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DEVELOPMENT OF ADAPTIVE CONTROL SYSTEM FOR TECHNOLOGICAL FACILITY OF PRIMARY OIL REFINING

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Abstract

As it is known, primary oil processing facilities are designed for the production of light-colored oil products and various oil fractions that meet modern requirements with their quality. The main equipment of these technological facilities are rectification columns operating under atmospheric and vacuum conditions, which perform the decomposition of crude oil and fuel oil into various product fractions. Generally, the quality indicators of product fractions produced in these columns are provided by stabilizing the temperature modes at certain points (plates) of these or rectification columns by regulating the irrigation consumption supplied to those plates.

It should be noted that currently, in accordance with the requirements of the time, the design and development of new control systems that can adequately respond to more dynamic and variable external and internal stimulating influences for complex oil refining technological facilities is one of the main problems facing the automatic control theory. The paper is dedicated to the issue of developing a new automated control system that can provide the required accuracy in terms of quality management. As an adaptive control system, the purpose of such systems is to compensate in time for disturbance influences in the technological devices and to ensure the production of oil products with stable quality indicators, regardless of these influences. The purpose of study is to develop a control system that can meet the given requirements and ensure the produced products with relatively stable quality indicators, regardless of the controlled and uncontrolled exciting effects affecting the oil refinery technological complex.

The principle of operation of this system is based not only on the compensation of disturbance influences but also on the calculation of new operation strategies depending on these effects. The development of new automated control system that is able to provide the necessary accuracy of quality control in the lack of information is relevant.

Keywords: quality indicators, adaptive control system, rectification column, irrigation consumption, temperature.

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1. Introduction

The experience of operating the optimal control systems of complex petrochemical and oil refining technological processes showed that the lack of information on the course of processes in many cases reduces their efficiency and productivity. On the other hand, the change in a wide range of quality indicators and consumption of raw materials for processing makes their efficiency even more unsatisfactory [1]. In some cases, this is due to the nonlinear and non-stationary dynamic characteristics of these systems [2].

Research works conducted on a large scale in the direction of minimization of energy costs during the production process in rectification column, mainly in their cubic part, did not always provide the expected results. According to experts [3], the problems in the development and application of control systems that can implement the minimization of energy costs in rectification columns are primarily related to their always working under the influence of internal and external stimulating factors, nonlinearity and non-stationarity of their dynamic features. In this regard, a number of research works deal with the issue of developing an adaptive control system which meet the standard requirements of various oil fractions produced at any value of consumption and quality indicators of raw material in the technological facility of primary oil processing [4, 5]. In a broad sense, adaptive control systems are the control systems that provide the obtaining of products with relatively stable quality indicators and meet the requirements regardless of the internal and external, controlled and uncontrolled stimulating influences that affect the technological facility as a whole [6]. In addition to ensuring the given regulatory quality as mentioned above [7].

As it is known, the absence of operational control tools for measuring the quality indicators of oil products obtained in the facilities that carry out initial processing of oil creates difficulties in their control. At the same time, it is characteristic for these facilities that the quality indicators and consumption of the raw materials supplied to them for processing vary in a wide range.

Thus, all these considerations suggest that due to the fact that the consumption (400–750 m^3/h) and quality indicators (0.850–0.895 kg/m^3) of raw materials supplied to oil refining facilities vary in a wide range, and automatic control tools are unavailable for measuring the quality indicators of the obtained raw materials and product fractions, the application of only traditional control systems for their optimal control and processing with minimum energy costs is ineffective in most cases. For this reason, it is necessary to design new control systems for such facilities that can work in conditions of information scarcity [8].

It should be noted that, generally, two techniques are selected to implement the required quality parameters in regulatory circuits [9].

The first technique involves the introduction of various self-tuning circuits into existing tuning circuits. This technique leads to certain complications in the structure of regulatory systems, which decreases their reliability, and in most cases, they do not always justify themselves from an economic point of view.

The second technique involves periodically tuning the regulatory systems without any complications in their structure. However, this way requires prompt assessment of dynamic features of the objects without disturbing the normal operating modes of technological facilities.

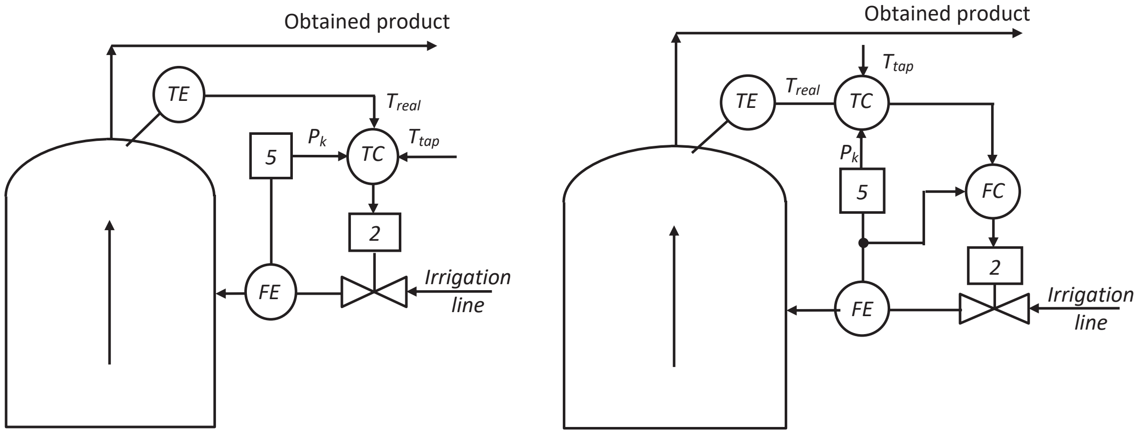
The main drawback of the known control techniques is related to their complexity and low reliability. Thus, in order to find the optimal task values of the regulators in the regulation circuits, it is required to know the functional dependences between the above-mentioned parameters depending on the available stimulating influences [10]. This, in turn, requires operative measurement of the factual values of all parameters characterizing the current technological progress of the process [11]. In addition, taking into account the fact that technological facilities operate under the influence of various stimulating factors, correction and adaptation of the parameters of previously obtained initial functional dependencies is required over time, which leads to additional difficulties [12]. Otherwise, the use of previous functional (mathematical) dependence leads to the production of waste products the quality of which does not meet certain requirements, and thus lowers the technical and economic indicators of the equipment.

2. Material and methods

2. 1. Development of combined control system

Taking into account the above, in the paper, as a research problem, the design of such a control system of the vacuum unit of the technological facility of primary oil processing is considered so that the system will provide the optimal operation of the system as a whole, regardless of various effects that occur in the technological facility. Using of only traditional control systems for their optimal control and processing with minimum energy costs is ineffective in most cases, when the consumption and quality indicators of raw materials supplied to oil refining facilities vary widely. For this reason, it is necessary to create new control systems for such devices that can work in conditions of lack of information. The design of such a control system requires the development of new regulatory tools at a lower level. In this regard, in order to eliminate the above-mentioned drawbacks in the existing regulatory systems, the paper proposed to use combined regulatory systems that involve superior features of two regulatory systems that work in the traditional way for the development of adaptive control system. The essence of the working principle of such control systems is that the effect of stimulating influences caused by the change in the consumption and quality indicators of the raw materials entering the technological facility, including fuel oil consumption, on the quality parameters of the target products obtained from the selected plate is compensated due to the proportional simultaneous change of the temperature or irrigation consumption in that plate.

Such a control system involves the addition of a certain corrective signal P_k to the appropriate controller of temperature and irrigation consumption. At this time, in the regulation system used for temperature regulation, the corrective signal added to the task value of the temperature controller is carried out proportionally to the change of the irrigation consumption supplied to the selected plate. It is shown in **Fig. 1**. In the second option, the corrective signal added to the task value of the irrigation consumption controller is carried out proportionally to the change of temperature in the selected plate. It is shown in **Fig. 2**.



a *b*

Fig. 1. A combined system operating under conditions of information scarcity for temperature control: *a* – single circuit control system; *b* – cascade control system

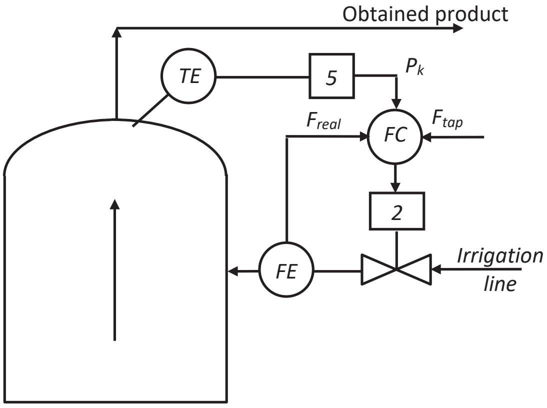


Fig. 2. A combined system operating under conditions of information scarcity for irrigation consumption control

The value of the irrigation consumption measured through transmitter 4 (**Fig. 1, *a***) enters the calculation structure 5. In this structure, based on the comparison of the current value of the irrigation consumption with the previous one, a corrective signal is generated, which enters temperature controller 1. The output signal of controller 1 enters the control valve 2 placed on the irrigation line. The current value of the temperature in the selected plate is measured through transmitter 3.

In the cascade control system (**Fig. 1, *b***), the output signal of the regulator 1 is transmitted to the task chamber of the consumption regulator 6, which is intended for regulating the irrigation consumption.

In the irrigation consumption control system given in **Fig. 2**, the current value of the temperature measured through the transmitter 3 is supplied to the calculating structure 5. In this calculating structure, the corrective signal entering the consumption regulator 1 is calculated depending on the difference between the temperature at the current moment *t* and its value at the previous moment (*t*–1). In this control system, the current value of irrigation is measured through transmitter 4.

The working principle of the proposed combined control system for temperature control is implemented as follows: as a result of the increase in the consumption of raw materials (crude oil or fuel oil) supplied to the column (or if lighter raw materials are used for processing), the volume of the hot mass rising up along the column will also increase. This, in turn, leads to an increase in irrigation consumption, as it is mentioned above, which in turn leads to an increase in the correction signal in the new system. Thus, this will lead to a slight increase in the temperature in the selected plate and the consumption of irrigation supplied to it at the same time. It is shown in **Fig. 3**.

It is clear that in the new system the effect of the increase in temperature on the quality indicators of the product obtained from the selected plate and the effect of the increase in irrigation consumption on these indicators compensate each other, as a result, the obtained product quality indicators will remain partially stable compared to those of the usual control system.

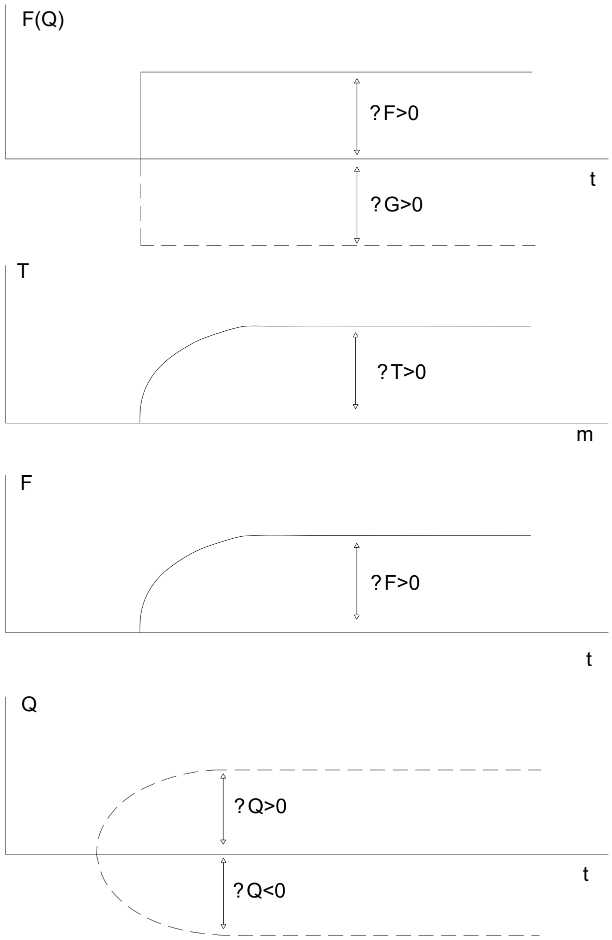


Fig. 3. Transitional processes generated from stimulating influences in the combined control system proposed for temperature

2. 2. Solving the problem of synthesis of an automatic control system for a rectification column

In order to evaluate the quality of regulation and prove the stability of the automatic system in the range of changes in the mode parameters of the rectification column it requires solving the problem of synthesis of an automatic control system. The solution to this issue consists of the following stages:

1. The determination the transfer function of the system.
2. Investıgatıon of the stabılıty of the automatıc control system.

3. Determine optimum controller settings.
4. Building of transient response.
5. Determine the quality indicators of transient process.

In order to determine the dynamic characteristic between the temperature and the irrigation consumption over the control valve, let’s determine the transfer function of the object by the Simoyu (fields) from the initial data. The transfer function of the control object is calculated in the following sequence. The transfer function defines the relation between the output and the input of a dynamic system. The step response is shown in **Fig. 4**. Here, in order to adjust the temperature it is necessary to change the irrigation consumption, that is, to change the movement of the actuator. On the commissioning curve, the distance of the actuator is $\Delta x = 10$ %, and the temperature change corresponding to this distance is 350–360 °C. A stepped control action was applied and a recording was made of the resulting output data, which was in the form of a transient response.

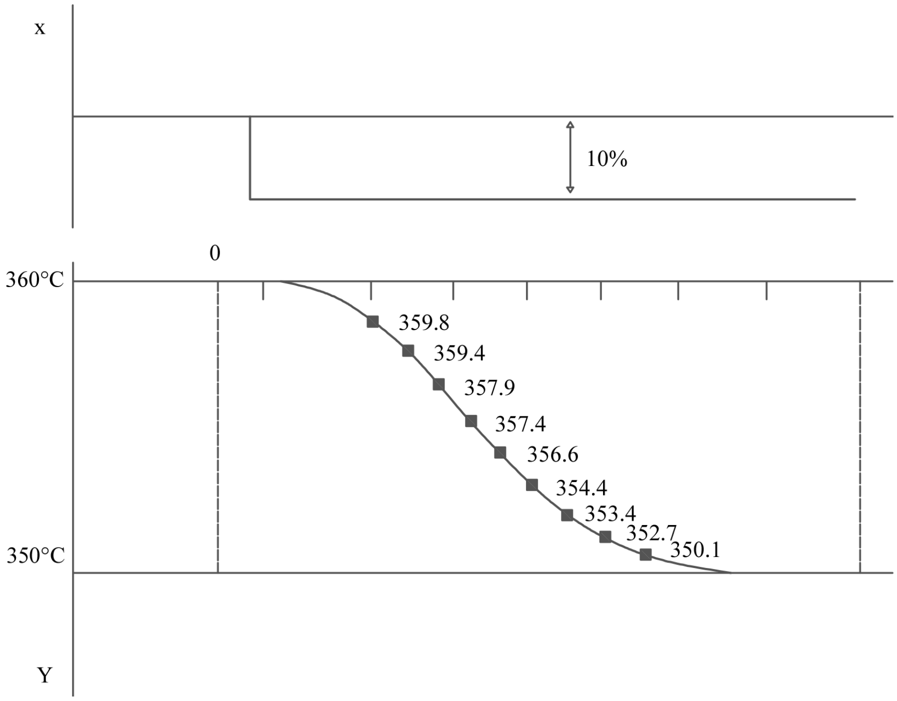


Fig. 4. Step response

In this method, the calculation is performed in the following sequence:
1. The time characteristic is divided into intervals with $\Delta t = 1$ min.
2. Let’s write down the ratio of the values $\Delta y(t)$ and Δymax corresponding to the intervals Δt.
3. The fields are determined by performing appropriate calculations.

Field $F1$ is defined as follows:

$$F1=\Delta t\{\sum[1-h(\mathrm{i}\Delta \mathrm{t})]-0.5[1-h(0)]\}, \tag{1}$$

$$F2=F12\Delta\theta\{\sum[1-h(i\Delta\theta)][1-i\Delta\theta]-0.5[1-h(0)]\}, \tag{2}$$

$$F3=F13\Delta\theta\{\sum[1-h(i\Delta\theta)][1-2i\Delta\theta+(i\Delta\theta)2/2]-0.5[1-h(0)]. \tag{3}$$

The results are shown in **Table 1**.

Based on the **Table 1**, let’s obtain the following values:

$$S_1=3.105,\ S_2=2.621,\ S_3=-0.852. \tag{4}$$

Table 1
The calculation results of transfer function

t	*h*(*t*)	1–*h*(*t*)	*tet*	1–*tet*	(1–*h*)(1–*tet*)	1–2*tet*+*tet*^2/2	(1–2*tet*+*tet*^2/2)(1–*h*)
0	0	1	0	1	1	1	1
0.5	0.04	0.96	0.161031	0.838969	0.80541024	0.690903491	0.663267352
1	0.08	0.92	0.322061	0.677939	0.62370388	0.407739644	0.375120472
1.5	0.15	0.85	0.483092	0.516908	0.4393718	0.15050494	0.127929199
2	0.24	0.76	0.644122	0.355878	0.27046728	–0.080797425	–0.061406043
2.5	0.36	0.64	0.805153	0.194847	0.12470208	–0.286170323	–0.183149007
3	0.5	0.5	0.966184	0.033816	0.016908	–0.465612239	–0.23280612
3.5	0.6	0.4	1.127214	–0.127214	–0.0508856	–0.619122299	–0.24764892
4.5	0.68	0.32	1.449275	–0.449275	–0.143768	–0.848350987	–0.271472316
5	0.8	0.2	1.610306	–0.610306	–0.1220612	–0.924069293	–0.184813859
5.5	0.85	0.15	1.771337	–0.771337	–0.1157006	–0.973856616	–0.146078492
6	0.88	0.12	1.932367	–0.932367	–0.111884	–0.997712889	–0.119725547
6.5	0.9	0.1	2.093398	–1.093398	–0.1093398	–0.995638407	–0.099563841
7	0.91	0.09	2.254428	–1.254428	–0.1128985	–0.967633196	–0.087086988
7.5	0.93	0.07	2.415459	–1.415459	–0.0990821	–0.91369691	–0.063958784
8	0.95	0.05	2.57649	–1.57649	–0.0788245	–0.83382964	–0.041691482
8.5	0.96	0.04	2.73752	–1.73752	–0.0695008	–0.728032125	–0.029121285
9	0.97	0.03	2.898551	–1.898551	–0.0569565	–0.59630305	–0.017889092
9.5	0.99	0.01	3.059581	–2.059581	–0.0205958	–0.438644052	–0.004386441
10	1	0	3.220612	–2.220612	0	–0.255053173	0
–	–	7.21	–	–	2.1890658	–	0.37551881
–	$S_1 = 3.105$		$S_2 = 2.621$	–	–	–	$S_3 = -0.852$

Here, since the third field of S_3 is negative, the transfer function will be as follows:

$$W(p) = \frac{b_1 p + 1}{a_2 p^2 + a_1 p + 1}.$$

Here it is possible to write a transfer function, given the calculated values $a_1 = S_1$, $a_2 = S_2$, $S_3 = F_3$. In order to find the transfer function, it is necessary to find gain coefficient:

$$k = S_3/S_2 = 0.32.$$

Considering that $k = 0.32$ the transfer function takes the following form:

$$W(s) = (0.32p+1)/(2.621p^2+3.105p+1). \qquad (5)$$

In order to evaluate the quality of regulation of the automatic system after obtaining the transfer function (5), let's find the amplitude-frequency, extended phase-frequency and extended amplitude-frequency characteristics of the system using the Matlab program. The extended amplitude-frequency response, extended phase-frequency and extended amplitude-phase-frequency responses are shown in **Fig. 5–7**, respectively.

A steady-state analysis in control systems is an exploration of behavior of transfer function after entire system has stabilized in defined manner. The stability of a system is its response to inputs or disturbance factors. A system, which remains in a previous state after the discontinuing of the influences of an external action.

Let's use the Nyquist criterion to study the stability of ACS. This criterion makes it possible to express the stability of a closed loop based on the amplitude-phase frequency of an open loop. For the stability of a closed loop, the following condition must be met: if the system is stable in the open state, then the closed system will be stable if $W(j\omega)$ does not cover the critical point (–1, $j0$) of the hodograph of the amplitude-phase-frequency response. This is shown in **Fig. 8**.

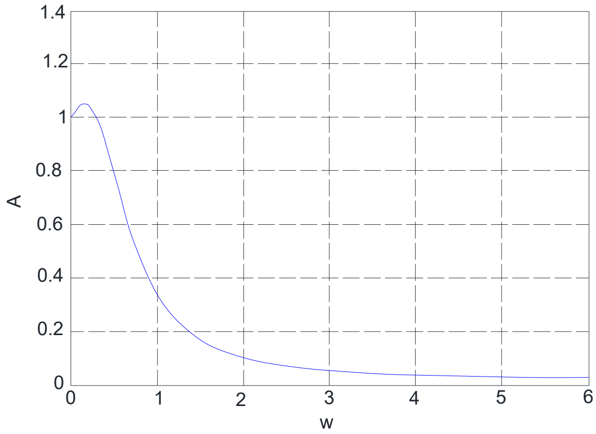


Fig. 5. The extended amplitude-frequency response

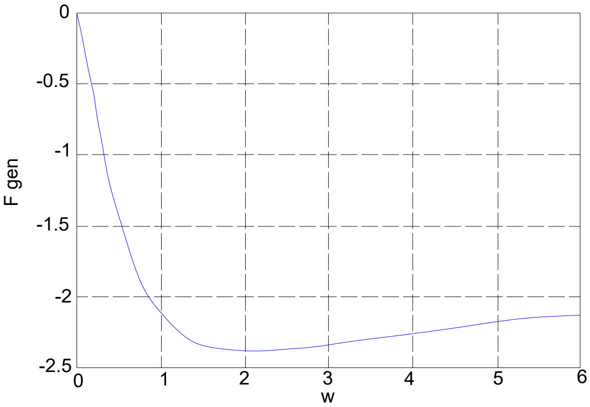


Fig. 6. The extended phase-frequency response

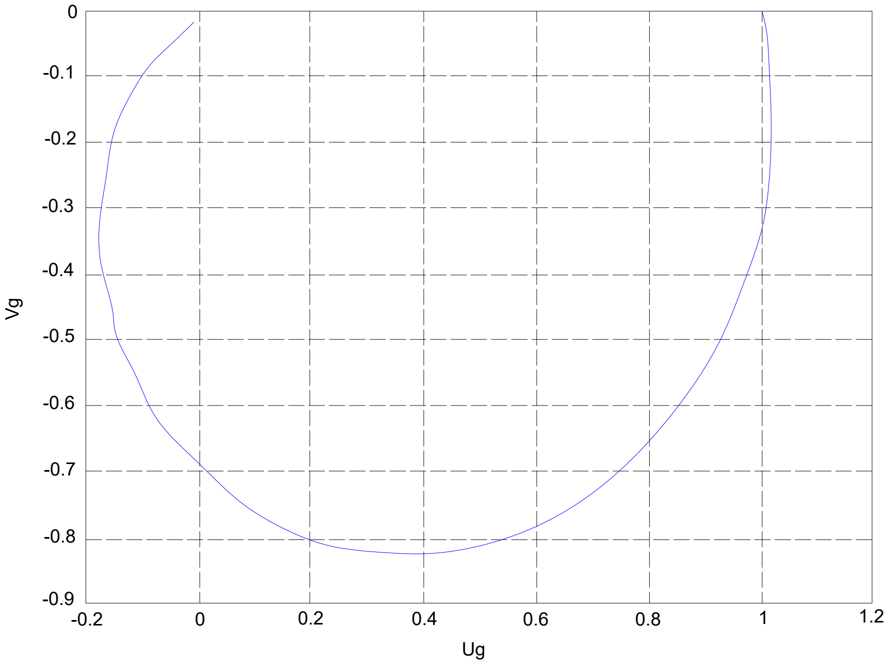


Fig. 7. The extended amplitude-phase-frequency response

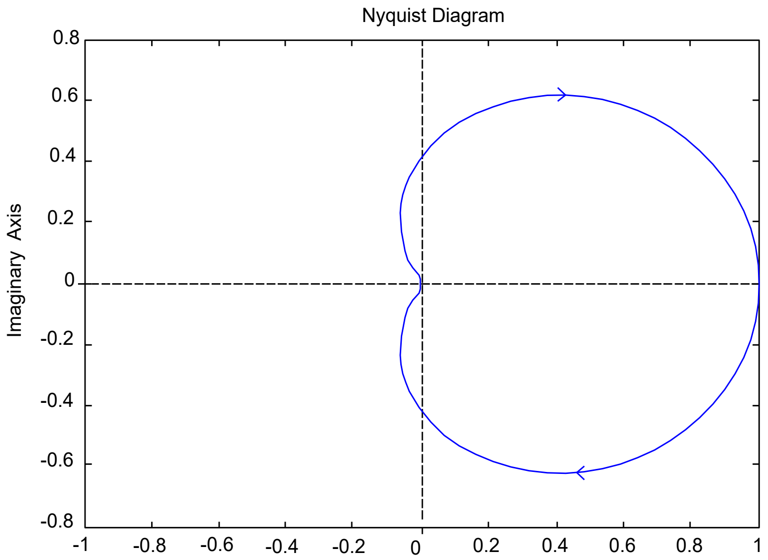


Fig. 8. Nyquist criterion

The selection of the controller parameters is essentially an optimization problem in which the designer of the control system attempts to satisfy some criterion of optimality, the result of which is often referred to as «good» control. The process of tuning can vary to find suitable control parameters for «good» control to an elaborate optimization calculation based on a model of the process and a specific criterion of optimal control. It is necessary to find the optimal values of the isodromic time of the *C*0 controller and the gain of the *C*1 controller, which are the tuning parameters of the controller, in order to obtain the transient response of the system. The optimal setting parameters of the controller are shown in **Fig. 9**.

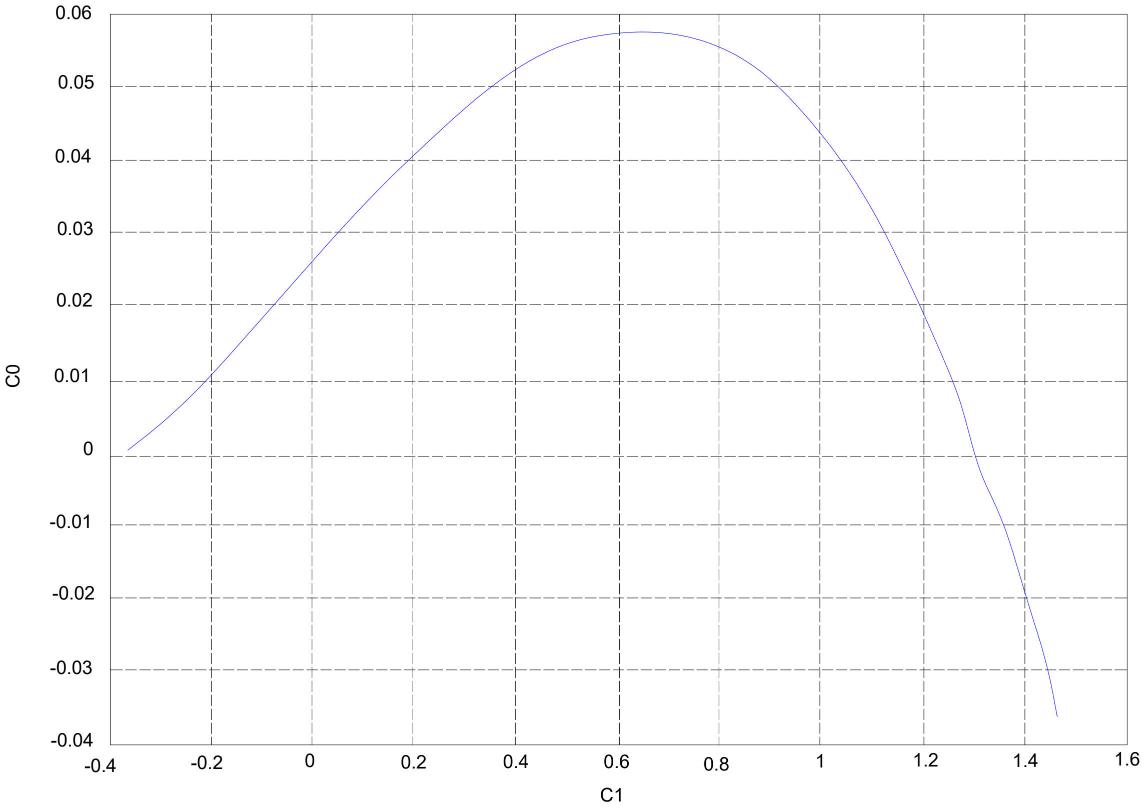


Fig. 9. The optimal setting parameters of the controller

The graph confirms that the optimal values of isodromic time and controller gain are $C0 = 0.055$ and $C1 = 0.8$.

After applying input to the control system, output takes certain time to reach steady state. So, the output will be in transient state till it goes to a steady state. Therefore, the response of the control system during the transient state is known as transient response. The transient state response of control system gives a clear description of how the system functions during transient state. The transition response is shown in **Fig. 10**.

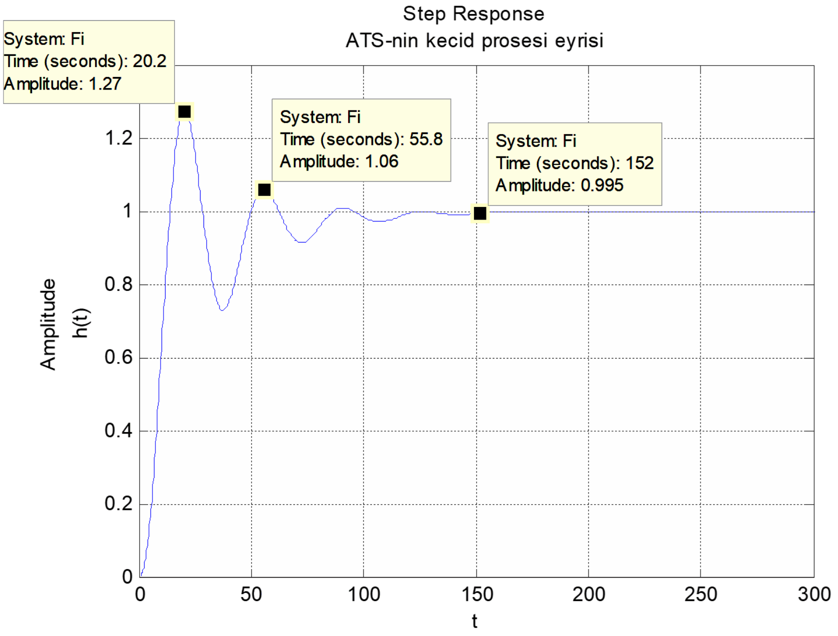


Fig. 10. The transition response

Based on the transition response, let's determine the following quality indicators:
– overshoot – 27 %;
– rise time – 20.2;
– the degree of damping – 0.77;
– static error – 0.005;
– adjustment time – 120 sec.
The transition response is shown in **Fig. 6**.

3. Research results

Before interpreting the results of the proposed adaptive control system, it is expedient to examine finding coefficients. The coefficient characterizes the dependence of the temperature on the selected plate at any moment of time on the irrigation consumption given to that plate $C_f(t)$ and the coefficient characterizes the dependence of the temperature on the selected plate at any moment of time on the temperature of the lower plate from which the target product is taken $C_T(t)$ used in the calculation of the corrective signal in the control systems.

It is necessary to conduct active experiments in the existing regulation system in order to find coefficient coefficients characterizing of dependence of temperature on irrigation consumption C_F and the dependence of the temperature on the selected plate on the temperature on the lower plate C_T used in the calculation of corrective signal P_k. For this, two ways are usually selected.

The first way involves «switching to manual mode» in the current regulation system. For this, the controller is «opened» from the regulation circuit. The irrigation consumption supplied for temperature control in the Automatic Control System for temperature is partially changed in pulses within the framework of the regulation. As a result of this change, it is clear that the temperature at the top of the tank will also partially change. Taking these changes into account, coefficient C_F is calculated:

$$C_F = \frac{\Delta T}{\Delta F_{suv}}. \tag{6}$$

At the same time, coefficient characterizing of dependence of temperature on irrigation consumption C_F:

$$C_T = \frac{\Delta T}{\Delta T_{lowpl.}}. \tag{7}$$

The drawback of this way is that in many cases it is not allowed to carry out this type of active experiments in various industrial facilities. This is due to the fact that such active experiments are required to be carried out periodically, in some cases they disrupt the normal operating modes of technological facilities and thereby create conditions for the occurrence of various unpleasant events.

According to the second way, it is necessary to carry out active experiments according to without disconnecting the controllers entering the existing regulation circuits. For this, it is necessary to bring the amplifier into gain signal form by changing the parameters of the regulators during the experiment period. For example, these parameters should be tuned for a PID controller as follows:

$$W_{ten}(P) = K_{ten},\ T_{in} \to \infty, T_{dif} \to 0, \tag{8}$$

where K_{con} characterizes transmission coefficient of the controller; this coefficient can be taken equal to unit in order to simplify the reports during experimental data processing. T_{in} characterizes the time constant of integration, and T_{dif} characterizes the time constant of differentiation.

The advantage of this method is its being safer and more reliable.

After bringing the regulator to the amplifier into manga form by changing its parameters, it is necessary to change (increase or decrease) its task value in pulses.

During the application of the proposed control system, the second way was more preferred for calculating coefficients characterizing of dependence of temperature on irrigation consumption C_F and the dependence of the temperature on the selected plate on the temperature on the lower plate C_T.

Before conducting experiments on the facility the current state of the technological process was as follows.

The set point of temperature controller: $T_{task} = 70°$ C, the irrigation consumption; $F_{irg} = 28$ m^3/hour, the temperature in K-5A column: $T_{k\text{-}5A} = 175°$ C, the irrigation consumption given to *K*-5*A* vacuum column: $F_{k\text{-}5A} = 80$ m^3/hour, $F_{K\text{-}5A} = 80\ \text{m}^3/\text{hour}$ the temperature in the *K*-5*B* vacuum column: $T_{k\text{-}5B} = 280$ °C:

$$T_{task} = 70\ °\text{C};\ F_{irg} = 28\ \text{m}^3/\text{hour};\ T_{k\text{-}5a} = 175\ °\text{C};\ F_{k\text{-}5a} = 80\ \text{m}^3/\text{hour};\ T_{k\text{-}5b} = 280\ °\text{C}.$$

When task values of the controllers were changed, after the transitional process occurring in the system, the new settled mode in the technological process was as follows.

The set point of temperature controller: $T_{task} = 74$ °C, the irrigation consumption: $F_{irg} = 20$ m^3/hour, the temperature in *K*-5*A* column: $T_{k\text{-}5A} = 180$ °C, the irrigation consumption given to *K*-5*A* vacuum column: $F_{k\text{-}5A} = 60$ m^3/hour, the temperature in the *K*-5*B* vacuum column: $T_{k\text{-}5B} = 300$ °C:

$$T_{task} = 74\ °\text{C};\ F_{irg} = 20\ \text{m}^3/\text{hour};\ T_{k\text{-}5a} = 180\ °\text{C};\ F_{k\text{-}5a} = 60\text{m}^3/\text{hour};\ T_{k\text{-}5b} = 300\ °\text{C}.$$

Considering these values in expression (1):

$$C_F = \frac{\Delta T}{\Delta F} = \frac{\left|T_{task} - T^*\right|}{\left|F_{irg} - F^*\right|} = \frac{|70-74|}{|28-20|} = \frac{4}{8} = 0.5\,\frac{°\text{C}}{\text{m/hour}},$$

$$C_T = \frac{\Delta T}{\Delta T_{low\,pl.}} = \frac{|175-180|}{|280-300|} = \frac{5}{20} = 0.250.$$

It should be noted that it is necessary to periodically calculate coefficients characterizing of dependence of temperature on irrigation consumption C_F the dependence of the temperature on the selected plate on the temperature on the lower plate C_T. The change in its value is directly influenced by the temperature of the irrigation used as a refrigerating medium in the column. The temperature of irrigation depends on the current state of the cooling system of the technological facility, as well as partly on the ambient temperature due to the season.

Long-term experiments conducted in the technological facility showed that the value of the corrective signal usually should not exceed temperature 5 °C.

The corrective signal should be equal or less than five:

$$|P_k| \le 5\,^{\circ}\mathrm{C}. \tag{9}$$

When such a situation occurs, a new operating mode of the equipment should be calculated taking into account stimulating influences at the upper level of the control system of the technological facility. In this case, it is clear that the calculation of the new operating mode will cause the corrective signal to be equal to zero.

Performance of the proposed automatic regulation system has been proven by solving of the problem synthesis of an automatic control system.

The graphs reflecting the results of the application of the control system, which includes such a regulation system, as well as the results of the application of the traditional control system in real production conditions are presented in **Fig. 11**, **12**.

As it is seen from the graphs, before the experiment, quality indicators of gasoline – the boiling point temperature and the end-boiling temperature were changed dramatically, but after the experiment, these indicators were relatively more stable. The conducted comparative analyzes show that the new combined regulation system proposed in the paper allows to produce oil products with more stable quality indicators compared to traditional systems.

All this shows that the application of such regulation systems in the development of the optimal control system of the vacuum unit in the technological facility of primary processing oil can provide effective results.

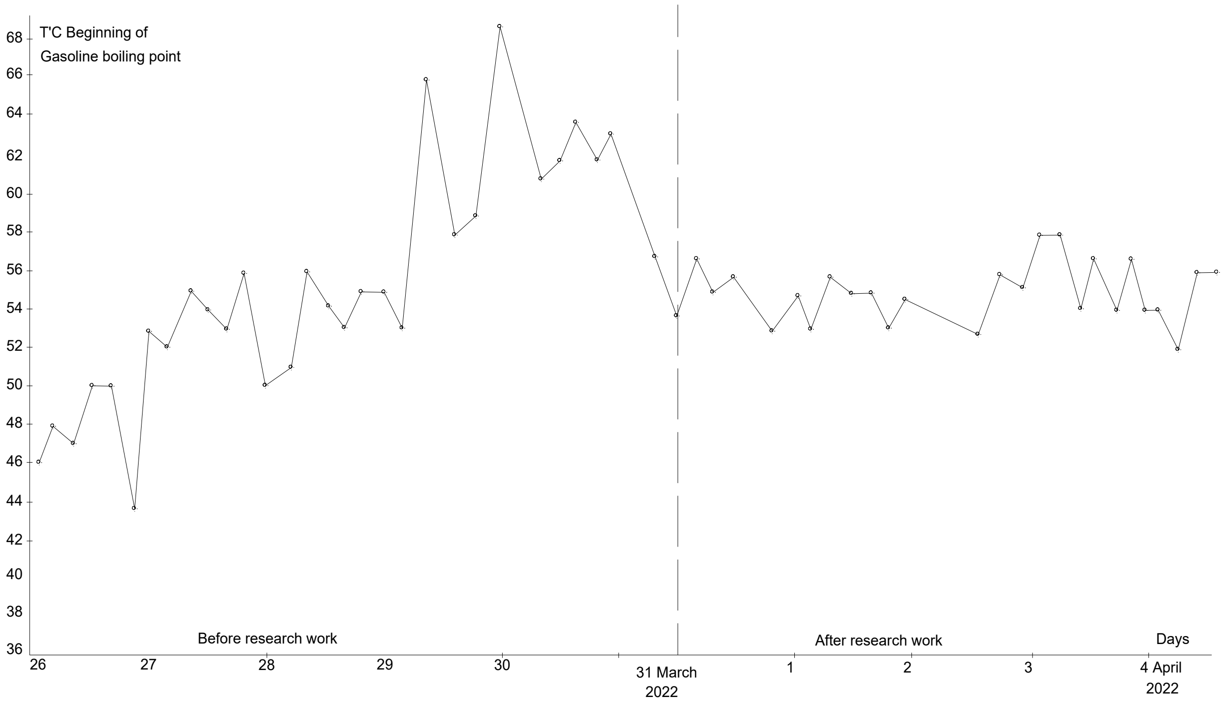


Fig. 11. The graph of the variation of the boiling point temperature of the gasoline produced in the rectification column

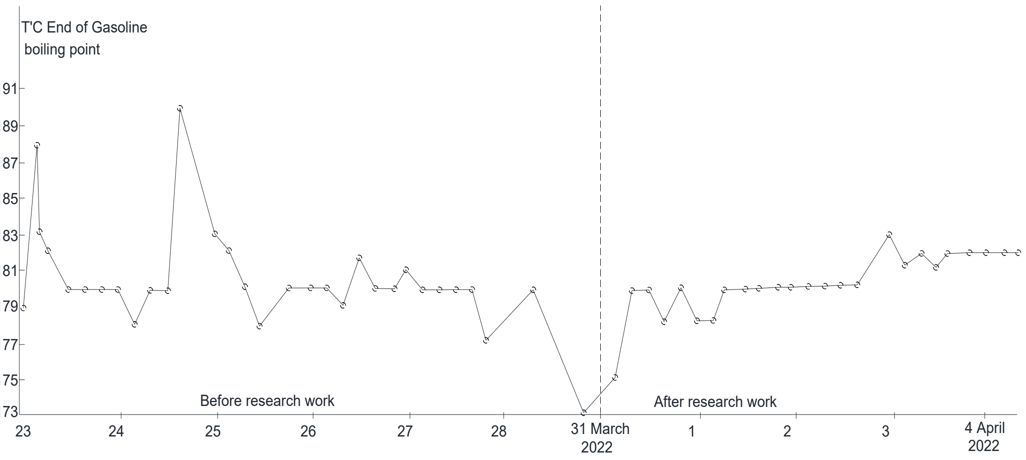


Fig. 12. The graph of variation of the end-boiling temperature of gasoline produced in the rectification column

4. Discussion

Comparative analysis data provide that the new combined control system proposed in the paper makes it possible to obtain oil products with more stable quality indicators compared to traditional systems. The results of the tests have been provided that this system, applied only in the upper part of the column, at the same time had a positive effect on the quality indicators of kerosene.

All this that the use of such control systems in the development of an optimal control system for a vacuum block in a technological complex for primary oil refining can give effective results.

The practical significance of the scientific results of the work is that in the fact that in the absence of some means of automatic control of the operational measurement of the quality parameters of input streams in technological objects of primary oil refining, they can provide the chosen optimality criterion for the system as a whole, regardless of changes in their consumption and quality indicators in a wide range. These control systems can be applied in the development of an optimal control system for a vacuum and an atmosphere block of primary oil refining unit. In more detail, it can play a special role in the ability to satisfy the chosen optimality criterion for the system as a whole.

It is intended in the further perspective of the research work, based on the results obtained in the article, the solution of the optimization problem which is solved at a high level of the control system and ensures an optimality criterion.

5. Conclusions

In order to improve the quality of the control system on «irrigation consumption – temperature» for the rectification column, which is the main fractionating technological equipment of the vacuum unit of primary oil refining facility, a combined control system was constructed and an algorithm for corrective signal calculation was developed according to the inclination of the regulated parameters.

This control system provides the quality control by compensating stimulating influences in technological facilities operating under heavy load in conditions of information scarcity, performing self-tuning function.

In the article, the definition of the corrective signal used in the control system was calculated based on the coefficients characterizing of dependence of temperature on irrigation consumption C_F and the dependence of the temperature on the selected plate on the temperature on the lower plate C_T. It has been obtained:

$$C_F = \frac{\Delta T}{\Delta F} = \frac{\left|T_{task} - T^*\right|}{\left|F_{irg} - F^*\right|} = \frac{|70-74|}{|28-20|} = \frac{4}{8} = 0.5,$$

$$C_T = \frac{\Delta T}{\Delta T_{low\,pl.}} = \frac{|175-180|}{|280-300|} = \frac{5}{20} = 0.25.$$

Long-term experiments conducted in the technological facility provided that the value of the corrective signal usually should not exceed temperature 5 °C.

The corrective signal should be equal or less than five:

$$|P_k| \leq 5\,°\text{C}.$$

It should be noted that the calculation of the coefficient should be carried out periodically, since the change in its value is directly affected by the temperature of the irrigation water used as a refrigerant.

The evaluation of dynamic model of the rectification column of a technological facility and the operational synthesis of automatic control system are solved.

As can be seen from the graphs, the range of change in the boiling point of gasoline before research was 43–69 °C and after implementing the new combined control system, the boiling point of gasoline was 52–57 °C. Before implementation the combined system the change interval of gasoline quality indicators was 26 °C, after implementation this indicator was 5 °C.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

Manuscript has no associated data.

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