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Economical operation of gas turbine topping at thermal power plant

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At present there is a tendency of the growth of industrial output in Russia, which leads to the increase of power consumption. Due to high rate of generation equipment deterioration there is power shortage. The main trend in the development of energy production is the reconstruction and modernization of existing power plants or the construction of new plants with the application of innovative technology of power production. In short period it can be achieved by the application of combined-cycle gas units (CCGU) and gas turbine units (GTU) at existing power plants.

Application of CCGU leads to the increase of power efficiency up to 50-60%. Besides, it leads to the decrease of fuel flow rate in amount of 10% that is equal to 20% of investments.

This article discuses and considers some ways to increase the operating efficiency of equipment by means of application of different types of gas turbine topping based on condensed power K-300-240 unit [1]. The nominal condition of a steam-turbine plant was chosen as the rated condition [2]. The parameters of a gas turbine were calculated by using the method presented in [3]. Variable conditions of the unit were calculated by application of Stodola-Flugel's equation and other generally accepted relations.

One of the ways of power plant reconstruction is the application of gas turbine topping with substitution of feed water regeneration by using gas-cooled water heating units of high and low pressure (GWU HP and GWU LP, figure 1). As a prototype a GTD-110 gas turbine with the temperature of its outlet gases t_{OUT} = 517 °C was used [2]. In order to choose the most efficient operating conditions some variants calculations were made. The outlet temperature of gases from GWU HP (t_G^{HP}) and the flow rate of turbine condensate (G_{TC}) to GWU LP were chosen as variable parameters. Other parameters to be considered were permanent: steam flow rate is equal to nominal value 172.62 kg/s; outgoing gas temperature is $t_{out}^G = 120$ °C; feed water temperature is $t_{FW} = 266$ °C.

The computational results are presented in figure 2.

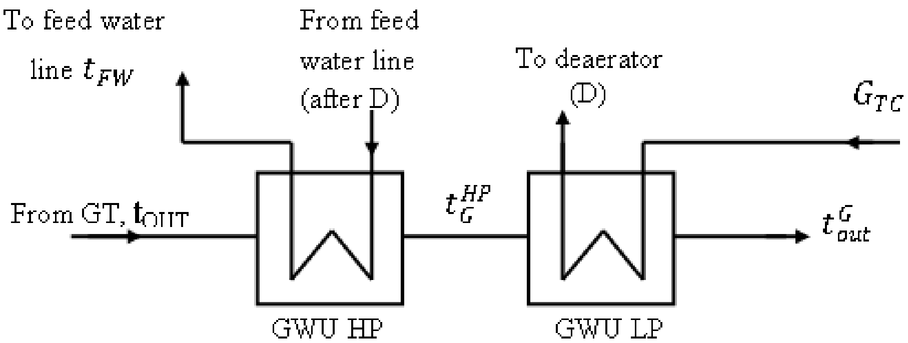

Fig. 2. Connection diagram with substitution of feed water regeneration

Figure 2 shows that variable values of outlet temperature of gases from GWU HP (t_G^{HP}) and the rate of turbine condensate (G_{TC}) through GWU LP are crucial parameters that have impact on the CCGU efficiency. Maximum efficiency depends on the optimal values of both parameters. Maximum thermal efficiency is achieved with $t_G^{HP} = 250$ °C and $G_{TC} \approx 60 - 65$ % from overhaul flow rate of turbine condensate of K-300-240. Moreover, with the increase of t_G^{HP} the flow rate of turbine condensate increases too. If the temperature is $t_G^{HP} = 200$ °C, the flow rate of turbine condensate will be limit and equal to 40% from overhaul amount.

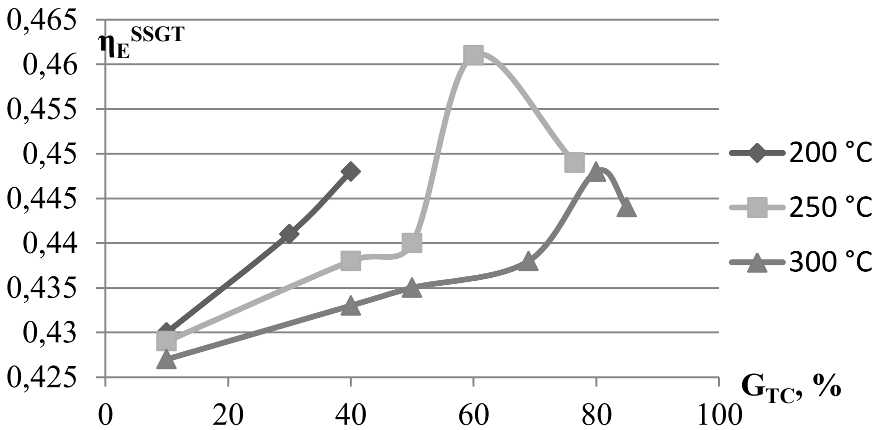

Fig. 2. Characteristic curve of efficiency of energy production by CCGTU depending on outlet temperature of gases from GWU HP ($\boldsymbol{t_G^{HP}}$) and rate of turbine condensate ($\boldsymbol{G_{TC}}$) through GWU LP

Calculating data show that power increase of a thermal power station for the best variant is almost 45 MWt, where the share of GTU is 65 MWt and steam power unit (SPU) is 280 MWt. The increase of power efficiency for the scheme with a substitution of feed water heating is 20% compared to traditional STU with K-300-240turbine.

Taking into account that potential of outflow gases is high, there is a possibility to accomplish the steam reheating (SR) in a heat-recovery boiler (scheme with substitution of steam reheating).

For such way of gas turbine topping the gas turbine unit should provide a superheating the steam, that comes from high-pressure casing of the turbine K-300-240, to the predetermined temperature of reheating. Thus was chosen two gas turbine Siemens V64-3A with the temperature of its outlet gases is t_{OUT} = 585 °C.

The connection diagram of including the heat-recovery boiler into STU with substitution of steam reheating is shown in Figure 3.

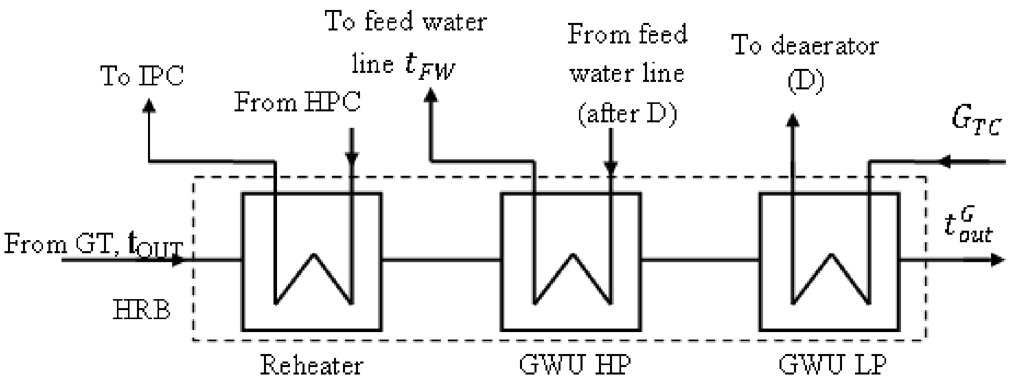

Fig. 3. Connection diagram of including the heat-recovery boiler into STU with substitution of steam reheating

The calculation of this variant was made for nominal steam flow rate in a condenser 172,62 kg/s. The research shows that application of outlet gases heat from GTU for steam reheating leads to the increase of the plant efficiency up to 48,5% which is 25% higher than in the initial scheme. In this case the electrical capacity of the station increases up to 419 MWt, where share of GTU is 139,5 MWt and steam power unit (SPU) is 279,5 MWt.

Comparison the energy characteristics of CCGU with substitution of feed water heating and steam reheating in comparison with general variant are showed in figures 4 and 5(where 1- general scheme of turbine K-300-240, 2 – scheme CCGU wit substitution of feed water heating, 3 - scheme CCGU wit substitution of steam reheating).

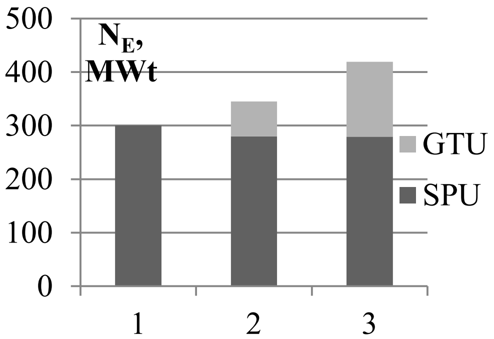

Fig. 4 – Power gain of the station by virtue of gas turbine topping

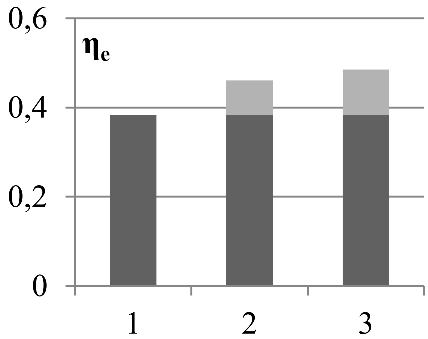

Fig. 5 – Efficiency of the ordinary power station scheme and schemes with application of gas turbine topping

CONCLUSION

1) Two different variants of gas turbine topping intended to increase the efficiency of the K-300-240 steam-turbine power generating unit with the substitution of feed water regeneration and substitution of steam reheating were considered.
2) Gas turbine topping increases the thermal power plant efficiency up to 20-40 % and power generation efficiency up to 15-25 %.
3) The combined-cycle plant scheme with the substitution of steam reheating has the highest efficiency ($\Delta\eta_э > 25\%$) compared to the scheme with substitution of feed water regeneration ($\Delta\eta_э \approx 15 - 20\%$).
4) The maximum of power generation efficiency is achieved by the optimal value of t_G^{HP} and G_{TC}.

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Современные системы контроля и оценки теплового состояния тяговых электродвигателей

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В настоящее время достаточно остро стоит вопрос тепловых перегрузок тягового оборудования электроподвижного состава. Данное обстоятельство является следствием эксплуатации тягового электропривода электровозов в постоянно тяжелых условиях работы. Другим фактором тепловых перегрузок электродвигателей являются перегрузки оборудования, возникающие в результат превышения весовых норм эксплуатируемого подвижного состава. При