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Mathematical Model and Algorithm of Control of Steam Pressure in the Reactor on the Basis of the Separation Criteria

Fayzullaev Ubaydulla Sagdullaevich, Kasimova Gulnora Ismoilovna, Tulyaganov Zoxidjon Yakubdjanovich

Senior Lecturer, Department of Information Technologies, Tashkent State Technical University, Tashkent, Uzbekistan.
Assistant, Department of Information Technologies, Tashkent State Technical University, Tashkent, Uzbekistan.

ABSTRACT: Currently, the preservation and rational execution of energy consumption remains an important topic. The development of energy-saving and resource-saving technologies and technical equipment, ensuring the efficient use of resources is great, appraisers of the main indicators of energy consumption. They include the optimization of energy engineering in the selection and commissioning of energy-saving methods.
In this state, a mathematical model and an algorithm for controlling the energy consumption of steam boilers, using in production processes, based on the criteria of separable. It is assumed that the cost of thermal energy in production will lead to an optimal level.

KEYWORDS:separator, reactor, production, optimal, pressure, temperature, thermal energy, mathematical model, algorithm, cost.

I. INTRODUCTION

Any achievements of science and technology have always been associated with the use of a mathematical apparatus for research, calculation, design and testing. However, as the complexity of technology and the introduction of research results in incommensurable in terms of space and time areas of the material world, as a narrow specialization of branches of science and technology is necessary to distinguish mathematical methods that are auxiliary in nature (usually relatively elementary), and mathematical methods that pave the way for fundamentally new solutions (usually very complex) [1].

Currently, in almost all areas of technology modeling is a necessary element in the process of creation, testing and implementation of new equipment. With the advent of complex technical systems, the role of modeling in assessing the parameters of the studied processes has increased significantly. This is explained by the features of the objects under study, resulting from the complexity of the functional relationships between the parameters of the system, changing environmental conditions and the estimated indicators[2].

Typically, when modeling complex systems are faced with a situation where the studied processes in the system and environmental conditions are probabilistic in nature, the number of factors that affect the estimated performance significantly and evaluation of the desired parameters need to be obtained for a wide range of changes in the operating conditions of the system [3].

II. MATHEMATICAL MODEL OF CONTROL OF STEAM PRESSURE IN THE REACTOR ON THE BASIS OF THE SEPARATION CRITERIA.

Currently, in the production of chemical products, the pressure of steam (d) obtained through a steam boiler (hereinafter the reactor) is used in a certain state [4]. If the pressure in the reactor is below any limit (d_0), in order to raise the water temperature, it is necessary to increase the temperature supplied to the reactor, and Vice versa, to reduce the temperature (d_m) with increasing pressure. Excessive pressure drops in the air. Of course, this can lead to excessive consumption of heat sources (gas, diesel fuel, coal). This means that the heat source must be optimized to ensure that the pressure in the reactor varies in the range $d_0<d<d_m$. The functional structure of the reactor is shown in figure 1.

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Depending on the state of the substance in the reactor, this process is a multistage process and the transition of the substance from one state to another can be considered as a transition through the separable criterion. For example, the solid state of water is stage 1, the liquid state of water is stage 2, and the water vapor state can be considered stage 3. Reactor control should increase heat if steam pressure is $d_0>d$ and reduce heat if $d>d_m$, usually performed based on the personal experience of the controller.

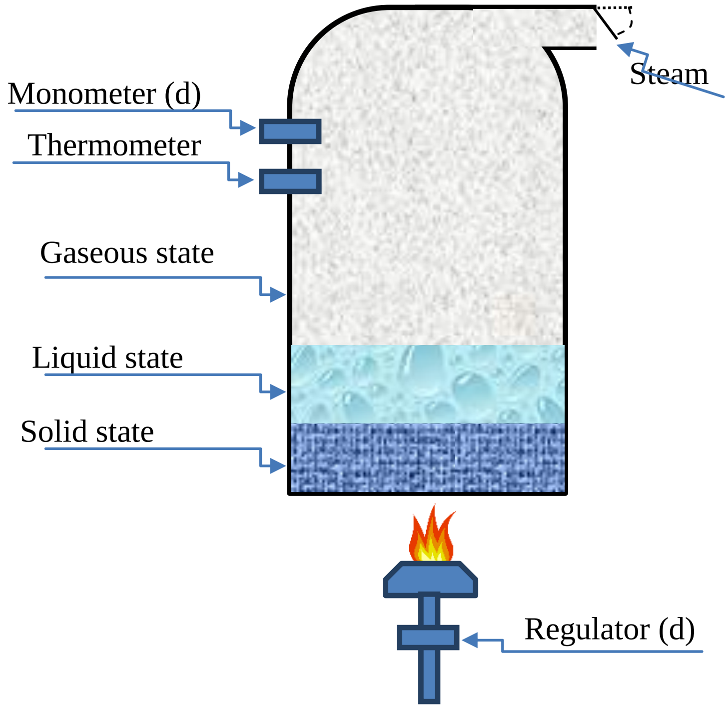

Figure 1. Functional structure of the reactor

The steam pressure in the reactor - d changes, after which the liquid switches to steam, and it can be considered d(τ). The temperature of the substance determines the state of the process. The temperature change of a substance depends on the substance to be determined in criterion separable[5].

Therefore, the temperature change function of the substance can be expressed through the mesh function and expressed as follows.

$$L_{n1+n2+n3}(t)=\begin{cases} L_{n1}^{k} - crystal, & \text{если } N\text{к} < \tau(t) < 0 \\ L_{n2}^{c}(t) - liquid, if\ Nc = 0 < \tau(t) < Nb \\ L_{n3}^{г}(t) - gas, & if \quad Nb < \tau(t) < Ny \end{cases}$$

Temperature change substances τ in turn depends on the amount of substance (V) and the amount of heat supplied (Q), is regarded as $\tau=\tau$ (V, Q). In the process of consideration $V=const$ and $Q=const$ was considered immutable. The time parameter t is the amount of heat given in a unit of time.

The lower *(+Nк)* and upper *(+Ny)* boundaries, if heat is removed from the substance (if the material is cooled), its temperature can not exceed *(+Nк)* and can not exceed the upper limit*(+Ny)*.

Values obtained from experience for each condition:

1- state $N\text{к}<\tau(t)<0=Nc$ for $(\tau_{1.1}, \tau_{1.2}, \tau_{1.3}... \tau_{1.n1})$;

2- state $Nc=\tau(t)<t<Nb$for$(\tau_{2.1}, \tau_{2.2}, \tau_{2.3}... \tau_{2.n2})$ Nc the amount of heat required for the transition to 2-state;

3- state $Nb<\tau(t)<Ny$ для $(\tau_{3.1}, \tau_{3.2}, \tau_{3.3}... \tau_{3.n3})$ Nb the amount of heat required to transition to 3-state.

Using the Lagrange interpolation formula, one can construct polynomials $L_{n1}^{k}(t), L_{n2}^{c}(t), L_{n3}^{g}(t)$ by n1, n2, n3 order[1]. We can use the *MathCad* application package to find polynomial coefficients. It should be noted that the process of changing the temperature of the substance is continuous, as well as in the transition from one state to another, that is, the cases remain continuous even at border points.

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This means that the temperature change function of the substance $\tau=\tau(t)$ with respect to the argument t has a differential of the 1st order, because

$$\lim_{\Delta\to 0}\left|\frac{\tau(t)-\tau(t+\Delta)}{\Delta}\right| = \frac{d(\tau(t))}{dt}$$

has the meaning.

The question itself arises: instead of the Langrage formula $L_{n1}^{k}(t), L_{n2}^{c}(t), L_{n3}^{g}(t)$, created for each case, is it acceptable that the values of all experiments used the Langrage formula $L_{n1+n2+n3}(t)$, passing through $\tau_1(t_1^k)$, $\tau_1(t_2^k)$ ... $\tau_1(t_{n1}^k)$, $\tau_2(t_1^c)$, $\tau_2(t_2^c)$ ... $\tau_2(t_{n2}^c)$, $\tau_3(t_1^b)$, $\tau_3(t_2^b)$ ... $\tau_3(t_{n3}^b)$?

The answer to this question can be found through the remnants of the Langrage Formula. Indeed, if $\tau(t)$ has the actual temperature function of the substance and the derivative $(n+1)$ of the order, then the residue formula for each case can be given as follows[1]:

$$Wk = \left|\tau(t) - L_{n1}^{k}\right| = \frac{\sup\limits_{t\in[Nk,Nc]}\left|\tau_1^{(n_1+1)}(t)\right|}{(n_1+1)!}\left|(t-t_1^k)(t-t_2^k)\dots(t-t_{n1}^k)\right|$$

$$Wc = \left|\tau(t) - L_{n2}^{c}\right| = \frac{\sup\limits_{t\in[Nc,Nb]}\left|\tau_2^{(n_2+1)}(t)\right|}{(n_2+1)!}\left|(t-t_1^c)(t-t_2^c)\dots(t-t_{n2}^c)\right|$$

$$W6 = \left|\tau(t) - L_{n2}^{g}\right| = \frac{\sup\limits_{t\in[Nb,Ny]}\left|\tau_3^{(n_3+1)}(t)\right|}{(n_3+1)!}\left|(t-t_1^6)(t-t_2^6)\dots(t-t_{n3}^6)\right|$$

and for the general Langrage formula

$$Wy = \left|\tau(t) - L_{n1+n2+n3}\right| = \frac{\sup\limits_{t\in[N\kappa,Ny]}\left|\tau(t)\right|}{(n_1+n_2+n_3)!}\left|(t-t_1^k)(t-t_2^k)\dots(t-t_{n1}^k)(t-t_1^c)(t-t_2^c)\dots(t-t_{n2}^c)(t-t_1^b)(t-t_2^b)\dots(t-t_{n3}^b)\right|$$

Comparing the residues among themselves

$|Wy| - |Wk| < 0$

$|Wy| - |Wc| < 0$

$|Wy| - |Wb| < 0$

if any of the conditions are met, we use the general Langrage formula for it*(- Wy)*.

III. ALGORITHM OF CONTROL OF STEAM PRESSURE IN THE REACTOR ON THE BASIS OF THE SEPARATION CRITERIA

Determine $d(Wy)$ using the pressure function($d(\tau)$) and reduce the amount of heat when $d(Wy)$-v=d_m (here v- is the time taken to reduce the amount of heat).

The algorithm for maintaining the steam pressure in the reactor in the required state based on the separable criterion is given below, which uses the following variables:

d - pressure measurement taken at each discrete time from the pressure gauge;

$d(t_0)$- pressure measurement during start-up;

an array consisting of the elements $\tau_1=(\tau_{1.1}, \tau_{1.2}, \tau_{1.3}\dots \tau_{1.n1})$, is used to assemble interpolation formula Language$L_{n1}^{\kappa}(d)$;

an array consisting of the elements $\tau_2=(\tau_{2.1}, \tau_{2.2}, \tau_{2.3}\dots \tau_{2.n2})$, is used to assemble interpolation formula Language$L_{n2}^{c}(d)$;

an array consisting of the elements D - $(d_{3.1}, d_{3.2}, d_{3.3}\dots d_{3.n3})$, is used to assemble interpolation formula Language$L_{n3}^{g}(d)$;

Q – regulator, a unit that determines the amount of heat that increases or decreases the amount of heat.

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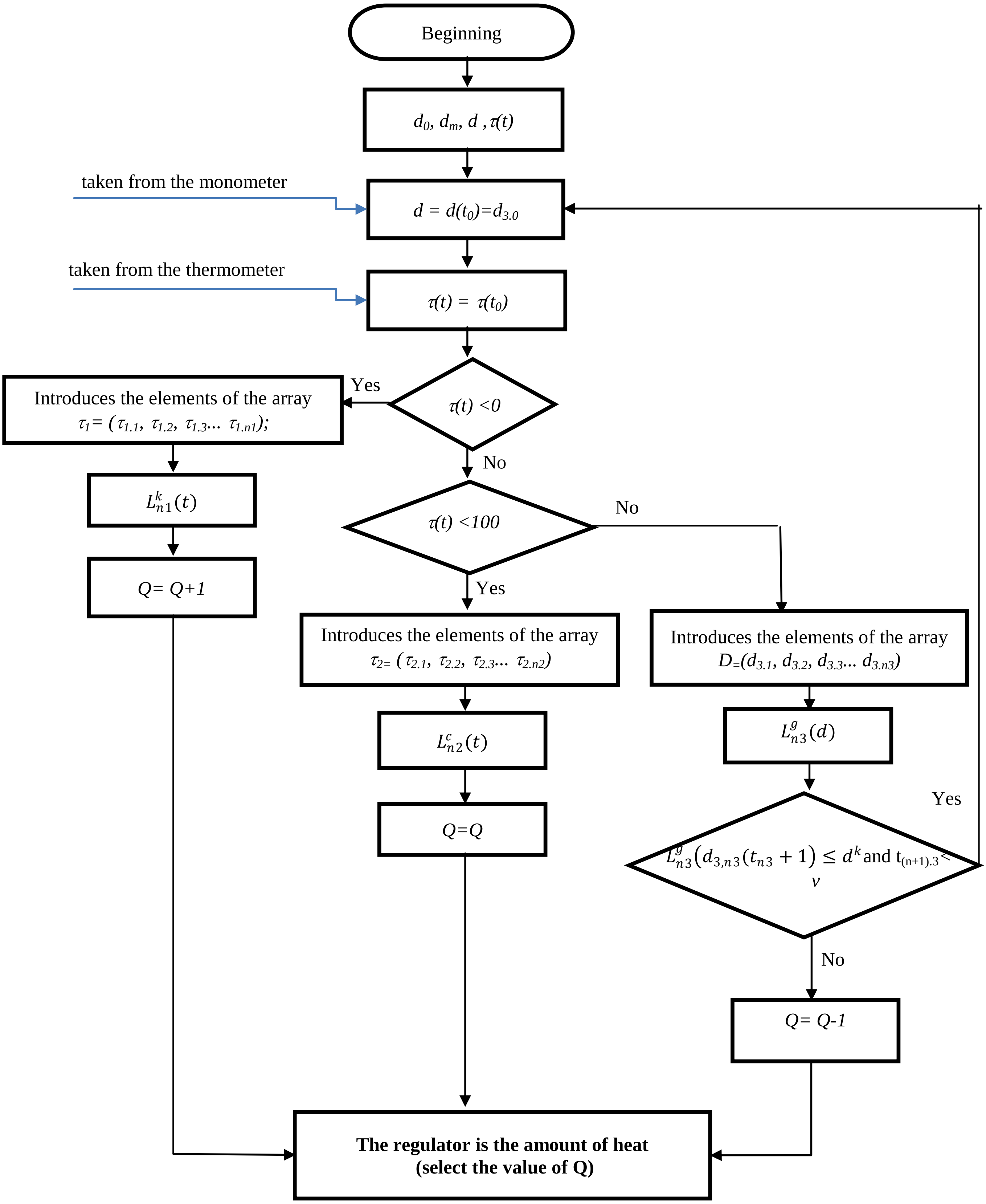

Figure 2. Process algorithm

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IV. CONCLUSION AND FUTURE WORK

The development of energy-saving and resource-saving technologies and technical equipment, ensuring the efficient use of resources is great, appraisers of the main indicators of energy consumption.The control methods and algorithms discussed above lead to an optimal variant of energy consumption in the production process. As a result, production costs will be reduced, and the amount of environmental damage will be significantly reduced.

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AUTHOR’S BIOGRAPHY

FayzullaevUbaydullaSagdullaevich Senior Lecturer.
Has more than 20 published scientific works in the form of articles, journals, theses and tutorials. Currently works at the department of “Information technologies” in Tashkent State Technical University.

KasimovaGulnoraIsmoilovna, Assistant.
Has more than 10 published scientific works in the form of articles, journals, theses and tutorials. Currently works at the department of “Information technologies” in Tashkent State Technical University.

TulyaganovZoxidjonYakubdjanovichAssistant.
Has more than 10 published scientific works in the form of articles, journals, theses and tutorials. Currently works at the department of “Information technologies” in Tashkent State Technical University.