ANALYTICAL METHOD OF DETERMINING OF INDUSTRIAL PID CONTROLLER PARAMETERS

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Annotation. *The study and justification of possibilities of using of analytical methods for the determination of the parameters of regulators in automatic control systems of technological processes are carried out. Areas of application of different types of regulators are identified.*

Key words: ***automatic control system, synthesis of controller, settings parameters***

In the automatic process control widely used linear proportional-integral-differential (PID) controllers. To determine the parameters of regulators is the most common frequency graph-analytical synthesis methods [1]. However, they are based on an automatic filing system as a combination of two elements - object control and regulator, and often do not address specific technical implementation of certain components of the automatic control system, such as the actuator. If the actuator or other possible elements of great importance because of constant time either through integrating properties with significant frequency and dynamic characteristics of the system, the complexity of the application of graph-analytical methods for the synthesis controller increases significantly. Then we can recommend the use of analytical methods [2,3].

The purpose of research - determining the possibility of using analytical methods of synthesis of regulators in the automatic process control. **Materials and methods of research.** Analytical method for determination of parameters of regulators based on the open-loop transfer function representation system in the form

$$W_{роз}(s) = W_{рег}(s) \cdot W_{нч}(s) \ , \tag{1}$$

where $W_{рег}(s)$ - transfer function of the regulator that is supplied in the form $W_{рег}(s) = K_p$ - for P-regulator, $W_{рег}(s) = K_i / s$ - for I-regulator, $W_{рег}(s) = K_p + K_i / s$ - for PI regulator, $W_{рег}(s) = K_p + K_i / s + K_d s$ - for PID regulator; $W_{нч}(s)$ - transfer function of the constant part of system, which can contain object in general management, primary measuring transducer and the actuator.
If desired advance wonder transfer fuktsiyeyu can determine the appropriate transfer function of the regulator and its settings by formula

$$W_{рег}(s) = \frac{W_{роз}(s)}{W_{нч}(s)}. \quad (2)$$

The method settings astatyzmu is the introduction of the compensation system and inertial parts due to the relevant regulators [2,3]. Desired open-loop system transfer function thus sought in the form

$$W_{роз}(s) = \frac{e^{-\tau s}}{T_o s \prod_{i=l+1}^{m} (T_i s + 1)}, \quad (3)$$

where - the time constant of the integrating component; - The number of compensated inertial links with large time constants; - The amount of uncompensated inertial links with small time constants.
If you choose to terms and conditions, which is the largest uncompensated time constants, the cutoff frequency is equal and the phase margin stability at such a cutoff frequency will be:

$$\Delta\varphi(\omega_з) = -\pi + \frac{\pi}{2} + \tau\omega_з + \sum_{i=l+1}^{m} arctg T_i \omega_з \quad .(4)$$

Since then and under. Then (4) can be written

$$\Delta\varphi(\omega_з) = -\frac{\pi}{2} + \tau\omega_з + \sum_{i=l+1}^{m} T_i \omega_з = -\frac{\pi}{2} + T_\mu \omega_з, \quad (5)$$

where $T_\mu = \tau + \sum_{i=l+1}^{m} T_i$ - the total uncompensated time constant.

Due to (5), expression (3) can be represented as:

$$W_{роз}(s) = \frac{1}{T_o s(T_\mu s+1)}. \qquad (6)$$

This closed system transfer function will look like

$$W_{зам}(s) = \frac{1}{T_o T_\mu s^2 + T_o s + 1} . \qquad (7)$$

The dynamic properties of the system with the transfer function (7) depend on the ratio of time constants. When $(T_o = 2T_\mu)$ is provided with little regulation time overshoot that meets the requirements of large objects. Therefore, such a configuration setting called the technical optimum. Then the desired transfer function of the open-loop system will look like

$$W_{роз}(s) = \frac{1}{aT_\mu s(T_\mu s+1)} \qquad (8)$$

and can be applied to systems with integrating and without links. **Results.** 1. The permanent part of the system does not have integrating links. For example, the object is approximated inertsinoyu control element with a delay, taking element - inertial link actuator - also inertial element (heater, fan, servo covered local hard reverse for the provision of communication regulator). Under this condition, this method can be applied to I-, PI-, PID regulation algorithms. This constant transfer function of the system is supplied as a

$$W_{нч}(s) = \frac{K \cdot e^{-\tau s}}{\prod_{i=1}^{m}(T_i s+1)}, \qquad (9)$$

The transfer function regulator according to at (2), (7) and (9) is as following:

$$W_{рег}(s) = \frac{W_{роз}(s)}{W_{нч}(s)} = \frac{\prod_{i=1}^{l}(T_i s+1)}{KT_o s} = \frac{\prod_{i=1}^{l}(T_i s+1)}{K2T_\mu s}. \qquad (10)$$

The number of possible compensated inertial units depends on the type of controller. a) When using the I-controller = 0 (all considered small time constants). In this case astatyzm introduced and ensured a regulation. The transfer function regulator:

$\cdot\ W_{рег}(s) = \dfrac{1}{K2T_{\mu}s}$ (11).

Parameter settings $K_p = \dfrac{T_1}{K2T_{\mu}}$, $K_i = \dfrac{1}{K2T_{\mu}}$.

.b) When using the PI controller = 1 (offset inertial link with a large time constant, others are considered small time constants). The transfer function regulator:

$$W_{рег}(s) = \frac{T_1 s + 1}{K2T_{\mu}s} = \frac{T_1}{K2T_{\mu}} + \frac{1}{K2T_{\mu}s} \ . \ (12)$$

Options settings $K_p = \dfrac{T_1}{K2T_{\mu}}$, $K_i = \dfrac{1}{K2T_{\mu}}$.

c) When using the PID controller = 2 (offset inertial links with two time constants and large). Then:

$$\cdot\ W_{рег}(s) = \frac{(T_1 s + 1)(T_2 s + 1)}{K2T_{\mu}s} = \frac{T_1 + T_2}{K2T_{\mu}} + \frac{1}{K2T_{\mu}s} + \frac{T_1 T_2}{K2T_{\mu}} s \ \ (13)$$

Configuration options $K_p = \dfrac{T_1 + T_2}{K2T_{\mu}}$, $K_i = \dfrac{1}{K2T_{\mu}}$, $K_d = \dfrac{T_1 T_2}{K2T_{\mu}}$.

2. The permanent part of the system has an integral link. For example, integrating links servomotor is without local feedback, object control without samovyrivnyuvannya. Then the transfer function of the constant will look like

$$W_{нч}(s) = \frac{K \cdot e^{-\tau s}}{s\prod_{i=1}^{m}(T_i s + 1)} \ . \qquad (14)$$

In the case of I-, PI- and PID controllers results in astatyzmu synthesized second order system, the application of this technique reserves reduces resistance and worsens the quality indicators transients. Therefore astatic systems with the same part, this technique can be applied to systems with a P-regulator. Then, based on the desired open-loop system transfer function (8) using expressions (2) and (14) we obtain the transfer function of the regulator

$$W_{рег}(s) = \frac{W_{роз}(s)}{W_{нч}(s)} = \frac{s\prod_{i=1}^{l}(T_i s + 1)}{KT_o s} = \frac{\prod_{i=1}^{l}(T_i s + 1)}{K2T_{\mu}} \ . \qquad (15)$$

If = 0 (no inertial units that offset) will have a transfer function P-regulator

$$W_{рег}(s) = \frac{1}{K2T_{\mu}}, \quad (16)$$

with parameter settings, which results in dynamic performance quality of the technical optimum, while static error is destroyed by integrating properties of the unchanging parts.

If = 1 and more difficulties arise due to greater physical implementation procedure numerator than denominator transfer function of the regulator. Thus, in the case of constant astatic system in the application of this technique can be recommended:

-The use of P-regulators;

If the time should be reduced by adjusting the compensation of inertial units should get rid intehruchyh links in a constant part of their coverage by the local feedback.

Conclusions

The proposed analytical method to determine the parameters of automatic regulators with multiple links and inertial delay, given the dynamic properties of the actuators.