AMERICAN Journal of Engineering,
Mechanics and Architecture
Volume 4, Issue 07, 2026 ISSN (E): 2993-2637

Solution of Problems in Distribution of Oil Products

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Abstract. The article discusses the existence of many problems in the distribution of oil (fuel) products in any condition, including extreme conditions. For example, It is recognized that in what tanks fuel products are stored, the vertical and horizontal location of the tank depends on the size of the slot 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 liquid level on the height of the liquid were scientifically discussed. Most importantly, the relationship between temperature range of [-10 ... +40] °C and density of oil (gasoline) products was calculated and graphed using the Excel program. In addition, a mathematical differential formula was developed for the time distribution or reception of gasoline used for military and agricultural vehicles, large quantities of products in the field and extreme conditions. 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, that is, it is formed in living organisms and consists of a gas, a liquid, and a solid composed mainly of hydrogen (H) and carbon (C), naturally flammable, multi-fraction black to brown liquid with a specific (muddy) odor with the general formula CnH2n+2 (n€N, n – the corresponding natural number). Oil products are mainly obtained by physical methods, when the number of carbon atoms in the composition is equal to (4 ... 5) and when the appearance is brown, light aromatic gasoline is obtained. If the number of carbon atoms is close to 10, then such an oil product is obtained only by a chemical method (cracking method) [1]. 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 fuel oil and asphalt [2].

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

Relevance of the problem. Despite the fact that there are many types of driving energies of the techniques, Today, oil products are still in the leading positions with great energy and relatively low emissions. Of course, the role of electricity, solar and green energy is incomparable today, but their level of scientific and practical research is less than 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 vertical and horizontal locations, and to develop algorithms for their time distribution. consists of output [3], [4], [5].

Methodology

The study was based on mathematical modeling, comparative analysis, and statistical calculation methods. The analysis employed Bernoulli's equation, differential equations, and calculation methods based on the relationship between the density of petroleum products and temperature. The calculations were performed using Microsoft Excel, and the results were presented and analyzed in the form of tables and graphs. The flow processes of petroleum products in vertical and horizontal storage tanks were comparatively analyzed.

Result and Discussion

There are more problems in the distribution (sale, exploitation) of oil products than in their storage. For example, a change in temperature causes the volume of oil products to increase (foaming) or decrease (clouding). However, given that most petroleum products are sold in volumes (liters), there is a correction for petroleum products at each temperature, we use the ratio of its mass and volume at t=20°C (the same), that is, at t=20°C, oil products change the least. In short, there will be no difference in selling petroleum products by volume or mass. If the temperature increases t_1>20°C, the volume increases, the product foams, V>m otherwise, if t2<20°C, the product will freeze, the same amount of oil product will be V<m. For a scientific and practical assessment of the distribution, we use D. Mendeleev's formula and the table of temperature correction of the density of oil products [6], [7], [8].

Table 1. Temperature correction for the density of oil 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		

Knowing that the temperature changes sharply in the conditions of the Republic of Uzbekistan, when the temperature differs by t=20°C due to the vibration of the hydrometer the density correction formula[9]:

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

where ρ^t – indicator of hydrometer (oil deximeter).;

t – the temperature °C of the fuel being tested;

α·- 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.

Matter. Suppose the density of diesel fuel at t=20°C is ρ^{20}=820 kg/m³, then the density of diesel fuel at 20°C is calculated as follows[10]:

$$\rho^{27}= 820-0{,}738\cdot(27-20) = 814{,}8 \text{ kg/m}^3$$

From Table 1, the temperature correction in the range (820.0 ... 829.9) equal to 0.738 was used. 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

$$\Delta V = m\left(\frac{1}{\rho_{27}}-\frac{1}{\rho_{20}}\right) = 10^3\left(\frac{1}{814{,}8}-\frac{1}{820}\right) = 10^3(0{,}001211827-0{,}001219512)m^3 = 10^3\cdot 0{,}00007685m^3 = 7{,}685(litr) \qquad (2)$$

Calculated by volume, it differs by ≈ 8 liters.

Looking at it from an economic point of view, 103 kg of oil product produces 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[11]

$$C=V_{yu}\cdot A=8\cdot 9\cdot 10^3=72000 \text{ soums damage.}$$

where C – cost, soum;

V_{yu} – lost volume, litre;

A – the price of gasoline at the time of investigation, soum.

In order to determine the general laws of temperature dependence of the density of oil products, using formula (1) and table 1 Based on the Excel program, the following linear link correlation was created (Figure 1)[12-13].

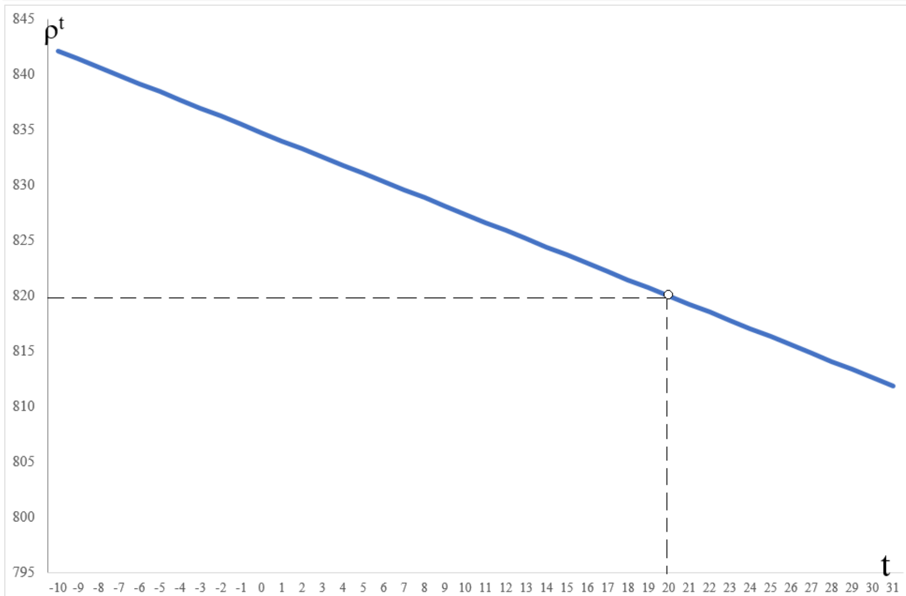


Figure 1. A plot of the proportional relationship between temperature and density (volume).

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, distribution of oil products is a multi-functional variable, since it depends on the geometric shape of the tank or container, the height of the notch relative to the ground, heat capacity and other parameters, the following function can be expressed in the form [14].

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

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

Mainly oil products are stored in horizontally installed reservoirs, In order to scientifically justify the fact that the time of its distribution in the vertical position is not the same, we will consider the issues of the following emergency situations (time dependence when receiving a large amount of oil products on railways) [15], [16], [17].

As an example, 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 notch is circular, its radius is $r_ж = 0{,}08м$ and it 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 velocity υ (m/s) from the slot (the slot) and the distance from the liquid surface of the container to the slot (the slot) is *h* (m), liquid flow rate is determined by the following formula [16].

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

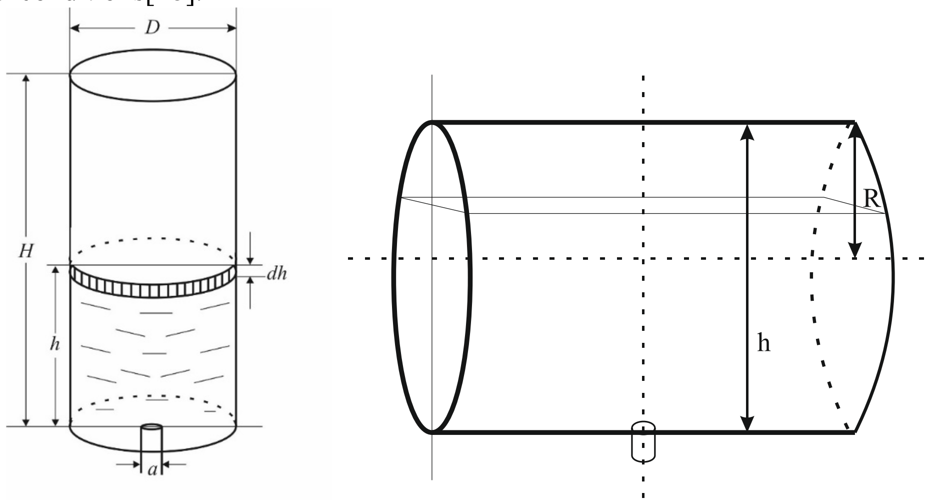
where **g** – free fall acceleration depends on geographic latitude (m/s^2), that is, at the equator 9,81 m/s^2 (The acceleration of free fall within the territory of the Republic of Uzbekistan is approx ≈9,73), σ – and the constant (dimensionless) coefficient depends on the properties of the liquid and equal to σ$_g$≈0,085 (fig.2)[17].

$$-\pi r^2 dh = \pi \sigma_g r_f^2 \sqrt{2gh}dt \tag{4}$$

Variables are exchanged, and in formula (4) r, h and σ are constants, and h and t are variables.

$$dt = -\frac{r^2}{\sigma_g r_f^2 \sqrt{2g}} \cdot \frac{dh}{\sqrt{h}} \tag{5}$$

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[18].



a) б)

Figure 2. Location of reservoirs: a) Vertical position, б) Horizontal position.

$$t = -\frac{r^2}{\sigma_g r_f^2 \sqrt{2g}} \cdot 2\sqrt{h} + C \tag{6}$$

$$0 = C - \frac{2r^2\sqrt{h}}{\sigma_g r_f^2 \sqrt{2g}} \tag{7}$$

$$C = \frac{2r^2\sqrt{h}}{\sigma_g r_f^2 \sqrt{2g}} \tag{8}$$

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.

$$t = \frac{2r^2\sqrt{h}}{\sigma_g r_f^2 \sqrt{2g}} [\sqrt{h_0} - \sqrt{h}] \tag{9}$$

The time for the liquid in the tank to completely flow out of the slot (the height up to *h=0)* is calculated using the following formula[19].

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

The condition of the matter is used ($r = 2$м; $h_0 = 6$м; $\sigma_б \approx 0{,}62$; $r_ж = 0{,}08$; $g = 9{,}81$ м/с^2)

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

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

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

$$\frac{\pi r^2}{4} \int_0^{2r} r dr = \pi \sigma_g r_f^2 \sqrt{4gr} \int_0^{\mathrm{T}} dt \tag{11}$$

$$\pi r \int_0^{2r} r dr = 2\pi \sigma_g r_f^2 \sqrt{g}\sqrt{r} dt \tag{12}$$

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[20].

$$T = \frac{2r\sqrt{2r} \cdot h}{3 \cdot \sigma_g \cdot r_f^2 \cdot \sqrt{g}} \tag{13}$$

Conclusion

No matter how the oil products are distributed, there are still inherent uncertainties in volume or mass, and these errors require more scientific research. Climate change, especially in the conditions of the Republic of Uzbekistan, characterizes these problems as more specific.

If we put the values in their place, we get the following result, i.e. if the time for diesel to flow from the tank in a vertical position is equal to 18 minutes and 58 seconds, in the horizontal position of the same reservoir, the time of diesel flow from the tank was equal to 21 minutes and 4 seconds. In both cases, the tank is located at the lower point of the reservoir and their dimensions are the same (experiments were conducted under the same conditions). The result of the ledger shows that, the change in the shape of the reservoirs under the same conditions of the same volume, the time difference of the fuel product flowing out of it 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, if an appreciable mass of petroleum products were to lose their weight as a result of evaporation in the gaseous state and the ecological environment in the atmosphere should be disturbed explosion or fire caused by carelessness in non-ventilated rooms is a scientific proof of this phenomenon.

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