METHODOLOGY FOR DETERMINING THE VISCOSE OIL RHEOLOGY IN LABORATORY CONDITIONS

МЕТОДИКА ОПРЕДЕЛЕНИЯ РЕОЛОГИЧЕСКИХ ПОКАЗАТЕЛЕЙ ВЯЗКОЙ НЕФТИ В ЛАБОРАТОННЫХ УСЛОВИЯХ

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***Abstract**: The crude oil samples produced from various fields are characterized by wide range of rheological characteristics. On the quantitative indicators of these parameters and, consequently, on the hydraulic resistance of the oil flow movement through the pipeline, significantly depend the possibilities of increasing the pipeline transport carrying capacity.*
The created physical model enables to determine rheological parameters of crude oil of various types, such as dynamic viscosity and solidification temperature with the dependence on preheating temperature and concentration of specialty solvents.

KEY WORDS: CRUDE OIL; RHEOLOGICAL CHARACTERISTICS; PIPELINE TRANSPORT CARRYING CAPACITY.

1. Introduction

It is commonly understood that at the current stage in developing the transport systems in the world, pipeline transport represents its particular type, whose role is essential in the process of continuous transportation of oil, oil products and natural gases at long distances.

One of the major parameters of pipeline transport is its high carrying capacity, increasing of which is possible by increasing conveyance speed of transported oil products. However, the oil transportation process through the pipeline, which has a high viscosity and wax content, is a complex process from both technical and technological standpoint.

An increase in the movement speed of viscose liquids through the pipeline with a minimum energy inputs is possible with improving such rheological parameters resisting movement, as density, viscosity, stock point and so on. Improvement of mentioned parameters is possible by using such effective methods as: thermal treatment; supplement of depressing agents; supplement of hydrocarbon diluents; mechanical action; heating of transported product up to a certain temperature in heat-exchanging devices.

2. Preconditions and means for resolving the problem

This experiment is aimed at studying the influence of change in rheological parameters on the speed of oil movement through the pipeline in different temperature conditions.

On the basis of experimental research, there have been determined the speed of oil movement through the pipeline at various temperatures and the appropriate consumed pumping power that is an important parameter with a view to energy-efficiency of transportation process.

For achieving the designated objectives of research, the experimental device was created. Fig. 1 presents a diagram of the experimental device. The operating principle of the device is as follows: the object of research – oil having initial temperature of 20^0C is heated in the reservoir by electrical heater, whose switching on and off for setting the different temperature regimes is regulated by means of a contact thermometer and relay P1. The heated oil is pumped through the pipeline by means of centrifugal pump unit, which is switched on through the switch. Power consumed by a pump unit at various regimes is determined by voltage meter and ampere-meter readings. A pressure of product transported through the pipeline is fixated by a manometer. The supply is regulated by taps, but time reading – by stop-watch that allows determining the volume flow rate or speed of oil movement through the pipeline dependent on preheating temperature. Dynamic viscosity of heated oil at different temperatures is determined by a viscosity meter, but density is measured by an aerometer.

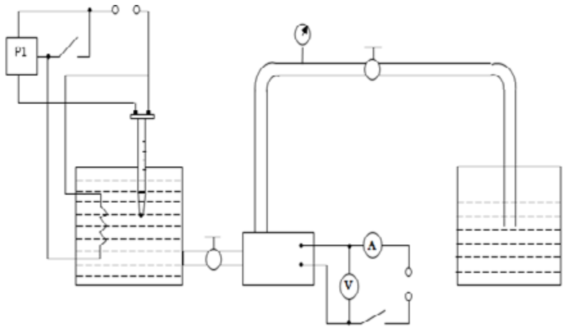

***Fig. 1.** The principal scheme of the experimental device*

The degree of improving the rheological parameters of thermally treated oil depends on its heating-up temperature. The existence of the optimal preheating temperature is associated with the following. On the surface of wax crystals, there are adsorbed the resinous substances concentrated in oil. At low oil preheating temperature, some wax crystals is dissolved and the released resinous substances are adsorbed on the surface of non-diluted wax crystals. Subsequent cooling results in that the small wax crystals fallen out of the solution form a tight structure increasing an effective viscosity and oil stagnation temperature. At elevation of oil preheating temperature, the number of dissolved wax crystals, and accordingly the number of the released resinous substances go up. During subsequent cooling, the non-adsorbedresinous substances foster the formation of large wax crystals that has a positive impact on the rheological characteristics of oil. The maximum effect of thermal treatment is achieved when all wax crystals are dissolved at heating. However, further overheating of oil results in irreversible disintegration of resinous substances concentrated in it, and the effect of thermal treatment goes down [1].

Since the content of wax in various types of oil is different, an optimal temperature of thermal treatment is determined by an experiment for each type of waxy oil.

Fig. 1.2 shows the effect of a temperature of thermal treatment on the rheological parameters of studying oil.

The analysis of the experimental research has shown that at a temperature of thermal treatment ($t_{т.о.}$) of about 60^0C, the solidification temperature not only decreases, but, on the contrary,even increases. Further elevation of the thermal treatment temperature results in reduction of a solidification temperature ($t_{зс}$).

Starting from the values of $t_{т.о.}$≥105^{0}C a solidification temperature of thermally treated oil increases again. The nature of dependence of the effective viscosity (V_0) of studying oil shows that sharp decrease of V_0 occurs only at tт.о≤ 20^{0}C, and further elevation of temperature practically does not provide effect.

On this account, the optimal temperature of thermal treatment of studying oil is 90^{0}C.

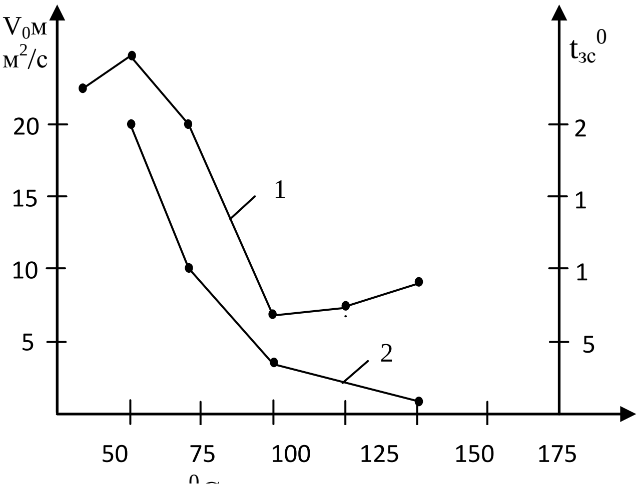

Fig. 1.2. *The effect of a temperature of thermal treatment on the rheological parameters of oil*
1 – Solidification temperature; 2 – Kinematic viscosity

After determining the optimal preheating temperature of oil, the objective of the experimental research was study of changes in pump delivery switched in the main line and in consumed power.

As a rule, during dispatching of oil to the dispatch stations, there mostly used the piston compressors and centrifugal pump units. In addition, transportation by using the piston compressors can be carried out at a height of 6-7,5 meters, and they are characterized by fairly high efficiency and continuity of supply, although they set in motion from the electrical or internal combustion engines that is associated with additional expenses.

At the present stage, with a view to oil transportation, in comparison of with the piston compressors the preferred devices are the centrifugal pump units, which are distinguished by high efficiency and simplicity of a design. In addition, it is well-known that such pump units considerably react to viscosity of transported oil. In particular, in addition to increasing viscosity, the pump unit cannot provide pressure and supply characteristics determined by published data.

3. Conclusion

The experimental studies that we carried out have shown that within the given preheating temperature interval (40--150^{0}C) of studying oil, pressure developed by centrifugal pump units switched in the main line, speed and efficiency of supply go up, and besides power consumed by pumping unit from the network goes down. In particular, within the given temperature interval, pump delivery increased by 3-5%, and accordingly the efficiency increased by 75-80%, as well as power consumed from the network reduced by 5-8%.

Based on the analysis of the experimental studies, we can conclude that it is necessary to place pump unit in the dispatching stations just after the heat-exchanging device. It should be also noted that the experimental studies carried out enable us to determine the optimal preheating temperature of studying oil (oil product), which an important parameter for choosing the type of the heat-exchanging device and for determining the optimal geometrical sizes by way of mathematical calculations. All this is aimed at increasing the carrying capacity of the long-distance pipeline and enhancing its economic efficiency. This efficiency will be even more important, if we will use in the heat-exchanging devices the natural energy sources, such as geothermal waters and solar power.

4. Literature

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