ANALYSIS AND CALCULATION OF THE ELECTRIC DRIVE
FOR THE EXTRUDER IN A CONTROLLABLE ELECTRICAL
COMPLEX FOR PRODUCTION OF SYNTHETIC YARNS

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The conditions that function $W_0(z)$, which ensures the minimum acceptable time of the switching process, must satisfy can be formulated as follows: — function $W_0(z)$ should have nulls equal to the poles of $W_0(z)$ positioned in the unit circle or outside of plane $z$; — function $W(z)$ or $1 - W_0(z)$ should have all nulls of $W(z)$ located in the unit circle or outside of plane $z$ as nulls; — function $W(z)$ or $1 - W_0(z)$ should contain $z^{-1}$ as cofactor $z^{-1}$. If $W_0(z)$ is an unstable unit impulse response, then $F(z)$ should contain all poles of $W_0(z)$ lying in the unit circle or outside of plane $z$ as nulls (with the exception of the poles for $z = 1$). If $W_0(z)$ has nulls located in or outside of the unit circle, these nulls must be nulls of $W(z) = 1 - (1 - z^{-1})$. In these two cases, the briefest time of the switching process will exceed the value which can be obtained for a system with a stable unit impulse response $W_0(z)$ which has no nulls in or outside of the unit circle of plane $z$.

A device for automatic control of spinning and winding of synthetic fibres was developed in the University’s Department of Electrical Engineering [1].

A mathematical model was proposed and digital modeling of an extruder microprocessor electric drive which should ensure operation in two basic modes: stabilization of the screw rotational speed and stabilization of the pressure in the extruder head. In the first case, the screw rotational speed must be kept constant with a deviation of 1-2% in the entire range of variation of the output and in the second case, the system must be stable.

Pulse and digital control of electromechanical systems has certain advantages. For example, interruption allows controlling high output by means of control elements; digital control provides for correction with programming and data processing; the interruption methods simplify the design of adaptive control systems for automatic control. On the other hand, interruption leads to undesirable pulsations at the output. These pulsations, which affect the system error, are frequently difficult to eliminate.

The output of the pulse element contains both a basic constituent and additional signal constituents. In pulse automatic control systems (ACS), when the error signal is interrupted, the active signal at the pulse element output contains basic and supplementary constituents, and only the basic constituent can reduce the effect of external perturbation. The supplementary constituents form pulsations within periods of interruption in output and worsen the characteristics of the system. Pulsations are always undesirable, since they not only cause a system error but also loss of power, increase the wear of mechanical gears, and worsen the quality of the system. The supplementary constituents of the signal, which appear as a result of an interruption, must be eliminated before the signal reaches the output. It is necessary to note that an important part of the high-frequency signal constituents is suppressed by the elements of the system between the pulse element and the output, and pulsations are flattened by incorporating a smoothing (storage) device in the system, which worsens the stability of the system. In designing a pulse ACS, it is necessary to reconcile the degree of smoothing of
Fig. 1. Structural diagram of an extruder digital electric drive for an electric control complex: $n_1$ is the control system task signal; $n_\delta$ is the rotational speed of the DCM; $e_1$ is the control error in the directional circuit; $e_\delta$ is the signal value at the correcting controller output; $e_\gamma$ is the control error in the high-speed circuit; $D(z)$ is the correcting controller transfer function that ensures the minimum process switching time and null steady-state error; $D_{k_r}(z) = K_w/(z - 1)$ is a digital controller with an integrator; $K_w$ is the controller amplification factor; $D_{k_\gamma}(z)$ is the high-speed controller transfer function; $\Theta_0$ is the signal at the high-speed controller output; $H(p)$ is the forming element transfer function; $\Theta$ is the signal at the forming element output; PE1, PE2, PE3 are ideal pulse elements.

Pulsations and the large introduced. An analysis of the pulsations in the intervals between locking and system error moments is given below.

A low-frequency filter or standard zero-order storage element is the most frequently used smoother. As in continuous ACS, the system error in processing a signal is an important parameter in designing pulse and digital ACS.

In continuous systems, the error is caused by energy storage elements. In pulse systems, the error is also caused by the interruption process. As a result of the interruption process, pulsations appear between locking moments in pulse systems. In switching modes, these pulsations are insignificant, but in the steady-state mode, they can become the basic constituent of the error of a pulse ACS. The steady-state error of the pulse ACS is manifested in locking moments both due to the effect of the final value of the gain in the feedforward circuit and due to the presence of energy-storage elements. In addition, pulsations are superimposed on the steady-state error during interruption periods.

In the investigated ACS, it is important to prevent static errors under the effect of prolonged perturbing events of a step or cyclically repeating type.

The designed system should satisfy the following requirements:
- it must be asymptotically stable;
- it must track a given control effect (setting) without any static error (steady-state values of a deviation) under the effect of a prolonged perturbing effect;
- it must satisfy the first two conditions even for erroneous values of the parameters of the object controlled, such as the deviation of these parameters from the real parameters or inaccurate assignment of the parameters of the model, i.e., ensuring robustness properties; in asymptotic stability of the control system with the real parameters of the control object, small differences in these parameters will not affect the stability of the system and as a consequence, it is sufficient to examine the robustness of the system only with respect to the controllability at the output.

The fundamental studies of digital electric drives (DED) involve large difficulties, since operation of the DED is described by a system of differential equations with pulse elements. Key elements which operate in the pulse mode, providing for digitization of the working signal by transforming it into amplitude-pulse modulation appear in structural and mathematical models.

Our structural scheme of a DED (Fig. 1) which operates in the controllable mode is investigated. The digital error signal $e_1[nT]$ is calculated in a microprocessor which implements a control action and the digital grid signal $\Theta_0[nT]$ from its output enters the input of ideal pulse element IE3 and is converted into the signal:

$$\Theta^*[nT] = \Theta(t) \delta(t - nT),$$

where $n = 0, 1, 2, ..., \Theta(t)$ is a $\delta$-function.