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MODELING OF OIL AND OIL PRODUCTS PROCESSING AND STORAGE SYSTEM IN OIL BASES

Yusupov Azamat Alijonovich
Associate Professor of Andijan Machine-building Institute, PhD.
E-mail: azamat7uzbek@gmail.com, tel:+99(897)7810960

Abstract
With the rapid digitization of data and technological advancements in oil bases, there is a pressing need to innovate and enhance measurement and control processes for storing oil and petroleum products. This paper aims to model an intelligent system that mitigates errors in volume measurement processes, focusing on horizontal cylindrical reservoirs. A novel method for measuring the volume and mass of liquid products in reservoirs is proposed, leveraging microprocessors in measurement devices to revolutionize layout and operational algorithms. This approach enhances information capabilities, accuracy, reliability, and performance. The integration of microprocessors enables swift and precise measurement procedures. Results from the research demonstrate the development of an algorithm utilizing ultrasonic level measuring devices for accurately measuring the level of oil and petroleum products. Additionally, a measurement processing algorithm is devised to facilitate quick control of levels in non-stationary situations, enhancing accuracy. The study also suggests methods to further increase accuracy. Analysis of the findings highlights the potential to augment the accuracy of ultrasonic level sensors through microprocessor integration. Furthermore, it underscores the significance of modeling oil processing and storage systems in reservoirs for process optimization and operational efficiency enhancement.

Keywords: oil product, level, measurement, reservoir, sensor, signaling, operator, volume, error.

Introduction

Oil products go through long technological processes until they become ready: first, exploration is carried out, then drilling, extraction, and then the obtained raw materials are sent through oil pipelines to facilities for preparation and processing. It is a connecting link of these processes and is a reservoir park.

Reservoir parks are an oil storage system that provides the necessary supply of oil products, which allows smooth operation of main pipelines and the supply of oil products.

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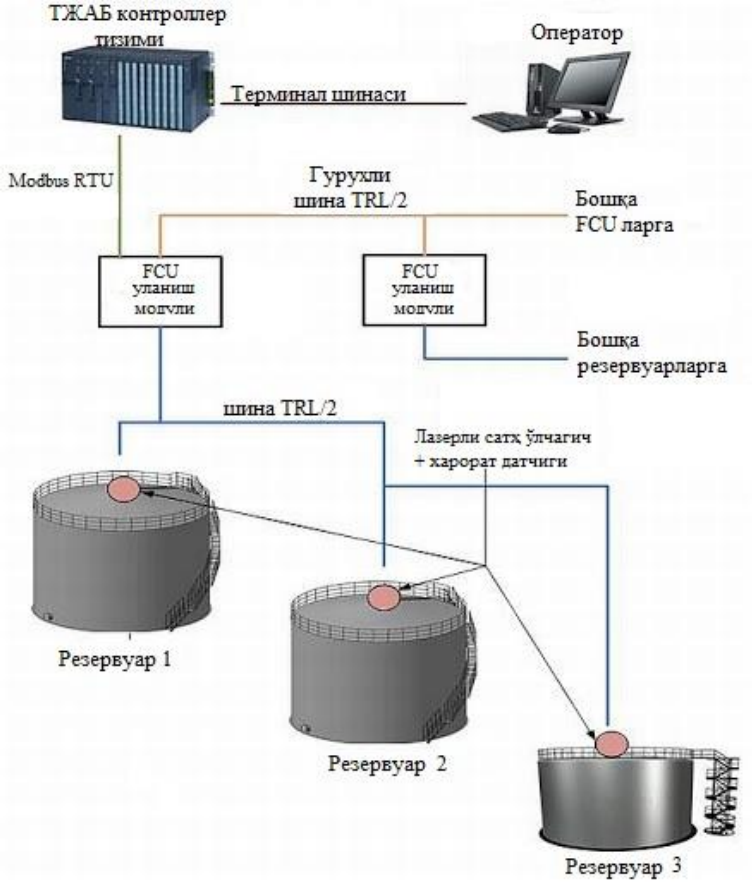

Fig. 1. Information transmission in the reservoir park management system.

Today, the use of monitoring and control systems for the technological processes of processing, preparation, storage and delivery of petroleum products to consumers is the basis for continuous improvement of the requirements for their quality, reliability and safety. For this purpose, the accuracy and reliability of the devices that are the object of control (sensors, alarm devices, level meters, counters, pumps, etc.), adaptation and modernization to the functional and switching capabilities of the operator stations with microprocessor devices will lead to a significant improvement of the system characteristics. will come. (Figure 1).
Modeling of oil and petroleum product processing and storage systems is the process of creating mathematical models that allow predicting the behavior of the system under various conditions. This allows to optimize the processes of oil processing and storage, to increase the efficiency and safety of work at oil bases.
One of the most important tasks of monitoring and control systems is to accurately and reliably determine the mass of oil products in reservoir parks. This is important for petroleum products, which are viscous liquids that change their behavior under certain storage conditions, because viscosity depends on temperature and increases with its decrease. Its density is used to calculate the mass of a product occupying a certain volume and, conversely, the volume of a product with a certain mass. Since the density and specific gravity of petroleum products depend on temperature, we will be able to know the volume and density and express their amount in mass units when receiving, issuing and accounting for oil and petroleum products. [1].

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To determine the mass (M), it is necessary to know three parameters at the same time - volume (V), density (r) and temperature inside the reservoir (Tr). The mass of the oil product is determined as follows, knowing the volume and density of filling the reservoir:

$$M=Vreal*\rho \quad (1)$$

The actual volume of the liquid (Hp) depends on the calibration volume of the liquid at a certain level of volume correction (Kv), which is determined by the difference between the average temperature in the container filled with height (Tr) and the outside air temperature (TT.x.) liq (2):

$$V_{xaq.}= V_{kalib.}* K_v \quad (2)$$

The average temperature of the oil product can be determined as follows:

$$t_{o‘rt.}=(t_{yu}+ 3t_{o‘r}+ t_p)/5 \quad (3)$$

where, t_{yu} is the temperature of the upper layer point sample, ^0C;

$t_{o‘r}$ - temperature of the middle layer point sample, ^0C;

t_p - is the temperature of the bottom layer point sample, ^0C;

Density depends on temperature. The following formula can be used to convert density at one temperature to density at another temperature:

$$\rho_i= \rho_{20} – x(T_{T.x.} – 20) \quad (4)$$

where, x is the correction for density change with temperature change of 1°C; p_{20} is the density of the oil product when the external temperature is $T_{T.x}$ = 200C.

It follows that in order to accurately measure the amount of oil, it is necessary to determine the total volume of oil, determine its temperature, take a sample and determine its density, the amount of water sediment in it and its quality. All three parameters (V, ρ, T_r) must be determined at the same time or almost at the same time, otherwise after some time (under the influence of external factors) all three values will change. For example, if the air temperature increases or the sun heats the surface of the reservoir, the three parameters change as follows: the temperature increases, the density decreases, and the volume increases accordingly.

In addition, a water level is formed under the product in the lower part of the storage tank, which affects the quality of oil products. This, which is not taken into account, leads to errors in the calculation of the residual volume.

Analyzing the management systems of existing reservoir parks today, the following shortcomings can be noted [2]:

- only the simple geometric shape of the reservoirs is used, it leads to an additional calculation error in reservoirs with a non-standard shape;
- it is not determined whether the quantity change depends on the ambient temperature and the average given temperature;
- the lack of a mechanism for accurate measurement of water under the product in the reservoir, its effect on the product has not been studied.
- Absence of a product level determination and evaluation system in each storage tank.

Management systems of the reservoir park do not take into account the geometric shape of the tank, as a result of the calibration tables based on empirical measurements, the amount of production is not predicted depending on the change of external influencing factors. Such unaccounted for effects lead to significant losses in terms of quality and quantity of oil at the enterprise.

Methods

These problems can be solved by creating an adequate mathematical model that takes into account the characteristics of the geometric shape of the reservoirs, climate and other external factors within the framework of the accounting system of oil products, which is a component of the management system of the entire oil refinery. When creating a mathematical model of oil product storage conditions, it is necessary to take into account all the above-mentioned unsolved problems and influencing factors [3]. The oil product and residual water levels in each reservoir can be estimated. It allows predicting the qualitative and quantitative indicators of the product, which directly affect the quality of the output product, in time, in accordance with the requirements of the technological process.

The developed method [4-6] can be used in the field of oil and oil products production, oil refining, aviation, medical, food and chemical industry due to its connection with control and measurement techniques. In these industries, the level of the working environment is one of the main technological parameters in terms of the need to ensure production safety and real-time accurate automated accounting of resources and the need to monitor product consumption and storage in volume or mass units.

The disadvantage of the existing methods is that most of them are designed only for reservoirs with the shape of a cylinder of a circular horizontal arrangement. However, there are other tank structures for storing petroleum products in tank farms and gas stations. Depending on the technical requirements, the reservoirs can be equipped with different side bottoms: elliptical, spherical and torospheric (Fig. 2). When calculating the volume or mass of liquid in such reservoirs, the accuracy of the filling height measurement affects two segments of the sphere of equal volume on both sides, and this situation must be taken into account.

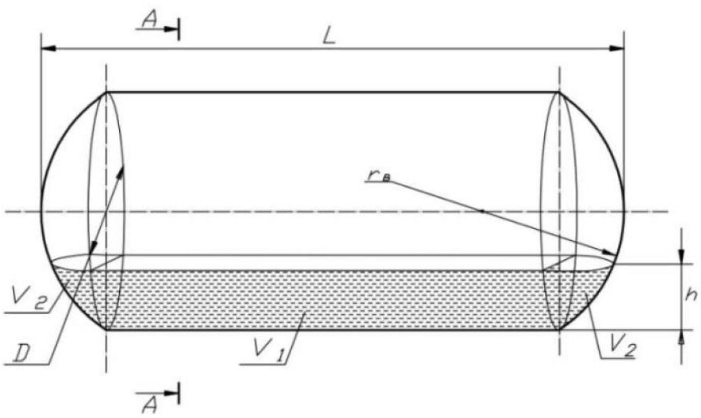

Fig. 2. Measuring the volume and mass of a liquid product in a horizontal cylindrical tank.

Results

Reservoir 1 is usually filled with liquid product 2, which is carried out by filling pipe 3 and discharged by means of discharge pipe 4. If a level gauge 5 is placed on the optically transparent window 6 installed in the upper part of the reservoir, then it is possible to determine the distance N from the upper part of the reservoir to the surface of the liquid material.

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In the process of measuring the level and volume of a liquid product, a non-standard horizontal cylindrical reservoir with spherical, elliptical or torospheric side bases creates a sum of two geometric shapes. (Fig. 2).

Here: the volume V_1 in the form of a horizontal cylinder in the central part of the reservoir, and the segment V_2 of two equal volumes. To find the total volume of liquid in the reservoir Vum, it is necessary to determine the volume of the central cylinder V_1 and add them to the volume of the side bottom with two identical values V_2.

Level gauge 2 of the measuring part is installed above the tank and serves to determine the distance N from the top of the tank to the surface of the oil product. The signal from the level meter 2 comes through the amplifier 7 and 11 the analog-to-digital converter ADC to the microprocessor 14 of the control unit 6, where the liquid product level h in the reservoir is determined: h =D - H, where D is the diameter of the reservoir. Since the temperature of the liquid in a large reservoir is not constant throughout the volume of the liquid, the change in temperature Δt is of interest to determine the change in volume due to a change in temperature.

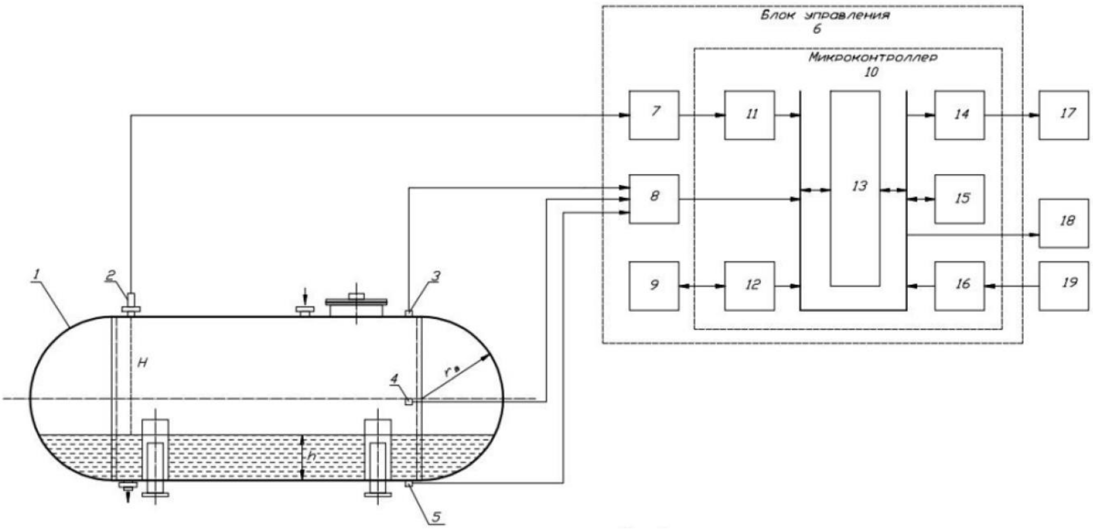

Fig. 3. Structural scheme of the intelligent microprocessor level measurement process of horizontal cylindrical reservoirs.

Discussions

The temperature of the liquid product or other similar liquid should be measured at different heights from the bottom of the container. Therefore, three temperature sensors 3, 4, 5 are installed in this measurement method: in the upper, middle and lower parts of the tank. The signals received from these sensors are transmitted through the amplifier 8 to the microprocessor 14, where the average temperature is calculated using the following formula**:**

t sr. = (t v. + t s. + t n.)/3, (5)

Microcontroller 14 can calculate temperature changes with an accuracy of 0.01°C ± 1%. The resulting density change is then calculated using the following formula:

Δρ= ρ 20 – x(tsr. – 20), (6)

where: x is a correction coefficient that differs from the normal ambient temperature of the constituent, according to which, when the temperature changes by 1^0C, it changes the density of the measured product to the appropriate value; p20 is the density of the product according to the table at t=+200C.

Conclusions

The volume of liquid product in horizontal cylindrical tanks by measuring the height of the liquid product in a horizontally located cylindrical reservoir, which provides control of the filling of the device with a liquid product and the use of a level gauge that provides an alarm, and a method of mass measurement was developed. It was also observed that errors were reduced by making corrections for the average value of the temperature affecting the volume and mass of the liquid.

Modeling of oil and oil products processing and storage systems in tank farms is of great importance to optimize processes and increase the efficiency of operations. Simulation allows for a variety of experiments and research in a virtual environment, which reduces risk and costs. It also enables optimization of processes.

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