Numerical Simulation Of Three-Dimensional Turbulent Reacting Gas Jets Arising Nozzle Rectangular Based “K-ε” Turbulence Models.

A. Kh. Avezov[1], M.Sh. Akhmedov[2], M.Sh. Saidzhonova[3], F.B. Ata-Kurbanova[4]
[1,3,4]Bukhara State University
[2]Bukhara Technological- Institute of Engineering Republic of Uzbekistan, 15 K. Murtazoyev Street.
maqsud.axmedov.1985@mail.ru

***Abstract*—The main tool for the study of gas dynamics, heat and mass transfer of turbulent jet flows of multi component gas mixtures is mathematical modeling, which in contrast to the physical experiment is often more cost-effective and often the only possible method of research. In general, the simulation of turbulent jet flows of the reacting gas mixtures based on the common system of coupled partial differential equations that express the laws of conservation of mass, momentum, energy and mass.**

Keywords—Turbulence models, arising nozzle, gas dynamics.

Introduction. In [1 ÷ 9] presents mainly the results of experimental and theoretical - numerical calculations devoted to research flow of air flowing from the nozzle of rectangular shape.

In this paper the method of calculation and some numerical results of the study of three-dimensional turbulent reacting gas jets emanating from the nozzle of rectangular shape.

Problem Statement. Consider reactive streams flowing from the nozzle of rectangular shape and extending wake (flooded) air flow. As the origin of the Cartesian system we choose the center of the initial section of the jet: the x-axis is directed along the jet and the axis OY and OZ parallel to the sides of the nozzle and the size respectively. Suppose that for symmetric about the axis OX and planes YOX, ZOX, which form the boundary of the domain of integration and that allow us to consider only one-quarter of the rectangular jet.

This flow is described by the following system of equations paralyzed [7 ÷11]:

$$\frac{\partial \rho u}{\partial x}+\frac{\partial \rho v}{\partial y}+\frac{\partial \rho w}{\partial z}=0, \qquad (1)$$

$$\rho u\frac{\partial u}{\partial x}+\rho v\frac{\partial u}{\partial y}+\rho w\frac{\partial u}{\partial z}=-\frac{\partial P}{\partial x}+\frac{\partial}{\partial y}(\mu_T\frac{\partial u}{\partial y})+\frac{\partial}{\partial z}(\mu_T\frac{\partial u}{\partial z}), \qquad (2)$$

$$\rho u\frac{\partial v}{\partial x}+\rho v\frac{\partial v}{\partial y}+\rho w\frac{\partial v}{\partial z}=-\frac{\partial P}{\partial y}+\frac{4}{3}\frac{\partial}{\partial y}(\mu_T\frac{\partial v}{\partial y})+\frac{\partial}{\partial z}(\mu_T\frac{\partial v}{\partial z})-\frac{2}{3}\frac{\partial}{\partial y}(\mu_T\frac{\partial w}{\partial z})+\frac{\partial}{\partial z}(\mu_T\frac{\partial w}{\partial y}), \qquad (3)$$

$$\rho u\frac{\partial w}{\partial x}+\rho v\frac{\partial w}{\partial y}+\rho w\frac{\partial w}{\partial z}=-\frac{\partial P}{\partial z}+\frac{4}{3}\frac{\partial}{\partial z}(\mu_T\frac{\partial w}{\partial z})+\frac{\partial}{\partial y}(\mu_T\frac{\partial w}{\partial y})+\frac{\partial}{\partial y}(\mu_T\frac{\partial v}{\partial z})-\frac{2}{3}\frac{\partial}{\partial z}(\mu_T\frac{\partial v}{\partial y}), \qquad (4)$$

$$\rho u\frac{\partial H}{\partial x}+\rho v\frac{\partial H}{\partial y}+\rho w\frac{\partial H}{\partial z}=\frac{1}{\Pr_T}\frac{\partial}{\partial y}(\mu_T\frac{\partial H}{\partial y})+\frac{1}{\Pr_T}\frac{\partial}{\partial z}(\mu_T\frac{\partial H}{\partial z})+(1-\frac{1}{\Pr_T})[\frac{\partial}{\partial y}(\mu_T u\frac{\partial u}{\partial y})+$$
$$+\frac{\partial}{\partial z}(\mu_T u\frac{\partial u}{\partial z})+\frac{\partial}{\partial z}(\mu_T v\frac{\partial v}{\partial z})+\frac{\partial}{\partial y}(\mu_T w\frac{\partial w}{\partial y})]+(\frac{4}{3}-\frac{1}{\Pr_T})[\frac{\partial}{\partial y}(\mu_T v\frac{\partial v}{\partial y})+\frac{\partial}{\partial z}(\mu_T w\frac{\partial w}{\partial z})]- \qquad (5)$$
$$-\frac{\partial}{\partial y}(\frac{2}{3}\mu_T v\frac{\partial w}{\partial z})+\frac{\partial}{\partial z}(\mu_T v\frac{\partial w}{\partial y})+\frac{\partial}{\partial y}(\mu_T w\frac{\partial v}{\partial z})-\frac{\partial}{\partial z}(\frac{2}{3}\mu_T w\frac{\partial v}{\partial y})$$

$$\rho u\frac{\partial C_i}{\partial x}+\rho v\frac{\partial C_i}{\partial y}+\rho w\frac{\partial C_i}{\partial z}=\frac{1}{Sc_T}\frac{\partial}{\partial y}(\mu_T\frac{\partial C_i}{\partial y})+\frac{1}{Sc_T}\frac{\partial}{\partial z}(\mu_T\frac{\partial C_i}{\partial z})+\dot{w}_i, \qquad (6)$$

$$\rho u\frac{\partial k}{\partial x}+\rho v\frac{\partial k}{\partial y}+\rho w\frac{\partial k}{\partial z}=\frac{\partial}{\partial y}(\frac{\mu_T}{\sigma_k}\frac{\partial k}{\partial y})+\frac{\partial}{\partial z}(\frac{\mu_T}{\sigma_k}\frac{\partial k}{\partial z})+G-\rho\varepsilon, \qquad (7)$$

$$\rho u\frac{\partial \varepsilon}{\partial x}+\rho v\frac{\partial \varepsilon}{\partial y}+\rho w\frac{\partial \varepsilon}{\partial z}=\frac{\partial}{\partial y}(\frac{\mu_T}{\sigma_\varepsilon}\frac{\partial \varepsilon}{\partial y})+\frac{\partial}{\partial z}(\frac{\mu_T}{\sigma_\varepsilon}\frac{\partial \varepsilon}{\partial z})+C_{\varepsilon 1}G-C_{\varepsilon 2}\rho\varepsilon)\frac{\varepsilon}{k}, \qquad (8)$$

где $G = \mu_T[(\frac{\partial u}{\partial y})^2 + (\frac{\partial u}{\partial z})^2]$

$$H = c_p T + \frac{u^2 + v^2 + w^2}{2} + \sum_{i=1}^{N_k} C_i h_i^* \qquad (9)$$

$$P = \rho TR \sum_{i=1}^{N_k} \frac{C_i}{m_i} \qquad (10)$$

$$\mu_T = \frac{C_\mu \rho k^2}{\varepsilon} \qquad (11)$$

In equation (1÷11) *x*, *y*, *z* - Cartesian coordinates, *ρ* - density: *u*, *v*, *w*- velocity components; T- temperature; Total enthalpy H, H-pressure; k - turbulent kinetic energy; ε - turbulent kinetic energy dissipation; C_i- the mass concentration; i- the component, N_k- number of components in the mixture; c_p- heat capacity at constant pressure; Pr_T, Sc_T - turbulent Prandtl number and Schmidt; h_1^* - heat of formation i – the component ; R – universal gas constant; m_i - molecular weight i- the component; w_i – the rate of formation i- the component, as well as $C_{\varepsilon l}, C_{\varepsilon 2}, C_\mu, \sigma_k, \sigma_\varepsilon$, - empirical constants "k- ε " turbulence model.

In this paper we present an effective method like SIMPLE, direct method to solve the Poisson equation for determining the corrections to the velocity. Allegedly unnecessary continuity equation used to calculate the weight imbalance. In contrast to [11,13] amendment provides for three components of the velocity. The solutions *u, v, w* the new iteration are expressed as estimated (u_p, v_p, w_p) Plus correction (u_c, v_c, w_c) and they are determined from the continuity equation administration building Q, $pu_c = \frac{\partial Q}{\partial x}$, $pv_c = \frac{\partial Q}{L \partial y}$, $pw_c = \frac{\partial Q}{\partial z}$ which is the solution of the Poisson equation:

$$\frac{\partial^2 Q}{\partial x^2} + \frac{\partial^2 Q}{L^2 \partial y^2} + \frac{\partial^2 Q}{\partial z^2} = Q_p \qquad (12)$$

where Q_P – source term.

References

1. VA Turkus The structure of the supply air plume coming out of the rectangular opening Heating and ventilation. 1933 N 5.
2. Palatnik IB Temirbaev D.Zh. On the propagation of free turbulent jets emanating from the nozzle of rectangular shape .// Problems of power engineering and thermo. Ed. Kazakh SSR, Alma-Ata, 1964, vol. 1, p. 18-28.
3. Sforza, Steiger, Trentakoste. The study of three-dimensional viscous jets. // Rocketry and Astronautics. 1966, N 5, p. 42-50.
4. Lariushkin MA Some entry-level patterns of influence of turbulence on the development of the rectangular jet. Tr. Moscow Power Engineering Institute, 1981, N524, p. 26 -30.
5. K. Aerodynamics Body jets issuing from a rectangular nozzle .// Industrial Heat Engineering, Volume 12, N 4, 1990, p. 38-44
6. Nikjooy M., Karki K.C., Mongia H.C. Calculation of turbulent three-dimensional jet - induced flow in rectangular epclosure .// AIAA pap -19900, n 0684 -p1 -10. RFZH 1991, N 1, 1B144.
7. J. Mack-Guirec. J., Rodi B. Calculation of three-dimensional turbulent free jets. / In Sat Turbulent shear flows. V.1. M .: Mechanical Engineering, 1982, p. 72-88.
8. S. Khodzhiyev study of three-dimensional turbulent jets reacting gas, expires at the wake (flooded) in the air flow in diffuse combustion .// Uzb. magazine. Problems of Mechanics. Tashkent, FAN, N2, 1993 p. 28-33
9. Agulykov A. Dzhaugashtin KE, Yarin LP Investigation of the structure of three-dimensional turbulent jets .// Math. USSR Academy of Sciences, Fluid Dynamics, 1975, N 6, p. 13-21.
10. Oran E., J. Boris. Numerical simulation of reacting flows: Trans. from English. -M .: Mir, 1990 - 660 p.
11. D. Anderson, J. Tonnehill., Pletcher R. Computational Fluid Dynamics and Heat Transfer. In the 2-mth .: -M. : Mir, 1990, p. 792 - 384.
12. A. Schwab The relationship between the temperature and speed of the gas plume models .// Proc. Research of combustion processes of natural fuel ed. GF Knorre, Gosenergoizdat 1948.
13. Patankar S.V. , Spolding D.B. Heat and mass transfer in boundory layers. - London: Morgan - Grampion, 1967 // Translation: Patankar S., D. Spalding Heat and mass transfer in boundary layers .- M .: Energy. 1971.127 p.
14. Dvoinishnikov VA Lariushkin NA VP Knyazkov The effects of the initial conditions for the development of a turbulent jet .// Energy and Transport. -M .: 1981, N 4. p. 167-170.
15. Wooleys LA, Yarin LP Aerodynamics fakela.-L .: Energy. 1978. -216 p.