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Research Article

Numerical Investigation of Two-Phase Non-Isothermal Vertical Flow

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Abstract

In the current work is described the algorithm of the solution to the equations for non-isothermal vertical flow by finite difference method and also are given some numerical results

Keywords: *Equations, numerical results, two-phase flow*

1. Introduction

The Finite difference depending upon the difference schemes is an express or implied. In the classical tasks with given initial and boundary conditions, the solution starts at point with given initial conditions and continues along the axis of the stream. When using explicit difference schemes value of the function can be defined directly in each subsequent section. In implicit difference schemes after each step is a system of related equations.

Below is used straight, explicit method of finite differences to solve the equations of motion, continuity, energy and heat content of the turbulent flow of fluids, which uses a difference schemes, proposed by Dyufort and Frankel (Antonov *et al*, 1995; Lien *et al*, 1996) conditionally designated as a scheme D.F. The main advantage of the obvious difference schemes type D.F. before implicit difference schemes lies in the fact that it is a direct (without intermediate conversions) and algebraically simpler. Simultaneously, there is no reason to expect it will take more machine time when calculating the longitudinal step, limited in selection on grounds of sustainability (Nam *et al*, 1991; Abramovich *et al*, 1984).

2. Algorithm of the Solution

The calculation of the parameters of two-phase turbulent non-isothermal jets happens in the following sequence

Introduction of input data

Using the scheme in finite differences of Dyufort Frankel to start calculation is imperative to enter parameter values for two consecutive elementary sections $(i=1,2)$. These value are set in a corresponding increase in the boundary layer (Antonov *et al*, 1995) and (Lien *et al*, 1996) or can be calculated using the relevant procedure of the implicit type.

The initial profiles of the parameters in the first section $(i=1)$ and $(0 \le y \le y_o)$ in analogy to that shown in (Lien *et al*, 1996) are determined by the expressions presented in Table. 1.

Table 1

$\bar{U}_{g1,j}$	$(1-jH)^{\frac{1}{n}}$
$\bar{U}_{p1,j}$	$(1-jH)^{\frac{1}{n}}$
$\bar{\chi}_{p1,j}$	$(1-j\chi)^{\frac{1}{n}}$
$\bar{T}_{g1,j}$	$\left[(1-jH).\left(\frac{T_{g0}.R}{U_{g0}^2}\right)^n + jH.\left(\frac{T_2.R}{U_{g0}^2}\right)^n\right]^{\frac{1}{n}}$
$\bar{T}_{p1,j}$	$\left[(1-jH).\left(\frac{T_{p0}.R}{U_{g0}^2}\right)^n + jH.\left(\frac{T_2.R}{U_{g0}^2}\right)^n\right]^{\frac{1}{n}}$
$\bar{\rho}_{g1,j}$	$\frac{P}{\rho_{g0}.U_{g0}^2.\bar{T}_{gi,j}}$
$\bar{K}_{g1,j}$	$(1.1-C_{k1}.\chi_0).\frac{C_4.K_{g0}.(1+jH)^{\frac{2(1-n)}{n}}}{C_3.U_{g0}^2.n^2}$
$\bar{K}_{p1,j}$	$(1.1-C_{k1}.\chi_0).\frac{C_4.K_{p0}.U_{p0}.(1+jH)^{\frac{2(1-n)}{n}}}{C_3.U_{g0}^3.n^2}$
$\bar{\varepsilon}_{1,j}$	$(1.02-C_{k2}.\chi_0)\frac{C_4.\varepsilon_0.y_0.(1+jH)^{\frac{2(1-n)}{n}}}{C_3.U_{g0}^3.n^2}$
$\bar{V}_{g1,j}$	0
$\bar{V}_{p1,j}$	0

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Profile of the parameters in second section ($i = 2$), ($0 \le y \le y_o$) are given in Table2.

Table 2

$\overline{U}_{g2,j}$	$(0.9 - 0.818181jH)^{\frac{1}{n}}$
$\overline{U}_{p2,j}$	$(0.9 - 0.818181jH)^{\frac{1}{n}}$
$\overline{\chi}_{p2,j}$	$(1.01 + 0.818181jH)^{\frac{1}{n}}$
$\overline{T}_{g2,j}$	$\left[(0.9 - jH).\left(\frac{T_{g0}.R}{U_{g0}^2}\right)^n + jH.\left(\frac{T_2.R}{U_{g0}^2} + 41.194709\right)^n\right]^{\frac{1}{n}}$
$\overline{T}_{p2,j}$	$\left[(0.9 - jH).\left(\frac{T_{p0}.R}{U_{g0}^2}\right)^n + jH.\left(\frac{T_2.R}{U_{g0}^2} + 41.194709\right)^n\right]^{\frac{1}{n}}$
$\overline{\rho}_{g2,j}$	$\frac{0,98P}{\rho_{g0}.U_{g0}^2.\overline{T}_{gi,j} - 0.5}$
$\overline{K}_{g2,j}$	$(1.1 - C_{k1}.\chi_0).\frac{C_4.K_{g0}.(1.02 + jH)^{\frac{2(1-n)}{n}}}{(C_3.U_{g0}^2.n^2 + 0.00005)}$
$\overline{K}_{p2,j}$	$(1.1 - C_{k1}.\chi_0).\frac{C_4.K_{p0}.U_{p0}.(1.02 + jH)^{\frac{2(1-n)}{n}}}{(C_3.U_{g0}^3.n^2 + 0.00005)}$
$\overline{\varepsilon}_{2,j}$	$(1.02 - C_{k2}.\chi_0)\frac{C_4.\varepsilon_0.y_0.(1.002 + jH)^{\frac{2(1-n)}{n}}}{(C_4.U_{g0}^3.n^2 + 0.000005)}$
$\overline{V}_{g2,j}$	$\frac{\overline{y}_{2,j-1}}{\overline{y}_{2,j}}.\frac{\overline{\rho}_{g2,j-1}}{\overline{\rho}_{g2,j}}.\overline{V}_{g2,j-1} - \frac{H.(\overline{y}_{2,j} - \overline{y}_{2,j-1})}{4K.\overline{y}_{2,j}.\overline{\rho}_{g2,j}} \times (\overline{\rho}_{g2,j}.\overline{U}_{g2,j} - \overline{\rho}_{g1,j}.\overline{U}_{g1,j} + \overline{\rho}_{g2,j-1}.\overline{U}_{g2,j-1} - \overline{\rho}_{g1,j-1}.\overline{U}_{g1,j-1})$
$\overline{V}_{p2,j}$	$\frac{\overline{y}_{2,j-1}}{\overline{y}_{2,j}}.\frac{\overline{\rho}_{p2,j-1}}{\overline{\rho}_{p2,j}}.\overline{V}_{p2,j-1} - \frac{H.(\overline{y}_{2,j} - \overline{y}_{2,j-1})}{4K.\overline{y}_{2,j}.\overline{\rho}_{p2,j}} \times (\overline{\rho}_{p2,j}.\overline{U}_{p2,j} - \overline{\rho}_{p1,j}.\overline{U}_{p1,j} + \overline{\rho}_{p2,j-1}.\overline{U}_{p2,j-1} - \overline{\rho}_{p1,j-1}.\overline{U}_{p1,j-1})$

Where: i-number of the point at x, j-number of the point at y, n=8

3. Numerical Results

At figure 1a-c are represented numerical results of the leakage flow in the cooler environment at three different temperatures of the stream. Numerical experiment was conducted under the following initial conditions

$T_{g0} = T_{p0} = 303$ K,$323K$ и 373K ; $T_2 = 283\ K$; $U_{g0} = U_{p0} = 30\ m/s$

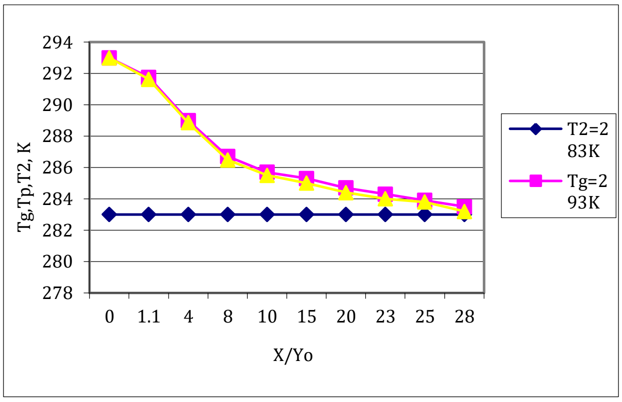

Fig.1a Distribution of the temperature at T_g=293K

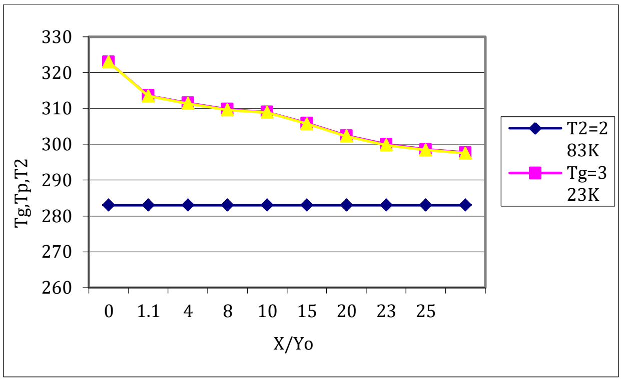

Fig.1b Distribution of the temperature at T_g=323K

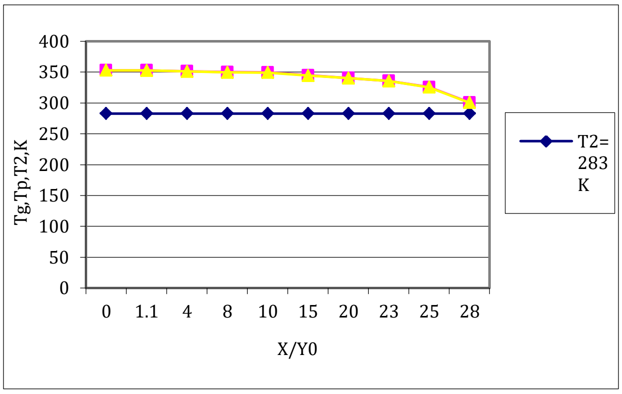

Fig.1c Distribution of the temperature at T_g=353K

The densities of the gas phase at the above mentioned temperatures, respectively $\rho_{g0} = 1,205;\ 1,093;$ и $1\ kg/m^3$. The density of the impurity phase is $\rho_{p0} = 1580\ kg/m^3$

The particle diameter is $D_p = 1mm$.

At fig. 2 a and b are shown the change in temperature of the gas phase and that the phase of impurities in the longitudinal direction of the following sections $X/Y_0 = 4,07;\ 10;\ 14,8$ и 20 :. Temperature of two-phase flow is $T_{g0} = T_{p0} = 293\ K$ adopted one discussed above, as ambient temperature is accepted $T_2 = 283\ K$.

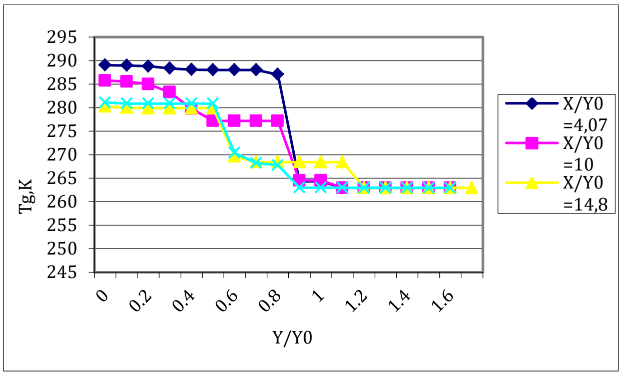

Fig.2a Distribution of the temperature of gas phase at different regimes

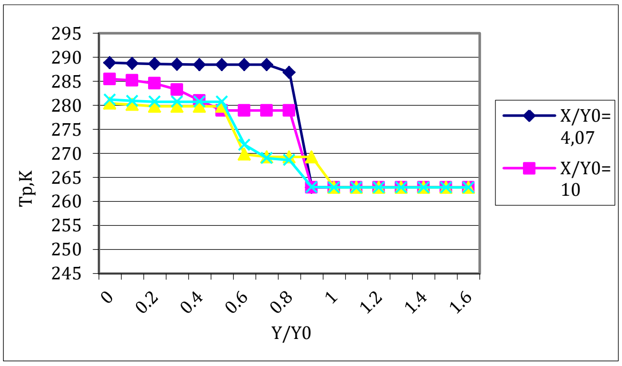

Fig.2b Distribution of the temperature phase of impurity at different regimes

In the figures it can be seen that the temperature of the gas phase decreases faster than that of the impurities .

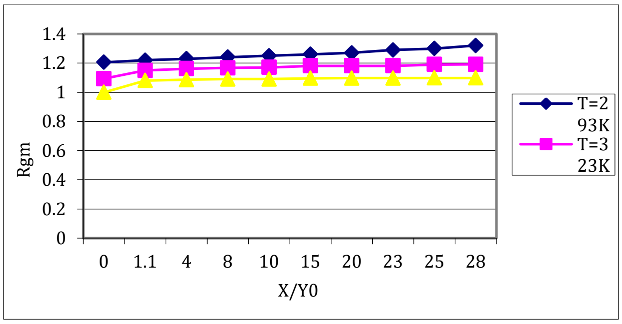

Fig.3 Distribution of the densities at different initial temperature

Fig. 3 shows the change in the density of the gas phase discussed above temperatures. From the figure it is clear that climate density is highest at the greatest difference in ambient temperatures and this gas phase.

Fig. 4. are shown distribution of velocity phase of impurities and the phase of gas discussed above initial conditions and $T_{g0} = 293K$.

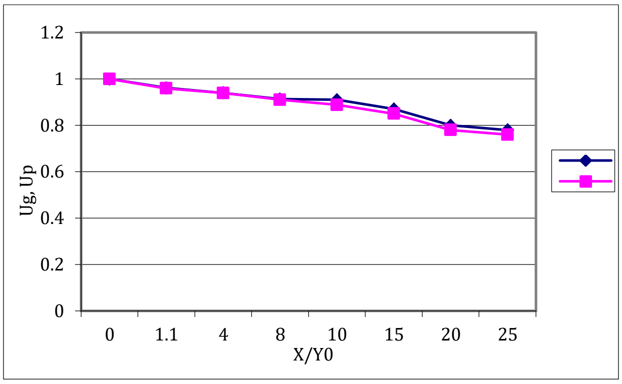

Fig.4 Distribution of the velocity

The chart shows that the velocity of the phase of impurities subsided somewhat more quick than that of the gas phase, which is due to the influence of the mass force of impurities and buoyancy force.

Conclusion

The proposed method of finite differences may be used with different models of turbulence. It can be used as a means of comparison for different methods and determining their area of use..

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