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MATHEMATICAL MODELING OF OIL HEATING PROCESS

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Abstract. This article is based on a mathematical model based on fuzzy logic in oil production. The obtained analysis was performed. The implementation of this task can be achieved by mathematical modeling of the oil heating process in the oil refining system. Mathematical modeling involves the calculation of a number of values and indicators

Key words: Fuzzy logic, oil, light fractions of oil, fuzzification, defuzzification, heat exchanger, MatLab practical program.

Introduction. The oil and gas industry occupies an important place in the economy of our country, and the industry is not only a source of energy, but also the main raw material base for the production of polymers and organic chemicals necessary for many industries. As a result of the work carried out in the field in the next two years, oil refineries produced an additional 204,000 tons of oil products, meeting the demand for gasoline and diesel fuel in the domestic market. Taking into account the following points, the creation of modern methods of oil processing remains a priority. [6].

Materials and methods. To process the oil, it is first heated. Gasoline fraction of hydrocarbon when oil is heated to 180-200 ^{0}C, 200-250 ^{0}C; The fraction with kerosene boils at 250-315 ^{0}C, the fraction with kerosene-gasoline boils at 315-550 ^{0}C. The residue consists mainly of tar. Mathematical modeling of this heating process is used to solve complex problems. The proposed management structure scheme of this technological system is as follows

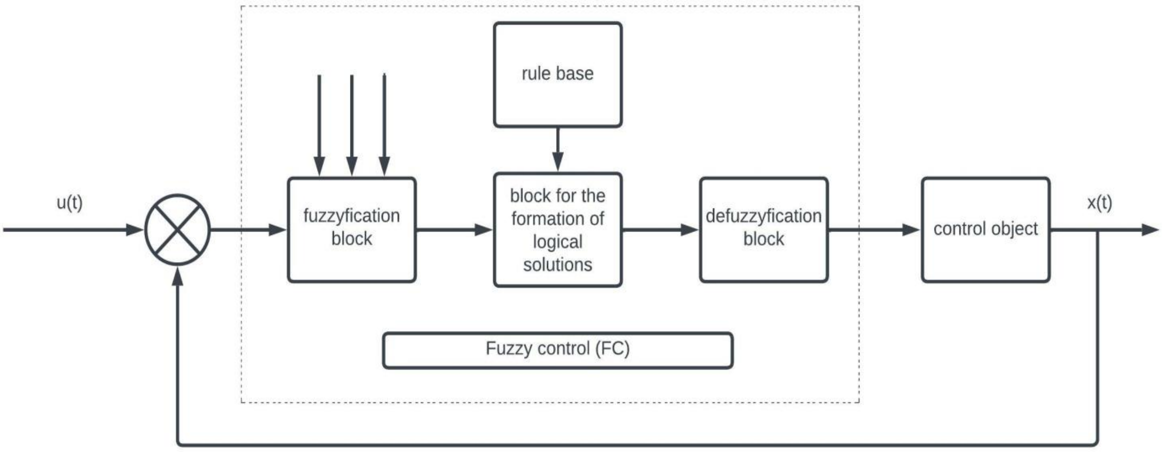


Figure 1. Functional scheme of the intelligent control system based on fuzzy logic.

Oil is a liquid substance consisting of a complex mixture of hydrocarbons. Oil with a temperature of around 10 ⁰C is transferred to the heat exchanger through a pipe. The imported raw material is introduced into the heat exchanger device. Gasoline, the light fraction of the produced oil, is used as a heating agent.

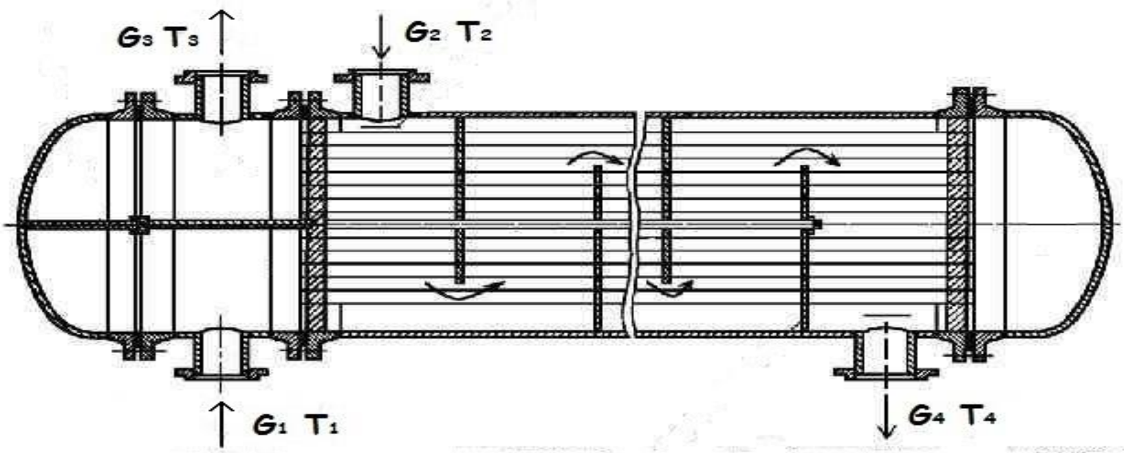


Figure 2. A view of a shell-and-tube heat exchanger.

Gasoline vapors formed in the upper part of the rectification column are used as a heating agent in the heat exchanger. This gasoline vapor is a mixed heating agent that releases a large amount of heat during condensation. The cooling process of gasoline vapors in the device is based on complex laws. High-temperature gasoline vapors are supplied to the heat exchanger. As a result, crude oil begins to heat up. This process is presented in the technological diagram above [1]. Taking into account the complexity of mathematical modeling of the technological system, we assume that the temperature T_2 of the heating agent at the entrance to the device is constant. A mathematical model for the oil heating process is created based on fuzzy logic for the case where T_2= unchanging. According to the law of conservation of energy, the amount of heat energy entering the device is equal to the amount of heat energy consumed and leaving the device (without taking into account the amount of heat energy released into the external environment).

$$Q = Q_{input} - Q_{output} \qquad (1)$$

where:

Q_{input} and Q_{output} are heat energy quantities of substances entering and leaving the device, respectively.

$$Q = GcT \qquad (2)$$

$$Q_{input} = Q_1 + Q_2 \text{ and } Q_{output} = Q_3 + Q_4 \qquad (3)$$

$$G_1c_1T_1+G_2c_2T_2=G_3c_3T_3+G_4c_4T_4 \qquad (4)$$

G_1, G_3- consumption of crude oil at the entrance and exit of the device, kg/s;

G_2, G_4- consumption of gasoline vapors at the entrance and exit of the device, kg/s;

T_1 va T_3 - temperature of crude oil at the inlet and outlet of the device, ^0C;

T_2 va T_4 - temperature of gasoline vapors at the inlet and outlet of the device, ^0C;

c_1, c_3 and c_2, c_4 are heat capacities of raw materials and heating agent at the entrance and exit of the device, respectively, $\frac{kJ}{kg\,^0C}$;

The heat capacities of substances entering and leaving the device do not change. The equation takes the following form:

$$G_1T_1+ G_2T_2= G_3T_3+G_4T_4 \qquad (6)$$

During mathematical modeling, the consumption (G_1) and temperature (T_1) of oil raw materials change depending on the state of the executive mechanism set in the technological scheme. The executive mechanism installs the heating agent at the entrance to the device and changes its consumption. The input parameters for the modeling are the temperature (T_1) and the product flow (G_1) entering the device. The output variable is heating agent consumption (G_2)[2].

Temperature values (T_1) are defined by the following linguistic terms:

TP–low, TO- average, TY– high.

Product consumption (G_1) is expressed by the following linguistic terms:

GK– less, GO-average, GP-many.

By changing the output variable of the algorithm, the heating agent consumption (G_2), the adjustment of the heating agent consumption (G_2) is carried out to ensure the specified value of the temperature of the product at the exit of the device (T_3) and corresponds to the following linguistic terms:

IJK-minimal, IK–less, IO-avarage, IP- many, IJP-a lot.

The following table was created based on the linguistic terms for decision making based on fuzzy logic (linguistic terms are listed above).

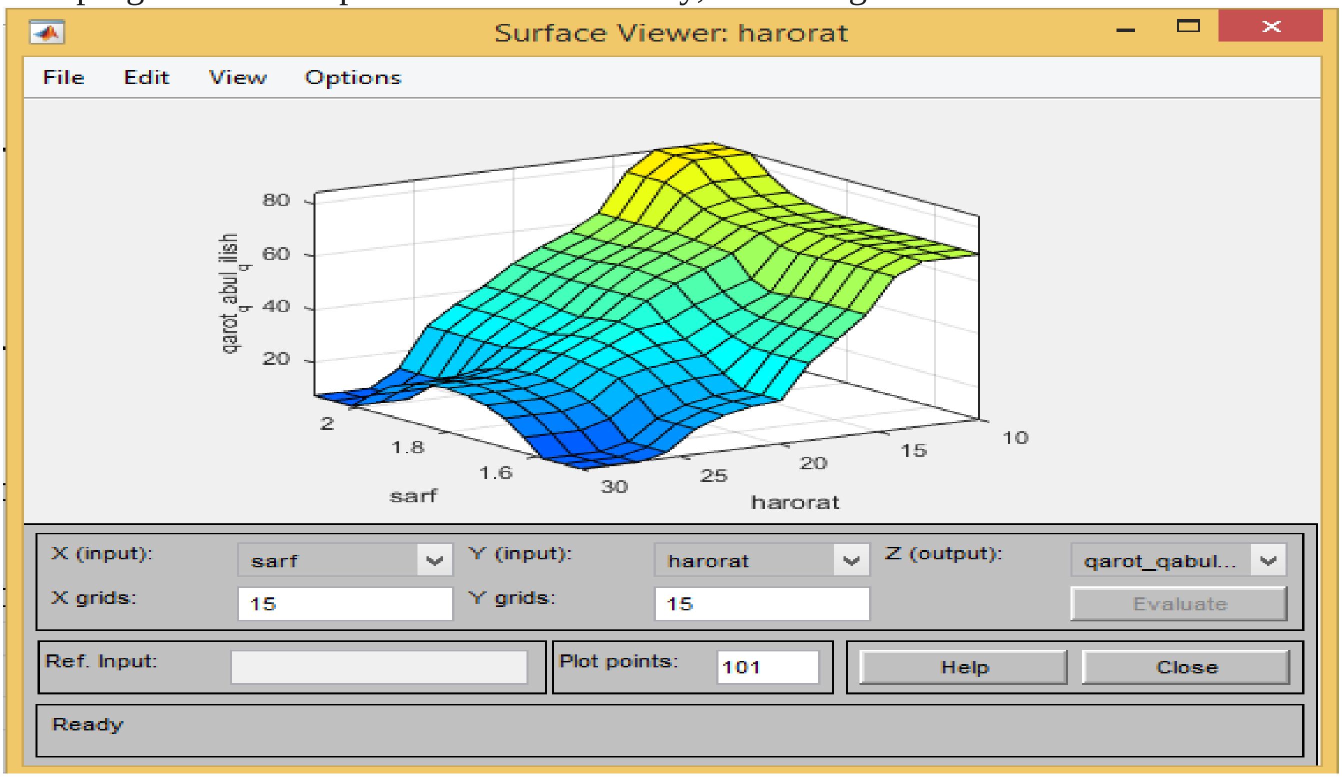
G_1 / T_1	TP	TO	TY
GK	IP	IO	IJK
GO	IP	IO	IK
GP	IJP	IK	IJK

Table 1. Table of linguistic rules.

Based on Table 1, the rules for the dependence of consumption (G_1) and temperature (T_1) values on heating agent consumption (G_2) were formulated as follows:

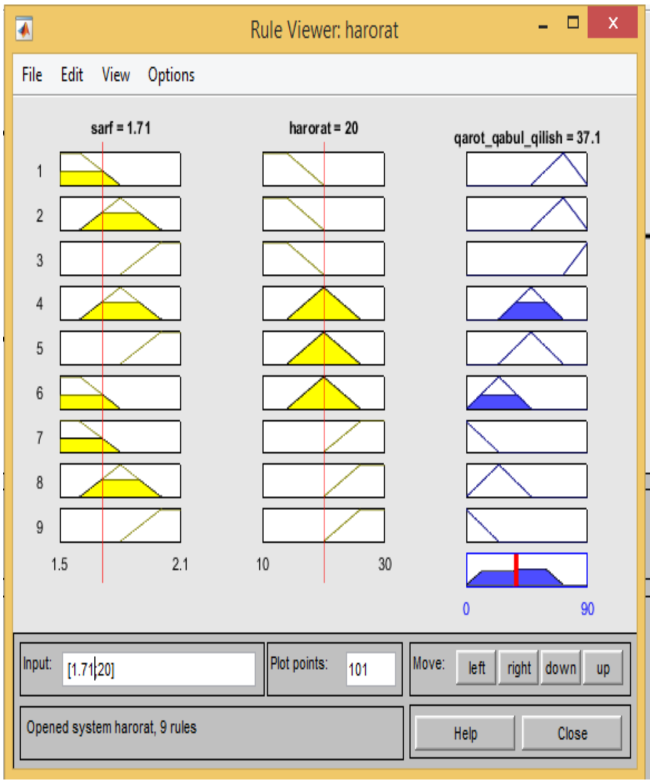
if G_1=GK and T_1=TP if so, G_2=IKP;
if G_1=GO and T_1=TP if so, G_2=IKP ;
if G_1=GP and T_1=TP if so, G_2=IJP;
if G_1=GK and T_1=TO if so, G_2=IO;
if G_1=GO and T_1=TO if so, G_2=IO;
if G_1=GP and T_1=TO if so, G_2=IK;
if G_1=GK and T_1=TY if so, G_2=IJK;
if G_1=GO and T_1=TY if so, G_2=IK;
if G_1=GP and T_1=TY if so, G_2=IJK ;

When solving the problems of mathematical modeling of systems using the theory of fuzzy logic, it is necessary to perform a large number of operations on linguistic variables, so that this sequence is understandable, the standard triangle function is used to perform fuzzy logic operations. This triangular function is drawn towards the center, that is, the sought solution is taken from the center of the triangle. Because there are many solutions inside the triangle, the point in the middle of the triangle is selected by the program as the optimal solution. Finally, the triangular function determines the



value of the heating agent consumption (G_2). The peculiarity of the management is that the words have been fuzzified into linguistic terms. After receiving the result, this process is determined by the defuzzification procedure. The structural scheme of this process is shown in Fig. 2 [3,4,5].

Results. The algorithm was modeled using the Fuzzy Logic Toolbox package of the Matlab application program. Due to the large number of operations on linguistic variables and ease of use in calculations, triangle and trapezium functions were used for variables. The input temperature T_1= is in the range from 10 ⁰C to 30 ⁰C, because in this interval the temperature and the input value consumption G_1=1.5 to 2.1 kg/s are optimal. When we entered raw materials with input consumption G_1=1.71 kg/s and temperature T_1=20 ⁰C, the program showed the value G_2=37.1 kg/s. In the created model, we can enter any value in the limit of temperature and consumption.Fig. 2



Conclusion. Fuzzy logic is a promising field in the direction of modeling systems with control, and it is very important to conduct model experiments using the detection of various noises, various disturbances and the study of system stability, as well as the study of systems with vector control behavior. is convenient. This offers a more optimal model using a modern method of modeling, slightly away from traditional modeling, and eliminates a number of difficulties in creating, studying and analyzing mathematical models of complex technological processes.

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