ANALYSIS OF THE EFFICIENCY OF A GAS TURBINE UNIT WITH TWO-STAGE COMPRESSION

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A promising direction in the development of the power engineering is the use of energy-saving technologies based on gas turbine units, which can significantly increase the efficiency of using fossil fuel. In a number of cases, the operation of a gas turbine unit is carried out at modes below the optimum in terms of efficiency. Therefore, the economic efficiency of the unit is of great interest. During the last years, gas turbine efficiencies were successfully improved by raising the compressor pressure ratio and the turbine inlet temperature. The challenge of constantly improving the gas turbine efficiency by these methods has reached a critical moment, raising of the compressor pressure ratio and the turbine inlet temperature ran up to the limit [1]. A high level of these parameters require the using of new expensive durable heat-resistant materials.

A cycle with multistage compression and intermediate air cooling in the compressor is analyzed. Intercooling is obtained by placing a heat exchanger between the low and high pressure compressors, allowing the inducted air to be cooled between compressions, reducing the compression work (Fig. 1).

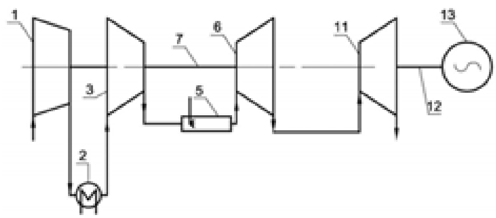

Fig. 1. Scheme of gas turbine plant with intercooler.

Intercooling has some positive and some negative effects on the efficiency. The major effect is the reduction of the compression work and the lower temperatures of the compressed air limit [2]. On the other hand, more fuel is needed to maintain the fixed turbine inlet temperature since energy is lost as heat in the intercooling.

The aim of the study is to optimize the parameters of a two-stage compression engine with intercooling. For this purpose gas-turbine drive AI-336-1/2-10 was taken as based gas turbine plant and its parameters are considered. The ambient temperature, the temperature in front of the turbine and the pressure ratio affect the optimum values of useful work and efficiency. The temperature in front of the turbine and the pressure ratio increase leads to high the efficiency of the plant. However, the higher pressure ratio the lower temperature of the gases downstream of the compressor turbine. A decrease in the temperature of gases behind the compressor turbine leads to a decrease in the efficiency of the power turbine. Obtaining maximum work with these parameters compensates the lower efficiency, compared to the basic cycle.

A two-stage compression system with inter-cooling is considered. The pressure ratio optimization was carried out at the maximum temperature in front of the turbine (1300 K). Thermodynamic calculation of the gas turbine thermal scheme unit was carried out with computer software Mathcad.

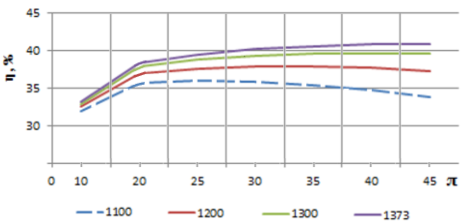

Fig. 2. Efficiency versus pressure ratio.

The analysis of the obtained dependences shows that optimal value of pressure ratio is different for effective work and efficiency (Fig. 2, Fig. 3).

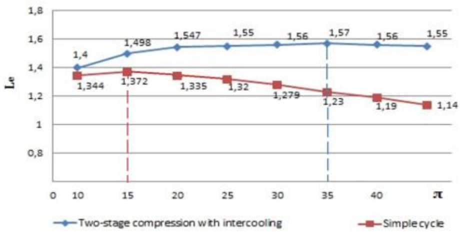

Fig. 3. Useful power versus pressure ratio.

Thus, optimal pressure ratio according to maximum cycle work and to maximum efficiency in the gas turbine plant are between the values pressure ratio corresponding to the maximum work and the maximum efficiency. In this case, increasing the overall efficiency by reducing the cycle work becomes ineffective. The relative increase in the overall efficiency is less than the relative decrease of the gas turbine effective work. Increasing the pressure increases the overall efficiency at a given maximum temperature, but increasing the pressure ratio, more 35 can actually reduce the overall cycle efficiency.

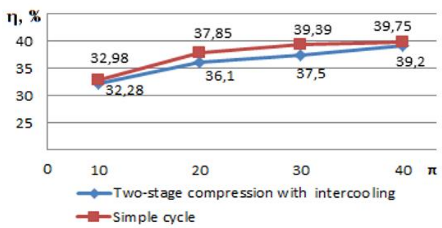

Fig. 4. Efficiency of gas turbine unit with intercooling versus pressure ratio.

Calculations show that the optimal value of pressure ratio is 35. With this parameter, useful power is maximal, with a slight decrease in efficiency.

References:

1. Теория авиационных газотурбинных двигателей / Ю.М. Терещенко, Л.Г. Волянская, Н.С. Кулик, В.В. Панин - К.: Книжкове вид-во НАУ, 2005. – 500 с.

2. Моляков В.Д., Осипов М.И., Тумашев Р.З. Повышение эффективности режимов работы газотурбинного двигателя // Вестник МГТУ им. Н.Э. Баумана. Сер. Машиностроение. 2006. № 3. С. 80-95.