UDC 621-83 681.51

V.B. Zvorykin, A.P. Egorov, A.I. Mikhalyov

STRUCTURAL IDENTIFICATION OF THE AUTOMATIC CONTROL SYSTEM OF THERMAL AGGREGATE

Annotation. *In the work are considered the objects and principles of the industrial control systems of thermal regime on the basis of objects using thermal automation tools. Regulators are described, the objects used to control actuators in the form of a heater and a shutter. The system for thermal management of electric heating furnace was offered. Implemented structural identification system of automatic control of temperature in the heating furnace.*

Key words: *control systems; thermal regime; regulators; control of temperature; heating furnace*

The use of electrical energy for heating blanks and articles facilitates adjustment of thermal conditions, can accurately maintain a specified temperature range and provides a high degree of uniformity of heating products [1]. In turn, if necessary, in the electric furnaces may be carried out by heating local control of individual sections of the product. It is possible [1], because the electric furnaces, as compared, for example, flaming furnaces much easier to seal, thus reducing heat loss from the exhaust gases, and this in turn provides a higher thermal efficiency of the unit. All this makes it relevant research automatic control systems (ACS) thermal mode of heating products for various purposes and the development of thermal automation in general.

Objects of control thermal automation

Consider some types of control objects and principles of industrial control systems, thermal control mode based on the object using a thermal automation tools.

Thermal objects in terms of creating automatic control systems can be divided into two types:

1) as executive mechanism heater (cooler) (fig. 1),

2) as executive mechanism in the form of a flap actuator (valve) and single-turn electric motor (fig. 2).

The first type electrical resistance heating furnace; a furnace in which heating takes place due to eddy currents; and etc.

The second type of objects include methodical furnaces, heated with gas; soaking pits.

 ISSN 1562-9945

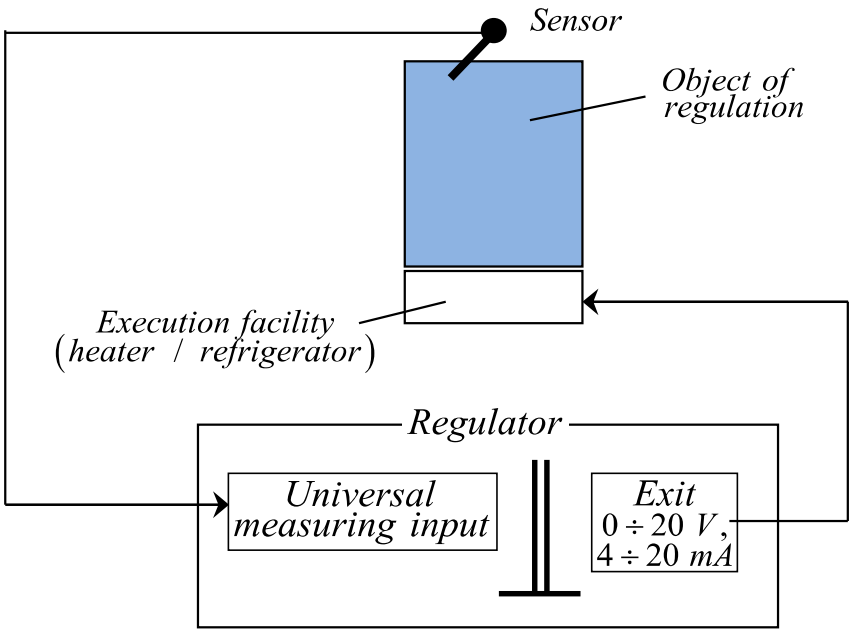

Figure 1 - ACS with executive mechanism heater (cooler)

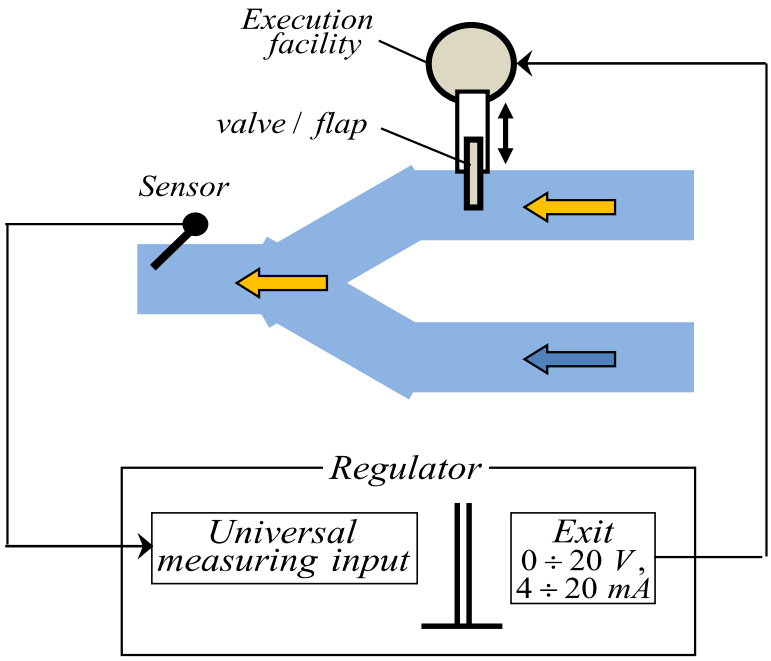

Figure 2 - ACS with executive mechanism in the form of a flap actuator (valve) and single-turn electric motor

In the local automation systems of heating objects are most common in proportion - integral - differential (PID) and the proportion - differential of the second order (PDD) regulators.

These controllers are available in a compact microprocessor devices and have the output either an analog signal or a relay-type signal, or pulse-width modulated signal.

The controller generates a control action so that the value of the controlled parameter $A_{изм}$ is aspired to a predetermined value $A_{зад}$. Thereby it compensating for the external impact on the controlled system.

In the process of adjusting the control is generated at the output of the PID controller signal U_p, the effect of which is aimed at reducing the deviation ε measure value $A_{изм}$ from set point $A_{зад}$.

$$U_p = K_p\left[1 + T_d p + \frac{1}{T_i p}\right]\varepsilon, \quad (1)$$

where ε - the difference between the target $A_{зад}$ and current $A_{изм}$ value controlled parameter; K_p - proportionality coefficient; T_d - constant differentiation of time; T_i - constant integration of time; $K_p\varepsilon$ - proportional component of the controller output signal; $\frac{K_p}{T_i p}\varepsilon$ - integral component of the signal at the output of the regulator; $K_p T_d p\varepsilon$ - differential component of the signal at the output of the regulator.

The control method (1) is used for executive mechanismheater (cooler).

In the case of the control object with single-turn actuator integral control method in the regulator is not applicable. In the direct channel control circuit of the structural there are two elements: the controller and the actuator. As a result, the control system becomes structurally unstable [2, 6]. Therefore, in such systems use proportional-derivative (PD) or proportional-differential second order (PDD) control method:

$$U_p = K_p\left[1 + T_{d1} p + T_{d2} p^2\right]\varepsilon. \quad (2)$$

To simulate and research ACS of the temperature was designed facility. It is an automatic temperature control system in the working space of the electric furnace made on the basis of the PID-controller TZN4W [3].

Fitting description - control system temperature control electric heating furnace

Functional diagram of ACS furnace temperature is shown in fig. 3, and functional structure diagram - fig. 4.

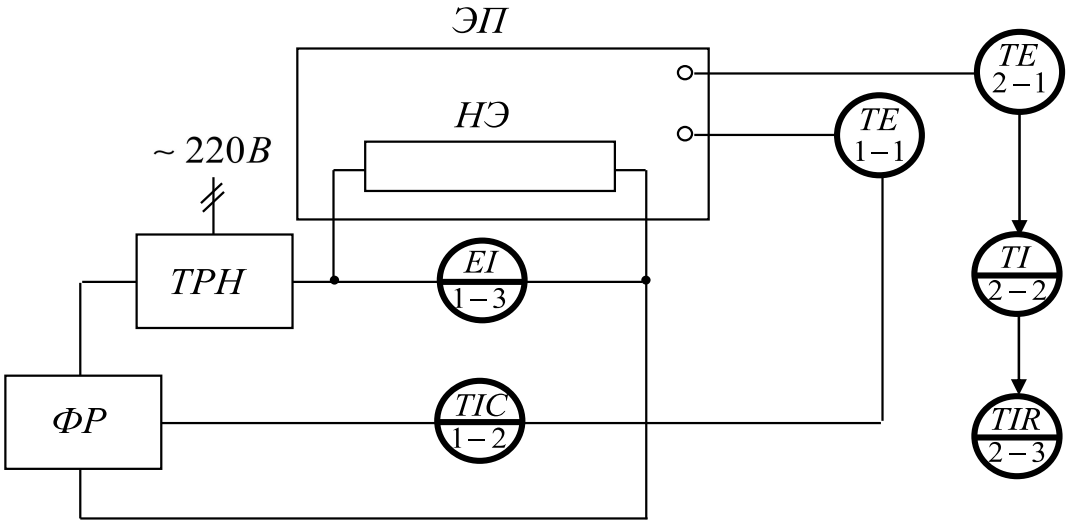

Figure 3 - Functional diagram of ACS furnace temperature

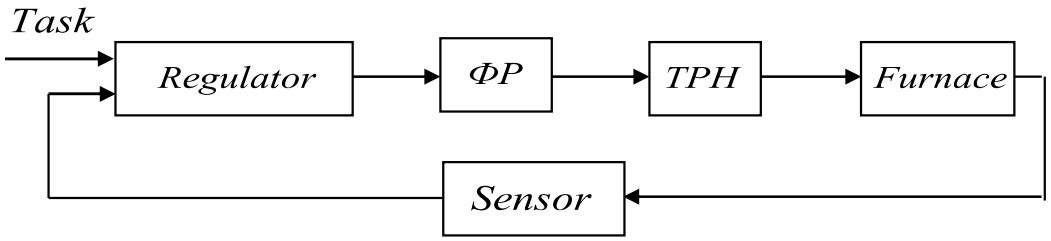

Figure 4 - Functional structure diagram of ACS furnace temperature

Laboratory facilityincludes:

- TSP1-11 temperature sensors, range temperatures of -50 ... + 250 °C (1-1), (2-1);
- regulating device TZN4W (1-2) [3];
- phase regulator *ФР* type RM1E [4];
- thyristor voltage regulator *ТРН*;
- laboratory furnace, model "Elektrodelo", 300 W, 220 V;
- the technological multichannel registrar RMT69 (2-3) [5].

The electric furnace *ЭП* (fig. 3) has a heating element *НЭ*, powered by a single-phase AC current through the thyristor voltage regulator *ТРН*. The temperature of the furnace workspace controlled by a temperature sensor TSP1-11 (1-1).

Automatic control of the furnace temperature is as follows.

Setting the desired temperature is generated in the controller TZN4W (1-2). The actual temperature in the oven *ЭП* is measured by a temperature sensor (1-1), whose signal is input TZN4W PID-regulator (1-2). Manipulated variable from output TZN4W (1-2) enters the phase control regulator *ФР*.

The phase controller $ФР$ affects on the thyristor voltage regulator $ТРН$. Thyristor regulator $ТРН$ changes the voltage at the terminals of the electric furnace $ЭП$ and, consequently, the current flowing through the heater $НЭ$. Changing the voltage at the terminals of the electric furnace $ЭП$ occurs before until equality is achieved between the actual value and the desired furnace temperature.

The voltage supplied to the furnace is controlled by a voltmeter (1-3).

Multi-channel recorder RMT69 (2-3) designed for the registration and control of temperature. Furnace temperature signal fed from the temperature sensor TSP1-11 (2-1) through a secondary converter (2-2) to one of the inputs RMT69 recorder (2-3).

At furnace temperatures affect the disturbance caused by a change in the supply voltage, as well as changes in the amount of air supplied to the furnace.

The task is, using developed facility, based on the results of experimental studies of the thermal unit to carry out the identification of the transfer function of control object with the subsequent calculation of the controller parameters for the class of heated products.

Structural identification of an automatic temperature control system

In this article, we solve the problem of structural identification system for automatic temperature control in an electric furnace. We proposed structure closed temperature control system in a heating furnace, and its transfer function is defined as a mathematical model in the frequency domain.

Block diagram of the ACS in the form of a chain of serially connected linear and non-linear units is shown in fig. 5.

The mathematical description of the system is based on the physics of processes occurring in it, when the controller $W_p(p)$ generates a control signal U_p, the effect of which is aimed at reducing the deviations ε of the measured temperature T from the set value $T_З$.

$$U_p = K_p\left[1 + T_d p + \frac{1}{T_i p}\right]\varepsilon. \qquad (3)$$

In turn, in the simulation of thermal facilities should be borne in mind that the object of regulation includes, in general, non-linear element

 ISSN 1562-9945

- the furnace and the temperature sensor, which may have different passport data for a certain class of thermal units.

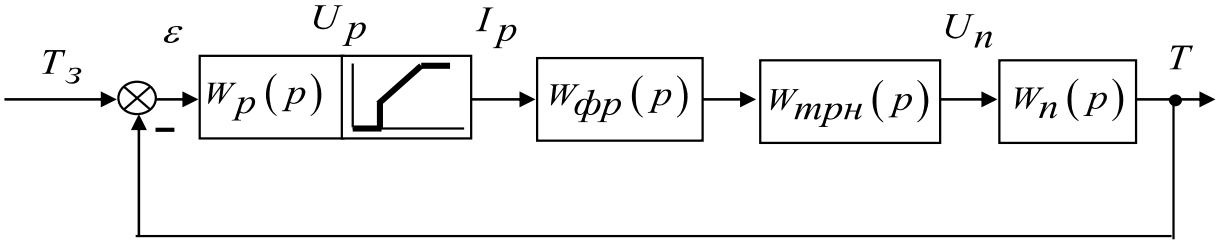

Figure 5 - Block diagram of the researching ATS temperature in the furnace: $W_p(p)$ – - transfer function PID-controller TZN4W; $W_{фр}(p)$ – the transfer function of the phase regulator RM1E; $W_{трн}(p)$ – the transfer function of the thyristor voltage regulator; $W_n(p)$ – the transfer function of the furnace and the temperature sensor; $T_з$ - set point temperature in the furnace; T - the current value of the temperature in the furnace; ε - disagreement on the regulator inlet.

In this context, for the proposed facility of the transfer function of the controlled system is defined as the multiplication of the transfer functions used in the furnace "Электродело" and the temperature sensor TSP1-11.

В свою очередь, при моделировании тепловых агрегатов следует учитывать, что объект регулирования включает в себя в общем случае нелинейный элемент - печь и датчик температуры, которые могут иметь различные паспортные данные для определённого класса тепловых агрегатов.

In this context, for the proposed facility of the transfer function of the controlled system $W_n(p)$ is defined as the multiplication of the transfer functions used in the furnace "Электродело" and in the temperature sensor ТСП1-11.

LITERATURE:

1. Технология металлов и других конструктивных материалов. Скобников К.М., Глазов Г.А., Петраш Л.В. и др. – М.: Машиностроение. 1972. - 520 с.
2. Єгоров О.П., Зворикін В.Б., Щербіна Г.С. Розрахунок лінійних регуляторів в системах автоматичного управління. - Навчальний посібник. - Дніпропетровськ, НМетАУ, - 2008. - 68 с.

3. Контроллер с двойной функцией автонастройки PID регулятора. Серия TZN/TZ. Техническое описание. - Autonics.- 22 с.
4. Solid state relays industrial, 1-phase analog switching type RM1E. Техническое описание. - Carlo Gavazzi. - 4 с.
5. Регистратор многоканальный технологический РМТ 69. Руководство по эксплуатации. - ООО НПП ЭЛЕМЕР - 93 с.
6. Zvorykin V.B., Mikhalyov A.I., Stanchyts G.Y. Modeling of transient processes in systems with delay // System technologies. Regional Interuniversity collection of scientific papers. - Issue 6 (95). - Dnepropetrovsk, 2014. - P. 127-133.

 ISSN 1562-9945