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SYNTHESIS OF A REGULATOR FOR A SULFONATION PROCESS

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Sulphonation is the reaction of organic substances and sulfuric anhydride or substances containing a sulfo group (–SO_3H) to form an organic compound with an S–C bond. The reactors in which such reactions occur are called sulfonators.

Sulphonator is a continuous reactor, the design feature of which is a steam jacket, in the apparatus there is a addition reaction between alcohol and sulfuric anhydride to produce a sulfoether (1):

$$R - OH + SO_3 \rightarrow R - O - (O = S = O) - OH. \quad (1)$$

The transfer function of the sulphonator on the control channel $G_{hs}(p) \rightarrow \Theta_e(p)$ (2) (G_{hs}, Θ_e – flow rate of heating steam and temperature of sulfoether respectively):

$$W_{obj}(p) = \frac{1{,}146}{222102{,}196p^2 + 1534{,}285p + 1}. \quad (2)$$

According to the obtained transfer function, the step response along the control channel is shown in the figure below (Fig. 1).

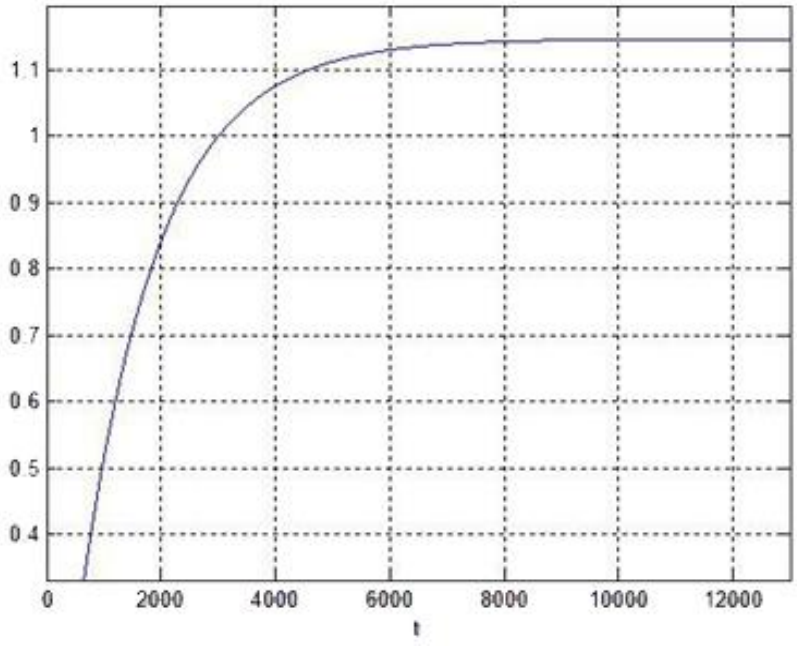

Fig. 1. Step response of the system by the control channel

On the basis of the mathematical model of the object and the dynamic characteristics obtained from it, as well as the comparison and analysis of the detailed reactors operation, the presence of a significant transport delay inherent in these automatic control systems was revealed, in this connection the decision was made to take into account the influence of transport delay by applying a more complex structure of the control system.

For synthesis of the given control system with a delay it is considered to use in a circuit the PPI-regulator (Fig. 2) (predictive PI-regulator). The PPI regulator is based on the Smith predictor and is one of its modifications, the purpose of which is to predict the behavior and model the output signal of an object before it actually appears on the output [2].

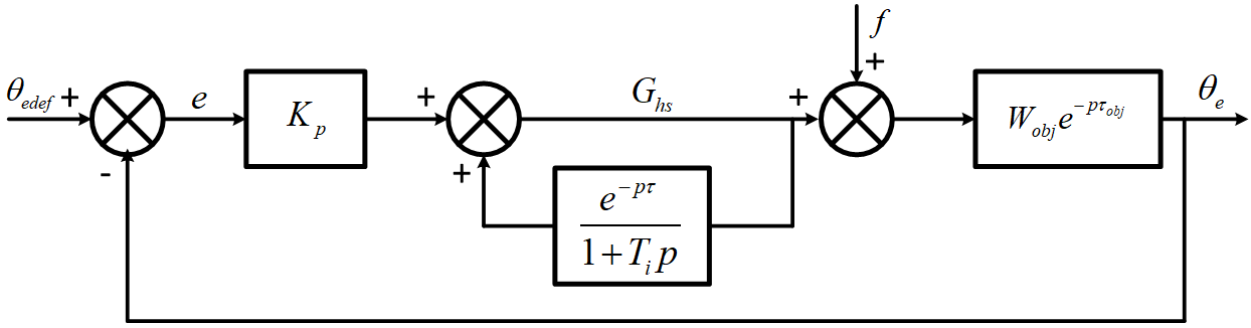

Fig. 2. The structural diagram of the system with PPI-regulator

To simplify the circuit (Fig. 2), it was decided to bring it to a single-loop form by isolating the transfer function of the PPI controller from it (3):

$$W_{reg}(p) = \frac{K_p}{1 - K_p \dfrac{e^{-p\tau}}{1 + T_i p}}. \tag{3}$$

Closed loop transfer function via control channel (4):

$$W(p) = \frac{W_{reg} W_{obj} e^{-p\tau_{obj}}}{1 + W_{reg} W_{obj} e^{-p\tau_{obj}}}. \tag{4}$$

The use of the PPI regulator allowed reducing the negative impact of transport delay and, as a result, improving the quality of the system's step response.

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