Automation of mass fraction determination of water in petroleum in the laboratory

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Abstract. Petroleum quality indicators should be monitored at all stages of petroleum production, preparation and transportation quickly and efficiently. Such a critically important indicator as the mass fraction of water in petroleum determines not only its quality, but also has a huge impact on the performance properties of the equipment and the pipeline. The article demonstrates the automation of laboratory research in determining the mass fraction of water in petroleum: the modernization of existing research using optical sensors and a data acquisition board. As a result, the complexity of the research is reduced, the work of laboratory research is optimized. The article presents the assembly diagram of the automated installation, compiled an algorithm for the software.

1. Introduction

Formation waters are companions of oil and gas fields [1, 2]. Water can be contained in petroleum and its products or in the form of a simple suspension, which is easily settled during storage, or in the form of an emulsion [3, 4].

The presence of water in petroleum products is undesirable, especially in products used at very low temperatures [5]. At these temperatures, the dissolved moisture begins to fall in the form of ice crystals, which can cause serious complications when using such oil products [6].

Oil delivered to refineries and intended for refining must meet the requirements of regulatory documents, which establish four indicators of oil quality: water mass fraction, chloride content, mechanical impurities, and vapor pressure at oil temperature at the point of delivery. [7, 8]

Modern petrochemical enterprises must have a laboratory that meets modern quality standards, performing its functions accurately, correctly and with minimal financial and time costs [9, 10]. Automation of technological processes of the laboratory will minimize their complexity, increase productivity and reduce the cost of living labour [11, 12].

The current method for determining the mass fraction of water in oil according to the Dean and Stark method is the most accurate, but remains very laborious, requiring the constant attention of a technician [13]. Laboratory research needs modernization: reducing man-hours spent by way of its automation [14].

2. Material and Methods

The quantitative content of water in the oil and in all petroleum products is determined by the method of Dean and Stark. [15]

The method consists in the fact that 100 g of the test oil is heated in a mixture with 100 cm3 of solvent in a Dean and Stark apparatus. The solvent, evaporating, carries with it the moisture contained in the oil product. Water and solvent vapors are condensed in a refrigerator, and distilled water settles to the bottom of the receiver - a graduated trap. By the amount of water in the trap, the percentage of its content in the oil product is calculated. [16]

The following apparatus, reagents and materials are used to determine the amount of water in petroleum and petroleum products:

- Apparatus for the quantitative determination of water content in petroleum, food and other products (Figure 1).
- Glassware.
- Electric heating device.
- Fridge.
- Solvents.
- Stopwatch.

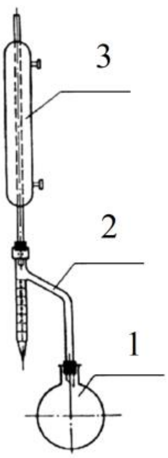

Figure 1. Apparatus for quantitative determination of water content:
1 – round bottom flask, 2 – receiver trap, 3 – refrigerator.

The result of the mass fraction in percent is calculated by the formula:

$$X = \frac{V_0}{m} \cdot 100 \qquad (1)$$

where V_0 - is the volume of water in the receiver-trap, cm^3;
m - is the sample mass, g.

3. Results and Discussion

The laboratory research process in determining the mass fraction of water in oil is automated as follows: a sensor (4) for determining the liquid level is installed in the lower part of the refrigerator (3), and a sensor (6) that reacts to the formation of droplets is installed at the point where the beveled part ends refrigerator tubes, in the upper part of the receiver-trap (5).

The wire (7) connects the sensors to the data acquisition board and transmits the information to the processing computer, based on the computer's counting results, the program decides whether the heating capacity of the heating mantle (9) is to be increased by means of the heating power regulator or signals the technician to participate in the analysis.

The task of automating the study is solved by installing it presented in the form of a diagram in Figure 2, where: (1) is a tripod, (2) are hoses for supplying and discharging coolant to a refrigerator.

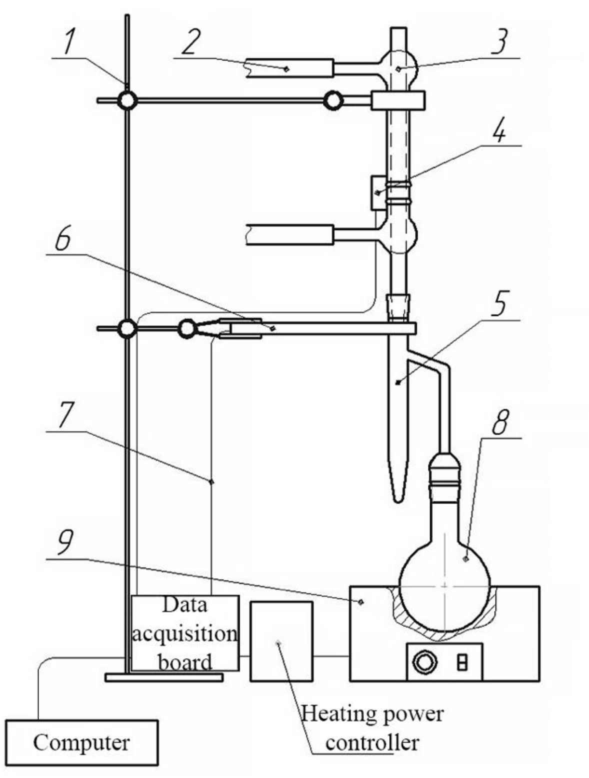

Figure 2. Apparatus for determining the proportion of water in oil with an automated process.

A fluid level sensor registers a critical boiling level. The dropping speed is determined by an optical sensor installed at the point where the beveled part of the refrigerator tube ends, at the top of the receiver-trap, and is calculated by the formula:

$$v\_ds = n/t \tag{2}$$

where n - is the number of drops registered by the sensor in t seconds, drops;

t - time, s.

The unit of power is set by calibrating the heating device and is determined empirically.

The automated laboratory research process for determining the mass fraction of water in oil is described by the algorithm in Figure 3.

Thus, because of the introduction of an algorithm for the automated process of determining the mass fraction of water in oil, the participation of a laboratory technician in the process is minimized. The laboratory technician remains to prepare the installation at the beginning of the test, check everything for leaks, turn everything on, and run the algorithm on the computer.

At the end of the analysis, the computer will independently notify the technician of the completion of the study and the need to measure the volume of accumulated water in the trap, and then disassemble the system.

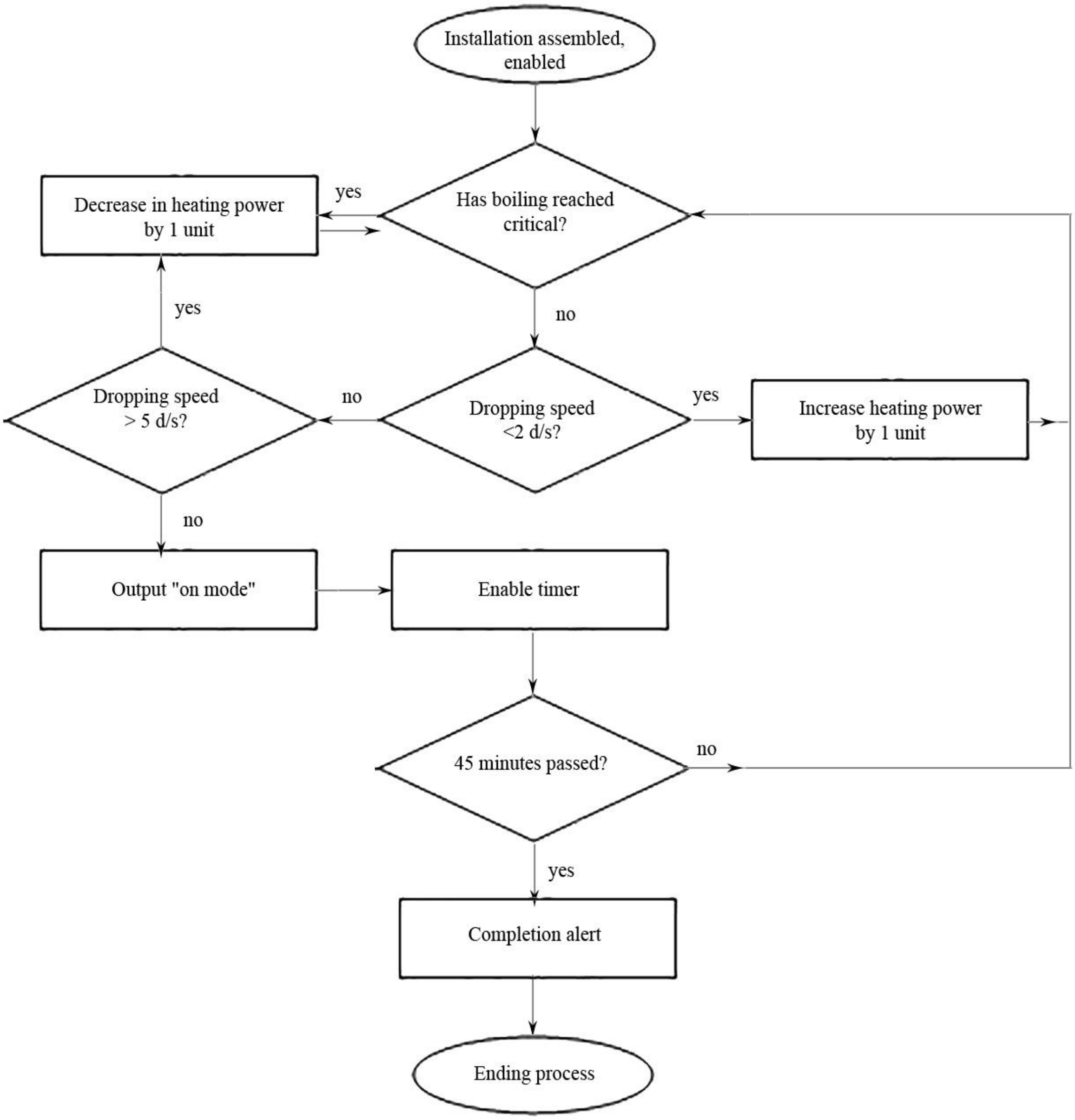

Figure 3. Algorithm for determining the share of water in oil in an automated process.

4. Conclusion

In the process, an automated system for determining the mass fraction of water in oil was developed.

This system has the following main functions:

- Control of the automated process of heating the flask.
- Control of boiling level.
- Access to the working boiling rate and maintaining it in the desired range.
- Visualization of the processes.

The algorithm was developed for automated laboratory research software for determining the mass fraction of water in oil.

Thus, it improves the quality of the test and reduces the human factor.

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