$$\tau = \frac{125000000\,ruble}{126144000\,\frac{ruble}{year}} \cong 1\,year \quad (5)$$

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APPLICATION OF NUMERICAL METHODS IN THE STUDY OPERATIONAL CHARACTERISTICS OF THE COMBUSTION CHAMBER (PUMPING UNIT GPA-16U) AT DIFFERENT LOADS

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One of the problems in the operation of the gas turbine is to provide the reliable operation of the combustion chamber. Modern pumping units with the growth of the thermodynamic cycle parameters influences on a variety of aspects, such as: increasing temperature, rising pressure and, at last reliability problems.

Thus, the purpose of paper is to study operational characteristics of the combustion chamber by using numerical simulation. The object of research is the pumping unit (GPA-16U) that is considered to be useful to develop cost-effective and significant recommendations for further design, manufacture and operation of the combustion chamber and the pumping unit.

A detailed study of the combustion chambers is performed in different modes in order to prevent abnormal situations in future.

Typically, the combustion chambers are divided into and embedded outrigger, depending on the relative location to the turbine housing and compressor. Furthermore, they are divided into countercurrent and co-current. These differences affect the characteristics of chambers- construction, fuel supply method, efficiency etc.

The determining of the leading position performance occupies a choice of flammable material combustion. To achieve a sustainable combustion of the fuel is necessary to provide a numerical equality to the rate of combustion and flow rate of the gas mixture.

The actual combustion temperature is the temperature of all inclusive heat losses, including the environment from heat transfer point of view [1].

The main indicators of the combustion chamber works:

$$Q_{KC} = B \cdot Q_H^P \qquad (1)$$

where B - burnt fuel consumption, kg/s;

Q^P_H – the lowest combustion heat kJ/kg.

The thermal efficiency of the combustion chamber, taking all heat loss into account:

$$\eta_{KC}^T = \frac{1-(Q_{H.C.}+Q_{\text{ОХЛ}})}{B \cdot Q_H^P} \qquad (2)$$

where $Q_{N.S.}$ – heat losses from incomplete combustion of fuel chemical and physical under burning (advanced combustors, these losses should not exceed 1...5% of the total heat consumption in the entire range on workloads and 1...3% when operating at rated load). Qohl - due to the heat loss to the surroundings recoil the heated surface of the chamber and the adjoining piping (losses are usually not more than 0.5% of heat consumption) [2].

The scheme of a simple gas turbine open cycle without heat recovery is shown in figure 1.

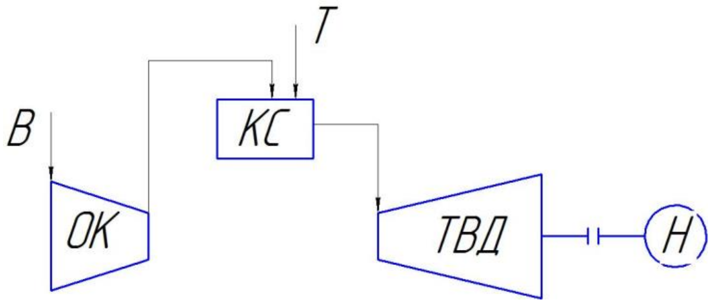

Fig. 1. Diagram of GTU

Combustion chamber design with the required performance and is reliable for a given resource and associated with carrying out a large amount of experimental work, both in plants and in the engine system. In this case the application of of numerical simulation by using different engineering packages such as ANSYS.

The essence of the numerical simulation is to create and study with the help of computer models the real objects and phenomena. The main difference of the numerical simulation of the pilot that all processes take place in the program, but not in reality, thereby getting rid of complicated and costly experiments, and also allows to save and study quick enough the properties and behavior of the model, which is an advantage theory.

To describe the characteristics of the turbulent gas we used two-parameters «k-ε» turbulence model Launder and Spalding [3]:

$$\frac{\partial \rho k U_i}{\partial x_i} = \frac{\partial}{\partial x_i}\left(\frac{\mu_t}{1{,}0}\frac{\partial k}{\partial x_i}\right) + C - \rho\varepsilon, \qquad (3)$$

$$\frac{\partial \rho \varepsilon U_i}{\partial x_i} = \frac{\partial}{\partial x_i}\left(\frac{\mu_t}{1{,}3}\frac{\partial \varepsilon}{\partial x_i}\right) + 1{,}44G\frac{\varepsilon}{k} - 1{,}92\rho\frac{\varepsilon^2}{k}, \qquad (4)$$

$$\mu_t = 0{,}09\rho\frac{k^2}{\varepsilon}\,, \qquad (5)$$

$$G = \left[\mu_t\left(\frac{\partial U_i}{\partial x_j} + \frac{\partial U_j}{\partial x_i} - \frac{2}{3}\delta_y\frac{\partial U_k}{\partial x_k}\right) - \frac{2}{3}\delta_y \rho k\right]\frac{\partial U_i}{\partial x_j}. \qquad (6)$$

where k, ε –kinetic energy of turbulence and its rate of dissipation;

δy – Kronecker simbol;

μt - turbulent viscosity;

q_i^{rad} - components of radioactive heat flow.

The overall energy balance of heat transfer by radiation plays an important role in combustion chambers. In the numerical study of radioactive heat transfer in the radiating, absorbing and scattering media, such as combustors, complicated integral-differential equation for the thermal radiation intensity is used. For an approximate solution of this equation in this paper, the method of spherical harmonics (his P1 approximation) is applied. This approach for modeling the thermal radiation in the combustion chamber due to its good compatibility with finite-difference methods is used. The mathematical formulation of the process of radioactive heat transfer within the P1 approximation of the method of spherical harmonics for sulfur emitting, absorbing and scattering medium includes the following differential equations is calculated:

$$\frac{\partial}{\partial \mathrm{x}}\left(\frac{1}{3\mathrm{k_B}}\frac{\partial \mathrm{H}}{\partial \mathrm{x_i}}\right) = -\mathrm{a}(4\sigma\mathrm{T}^4 - \mathrm{H}), \qquad (7)$$

$$\frac{\partial q_i^{rad}}{\partial x_i} = a(4\sigma T^4 - H). \qquad (8)$$

where H - the spatial density of the incident radiation, W/m2;

ke = a - medium attenuation coefficient 1/m;

a - absorption coefficient 1/m;

σ - Stefan-Boltzmann constant.

For the numerical simulation of a chemical reaction in a turbulent flow of one of the commonly used model is the model of Spalding (Eddy-Break-Up-EBU). According to this model, the chemical reaction rate is proportional to the intensity of turbulent mixing. However, the effect of temperature on the flow rate of the chemical reactions EBU-model does not take into account that does not allow modeling the flow of combustion mode transition, defining the conditions of existence of the flame.

The modified model is based on sharing model Spaulding and kinetic models, expands the possibilities of the model and allows you to take into account the different flow regimes.

The purpose of the simulation is to carry out the experimental part with the help of computer analysis and comparison of the results with real phenomena studied object.

Numerical simulation can be divided into several stages [4]:

1. formulation of the problem;
2. development of the model, the main elements of the object;
3. development of a mathematical model, i.e, creation algorithm calculation
4. conducting experiments using a specific calculation algorithm;
5. analysis, comparison of the results, conclusions.

The simulation process is similar to the results of a calculation method, and can bring the real conditions of COP operation which may allow to eliminate or prevent the consequences of potential accidents or other situations. It also allows to expand the field of knowledge about combustion chamber and to make a research for improvement units.

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COMPLEX OF TECHNOLOGIES FOR THE POWER-GENERATING EQUIPMENT ECO-FRIENDLY SHUTDOWN

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National power economy modernization requires an effective system for the power-generating equipment eco-friendly shutdown. The problem of the power unit's eco-friendly shutdown is very complicated. In this research there were selected two basis technologies and considered a possibility of their combined appliance.