İSTANBUL ANALYSIS SEMINARS

ABOUT APPROXIMATE SOLUTION OF THE EQUATION OF GAS FLOW OVER MULTISTAGE CHANNELS OF HEAT AND MASS TRANSFER APPARATUSES

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Abstract: The length of the majority of channels with multistage interaction of phases of mass-transfer tower devices is very great. Therefore the open calculation of dynamic characteristics by numerical methods requires very large volume of memory of the computer and score time. Thus because of repeated reiteration of computing procedures there is an accumulation of rounding errors. For the solution of this problem we used the method which would be possible to call a principle of hydrodynamic establishment. This effect is simulated by the appropriate boundary and initial conditions, and also with conjugation conditions:

$$U_S = ku_0, \qquad \vartheta_S = 0, \qquad \omega_S = z(\psi_S, \psi_{S-1}, \psi_{S+1}), \tag{1}$$

where k is the coefficient of reduction depending on dispersion of the general flow rate of gas; u_0 is the average flow speed of gas; ψ is the current function; S is the curve which can be considered the symmetry line between two rows of the flows which are streamlining 2 rows of elements of nozzles or boundary of a canal's wall; ω_S is the value of vorticity on a separating line; $z = z(\psi_S, \psi_{S-1}, \psi_{S+1})$ is the function generally received by three-point approximation of a boundary condition for function of vorticity:

$$\frac{\partial \psi}{\partial n}\Big|_S = 0. \tag{2}$$

Navier-Stokes equations in Helmholtz variables, simulating a gas current in channels and mass exchange devices have the following form:

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} = \omega, \tag{3}$$

$$\frac{\partial \omega}{\partial t} + u\,\frac{\partial \omega}{\partial x} + v\,\frac{\partial \omega}{\partial y} = \nu \left(\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} \right), \tag{4}$$

where ω is the function of strength of a curl; u, v are the velocity vector components in the longitudinal and cross directions; ν is the viscosity coefficient; t is time. Boundary conditions for current and vorticity functions (implicitly) are

$$\psi_S \equiv \text{const.}, \tag{5}$$

$$\frac{\partial \psi}{\partial n}\Big|_S = 0. \tag{6}$$

We used a method of Patankar-Spolding [1, 2]. In a turbulent mode the mathematical model has the following appearance:

$$\frac{\partial}{\partial x}\left(\frac{1}{\rho}\frac{\partial \psi}{\partial x}\right) + \frac{\partial}{\partial y}\left(\frac{1}{\rho}\frac{\partial \psi}{\partial y}\right) - \omega = 0, \tag{7}$$

$$\frac{\partial}{\partial x}\left(\omega\frac{\partial \psi}{\partial y}\right) - \frac{\partial}{\partial y}\left(\omega\frac{\partial \psi}{\partial x}\right) - \frac{\partial}{\partial x}\left(\frac{\partial(\mu_{ef}\omega)}{\partial x}\right) - \frac{\partial}{\partial y}\left(\frac{\partial(\mu_{ef}\omega)}{\partial y}\right) - S_\omega = 0, \tag{8}$$

$$\frac{\partial}{\partial x}\left(k\frac{\partial \psi}{\partial y}\right) - \frac{\partial}{\partial y}\left(k\frac{\partial \psi}{\partial x}\right) - \frac{\partial}{\partial x}\left(\frac{\partial(\mu_{ef}k)}{\partial x}\right) - \frac{\partial}{\partial y}\left(\frac{\partial(\mu_{ef}k)}{\partial y}\right) - S_k = 0, \tag{9}$$

$$\frac{\partial}{\partial x}\left(l\frac{\partial \psi}{\partial y}\right) - \frac{\partial}{\partial y}\left(l\frac{\partial \psi}{\partial x}\right) - \frac{\partial}{\partial x}\left(\frac{\partial(\mu_{ef}l)}{\partial x}\right) - \frac{\partial}{\partial y}\left(\frac{\partial(\mu_{ef}l)}{\partial y}\right) - S_l = 0. \tag{10}$$

Distinctive properties of dynamic functions are reflected by source members. Let us give their expressions in rectangular coordinate system [1, 2]:

$$S_\omega = 0, \tag{11}$$

$$S_k = W_{k,t} - D_k = \mu_t\left[4\left(\frac{\partial^2\psi}{\partial x\partial y}\right)^2 + \left(\frac{\partial^2\psi}{\partial x^2} - \frac{\partial^2\psi}{\partial y^2}\right)^2\right] - C_D\rho k^{3/2}l, \tag{12}$$

$$S_l = C_S\rho k^{1/2} - C_B l k^{-1} W_{k,t}, \tag{13}$$

$$\mu_{ef} = C_\mu \rho k^{1/2} l. \tag{14}$$

For use of a mathematical model (8)−(13) for calculation of dynamic characteristics in channels with other forms of nozzle elements it is necessary to lay down the appropriate initial and boundary conditions describing geometry of nozzles, and also to select values of constants C_S, C_D, C_B, C_μ.

References

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[2] L.P. Kholpanov, B.R. Ismailov & P. Vlasec, "Modelling of multiphase flow containing bubbles, drops and solids particles," *Engin. Mech.* **12** (2005), no. 6, 1-11.

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