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MATHEMATICAL SOLUTION OF PROBLEMS OF DISTRIBUTION OF FUEL PRODUCTS IN EXTREME CONDITIONS

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Abstract

The article discusses the existence of many problems in the distribution of oil (fuel) products in any situation, including extreme conditions. For example, it is recognized that fuel products are stored in tanks, the vertical and horizontal location of the tank, the size of the slot (sink) through which the liquid flows, and its geometric shape (circle, cone, etc.).

Based on Bernoulli's laws, the flow of liquid and the dependence of the height of the liquid level were scientifically discussed. Most importantly, the relationship between temperature and density of oil (gasoline) products in the range [-10 ... +40] °C was calculated and graphed using the Excel program. In addition, a mathematical differential formula for the time distribution or reception of gasolines used for military and agricultural vehicles, large quantities of products in field and extreme conditions was developed.

Based on the laws of molecular dynamics, the flow times of fuel (gasoline) in vertical and horizontal containers under the same conditions were analyzed.

Keywords: *Reservoir, density, temperature, fuel, Bernoulli's law, differential equation, extreme, oil product, D. Mendeleev's formula, correction, volume, time, horizontal and vertical.*

Introduction. Oil is a complex liquid organic product, i.e., it is a gas, liquid, and solid formed in living organisms, consisting mainly of hydrogen (H) and carbon (C), naturally combustible, multi-fraction black to brown, with the general formula CnH2n+2 (n€N). n - the corresponding natural number) is a liquid with a specific (muddy) smell. Light aromatic gasoline is obtained when the appearance of petroleum products is brown in color when the number of carbon atoms in the composition is equal to (4 ... 5).

If the number of carbon atoms is close to 10, such an oil product can be obtained only by a chemical method (cracking method). In turn, colored compounds of oil are diesel fuel. Diesel fuel is also complex, in which the average molecular mass of hydrocarbons is (110 ... 230) kg/mol, and the boiling temperature is in the range of (170 ... 380)°C. In addition, lubricants, which are several times heavier than diesel fuel by mass, and the next fraction are mazut and asphalt.

In the storage of petroleum products, non-corrosive or less corrosive metal, reservoirs, tanks, as well as tanks of military vehicles are used.

There are more problems in the distribution (sale, exploitation) of oil products than in their storage.

Current status of the problem under consideration and links to resources.

In our republic and by foreign scientists, multi-faceted work has been carried out on the issue of sediments formed in reservoirs during long-term storage of fuel reserves, theoretical research, practical experimental research on providing equipment with high-quality fuel products, as well as on protection from organic and inorganic substances that pollute products. developments are developed and results are achieved. According to the achieved results, S.L. Davidov, Y.S. Drugov, E.I. Udler, I.A. Zakharov, V.I. Tagasov, V.B. Dzherikhov, I.A. Toshev, A.U. Nusratullaev, A.U. Achilov, M.Z. Komolov and a number of other scientists can be recognized.

A number of scientists who conducted research on the creation of a mechanized method aimed at the removal of mechanical impurities and alloys remaining in the capacity, as well as vertical reservoirs and oil pouring techniques. Vasilsov, S.I. Ivanova, P.I. Kochkin, M.P. Nesterova, B.I. Djalilov, A. U. Ochilov and other scientists can be mentioned.

Regarding the creation of technology for cleaning various types of technical parts from the residues of dirty oil products, S.V. Karmanov, N.F. Telnov, S.A. Melnikov, Z.S. Salimov, U.K. Akhmedov, F.I. Erkabaev, A.M. Kudratov, D.J. Jumaeva and other researchers have implemented.

However, it should be noted that today, in the warehouses of the Republic of Uzbekistan, storage of fuel reserves with a volume of 4 to 120 m3 is carried out in reservoirs and automobile and railway tanks and tanks. The problem of sediments in these storage facilities has not been solved by mechanized cleaning methods, the reasons for this are that the distribution of organic and inorganic substances, mechanical impurities on the walls of these storage tanks has not been seen, as well as there is not enough accurate information on the amount and volume of these organic and inorganic substances, mechanical impurities. For this reason, we believe that it is appropriate to review and carry out scientific research on the adhesion of organic and inorganic substances, mechanical impurities in all types of existing fuel stock storage horizontal tanks and automobile and railway tanks and capacity.

Statement of issue.

Despite the fact that there are many types of technologies that drive energy, petroleum products are still in the leading positions today, providing great energy and relatively low emissions. Of course, the role of electricity, solar and green energy is incomparable today, but their scientific and practical level of study is less studied than that of oil products.

Therefore, the purpose of the article is to mathematically analyze the flow times of a large amount of gasoline (fuel) in reservoirs with the same conditions (volume, temperature, reservoir and slot (groove) dimensions), but with a vertical and horizontal location and to develop algorithms for their time distribution consists of output.

Statement of issue. Development of a method for assessing the reliability of automated systems incorporating radio electronics and information technology based on modern requirements.

Solution method (methods). "Theory of Probability and

Mathematical Statistics", "Theory of Reliability" methods and methodologies were widely used in conducting the research work.

Analysis of results and examples.

In the storage of petroleum products, non-corrosive or rare metals, reservoirs, tanks, and fuel storage tanks are used in military equipment.

There are more problems in the distribution (sale, exploitation) of oil products than in their storage. For example, changes in temperature cause the volume of oil products to increase (foaming) or decrease (freezing). However, considering that petroleum products are mainly sold in volumes (liters), there is a correction for petroleum products at each temperature, and we use the ratio of their mass and volume at t=20°C (the same), that is, at t=20°C, petroleum products are the least will change. In short, there will be no difference in selling petroleum products by volume or mass. If the temperature increases t1>20°C, the volume increases, the product foams, V>m otherwise, if t2<20°C, the product freezes, the same amount of oil product will be V<m. We use D. Mendeleev's formula and temperature correction table of oil product density for scientific and practical assessment of distribution.

Table 1

Temperature correction for the density of petroleum products.

Density, kg/m³	Temperature correction per 1°C	Density, kg/m³	Temperature correction per 1°C	Density, kg/m³	Temperature correction per 1°C
690,0…699,9	0,910	800,0...809,9	0,765	910,0...919,9	0,620
700,0...709,9	0,897	810,0...819,9	0,752	920,0...929,9	0,607
710,0...719,9	0,884	820,0...829,9	0,738	930,0...939,9	0,594
720,0...729,9	0,870	830,0...839,9	0,725	940,0...949,9	0,581
730,0...739,9	0,857	840,0...849,9	0,712	950,0...959,9	0,567
740,0...749,9	0,844	850,0...859,9	0,699	960,0...969,9	0,554
750,0...759,9	0,831	860,0...869,9	0,686	970,0...979,9	0,541
760,0...769,9	0,818	870,0...879,9	0,673	980,0...989,9	0,528
770,0...779,9	0,805	880,0...889,9	0,660	990,0...999,9	0,515
780,0...789,9	0,792	890,0...899,9	0,647		
790,0...799,9	0,778	900,0...909,9	0,633		

Given the sudden temperature change in the conditions of the Republic of Uzbekistan, the correction formula for density when the temperature differs by t=20°C as a result of the oscillation of the hydrometer:

$$p^{20} = p^{t} + \alpha \cdot (t-20) \qquad (1)$$

where p^t is the hydrometer (oil deximeter) indicator;

t- the temperature of the tested fuel in °C;

α - the temperature correction in 1°C is obtained from Table 1.

If the temperature t is less than 20 °C, the correction is subtracted, otherwise it is added.

An example. Suppose the density of diesel fuel at t=27 °C is p^{27}=820 kg/m3, then the density of diesel fuel at 20°C is calculated as follows.

$$p^{20} = 820+0{,}738\cdot(27-20) = 825{,}2 \text{ kg/m3}.$$

From Table 1, the temperature correction in the range (820.0 ... 829.9) was used, equal to 0,738. If the diesel fuel in the tank is equal to m=103 kg of diesel fuel, when the temperature changes to 20 °C, when distributed by volume

$$\Delta V = m\left(\frac{1}{\rho_{20}} - \frac{1}{\rho_{27}}\right) = 7{,}685\ (litr) \qquad (2)$$

Calculated by volume, it differs by ≈ 8 liters.

From an economic point of view, 10^3 kg of oil produced a reduction of 8 liters of diesel fuel due to a temperature change of 7°C. If we consider that the average price of gasoline in the Republic of Uzbekistan today is 9000 soums, then

$C=V_l \cdot A=8\cdot 9\cdot 10^3=72000$ soums will be damaged.

Here C is the cost, soum;

Vl - lost volume, liter;

A is the price of gasoline at the time of investigation, soums.

In order to determine the general laws of temperature dependence of the density of oil products, the following linear correlation correlation was created based on the Excel program using formula (1) and table 1 (Fig. 1).

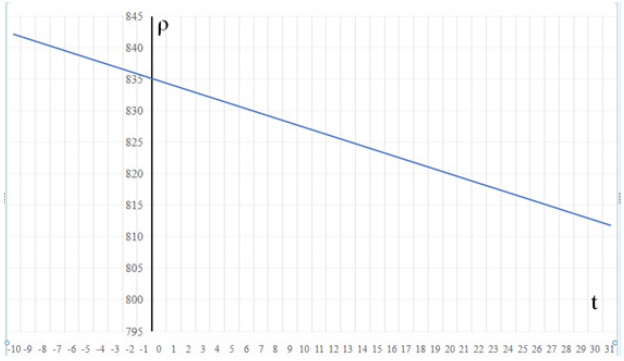


Figure 1. A plot of the proportional relationship between temperature and density (volume).

From the above example, it can be seen that a single change in temperature causes a change in the volume of the oil product. In addition, the distribution of oil products is a multi-functional variable, and since it depends on the geometric shape of the reservoir or container, the height of the notch relative to the ground, heat capacity and other parameters, it can be expressed in the form of the following function.

$$f(x; y; z; T; t; p; h; q;....)$$

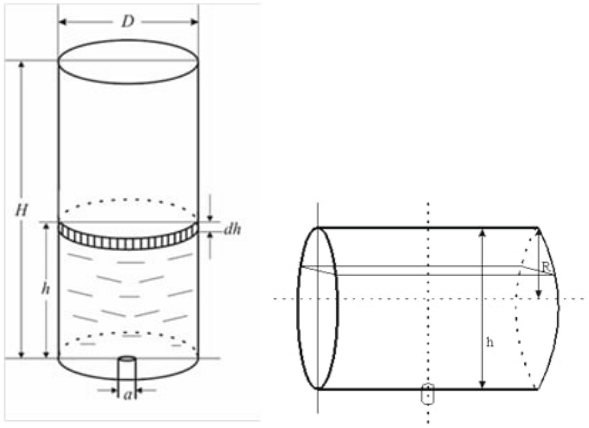


Figure 2. Location of reservoirs: a) vertical position, b) horizontal position.

Location of reservoirs in the storage of oil products. In warehouses, reservoirs are mainly used in two types, horizontal and vertical (Fig. 2).

In order to scientifically justify the fact that oil products are mainly stored in horizontally installed reservoirs, and their vertical distribution time is not the same, we will consider the issues of the following emergency situations (time dependence of receiving a large amount of oil products on railways).

As an example, suppose a cylinder tank is 6 m high and 4 m in diameter, and it is filled with a fuel product. If the shape of the groove is circular, its radius is located at the bottom point of the cylinder. It is required to determine the flow

times of the liquid in the cylinder.

The volume of liquids does not change, but the shape adapts to the shape of the container.

Bernoulli's formula is used to solve the given problem. If the liquid is flowing from the tank or reservoir with a speed (m/s) and the distance from the liquid surface of the tank to the slot is h (m), the liquid flow rate is determined by the following form

$$\upsilon = \sigma\sqrt{2gh} \qquad (3)$$

In this case, g is the acceleration of free fall depending on the geographical latitude (m/s2), that is, 9.81 m/s2 at the equator (in the territory of the Republic of Uzbekistan, the acceleration of free fall is approximately ≈9.73), σ and the constant (dimensionless) coefficient depends on the properties σ_o≈0,085 of the liquid equal (Fig. 2).

$$-\pi r^2 dh = \pi\sigma_o r_f^2\sqrt{2gh}dt \qquad (4)$$

The variables are changed and in formula (4) it is taken into account that both are **r**, **h** constants **h** and **t** are variables.

$$dt = -\frac{r^2}{\sigma_o r_f^2\sqrt{2g}}\cdot\frac{dh}{\sqrt{h}} \qquad (5)$$

Integrating both sides of the last equation, we find the value of the constant C (h=h_0=6m; t=0) using the initial conditions.

$$t = -\frac{r^2}{\sigma_o r_f^2\sqrt{2g}}\cdot 2\sqrt{h} + C \qquad (6)$$

$$0 = C - \frac{2r^2\sqrt{h}}{\sigma_o r_f^2\sqrt{2g}} \qquad (7)$$

$$C = \frac{2r^2\sqrt{h}}{\sigma_o r_f^2\sqrt{2g}} \qquad (8)$$

Then the relationship between the height of the liquid (**h**) and the time it flows through the slit (**t**) is determined by the following formula.

$$t = \frac{2r^2\sqrt{h}}{\sigma_o r_f^2\sqrt{2g}}[\sqrt{h_0} - \sqrt{h}] \qquad (9)$$

The time for the liquid in the tank to completely flow out of the slot (up to h=0 the height) is calculated using the following formula.

$$t = \frac{2r^2\sqrt{h}}{\sigma\rho^2\sqrt{2g}} \qquad (10)$$

The condition of the problem is used (r=2m; h_0=6m; σ ≈0,62; r_f=0,08; g=9,81m/s²)

In two *dt* ways, the volume of the fuel product is calculated at an infinitesimally small time interval dt.

On the one *d ω* hand, this volume is equal to the product of the fuel dh surface area.

As can be seen from the above figure (Fig. 2, b), the volume of the cylinder of the horizontal tank varies with the liquid diameter and was calculated according to the following differential equation.

$$\frac{\pi r^2}{4}\int_0^{2r} r dr = \pi\sigma_o r_f^2\sqrt{4gr}\int_0^T dt \qquad (11)$$

$$\pi r\int_0^{2r} r dr = 2\pi\sigma_o r_f^2\sqrt{g}\sqrt{r}dt \qquad (12)$$

As a result of solving the last calculated differential equation, the formula for the time distribution of oil production for a horizontal reservoir is derived.

$$T = \frac{2r\sqrt{2r}\cdot h}{3\cdot\sigma_o\cdot r_f^2\cdot\sqrt{g}} \qquad (13)$$

Conclusion.

In other words, no matter how the oil products are distributed, there are still certain uncertainties and deficiencies in volume or mass, and these errors require more scientific research. Especially in the conditions of the Republic of Uzbekistan, when climate change is sharp, these problems are characterized by their uniqueness.

If we put the values in their place, we get the following result, that is, the time for diesel to flow from the tank in a vertical position is 18 minutes and 58 seconds, while in the horizontal position of the same tank, the time for diesel to flow from the tank is 21 minutes and 4 seconds. In both cases, the tank is located at the lower point of the tank and their dimensions are the same (experiments were conducted under the same conditions). The results of the calculations show that the time difference of the fuel product flowing out of the reservoirs under the same conditions of the same volume is 1,15. In the conducted scientific research, only the phenomenon of evaporation in the distribution of oil products was not taken into account. In fact, the fact that a significant mass of petroleum products loses its weight due to evaporation in the gaseous state and causes a violation of the ecological environment in the atmosphere, resulting in an explosion or fire due to carelessness in rooms without air exchange, is a scientific proof of this phenomenon.

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