Efficiency increase of gas turbine work in the summer period

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Efficiency increase of gas turbine work in the summer period

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Abstract. The operation of thermal power plants on the basis of steam-gas and gas-turbine installations in the summer period of the year is accompanied by a drop in the generation of electric energy, which leads to a decrease in the profitability of the station as a whole. The article discusses one of the options for improving the efficiency of gas turbines through the use of absorption chillers.

During operation of the gas turbine in normal conditions, the air content in the gas-air mixture reaches 97-98%. In the warm season, as the temperature rises, the air density decreases, which has a significant impact on the operation of the gas turbine unit (GTU). There is an increase in the energy expended on the process of air compression in a GTU compressor, which is quite clearly seen from formula (1).

$$l_к = c_p \cdot T_0^к \left(\pi_к^{\frac{k-1}{k}} - 1 \right) \cdot \frac{1}{\eta_{oi}^к}, \text{ kJ / kg.} \quad (1)$$

where c_p – isobaric heat capacity of air, kJ / kg • ° C;
T_0^k – air temperature before the compressor, ° C;
k – air adiabat index;
π – compressor compression ratio;
$\eta_{oiк}$ – compressor efficiency.

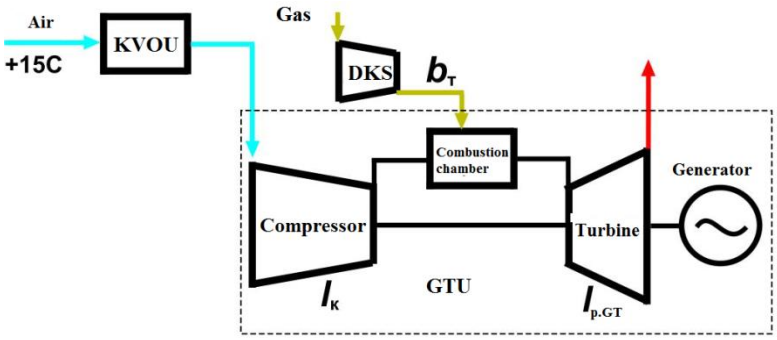

Fig. 1 Scheme of operation of GTU

The cost of compressing air in a compressor caused by an increase in outside air temperature consists of a part of the useful work of $l_{p.GT}$ gas turbine and part of the fuel burned in the combustion chamber $b_т$, the specific consumption of which increases with deviation of the nominal GTU operating mode. Thus, the cost of working on compressing air in a compressor is mathematically written in the form of expression (2).

$$l_к^{t_i} = \Delta l_{p.GT} + \Delta b_т \quad (2)$$

where $\Delta l_{p.GT}$ – part of the useful work, perfect gas turbine, which is spent on the process of compressing air in the compressor;

$\Delta b_т$ – the increase in consumption of combustible fuel in the combustion chamber associated with the deviation from the nominal mode of operation of the GTU;

$l_к^{t_i}$ - work spent on the process of compressing air in the compressor.

In order to reduce the effect of high temperature of air compressed in the compressor on the generation of electrical energy from the combined-cycle plant (CCP), which includes the considered gas turbine unit (GTU), it is proposed to apply pre-cooling of the air before the compressor in the heat exchanger of the integrated air-cleaning unit (IACU). As a source of cold, it is proposed to use a lithium bromide absorption chiller (LBAC) [1].

In order to divert low-potential thermal energy from LBAC, a cooling tower installation is needed, and therefore an analysis of the cooling water flow at the existing thermal power plant (TPP) was performed and the possibility of connecting LBAC absorber cooling system and condenser to the existing TPP circulating water supply system was identified, thus eliminating , the cost of building an additional cooling tower for LBAC. Circulation water consumption for one installation of LBAC is 540 m3 / h (in total it is supposed to install two LBAC).

The analysis of underproduction of electricity in the period from April to October 2017 was carried out, the results of which are shown in Table 1.

Table 1. Electric power underproduction of a combined-cycle plant from April to October.

Month	**Underproduction electricity, thousand kW • h**
April	330,0745
May	1593,0244
June	2239,7154
July	3468,4574
August	4169,1656
September	391,9728
October	14,4805
Total	**12 206,89**

The analysis of electric power generation was carried out relative to the work schedule, which takes into account the dependence of the power of GTU on the outside temperature (Fig. 2) [2].

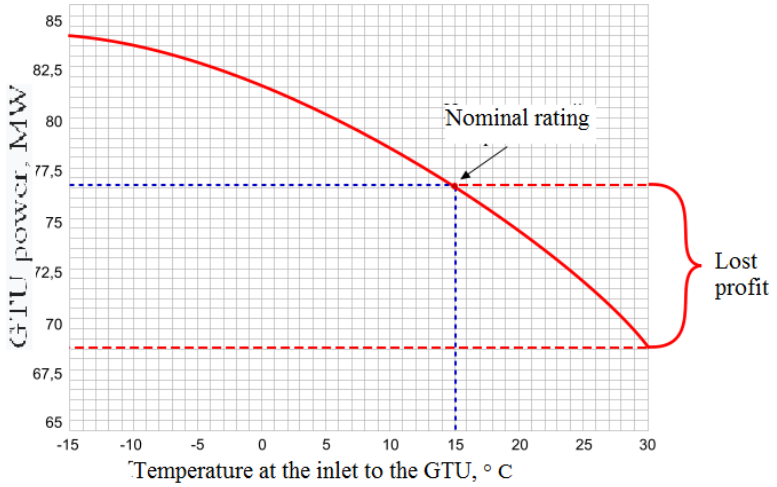

Fig.2. Dependence of GTU power on the outside air temperature

It can be seen from the graph that an increase in the ambient air temperature already to 30 ° C leads to a drop in the power of GTU by almost 9 MW, which leads to a decrease in the supply of electrical energy. All this, in turn, directly affects the payback period of the combined-cycle plant and the profit from the sale of electricity by an enterprise in the wholesale electricity and capacity market (WECM) [3].

The installation of LBAC, as one of the options for cooling the air in front of the compressor, allows you to eliminate the above problem and thereby ensure the production of electricity in the warm period of the year in the mode close to the nominal.

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