Part 6

# ADVANCED TECHNOLOGIES AND POWER INSTALLATIONS FOR THERMAL AND ELECTRIC ENERGY GENERATION

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

### 6.1.1. Influence of initial steam parameters on thermal economy of power plants

*Ilyin E.T. CJSC “Complex energy systems”, Tishin S.G. MPEI(TU)*

Methods of increase in thermal economy of power plants are well-known. Let’s consider the opportunities for power plant efficiency increase due to application of traditional methods. Heat and nuclear power plants operate under the Rankin cycle. Thermal efficiency $\eta_t$ of the Rankin cycle significantly depends on a number of factors and, firstly, on initial steam parameters before the turbine: pressure $p_0$ and temperature $t_0$.

Thermal efficiency of power plants considerably depends on the thermal performance index, which is defined by:

$$\eta_t = \frac{H_a}{q_0} = \frac{H_a}{H_a + q_{\kappa.a.}}, (6.1.)$$

where $H_a$ is an adiabatic work, performed by 1 kg of steam in the ideal turbine, kJ/kg; $q_0$ - amount of heat, supplied to 1 kg of working medium in the "hot well" (a boiler or a steam generating nuclear installation), kJ/kg; $q_{\kappa.a}$ - amount of heat, removed from 1 kg of working medium in the "cold well" (in the turbine condenser), kJ/kg.

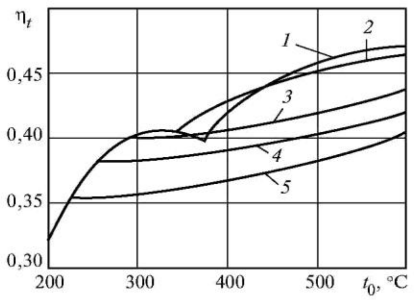


**Fig. 6.1. Impact of the thermal performance index of Rankin cycle $\eta_t$ on initial steam parameters before the turbine $p_0$ and $t_0$:** *1* — for dry saturated steam with $p_0$ = 22 MPa; *2—5* — for superheated steam with $p_0$ = 16; 8,8; 5,4; 2,85 MPa accordingly

In Fig. 6.1 dependences $\eta_t$, calculated by formula (6.1), depending on initial steam temperature before the turbine $t_0$ for a number of constant values of initial pressures $p_0$ are presented. The curve 1 is based on an assumption that dry saturated steam is supplied to the turbine. This curve has the maximum $\eta_t$ at approximate temperature of 350°C. For the superheated steam with initial temperature raise, $\eta_t$ increases monotonically for all values of initial pressure $p_0$, MPa.

Certain values of initial temperature definitely depend on the steel grade, used for production of the most energy intensive elements of the boiler and turbine.

For perlite class steel under the terms of long-life strength a starting temperature of steam before the turbine should not exceed 540...560°C, and for austenitic steel - 600...650 °C.

Thus, for each specific steel grade selection of initial parameters results in the problem of finding the optimal $p_0$, if $t_0$ is constant.

It should be noted that with increase in pressure $p_0$ (at $t_0$ = const), a final steam moisture at the outlet of the turbine flow path $\omega_k$ raises. Growth of final moisture content leads to the increased erosive wear of a blade system of the last turbine stages.

For the given initial temperature the initial pressure $p_0$ is chosen so, that the final steam moisture $\omega_k$ should not exceed the limiting value by approximately 13%. Limiting moisture content is chosen taking into account that working time of the blade system of the turbine last stages is more than 10 years.

It should be noted that increase in initial steam parameters leads to building-up the equipment steel intensity and, consequently, to reduction of its maneuvering characteristics.

In such a way, switching to a new technology – a higher level of initial parameters, on the one hand, leads to fuel savings, but on the other - to increasing in capital investments in equipment. Therefore, decision of adoption of the higher initial parameters requires essential technical and economic assessment, which should be carried out, primarily, for installations, intended to operate at the base part of the curve of electrical loads.