Laboratory work No 3

Experimental implementation of the qualitative regulation method of the heater power.

Objective: to Familiarize the student with the fundamentals of the execution thermo-technical engineering experiment and to teach how to make heat balance.

Empirical dependence of the heater power on the temperature and coolant flow rate traditionally is represented in the form of a power function:

$$Q_h = Q_{nom}\,(\Delta t/\Delta t_{nom})^m\,(G/G_{nom})^P \tag{1}$$

A constant Q_{nom} is a nominal conditional power of the heater. When the coolant flow rate through the heating device is constant, thermal power of the heater will depend only on the coolant temperature. The power of the heating device in this case as in general and under other operating conditions will be calculated using the balance ratio:

$$Q_h = GC_P\left(t_{in} - t_{out}\right), \tag{2}$$

Therefore, equality must be fulfilled

$$Q_h = Q^*\left(\Delta t/\Delta t_{nom}\right)^m = GC_P\left(t_{in} - t_{out}\right),$$

Q^* is power of the heating device, reduced to the actual flow rate of the coolant;

$\Delta t = \dfrac{t_{in} + t_{out}}{2} - t_{air}$ – the average temperature difference

Δt_{nom} – the nominal difference between the average surface temperature of the heating device and the internal temperature in the room, which is achieved under the design operating conditions and is taken equal to 70 ºC.

Experiments on measuring the power of the heating device consist in establishing and maintaining a constant specific flow rate of the coolant and varying the temperature of the coolant at the entrance to the heating device. All measurements shall be carried out under steady-state conditions, i.e. under constant conditions of all operating parameters. To perform the experiment, one heating device HD1 is switched on in the circulation circuit.

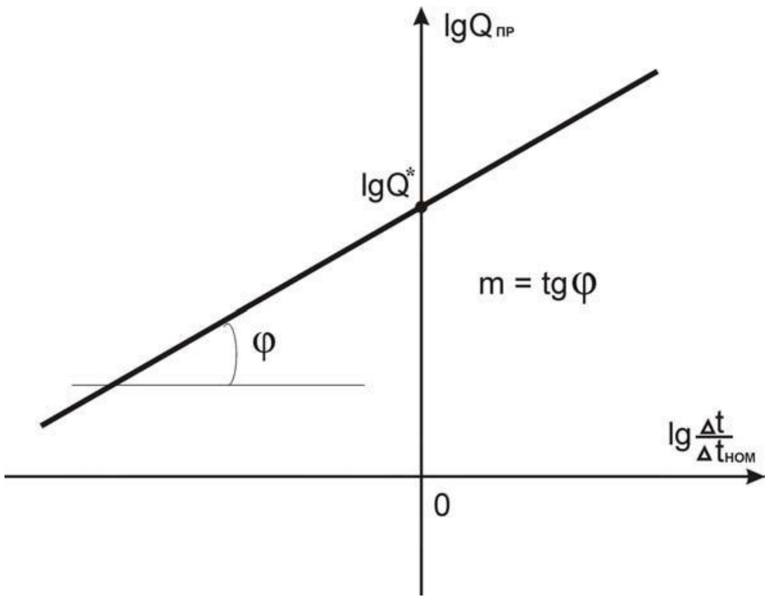
The results of the experiments should be drawn up in a protocol in the prescribed form.

Table of measurement results

№	t_{in} , ºC	t_{out} , ºC	Δt , ºC	Q_h , Вт	G
1					
2					
3					
4					

The results of the experiments can be represented by a graph in logarithmic coordinates $\lg Q_h$ and $\lg \Delta t/\Delta t$ nom.

In these coordinates equation (1) will be: $\lg Q_h = \lg Q^* + m \lg \Delta t/\Delta t_{nom}$, having the form of linear dependence. In this case, Q* determined by the intersection point of the resulting linear function with the ordinate axis, and the coefficient m as the angular coefficient of the line.



Pic. 2 Graph of dependence $\lg Q_h$ on $\lg \Delta t/\Delta t_{nom}$

Control question:

1. Heat balance of the heater.
2. Where quantity regulation is conducted?
3. Where qualitative regulation is conducted?
4. Advantages and disadvantages of two types of regulation.

Experimental implementation of the quantitative regulation method of heater power

Objective: Familiarization of the student with the basics of thermos-technical experiment. Acquaintance with methods of statistical processing of results of experiments and definition of empirical coefficients depending on power of heaters from variable regime factors.

Empirical dependence of the heater power on the temperature and coolant flow rate traditionally is represented in the form of a power function:

$$Q_h = Q_{nom}\,(\Delta t/\Delta t_{nom})^m\,(G/G_{nom})^P$$

A measure of the influence of flow rate in this dependence on the power of the heating device is negligible because of the smallness of the exponent p = (0,01÷ 0,08).

In practice, the quantitative control method is widely used. The reason for this is that the consumption indirectly affects the power of the heating device. The change of coolant flow rate leads to a change in the temperature difference at the inlet and outlet of the heater. This leads to a change in the average temperature pressure and thus to a change in the power of the heater, determined by the heat transfer equation

$$Q_h = k_h F_h \left(\frac{t_{in} + t_{out}}{2} - t_{air} \right), \qquad (3)$$

k_h is the heat transfer coefficient, W/m²°C;

m².

$$Q_h = \frac{2GC_p k_h F_h \left(t_{in} - t_{out}\right)}{k_h F_h + 2GC_p}$$

…n for the coolant (2) results in a… …w rate:

$$Q_h = \frac{2GC_p k_h F_h \left(t_{in} - t_{out}\right)}{k_h F_h + 2GC_p},$$

The resulting ratio can be tested by experiment.

The configuration of the connections is set before the experiments. The heat generator is in a stationary mode. The maximum temperature is determined by the static pressure in the circuit and can approach the saturation temperature at a given pressure. In other cases, the temperature at the output of the heat generator will be assigned to the task of the temperature controller.

The set temperature value at the heating system inlet will be formed in a high-speed automatic mixer. There are two options for performing experiments:

1 - with one heating device;

2 - with two heating devices switched on according sequential scheme.

Since both heating devices are identical, the required minimum data set defined by the processing technique will be obtained faster when performing the experiments according to the sequential scheme.

Experiments are performed at a given constant temperature of the coolant at the inlet to the system and varying the coolant flow rate. Each value of the input temperature will correspond to the power dependence on the flow rate. The set of input temperature values will correspond to the family of static characteristics of the heating device. The results of the experiments should be recorded in the table.

Table of measurement results

№	G, g/s	t_1, ºC (in generator)				t_2, ºC (in generator)			
		Q_1, W	t_{1in}, ºC	Q_2, W	$t_{2\,in}$, ºC	Q_1, W	t_{1in}, ºC	Q_2, W	$t_{2\,in}$, ºC
1									
2									
3									
.									
.									
N									

The results of the experiments should be drawn graphically in the form of a family of characteristics $Q_h = f(G, t_{in})$.

Control question:

1. What is the nominal power of the heating device?
2. What processes are determining the intensity of heat transfer from the coolant to the internal environment of the heated room?
3. What is the temperature difference, the average temperature difference?