MODELING AND SOME NUMERICAL RESULTS OF THE STUDY OF THREE-DIMENSIONAL TURBULENT REACTING JETS.

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The regularities of three-dimensional jet turbulent flow underlie the organization of work processes of a large number of technical devices, the range of which is continuously expanding. Three–dimensional turbulent jet flows, especially by chemical reactions, have become the subject of numerous experimental and computational - theoretical studies over the past decade.

This paper presents some numerical results of the study of chemically reacting turbulent jets flowing out of a rectangular nozzle with a finite ratio of the lengths of the sides to the satellite (flooded)oxidizer flow.

Three-dimensional parabolized systems of Navier-Stokes equations for multicomponent chemically reacting gas mixtures are used to simulate the flow, as well as by connecting the kinetic energy (1) and kinetic energy dissipation (2) equations of turbulence to calculate the turbulent viscosity, which has the following form:

$$\rho u\frac{\partial k}{\partial x}+\rho\vartheta\frac{\partial k}{L\partial y}+\rho\omega\frac{\partial k}{\partial z}=\frac{1}{L^2}\frac{\partial}{\partial y}\left(\frac{\mu_T}{\sigma_k}\frac{\partial k}{\partial y}\right)+\frac{\partial}{\partial z}\left(\frac{\mu_T}{\sigma_k}\frac{\partial k}{\partial z}\right)+G-\rho\varepsilon. \quad (1)$$

$\rho u\frac{\partial\varepsilon}{\partial x}+\rho\vartheta\frac{\partial\varepsilon}{L\partial y}+\rho\omega\frac{\partial\varepsilon}{\partial z}=\frac{1}{L^2}\frac{\partial}{\partial y}\left(\frac{\mu_T}{\sigma_\varepsilon}\frac{\partial\varepsilon}{\partial y}\right)+\frac{\partial}{\partial z}\left(\frac{\mu_T}{\sigma_\varepsilon}\frac{\partial\varepsilon}{\partial z}\right)+(C_1G-C_2\rho\varepsilon)\frac{\varepsilon}{k}$, (2) where $G=\mu_T\left[\left(\frac{\partial u}{L\partial y}\right)^2+\left(\frac{\partial u}{\partial z}\right)^2\right]$,

and connection μ_T through k and ε is given by the ratio $\mu_T=C_\mu\rho k^2/\varepsilon$ (3).

In equations (1-2) and in relation (3) k and ε respectively, the kinetic and kinetic energy dissipation of turbulence, $L=a/b$ (a and b are the half-height of the rectangular nozzle), $C_\mu, C_1, C_2, \sigma_k, \sigma_\varepsilon$ - constants "$k-\varepsilon$" models, and the rest of the designations are generally accepted.

A modification of the SIMPLE (Semi-Implicit Method for Pressure-Linked Equations) method is applied for numerical integration of the system of Navier-Stokes equations taking into account (1-3). To find the correct pressure distribution, the equations of motion and continuity are used.It is assumed that velocity corrections are determined by pressure corrections in accordance with very approximate three equations of motion in which the longitudinal convective terms are balanced only by pressure terms.

The diffusion combustion of a propane-butane mixture flowing out of a square-shaped nozzle in a flooded air oxidizer stream has been numerically investigated.

In this paper, the distribution k and ε on the nozzle slice is defined by the expressions $k=\alpha u^2$, $\varepsilon=\beta u^{3/2}$, α,β - dimensionless constants . The "arbitrariness"of the choice of these values should provide the values of turbulent viscosity (3) corresponding to the actual flow pattern.

Based on the proposed method and calculation algorithm, the effect of the initial turbulence value on the parameters of the flare is numerically investigated. As an example, calculations were carried out with the following initial data:

I. Oxidizer zone: $u_1=0$; $T_1=300\ K$; $(C_1)_1=0,232$; $(C_2)_1=0$; $(C_3)_1=0$; $(C_4)_1=0,768$; $k_1=\beta_1u_1^2$; $\varepsilon_1=\gamma_1k_1^{3/2}$;

II. Fuel zone: $(C_4)_2=0,88$; $T_2=1200\ K$; $u_2=61m/s$ $(C_2)_2=0,12$; $(C_1)_2=0$; $(C_3)_2=0$; $k_2=\beta_2u_2^2$; $\varepsilon_2=\gamma_2k_2^{3/2}$;

where $\gamma_1,\gamma_2,\beta_1,\beta_2$ - some dimensionless constants (index 1 refers to the parameters of the oxidizer, and 2 refers to the parameters of the fuel).

In calculations β_2 it varied so that the dimensionless initial value of the kinetic energy of turbulence did not exceed 10% of the dimensionless initial velocity of the fuel jet, and the initial values of the dissipation of the kinetic energy of turbulence of the fuel and oxidizer, respectively, did not exceed 5% of the dimensionless initial velocity value. When increasing the dimensionless initial value k_2, i.e. for $k_2=0,05$. the core of the jet decreases and as it moves away from the nozzle mouth, the longitudinal velocity values fall faster and the displacement area becomes wider. From the longitudinal velocity profiles obtained in $\overline{x}=10$ it follows that its changes along the y and z axes become similar, i.e. the shape of the jet has acquired a round shape. It should be noted that an increase in the intensity of turbulence leads to the intensity of mixing and gorenje, which leads to a narrowing of the width and shortening of the length of the torch.

Satisfactory matching results with experimental data were obtained in the initial sections of the jet when selecting empirical parameters $C_\mu=0,08; C_1=1,3; C_2=1,5; \sigma_k=1; \sigma_\varepsilon=1,3$ "$k-\varepsilon$" models of turbulence.

The proposed method and algorithm for calculating the solution of the Navier-Stokes equations for multi component chemically reacting gas mixtures make it possible to obtain the desired width and length of the torch when selecting the input values of the parameters of the fuel and oxidizer.