ADVANCED TECHNOLOGIES AND POWER INSTALLATIONS FOR THERMAL AND ELECTRIC ENERGY GENERATION

6.1. Improvement of the thermal cycle of traditional combined-cycle TPPs

6.1.2. Influence of steam superheating on thermal economy of a steam-turbine plant

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Significant fuel safety can be reached due to application of intermediate superheating. For condensing installation the inner absolute efficiency is defined from the relation:

$$\eta_i = H_i/q_0 \qquad (6.2)$$

where H_i is work, performed by 1 kg of steam in the wheel space, kJ/kg; q_0 is a volume of heat, supplied to the working substance, kJ/kg.

For installation without steam intermediate superheating:

$$H_i = h_0 - h_c; \qquad (6.3)$$

$$q_0 = h_0 - h_{f.w}. \qquad (6.4)$$

For installation with the steam intermediate superheating:

$$H_i = h_0 - h_{is1} + h_{is2} - h_c; \qquad (6.5)$$

$$q_0 = h_0 - h_{f.w.} + h_{is1} - h_{is2}. \qquad (6.6)$$

In formulas (6.3)—(6.6): h_0 is an enthalpy of steam at the turbine inlet, kJ/kg; h_c - enthalpy of steam at the turbine outlet (at the condenser inlet), kJ/kg; $h_{f.w}$ - enthalpy of the boiler feed water, h_{is1} and h_{is2} - enthalpy of steam at the input in the intermediate superheater and at its output, accordingly, kJ/kg.

Steam intermediate superheating can be carried on at any pressure p_{is} in a range between the pressure in a condenser of the turbine installation p_c and the steam pressure at the turbine inlet p_0. Setting a number of pressure of the steam intermediate superheating, using the dependences (6.2)—(6.6), the curve is drawn

$$\eta_i^{is}/\eta_i = f(p_{is}).$$

As it can be seen from Fig. 6.2, there are two pressure zones of the intermediate superheating *I* and *II*. In the zone I the intermediate superheating leads to increase in thermal efficiency. In this case there is an optimum value of pressure of the steam intermediate superheating, at which maximum performance index increment of installation is observed.

Domestic installations have a single-shot intermediate steam superheating up to the temperature of about the initial temperature of steam before the turbine. At this time p_{is}^{opt} = (0,15...0,25) p_0.

Single-shot intermediate superheating (at p_{is}^{opt}) can provide an increase in performance index by 4...5 %. In case of a double-shot intermediate superheating of steam p_{is1}^{opt} = (0,25...0,3)p_0 and p_{isII}^{opt} = (0,06...0,09)p_0, introduction of the second intermediate superheating of steam can increase the thermal efficiency approximately by 1,5 %.

At TPPs only power units with turbine installations T-250 and T-180 have an intermediate superheating of steam. This can be explained by the fact that they have been created on the basis of condensing power units with turbines, K-300 and K-200, correspondingly, where intermediate superheating of steam is used.

At that, high-pressure cylinders (HPC) of turbines were unchanged, and therefore, at these installations steam parameters at intermediate superheating are the same as those, accepted for the condensing power units. Such an approach permitted in addition to the unchanged turbine HPC to keep the regeneration system of high pressure without changes and use the same types of boilers, as at condensing power units. It is necessary to note that by that equipment unification was achieved, loosing thermal efficiency of installations. Indeed, at operation of installations in heat-extraction mode, steam entering the turbine, can be divided conditionally into two flows: with the ultimate pressure in the condenser p_u and in the heat extraction p_h. For the second flow p_{is}^{opt} will be always higher than for the condensing steam flow. Thus, it is clear, that p_{is}^{opt} for the heating installation is always higher than for the condensing at all other conditions being equal. At that, maximum of the curve $\eta_i^{is}/\eta_i = f(p_{is})$ will move to the right and will be less, than for the condensing installation.