the experiment should not exceed 2 °C (Table 7.1).

Compare the experimental results with the indicators of the standard.

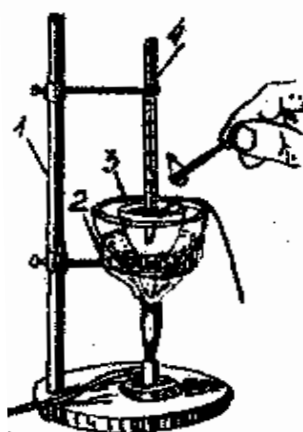


Figure 7.1 – Metal crucible: 1 - tripod; 2 - sand bath; 3 - crucible; 4 – thermometer

Table 7.1 - Indicators of the flash point of motor oils

Indexes	Motor oil brands according to SAE J300							
	AZMOL 20W40	AZMOL Super 15W40	AZMOL Turbo 210W40	AZMOL Leader M-5/40	AZMOL M-2042 (M- 8Г2K)	AZMOL M-3042 (M-10G2K)	ESSO ULTRA 530	ESSO ULTRA 1040
Flash point in an open crucible, °C, not lower	210	210	205	205	210	220	225	215

The indicators of the flash temperature measured experimentally and the indicators according to the relevant GOST should be recorded in the table. 7.2, determining the brand of oil.

Table 7.2 – Results of flash point measurements of the tested oil sample

Sample name	Indexes		Oil brand
	research	according to SAE J300	

Make a conclusion about the possibilities of using the tested oil.

### Control questions

1. What characterizes the flash point of oil and how is it determined?
2. What effect does the deviation of the flash temperature from the requirements of the standard have on the operation of the engine?
3. What changes do the properties of the oil undergo during its operation in the engine?
4. Does the flash point of the oil affect its consumption?
5. Is it possible to predict the fractional composition of oil based on flash point indicators?
6. What does a decrease in the flash point of used oil indicate?
7. Does the flash point affect the life of the oil?
8. Do oils for gasoline and diesel cars differ in flash point?

### Literature [21, 22]

## **Laboratory work No. 8**

### **DETERMINATION OF THE SOLIDING TEMPERATURE**

#### **DIESEL FUEL**

##### **The purpose of the work**

The purpose of the work is to get acquainted with the method of determining the low-temperature properties of diesel fuels according to GOST 20287 and to give an estimate of their influence on the supply and pumpability of diesel fuel.

##### **Equipment, reagents and materials**

1. Device for determining the solidification temperature.
2. Thermometer.
3. Cooling mixture (alcohol and solid carbon dioxide).
4. Sample of diesel fuel (50 ml).

##### **Content and order of work**

Before performing laboratory work, it is necessary to familiarize yourself with the recommended literature, paying special attention to the properties of diesel fuels that affect the trouble-free operation of diesel engines. Tasks: to determine the clouding and solidification temperature of the fuel; to compare the obtained data with the requirements of DST, to determine the type and brand of fuel, to draw a conclusion about the possibilities of its use in diesel and about the effect of low-temperature properties of fuel on the engine's operating mode.

Pour the tested fuel, previously checked for the absence of water, into test tube 2 with an inner diameter of  $20 \pm 1$  mm (Fig. 8.1). The fuel level after immersion of the thermometer 4 in it should coincide with the mark applied on the outer surface of the test tube and located at a distance of 30 mm from the bottom of the latter. The thermometer

should be centered and fixed with the help of cap 3, and its mercury or alcohol reservoirs should occupy the central position in the volume of the filled fuel in order to remove supercooling of the tested fuel in the layers adjacent to the walls of the test tube. Place a glass sleeve on the test tube (if possible, parallel to it). The assembled device is vertically immersed in a bath with a cooling mixture, the temperature of which, according to the standard, is maintained below the expected solidification temperature by 5 °C.

As the temperature decreases, it is necessary to periodically remove the device from the bath and, having deviated it by 45° from the vertical, observe the position of the fuel level in the device. If a level shift is observed in the tilted device in less than 1 minute, then it is worth continuing the cooling.

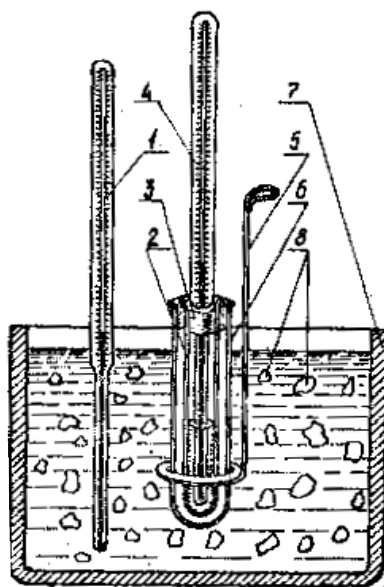


Figure 8.1 – Device for determining the solidification temperature of fuel: 1 - thermometer; 2 - test tube; 3 - plug; 4 - thermometer; 5 - stirrer; 6 - glass coupling; 7 - thermostat; 8 - cooling mixture

In the future, repeating the control in the specified way, stop at the temperature at which a shift in the fuel level in a test tube inclined at 45° will not be detected for 1 minute. It is the temperature that corresponds to the loss of fluidity of the fuel that should be considered the solidification temperature.

Compare the obtained data with the indicators of DSTU 3868.

Enter the results of the experience in the table. 8.1.

Table 8.1 – Results of measurements of solidification temperature of diesel fuel

Sample name	Indexes		DSTU 3868 and fuel brand
	research	according to DSTU	

Compare the obtained solidification temperature values of the tested fuel with the normative data of the table. 8.2.

Table 8.2 – Normative indicators of solidification temperature of diesel fuel

Indicator	DSTU 3868	
	w	s
Solidification temperature, °C, not higher	-25	-10

Give an assessment of fuel quality, determine its type and brand, draw a conclusion about the effect of low-temperature properties of diesel fuel on the operation of the engine.

### Control questions

1. What are the solidification temperatures of diesel fuels?
2. How does the solidification temperature of the fuel affect the operation of the engine?
3. What is the difference between winter and summer types of diesel fuel?
4. What technical, operational and technical properties of fuel depend on the reliability of its supply to the engine cylinders?

5. What additives to diesel fuels are used to improve technical, operational and technical properties?

6. How does the molecular mass of fuel hydrocarbons affect its solidification temperature?

7. What characterizes the "limiting temperature of filtration" indicator?

8. What qualitative indicators of diesel fuel affect its ability to be pumped and filtered?

**Literature [20,21].**

## Laboratory work 9

### DIAGNOSTICS OF THE QUALITY OF REFRIGERANTS

#### LOW FREEZING LIQUID

##### The purpose of the work

Get acquainted with the method of determining the composition and solidification temperature of low-freezing liquids.

##### Equipment, reagents and materials

1. Hydrometer.
2. Thermometer.
3. Antifreeze under investigation.

##### The content of the work

#### 1. General information

Shi-roko low-freezing coolants (antifreezes) are used in engine cooling systems. For tractor engines, for example, ethylene glycol antifreezes are used. Ethylene glycol  $C_2H_4(OH)_2$  – diatomic alcohol (containing two hydroxyl groups), is a poisonous liquid without color and odor, mixes well with water in any ratio, density at 20 °C is 1113 kg/m<sup>3</sup>, freezes at minus 11.5 °C. However, when mixing ethylene glycol with water, the solidification temperature of the mixture becomes lower than that of each of its components (Fig. 9.1).

When mixing ethylene glycol with water in various ratios, it is possible to obtain mixtures that freeze from 0 °C to minus 70...75 °C.

Due to the fact that ethylene glycol and water have different densities, mixing them in different ratios changes the density of

antifreeze. The freezing point of the antifreeze can be predicted by the density of the antifreeze.

Industrial samples of antifreeze brands 40, 65 and concentrate brand 40k are shown in the table. 9.1.

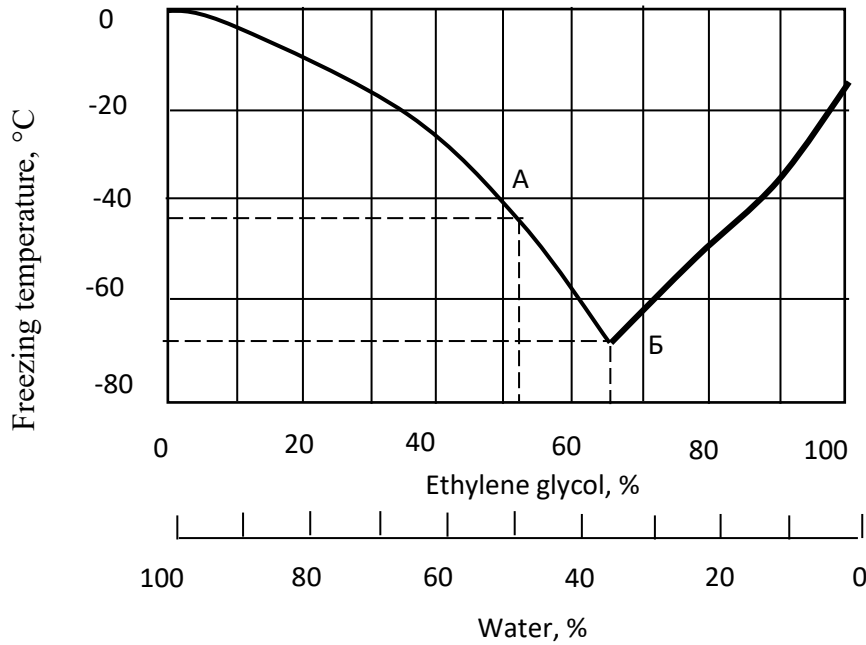


Figure 9.1 – Crystallization curve of water-ethylene glycol mixtures

Table 9.1 – Low-freezing coolants

Indicator	Standard for the brand		
	40	65	45κ
Colors	Light yellow	Orange	Yellow
Density at 20°C, kg/m <sup>3</sup>	1067...1072	1085...1090	1110...1115
Composition, % by mass.			
Ethylene glycol, no less	52	64	94
water, no more	47	35	5
Freezing temperature, °C, not higher	-40	-65	-

Application temperature, °C	-40.....+95	-60.....+95	—
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Antifreeze brand 40 is intended for the operation of engines in winter time in the middle lane.

Antifreeze brand 65 is produced for the operation of engines in the cold season in the regions of the North and Siberia. When mixing 1 liter of concentrate 40k with 0.73 liters of water, coolant brand 40 is obtained.

Ethylene glycol has inherent corrosive properties, so anti-corrosion additives (dextrin, disodium phosphate, sodium molybdenum) are added to such coolants. Dextrin is a carbohydrate of the starch type, it is introduced into antifreeze in the amount of 1 g/l. It protects aluminum, copper and lead-tin solder from corrosion. A certain part of dextrin (5...10%) does not dissolve in antifreeze and remains in it in the form of a colloid. Therefore, the antifreeze becomes somewhat cloudy. Dextrin can precipitate during storage, and antifreeze becomes transparent. Both cloudy and sedimented antifreeze, dextrin is suitable for use.

Disodium phosphate in the amount of 2.5...3.5 g/l prevents corrosion of steel, cast iron and partially copper parts.

Sodium molybdenum acid is introduced into antifreeze in the amount of 7...8 g/l to prevent corrosion of zinc and chrome coatings. Low-freezing coolants Tosol (Tosol A-40, Tosol A-65, Tosol A) are also used. All of them are painted in blue colors and are used all season with the addition of anti-corrosion and anti-foam additives.

Antifreeze A is a concentrate, when diluted by 50% with distilled water, antifreeze with a crystallization temperature of -35 °C is obtained. With the appropriate solution of the concentrate with distilled water, Tosol A-40 with a freezing temperature of -40 °C and Tosol A-65 with a freezing temperature of -65 °C are obtained.

The Tosol brand can be determined by its density at 20 °C, because it is 1120...1140 kg/m<sup>3</sup> for Tosol A, 1075...1085 kg/m<sup>3</sup> for Tosol A-40, and 1085...1095 kg/m<sup>3</sup> for Tosol A-65.

Ethylene glycol coolants are strong poisons, so you should work with them quite carefully.

## 2. Conducting diagnostic tests

The composition of antifreeze is determined with a hydrometer. There are special hydrometers that measure the content of ethylene glycol in antifreeze and its freezing point. The hydrometer (Fig. 9.2) is a hydrometer supplied instead of a density scale with a double scale - the content of ethylene glycol and the freezing temperature.

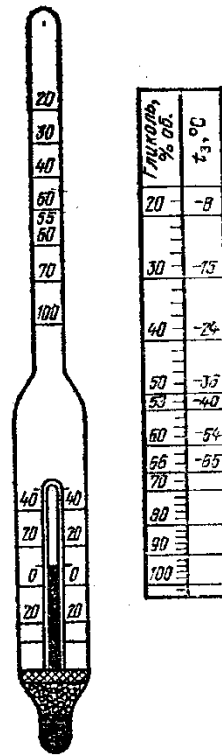


Figure 9.2 – Hydrometer and its scale

When conducting the experiment, the temperature of the antifreeze should be 20 °C, for which the antifreeze poured into the cylinder is kept in a thermostatic device for 15 minutes. Under these conditions, it is not necessary to make appropriate temperature corrections to the diagnostic result.

Carefully lower the hydrometer into the cylinder with antifreeze. After setting the hydrometer, at the upper border of the meniscus, read off the antifreeze composition and solidification temperature on the scale. If the composition of the antifreeze was not determined at 20 °C, then appropriate corrections should be made to the readings of the hydrometer (Table 9.2).

Table 9.2 – Corrections to hydrometer readings

The temperature of the tested antifreeze, °C,	Ethylene glycol content, % (by volume)								
30	17	22	27	32	36	41	46	5	55
20	20	25	30	35	40	45	40	55	60
15	21	26	32	37	42	47	52	57	63
10	22	27	33	38	44	49	54	59	65
0	24	29	29	35	40	47	52	63	69
-10	26	31	37	43	50	56	62	67	73

In the first column of the table, the temperature at which the experiment is carried out is determined, and along the horizontal line - the reading of the hydrometer at the temperature of the experiment. Then in the same column, but in the row corresponding to 20 °C, find the actual content of ethylene glycol in the antifreeze.

For example, at a temperature of 10 °C, the content of ethylene glycol according to the hydrometer is 38%. The actual content of ethylene glycol (at 20 °C) will be 35%. If there are no temperature values and hydrometer readings in the table, interpolation is used. After the valid composition of antifreeze is found, its freezing temperature is determined on the scale of the hydrometer.

In the event that the composition of the antifreeze does not meet the standards, a mixture of the required quality is made. The necessary addition of water or ethylene glycol when correcting antifreeze is calculated by the formula.

$$M = \frac{a-b}{b} H ,$$

and when adding water according to the formula

$$M = \frac{c-d}{d} H ,$$

where M is the amount of the adding component, l;

H - volume of the original sample, l;

a and b – water content in the initial sample and in the specified mixture, % by volume;

c and d – the content of ethylene glycol in the initial sample and in the specified mixture, % (volume).

### **Control questions**

1. What is antifreeze?
2. What are the main indicators of low-freezing liquid?
3. Under what conditions should antifreeze or antifreeze be changed?
4. What is the role of coolant in the engine?

### **Literature [18, 21]**

**Laboratory work 10**  
**DIAGNOSTIC QUALITY OF OILS**  
**ON THE MFS-7 SPECTRAL INSTALLATION**

**The purpose of the work**

To acquire practical skills in determining the amount of additives in oils using the MFS-7 photovoltaic installation with the possibility of making a decision regarding the feasibility of using the selected oil for a specific unit.

**Equipment, devices and materials**

1. Oil samples M-10G2k, MC-20.
2. Photoelectric installation MFS-7.
3. Electromechanical stirrer.
4. Device for oil sampling.
5. Capacity 250 ml.
6. Gasoline B-70.
7. Carbon electrodes of the C-2 brand.
8. Device for calibrating electrodes.

**Content and order of work**

Existing oils, depending on the degree of engine forcing, are distinguished by the nature of action and the content of additives or their compositions, which reach 0.5...20% or more.

When the engine is running, oil additives are activated and their concentration decreases. The rate of reduction of the initial concentration of additives in the oil during engine operation depends on their quantity, efficiency and degree of engine forcing, its technical condition, fuel quality and engine operating conditions.

A decrease in the additive content in the oil is indicated by a change in its alkalinity. However, this method is suitable only for oils with additives, which include compounds that cause an alkaline environment of the solution.

More precisely, the concentration of additives in oil can be judged by the content of their main components (barium, calcium, zinc, phosphorus, magnesium, molybdenum, etc.). In the table 10.1 lists the additives that are most often found in oils.

Table 10.1 - Oil additives

Brand	Concentration in oil, %	Other properties and features application
1	2	3
<i>Antioxidant</i>		
DF-11	1,0–2,5	Anti-wear, anti-corrosion
DFB	1,0–2,2	Anti-wear, anti-corrosion, also has an anti-friction effect
DF-1	2,0	–
VNIINP-354	2,0–2,2	Anti-wear, anti-corrosion
IHP-21	2,4–2,6	Anti-wear, anti-corrosion, also has high thermo-oxidative stability
MNIIP-22k	4,0–4,6	Anticorrosive, detergent
KASP-13	–	Anti-corrosion, anti-wear
Borin	–	–
DBK (ionol)	–	–
Agidol-2 (NG-2246)	–	For stabilization of oils, greases, rubbers and other products
<i>Detergents and dispersants</i>		
PMS	2,2–18,0	Neutralizing
S-150	1,5–5,0	The same
S-300	20,0–25,0	The same
PMS (barium)	3,2	–

Continuation of table 10.1

1	2	3
PMS (calcium)	1,5–5,0	–
SB-3 SB-3u	2,0–3,0	–
NSC	8,0–13,0	–
TSIATIM-339	3,0–6,0	Anti-corrosion
VNIINP -360	3,5–6,0	Anti-corrosion, anti-wear
VNIINP -370	5,0–15,0	Anti-corrosion
VNIINP -371	2,0	
BfKu	6,0–10,0	The same
ACK	$\geq 0,5$	Antioxidant, resistant to the influence of fresh and sea water
MASK	3,8–14	Neutralizing, antioxidant, resistant to the influence of fresh and sea water
ASB	–	Resistant to fresh and sea water
Detersol-50	$\geq 0,5$	Antioxidant, resistant to the influence of fresh and sea water
Detersol -140	3,8–14	Neutralizing, antioxidant, resistant to the influence of fresh and sea water
<i>Dispersants</i>		
C-5A	–	–
Dniprol	2–3	–
<i>Lubricating (anti-scratch, anti-wear, anti-friction)</i>		
ETF	5–6	Anti-wear
ADTP	–	It has anti-friction and anti-wear properties
LZ-309/2	–	Improves anti-wear properties
VIR-1	4,0–6,5* 2,0–3,5**	It has high antioxidant and antifriction properties
OTP	–	Anti-scratch
ABES	– 6-9	To improve the anti-seize properties of transmission and industrial oils

End of table 10.1

1	2	3
LZ-23K	0.5 (for motor oils), 5-6 (for transmission oils)	Anti-scratch
KYNH-2	–	The same
IHP-14A	–	The same
BMA-5	–	–
<i>Depressing</i>		
AzNII	Up to 0.5	–
AzNII - TSIATIM-1	1	–
AFK	1	–
PMA «D»	1	Has thickening properties - increases viscosity and viscosity index
<i>Viscous</i>		
KP-5, KP-10, KP-20	2–3, 20	For obtaining thickened, motor, industrial, gearbox and hydraulic oils
PMA «V-1»	18	In motor, transmission and hydraulic oils
PMA «V-2»	6	In engine oils and working fluids for hydraulic systems
VINYPOL	–	Thickening additive for hydraulic, compression and other oils
<i>Antifoam</i>		
PMS-200A	0,001–0,005	

\* Transmission oils.

\*\* Industrial oils.

Photoelectric installation MFS-7 is designed for excitation of emission spectra and registration of analytical signals of spectral lines of various elements of wear products and additives in oil.

The set includes a polychromator with a special stand for liquid sample analysis, a personal electronic computer; printing device, DPS-28 spectrum excitation source, C-0.75 electromagnetic voltage stabilizer, STS-2M stabilizer.

The sample to be analyzed is placed in a tripod (Fig. 10.1) and fed to a rotating carbon rod electrode by a rotating quartz disk immersed in a bath of oil.

The radiation of the discharge is directed to the entrance slit of a polychromator with a concave diffraction grating, which decomposes the radiation into a spectrum. The output slits of the polychromator isolate the necessary analytical lines from the spectrum.

The allocated radiation flow is directed to the photocathode of the corresponding PMU (photoelectric multiplier). A current flows in the anode circuit of the PV module. In order to obtain stable results of observations, it is necessary to average the spectroanalytical signals during some selected period of time. In the installation, this averaging is achieved by accumulating (integrating) charges on capacitors with a capacity of  $C$ , turned on in the anode circuit of the PV module (in the integrator block). All capacitors are charged simultaneously.

At the end of the integration time  $T$ , the control program performs a sequential survey of the capacitors. The signal in the binary-decimal digital code is sent to the computer, and according to the given program, the signals are processed and transferred to the monitor screen.

The final results are the transformed values of the signals, proportional to the absolute or relative intensity values of the spectral lines or the concentration values of the analyzed sample elements.

During the operation of the installation, commands are sent to the decoder of the controller block  $K$ . The decoder converts digital signals, which are amplified by power and fed to the executive devices of the DPS automation and the IN block.

The duration of the integration time in the installation is achieved by software through the use of a clock generator. At the same time, it is possible to obtain signals proportional to the absolute value of the intensities of the spectral lines.

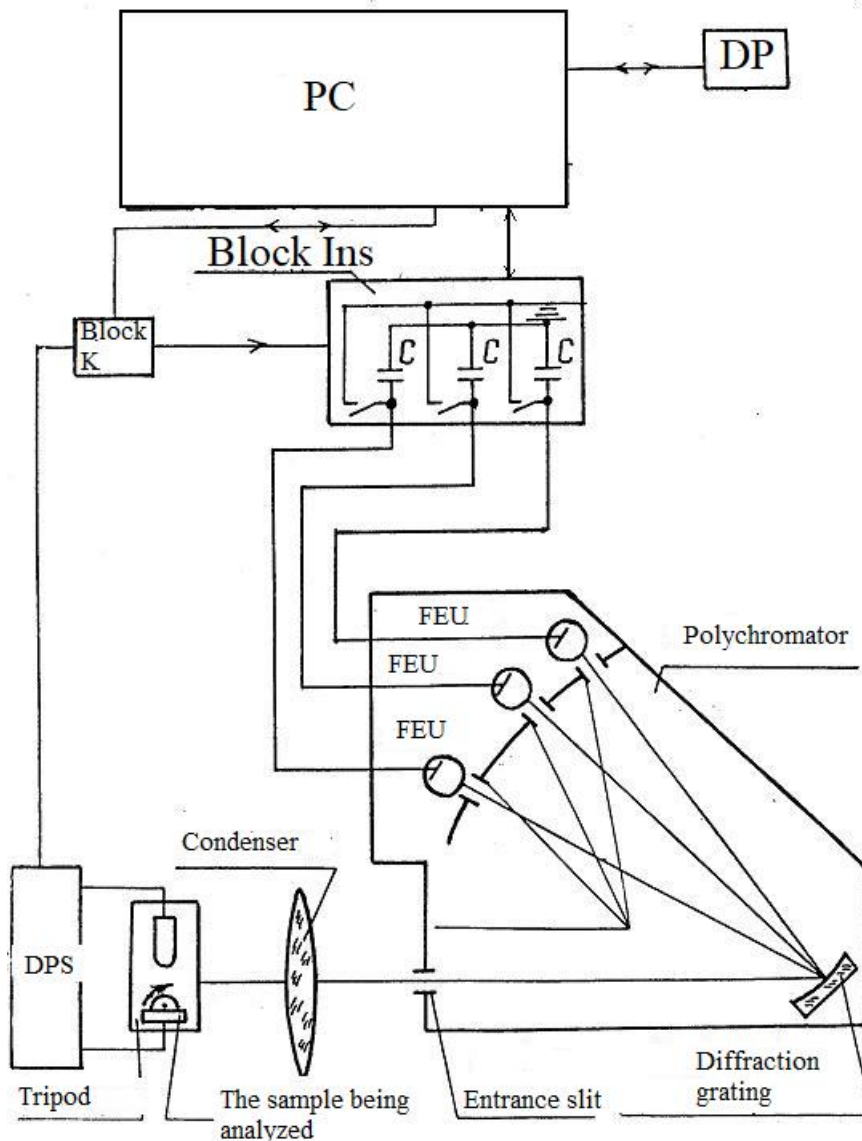


Figure 10.1 – Functional diagram of the MFS-7 photovoltaic installation: DP – printing device; FEU - photoelectronic multiplier; C – condenser; DPS is a source of spectrum disturbance; IN - integrators; K – controller; A personal computer is a personal computer.

The total time of analysis of one oil sample for 16 elements is 3..4 minutes, covering:

- washing the dosing disk;
- placement of electrodes;
- filling the tub with the analyzed oil sample and placing it in the tripod;
- preliminary heating of electrodes, firing and exposure;

– printing results.

Before starting the analysis, it is necessary:

1. Using an electromechanical stirrer, thoroughly mix the sample for 5 minutes, pour it into a bath and place it in a tripod.
2. Turn on the power supply of the MFS-7 installation using the circuit breaker.
3. Turn on the computer.
4. Turn on the monitor.
5. Enter the "QUANT1" program.
6. Enter the "Setting the analytical program" mode.
7. Enter "PRO".
8. Enter "M10M2".
9. Enter the "Analysis" section and answer the questions in dialogue mode.
10. Turn on the "network" switch on the KSM power supply unit.
11. Turn on the "network" switch on the DZS-28 unit.

Convert the obtained results in volts to g/t concentration (using calibration charts). Put the obtained result along the ordinate axis, find the intersection point on the graph, and, lowering the perpendicular to the abscissa axis, get the result in g/t (Fig. 10.2).

Compare the obtained results with the possible permissible concentrations (Table 10.1) and provide a conclusion regarding the presence of additives in the selected oil.

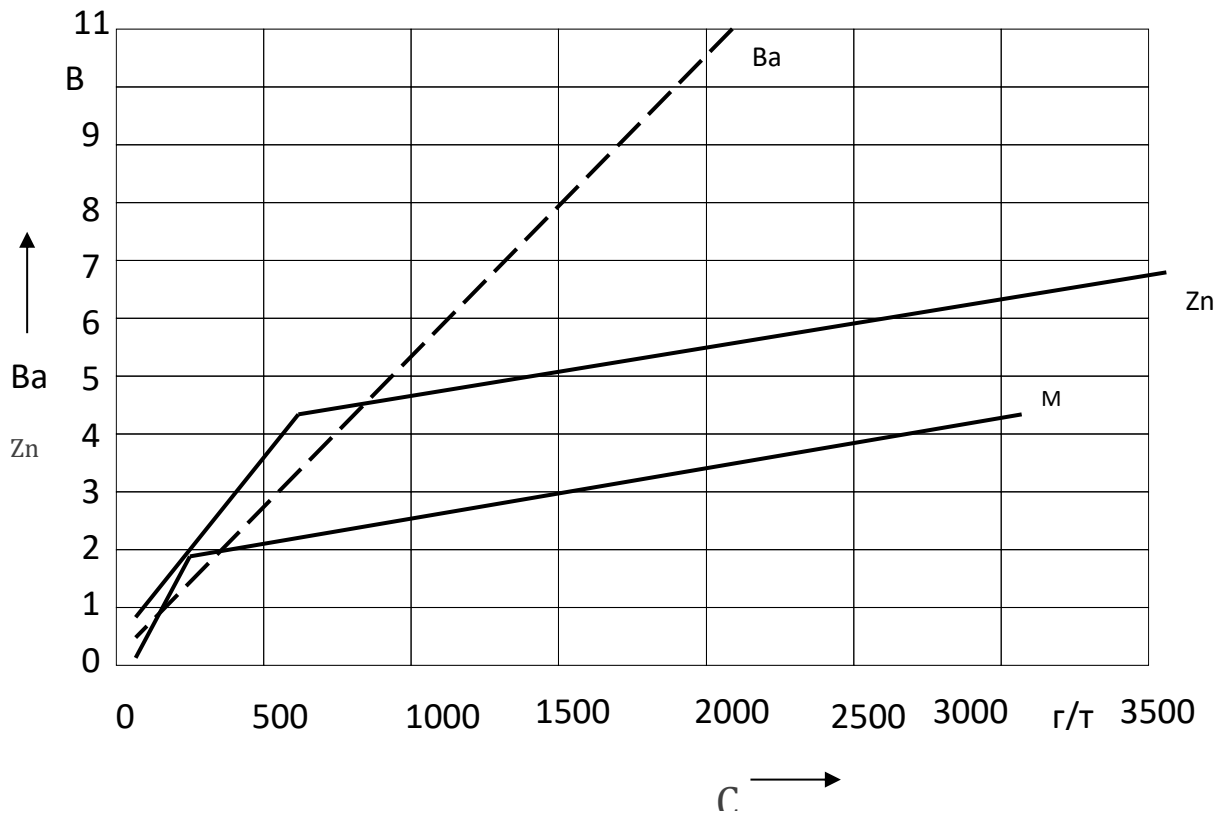


Figure 10.2 – Tare schedule

### Control questions

1. What is the role of additives in modern oils?
2. How does engine oil differ from transmission oil?
3. What is the role of an additive containing molybdenum?
4. What additives can improve several properties of oils?
5. For what purpose is the antioxidant added to the oil?

**Literature [18, 21]**