MATHEMATICAL MODEL OF THERMAL SCHEME OF BACK-PRESSURE TURBINE 100 MW

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The reduction of energy consumption, combined with a steady increase in energy prices, the increase in tariffs for electricity and heat energy, characteristic of recent decades, all contributed to a sharp increase in interest in improving the efficiency of CHP (cogeneration combined heat and power). Since the power units of power plants not only operate at rated power, but often change their load, it is obvious that their design and operation should be provid ed with the following conditions:

– changing the load should not reduce the reliability of the unit;

– the change in the load should be as low as possible compared with the nominal regime of deterioration of efficiency. Therefore, the purpose of this work was to determine the optimal operating parameters of the thermal scheme of the power plant with backpressure turbines.

The literature on existing ways of expanding the range of regulation of CPP (condensing power plant) and CHP (cogeneration combined heat and power) was reviewed. The methods implemented by changing the existing structure of the thermal scheme are considered, they include:

– moving the initial pressure of fresh steam;

– variable temperature of fresh steam;

– disconnection of the high pressure heaters (HPH);

– combined method.

Traditionally, only the steam pressure selected for production needs is regulated in type P turbines, and its temperature can vary widely depending on the values of thermal loads. When regulating the power of the unit with the help of steam distribution of the turbine, the boiler and the steam lines of fresh steam are constantly under the influence of the nominal initial pressure. When regulating the power of the boiler, when the load of the unit corresponds to approximately proportionally varying initial pressure, long-term operation at low pressure increases the durability of the metal heating surfaces of the boiler and steam lines going to the turbine. At the same time the reliability of the turbine increase. Since the steam pressure in front of the turbine changes (slides) according to the load, and the steam temperature is maintained constant, the temperature in most critical elements of the turbine remains unchanged. Due to this, when the load changes, additional thermal expansion does not appear, there is no uneven heating along the circumference, specific to the partial load of turbines with nozzle steam distribution, the stresses, especially dynamic, in the blades of the first stage, i.e. the reliability of the turbine operation and its ability to maneuver increase. Since the regulation of the sliding pressure does not require a dedicated first (control) stage, partial supply and nozzle boxes for individual groups of nozzles, on the one hand, the turbine design is somewhat simplified, on the other hand, the turbine efficiency increases at the nominal mode.

However, for the qualitative conduct of the technological process in a number of industries (chemical, petrochemical, etc.) precise regulation of the temperature of the selected steam, as well as its pressure is required. Therefore, a number of enterprises using turbines of type P, on their own set up steam lines regulating heat exchangers, where water injection is used to reduce the temperature of the steam behind the turbine or the release of fresh steam from the boiler through the RCI (reduction cooling installation) to increase this temperature. Of course, the use of this method to regulate the temperature of the steam behind the turbine is accompanied by a loss of heat, which leads to fuel overruns. In addition, the use of cooling water is limited to the occurrence of hydraulic thermal shocks, and the implementation of the above method leads to a complication and increase in the cost of the scheme, as well as to a decrease in reliability.

The study of the thermal scheme of the unit with a turbine type P-100-130/15 was carried out by numerical method. For this purpose, a mathematical model for calculating the schematic thermal diagram was developed which was implemented using the mathematical package Mathcad. The thermal scheme of the power unit is shown in Figure 1. It includes equations of thermal and material balances of elements of the thermal scheme and equations of elements of the control system.

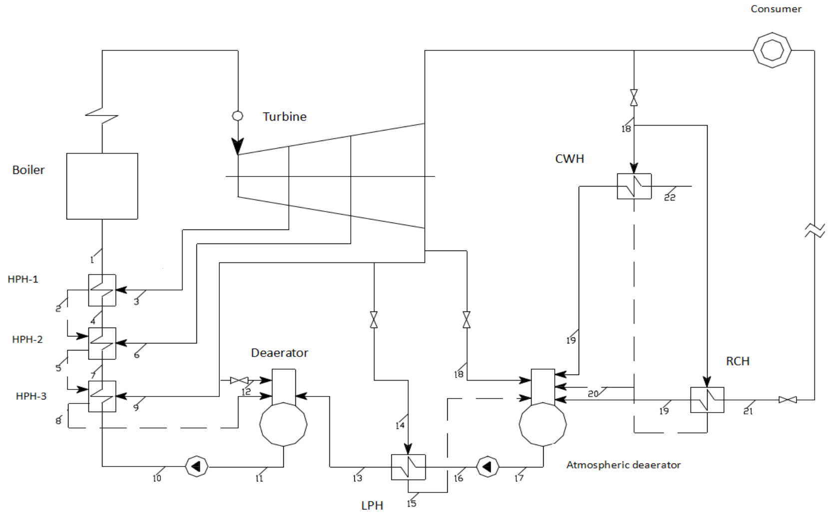

Fig. 1. The basic thermal scheme of P-100-130/15

To check the adequacy of the developed mathematical model, the calculation of the parameters of the thermal scheme of the turbine at characteristic points was carried out and the values of the steam flow in the elements of the thermal scheme of the turbine were determined and the internal efficiency of the turbine was determined. The calculation results are presented in Figures 2, 3. The figures also show the typical energy characteristics of the turbine P-100-130/15.

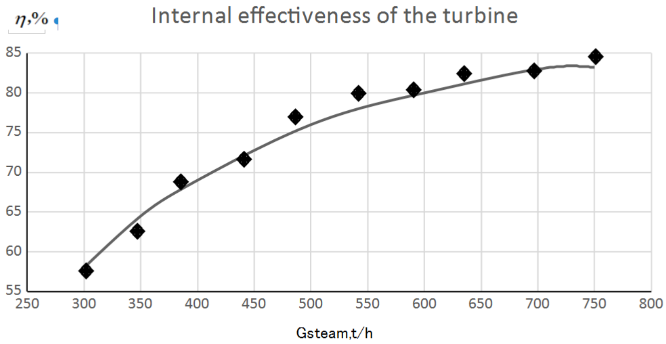

Fig. 2. Internal effectiveness of the turbine

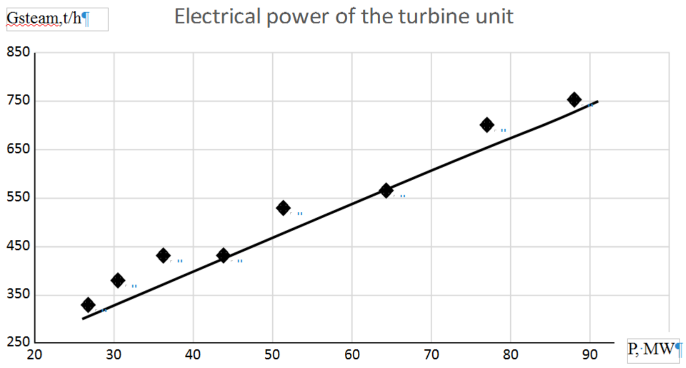

Fig. 3. Electrical power of the turbine unit

As follows from the results, the developed simulation model allows to determine the main parameters of the turbine unit at different loads with an accuracy of less than 5 %. Determining the impact of individual parameters on the efficiency of the work is the next step in the research.