ADVANCED CONTROL SYSTEM FOR THE DRYING PROCESS OF POTASSIUM CHLORIDE IN A DRUM DRYER

[1]Bekkulov Zhakhongir Sherboevich

[1]Karshinsky Institute of Engineering and Economics, Department of Automation and Control of Technological Processes

Address:180100, Karshi, Kashkadarya region,

Karshi city street, Mustakillik 225.

E-mail: jbekqulov@mail.ru,Phone:+998-99-081-09-55

Annotation: The modern state of the theory and practice of advanced management, which is a virtual analyzer in the structure of control and management of technological processes of the production of potash fertilizers, has been critically analyzed and trends in their further advancedment have been identified.

Keywords: Advanced control system, technological parameters, drum dryer, virtual analyzer, structural functional scheme, adaptive management.

Introduction. When assessing the quality indicators or predictions of final products after drying in a potassium chloride – drum dryer, virtual analyzers are used as a crucial element of advanced control systems [1-2]. In addition, the dependence of the output parameter on the input parameter will not be linear, since the wet concentrate is dried in the drum at a constant or decreasing rate (the level of characteristic equations can be two or more), and the process under consideration has a stochastic mathematical description. Because it is continuously influenced by external agitators. The functional scheme of the adjustment of the process of drying potassium chloride in the drum dryer as well as the dependence of technological parameters affecting moisture is expressed in Figure 1.

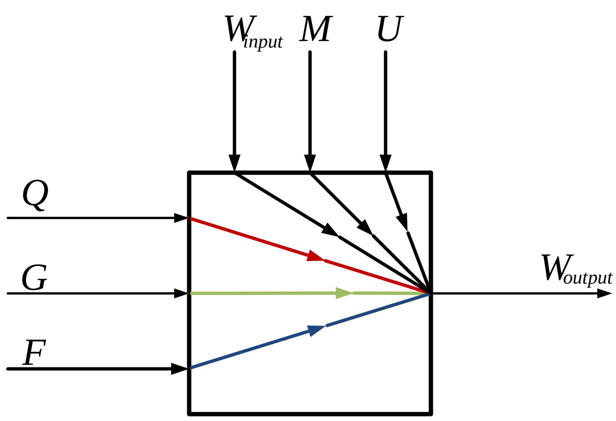

Figure 1. Functional scheme of the adjustment of the process of drying potassium chloride as well as the dependence of technological parameters affecting moisture:

Q – drying agent consumption[m^3/h];G – primary air consumption [m^3/h]; F – secondary air consumption [m^3/h]; W_{input} – material Inlet moisture [%]; M – material consumption [m^3/h]; U – air inlet humidity [%]; W_{output} – moisture content of the material at the exit [%].

The process of drying potassium fertilizers in question is complicated due to the adjustment time of control, changes in humidity, immeasurable changes in the properties of the product. Therefore, the drying process is controlled using continuous temperature adjusters. At the same time, the transfer function on each channel of the adjustment consists of a delay non-linear zveno.

$$W_{ij}(p) = \frac{K_{ij}}{T_{ij}+1} \cdot e^{-\tau_{ij} p} \quad , \tag{1}$$

where: i– serial number of incoming parameters; j – output parameter serial number; K – reinforcement coefficient; T– time constant; τ – delay time (seconds).

In order to improve the adjustment given in the process of operation of the automatic adjustment system of objects when choosing the main channel of adjustment, it is necessary to change the dynamic characteristic of the adjusting device in such a way that it is necessary to ensure that the characteristics of the control object are compensated for unchanged. The object under study can be described in the form of a drum dryer linear conversion equation model.

$$y_x(M) + a_1 y_x(M-1) + ... + a_n y_x(M-n) = b_1 x(M-d-1) + ... b_u u(M-d-n), \tag{2}$$

where k is the delay;

$$\left. \begin{aligned} x(M) &= x_0(M) - x_1 \\ y(M) &= y_0(M) - y_1 \end{aligned} \right\},$$

in this: n – number of quantization cycles; $x(M), y(M)$ – aughys; $x_0(M), y_0(M)$ – change values; x_1, y_1 – fixed (given) values. z by applying replacement $y(k+i) = z^i y(k)$ for the (2) subtraction equation given by the ratio, the operator form of the discrete model is obtained.

$$(a_0 + a_1 z^{-1} + ...a_n z^{-n}) y(k) = (b_0 + b_1 z^{-1} + ...b_m z^{-m}) x(k). \tag{3}$$

Starting from (3), when the initial conditions are zero, the transmission function of the linear system representing the ratio of the input signal to the output signal z can be obtained.

$$W(z) = \frac{y(z)}{u(z)} = \frac{b_0 + b_1 z^{-1} + ...b_t z^{-t}}{a_0 + a_1 z^{-1} + ...a_s z^{-s}} \cdot z^{-K} \tag{4}$$

$$\Theta_j(k) = \left[a_{1j}(m); a_{2j}(m); a_{3j}(m); b_{1j}(m); b_{2j}(m); b_{3j}(m)\right]^{\tau}.$$

Recommended algorithm for evaluating Model parameters:

1. $y_j(m)$ and $x_j(m)$, $j = 1, i = 1,...,6$ s measurement;

2. $e_j(m) = y_j(m) - \psi_j^T \Theta_j(m-1)$ finding the equation error; $e_j(m)$ – error of equation; $y_j(m)$ – new measurement; $\psi_j^T \Theta_j(m-1)$ – predicted value.

3. Calculating the new values of the parameters

$$\Theta_j(m) = \Theta_j(m-1) - \xi_j(m-l)e_j(m), \qquad (5)$$

where: $\Theta_j(m)$ – new grade; $\Theta_j(m-l)$ – old Grade; $\xi_j(m-l)$ – correction vector; $e_j(m)$ – equation error.

4. Formation of new vectors of data

$$\psi_j^T(m+1) = \left[-y_{1j}(m); -y_{2j}(m); -y_{3j}(m); x_1(k-d_{ij}); x_2(m-d_{ij}); x_3(m-d_{ij})\right]. \qquad (6)$$

$$P_j(m)\cdot\psi_j^T(m+1) = \begin{bmatrix} P_{11j}(m) & \cdot & \cdot & \cdot & P_{16j}(m) \\ \cdot & \cdot & & & \cdot \\ \cdot & & \cdot & & \cdot \\ \cdot & & & \cdot & \cdot \\ P_{61j}(m) & \cdot & \cdot & \cdot & P_{66j}(m) \end{bmatrix} \cdot \begin{bmatrix} -y_{1j}(m) \\ \cdot \\ \cdot \\ \cdot \\ -y_{6j}(m) \end{bmatrix} = \begin{bmatrix} i_{1j} \\ \cdot \\ \cdot \\ \cdot \\ i_{6j} \end{bmatrix}. \qquad (7)$$

5. Calculation

The measured output $y(M)$ has adaptive random perturbations $n(M)$. Regression equations are used to describe the signals generated by external stimuli in the form of mathematical expressions:

$$n(M) + C_1 n(M-l) + ... + C_p n(m-p) = V(M) + d_r V(M-l) + ... + d_p V(M-p) \qquad (8)$$

where: $V(M)$ – limits of a sequence of distribution functions that quantitatively characterize external disturbances.

The external perturbations are expressed as a discrete transfer function, and it is described as follows:

$$G_v(P) = \frac{n(p)}{V(p)} = \frac{D(p^{-1})}{C(p^{-1})} = \frac{1 + d_1 p^{-1} + ...d_p p^{-m}}{1 + c_1 p^{-1} + ...c_p p^{-m}}. \qquad (9)$$

Thus, we tariff the object model, in which an external Riot is involved:

$$y(p) = \frac{B(p^{-1})}{A(p^{-1})} \cdot p^{-d} \cdot u(p) + \frac{D(p^{-1})}{C(p^{-1})} \cdot V(p). \qquad (10)$$

The issue of parametric identification consists in obtaining an estimate of the model parameters, namely the coefficients of polynomials $A(p^{-1})$ and $B(p^{-1})$, as well as $C(p^{-1})$ and $D(p^{-1})$ [2-4].

To implement such approaches, it is necessary to apply or identify special methods based on calculations on the transient process. The most acceptable for automatic adjustment system quality drying is adaptive control system. Adaptive control is built on the basis of a system that controls the main adjusting size (W_{output}) according to the deviation, adaptively compensates the deviation drying agent for consumption (Q), primary air consumption (G), primary air consumption (F) and external disturbances for wet concentrate on Inlet moisture, material consumption and air inlet moisture [3-5]. Figure 2 shows the structure of the adaptive control system of the drying process.

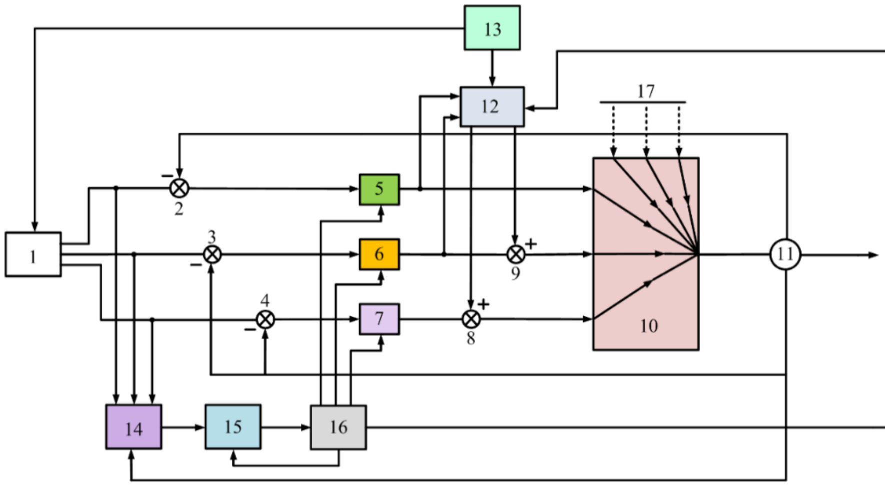

Figure 2. Structure of improved adaptive control system of drying process: 1-Task formation block, 2,3,4-comparators, 5,6,7-consumption sensors, 8,9-summators, 10-control object, 11-humidity analyzer, 12-compensator, 13-function Block, 14-identification Block, 15-parameter adjustment block, 16-adaptive control Block, 17-external disturbances.

The proposed process of drying potassium fertilizers is characterized by an advancedadaptive control method, as well as the fact that the parameters of the adjusting system in the process of Operation do not change and correspond to adjustments. The improved adaptive control system changes the T time constants of the compensatory device in the case of changes in the parameters of the control object in the process of operation [5-7]. The resulting change can occur only in cases where the adjustment quality is poor in the change in the result of the characteristics of the control object. This ensures the necessary reserve of stagnation of the system. The structural-functional scheme of the improved control system of the drying drum, proposed below, is shown in Figure 3.

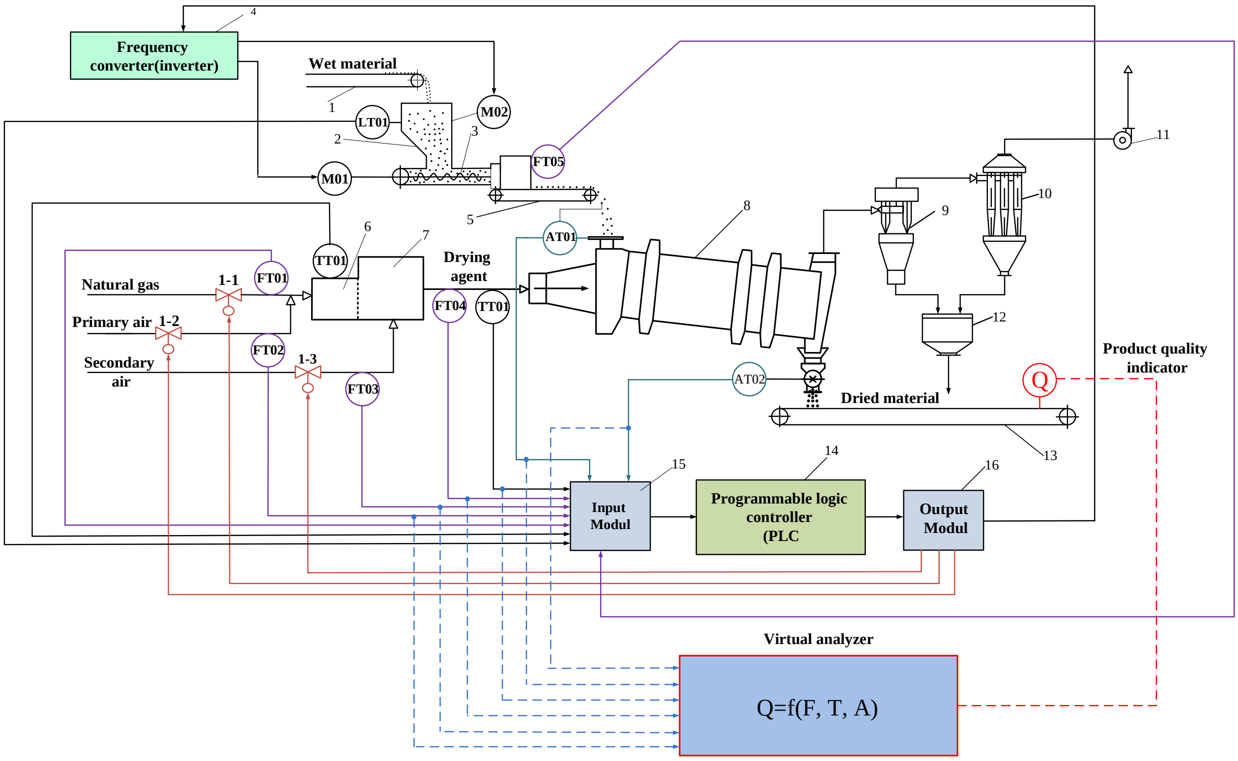

Figure 3. Structural functional scheme of the improved control system of the drying drum: 1 - wet material supply conveyor; 2 - wet material Bunker; 3 - Doser, 4 - frequency adjuster (frequency changer); 5 - supply conveyor; 6 - calorifer; 7 - Mixer ; 8 - drum dryer; 9,10 - cyclones; 11 - dust puller; 12 - collector bunker; 13 - conveyor sending dry material to the refrigerator; 14 - programmable logic controller (DMK), 15 - analog input (Input module), and 16 - analog output (output module) blocks; tt01, tt02 – temperature sensors; FT01– gas consumption sensor; ft02 – primary air consumption sensor; FT03-secondary air consumption sensor; FT04 – drying agent consumption sensor; FT05 – wet concentrate consumption sensor; LT01 – surface sensor; M01, M02 – electric motors.

The structural-functional scheme of the proposed, improved control system of the drying drum to the input of the virtual analyzer TT01,TT02 - temperature sensors in the drying drum; FT01 – gas consumption sensor; FT02 – primary air consumption sensor; FT03 – secondary air consumption sensor; FT04 – drying agent consumption sensor; FT05 – wet concentrate consumption sensor; AT01, AT02 – incoming and outgoing humidity analyzers; LT01 predicts the quality of dried potassium chloride by adopting process parameters that are measured and controlled using level sensors. The output of the Virtual Analyzer is considered to be a qualitative indicator of technological processes or the product produced. In addition, signals transmitted by primary switches are received by a programmable logic controller (DMK) and control signals (effects) are formed by the controller into all executive mechanisms [7]. This in turn is stored in the database archive. The effects of controlling the improved control system of the process of drying potassium chloride in a drum dryer and the results of the implementation of the output variables are shown in Figures 4 and 5.

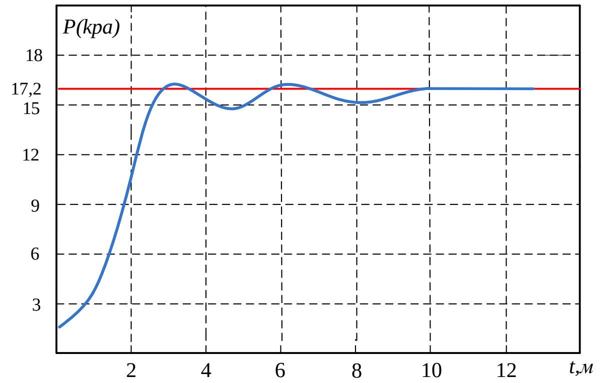

Figure 4. Graph of change after advanced gas pressure control

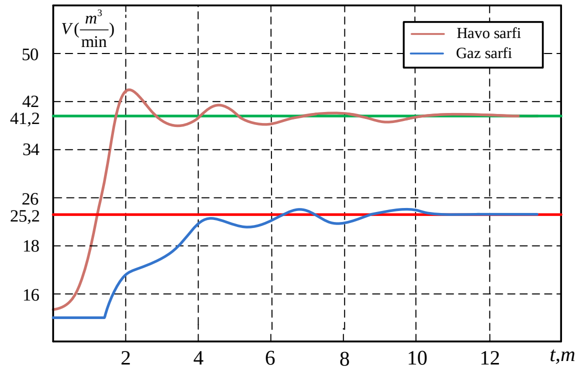

Figure 5. Graph of change after advanced control of gas and air consumption.

On the personal computer monitor at the central control point of the plant, one can see the mnemoscheme of the combustion process of the drum dryer and calorifier, the values of the technological parameters involved in the combustion process and affecting moisture, the characteristics of the change. Based on the application installed on an industrial computer, calorific can carry out the archiving of information from the control cabinet as well as their processing, the construction of graphs of change of technological parameters and the remote control of the drying process of mineral fertilizers. Software has been developed that implements the operation algorithm of the improved control system of the drying drum [6-8].

Conclusion. Analysis of the problems of control and management of technological processes of potash fertilizers production, existing methods of measuring the quality of mineral fertilizers indicates the need to develop new and improve existing methods of measuring the quality of potash fertilizers. The demand for the development of new and modernization of existing technologies for measuring the quality and quantity of mineral fertilizers to obtain products of the required quality is shown. In addition, there is a tendency to develop control and management algorithms at different levels of management - from the management of production processes to the level of effective support for managerial decision-making. The work on choosing the optimal structure of the potassium chloride drying process control system, determining the technological parameters that affect the quality of the product during the drying process was carried out in the normal operating mode of the drum dryer. As a result, an improved control system was developed as the control object of the drying drum, as well as the software of the same system.

References:

[1]. Potocki, V.A., Fadeev, V.M., Maksimov, E.A., Bakhtadze, N.N. (2004). Virtual analyzers of the quality of technological process control based on a nonlinear dynamic predictor. Abstracts of the 5th International dokpads. Conferences "Problems of management and energy".Tbilisi, Georgia, 35 p.

[2]. Юсупбеков Н.Р., Беккулов Ж.Ш. /Синтез системы адаптивного регулирования процесса сушки минеральных удобрений в барабанной сушилке//«Фан ва технологиялар тараққиёти, илмий – техникавий журнал», №1.2023.187-195б. https://journal.bmti.uz.

[3]. Аралов, Ғ. М., & Беккулов, Ж. Ш. (2017). Классификация методов контроля и диагностики состояния и режимов работы системы контроля и регулирования параметров технологических процессов. Міжнародний науковий журнал Інтернаука, (3 (1)), 110.

[4]. Yusupbekov N.R.Gulyamov Sh.M., Ergashev F.A., Doshchanova V.Yu. Adecvanced Control of Complex technological Processes and Production on the Example of Drying and Granulation of Mineral Fertilizers// International Journal of Advanced Research in Science, Engineering and technology Vol.6,Issue 3, March 2019. India-PP.8361-8366.

[5]. F. T. Ademiluyi , M. F. N. Abowei , Y. T. Puyate & S. C. Achinewhu (2010): Effects of Drying Parameters on Heat Transfer during Drying of Fermented Ground Cassava in a Rotary Dryer, Drying Technology: An International Journal, 28:4, 550-561

[6]. Юсупбеков Н. Р.,Беккулов Ж. Ш., Холманов Ў.У. Программное обеспечение для интеллектуальной системы управления процессом сушки калийных удобрений/Агентство по интеллектуальной собственности Республики Узбекистан. № DGU 18540,2022 г.

[7]. Bekkulov, J., Ibragimov, B., & Eshonkulov, M. (2021). Mathematical model of the trajectory of moving control objects. In Технические науки: проблемы и решения (pp. 110-116).

[8]. Беккулов, Ж. Ш., & Ибрагимов, Ш. (2021). оптимальное управление периодическими процессами. Central Asian Journal of Theoretical and Applied Science, 2(5), 184-190.