STUDY OF THE EFFICIENCY OF AUTOMATIC CONTROL SYSTEMS

Abstract. The article proves that the automation of the sugar industry ensures high-quality, efficient work of all technological sections of the sugar factory only
with the help of a comprehensive approach to the solution of this problem. Measuring the humidity of sugar at the exit of the drying drum, carried out by a microwave sensor mounted at the exit of the drying unit and should be immersed in the studied environment, is considered. Then the readings of the humidity sensor would correspond to the humidity of this environment. The cases when, due to the unevenness of the flow of sugar, the readings of humidity would depend on the degree of immersion of the sensor in the medium under study were considered. It was emphasized that such a signal's change rate would be much higher than the useful humidity signal.

A change in the signal at the input of the control system could lead to instability of the control and unjustified changes in the parameters of warm air flow or the angle of the drum inclination.

The sign-sensitive low-frequency filtering of input signals to improve the stability of the control system. To reduce the influence of uneven passage of the investigated medium past the humidity sensor, a discrete autoregressive filter was developed with a different effect on the signal depending on the direction of its change. Using the developed filter made it possible to reduce the influence of uneven sugar flow on the operation of the control system.

**Keywords:** processes, stability, re-adjustment, integral criteria, system stability, utfel drying, humidity adjustment, automatic regulator.

**Problem statement.** Automation of production and technological processes should be considered both from the point of view of improving equipment, technological equipment, and process quality, as well as ensuring technical and economic efficiency.

Automation of the sugar industry ensures high quality, efficient work in all technological areas of the sugar factory only with the help of a comprehensive approach to the solution of this problem.

Drying of large volumes of tuff is carried out using a drum drying unit. Its design involves heating the raw materials with warm air supplied from the outside, as well as mixing the raw materials during the drying process to increase the area of interaction of the crystals with the warm dry air.

Measuring the moisture of sugar at the exit of the drying drum is carried out by a microwave sensor. The microwave sensor is mounted at the outlet of the drying unit. Structurally, it should be immersed in the environment being tested, and then the readings of the humidity sensor would correspond to the humidity of this environment. However, due to the unevenness of the sugar flow, the humidity readings would fluctuate depending on the degree of immersion of the sensor in the tested environment, and not on humidity. At the same time, the rate of change of such a signal would be much higher than the useful humidity signal.

**Analysis of recent research and publications.** Many domestic and international experts have addressed the issue of studying the effectiveness of
automatic control systems. We have summarized their experience and based our research on it.

**Purpose Of The Article:** (ACP), research of the quality of ACP according to the graphs of transient processes, and adjustment of ACP setting parameters to ensure the necessary system quality.

**Presentation Of The Main Material.** A change in the signal at the input of the control system could lead to control instability and unjustified changes in the parameters of the warm airflow or the angle of the drum.

Stability is a necessary but not sufficient property of an automatic control system, since very slowly decaying, long transients could occur in a stable system. There is a need to quantitatively assess the effectiveness of regulation processes during the stable operation of the system. The most common criteria in automation are static and dynamic errors, adjustment time, over adjustment value, damping degree, and integral criteria.

From the graph in Fig. 1.1, it is easy to determine some quality criteria

\[ y_{\text{ct}} = |y_y - y_{\text{зад}}| \]  \hspace{1cm} \text{(1.1)}

So, the static error \( y_{\text{ct}} \) is equal to the difference between the constant value of the regulated quantity \( y_y \) and its set value \( y_{\text{зад}} \):

The static error characterizes only the accuracy determined by the regulation law and does not take into account the accuracy of the measurement and other devices and devices of the system. Considering the proportional-differential (PD) law of regulation, we could say that it implements this law of regulation in the form
of a system containing two parallel working typical links - proportional and perfectly differentiating. Proportional-integral-differential (PID) regulation law (automation) is the simplest algorithm for the operation of an automatic regulator, which includes the influence of all considered laws. PD - the regulation law does not allow avoiding a static error (the only exception is an astatic object when disturbed by the task). In real systems, the value of the static error should not exceed the permissible limits determined by the technological requirements. For the static error should be small or equal to zero. It is necessary to use regulators with an integral component in the regulation law (I-, PI-, PID-), which provide regulation without static error. Integral (I) law of regulation in automation — the law according to which the control signal produced by the automatic regulator is equal to the integral of the time offset. The integral regulation law is implemented with an astatic or I-regulator with a setting parameter.

The dynamic error is equal to the largest deviation in the transient process of the regulated value from its constant value:

$$Y_{дин} = Y_{макс} - Y_0$$ \hspace{1cm} (1.2)

The adjustment time $t_p$, that is, the duration of the transition process, is determined until the moment when the deviation $Y_0 - Y_0$ enters the pre-set small limits, for example, $\pm 5\%$ of $Y_0$(Fig. 1.1). Sometimes regulation is characterized by the speed of the system. The degree of attenuation serves as a quantitative estimate of the oscillatory process damping intensity $\Psi$:

$$\Psi = (Y_1 - Y_2)/Y_{фате \ unit}$$ \hspace{1cm} (1.3)

The values most often used in practice $\Psi$ are between 0.75 and 0.9. Another important characteristic of quality is readjustment $\eta$:

- for astatic systems ($Y_0 = 0$):
  $$\eta = (Y_1)/100\%$$ \hspace{1cm} (1.4)

- for static systems:
  $$\eta = (Y_{макс} - Y_0)/100\%$$ \hspace{1cm} (1.5)

Of course, there is a demand for readjustment to the systems: $\eta \leq 20 \div 30\%$

There are several types of integral criteria, of which the integral quadratic criterion has become the most widespread $I^2$:

$$I^2 = \int_0^\infty y^2(t) \, dt$$ \hspace{1cm} (1.6)
Criterion (1.6) gives a summary assessment of the quality of the transient process, taking into account the duration of the process and the dynamic deviation of the regulated value from the set value.

The following questions are essential for assessing the quality of ASR work:

- whether the regulator would bring the regulated value exactly to the set value or whether a static error would occur;
- what is the maximum amount of imbalance during regulation;
- what is the speed of the system, that is, how quickly the transition process would be completed.

You could answer these questions by knowing the properties of the object and the regulator, at which the ACP works in the best way (optimal 10 tuning), ensuring the optimal transitional process in the regulation system.

Let's consider the proposed structural diagram of the utfel drainage system.

Warm dry air heats the raw material, which intensifies the process of moisture absorption. In addition, the airflow, after flowing around the raw material and absorbing moisture, carries it outside. The amount of air that enters the drying drum directly affects the intensity of drying. The drying time depends on the ability of air to absorb and remove moisture, as well as on the time of raw materials interaction with warm dry air.

When the drum of the drying unit rotates, the raw material moves along it at a speed that depends on its fluidity and under the influence of gravity. Liquidity depends on many factors, so it is difficult to change it. It is possible to change the speed of raw materials advancement along the drum by changing the raw materials interaction with the force of gravity, by changing the angle of the drying drum axis inclination.

Heated and dried raw materials should be cooled before storage. Cooling is carried out by a flow of cold, dry air to a given temperature. Thus, three control loops are used for system operation.

- Maintaining the specified humidity of the raw material by controlling the specific time of the raw material in the drum.
- Maintaining the specified humidity of the raw material by controlling the intensity of the flow of heated air.
- Maintaining the set temperature of the dried medium at the exit of the drum by controlling the intensity of the cooling air.

With an unchanged design of the drying system with a fixed mass of dried raw materials, the drying time, air temperature, air humidity before interaction with the raw materials, and air volume remain variable parameters. The drying time depends on the ability of air to absorb and remove moisture, as well as on the time of interaction of raw materials with warm dry air.
The moisture content of the raw material at the exit from the drum depends on the time of interaction with the drying air and the intensity of blowing. The structural diagram of the system for maintaining the specified humidity of raw materials is shown in Fig. 1.2

![Diagram](image)

**Fig.1.2: Structural diagram of raw material moisture control at the outlet of the drying unit**

A change in the signal at the input of the control system could lead to instability of the control and unjustified changes in the parameters of the flow of warm air or the angle of inclination of the drum.

The stability of the control system could be improved by applying sign-sensitive low-frequency filtering of input signals. To reduce the influence of uneven passage of the investigated medium past the humidity sensor, a discrete auto-regression filter was developed with a different effect on the signal depending on the direction of its change. Analytically, such a filter is described by the dependence:

\[
\begin{align*}
    y_i &= \begin{cases} 
    (1 - \alpha_1) \cdot x_i + \alpha_1 \cdot y_{i-1} & y_{i-1} > x_i \\
    (1 - \alpha_2) \cdot x_i + \alpha_2 \cdot y_{i-1} & \text{otherwise}
    \end{cases}
\end{align*}
\]  

(1.7)

where \( \alpha_1 \) is the smoothing coefficient on the falling part of the signal, \( \alpha_2 \) is the smoothing coefficient on the rising part of the signal.

An example of applying such a filter to a sinusoidal variable test signal is presented in Fig. 1.3

![Graph](image)
Conclusions. Therefore, the use of the developed filter made it possible to reduce the influence of uneven sugar flow on the operation of the control system. Humidity regulation is carried out by two executive mechanisms with one input parameter, while the proportional -integral law of regulation is applied to control each of the mechanisms - separately for changing the flow of warm air and changing the angle of the drum.

References: