SAT-9.3-1-HP-07

Influence of initial conditions on the distribution of vertical turbulent jet carrying solid impurities

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In current work is investigate vertical non-isothermal turbulent two-phase jet which flow in medium with temperature different from the jet. This requires inserting in the system of equations Archimedes (lifting) force. The decision is made based on numerical integral method. In the work are given numerical results on the impact of the main determining the nature of the flow parameters.

Key words: vertical jet, basic parameters, numerical solution

THEORETICAL MODEL OF THE FLOW

The basic equations on which have been developed mathematical model used so called two - fluid scheme of the flow. In it each one of the phases is considering as a separate fluid medium with its own velocity, density and temperature. Equations which are used are from Reynolds write for phases, the connection between them are forces of interfacial interaction. On regards to the phase of impurities are imposed the following restrictions: it is considering as not solid fluid medium and it not posses its own tensor internal stresses (it has no pressure and viscosity, but has its own turbulent stresses) and it is obeyed on the law of Klaypeyron for the state of gas.

Integrated conditions which are received on the basis of the above equations are physically grounded and adequacy of the decision is ensure. The received system of integral conditions is solved by using similarity of the cross-section distribution of the parameters, which give a system of functional-differential type. Turbulent viscosity phase is determined by modifying the model of turbulence of Shets which taking into account the nature of two-phase flow. [1,2,3].

After appropriate adaptation the system of equations is reduced to an algebraic equation of the seventh degree of $\overline{U_{gm}}$ which is solved numerically by the method of Newton-Rapshan. The result is the most essential parameters of flow needed for his research are received.

A description of the parameters and methodology for the study is described in detail in our work [4,5,6] as most of them are published in accessible for the reader magazines and yearbooks.

ANALYSIS ON INFLUENCE OF INITIAL CONDITION ON DISTRIBUTION OF VERTCIAL NON-ISOTHERMAL FLOW CARRING SOLID IMPURITIES

In this section results of numerical experiments for the development of vertical non-isothermal jet carried solid impurities are given. In the decision is taken that the impurities (denoted by index "p" for the gas phase "g") are particles which having a spherical shape with a diameter $D_p = 45\mu m$ and is not counted their roughness. The initial concentration of impurities is $\kappa = 1$. The ambient temperature is equal to $T_2 = 288K\left(15^0 C\right)$ and $T_2 = 303K\left(30^0 C\right)$. Flowing vertical stream has initial temperatures $T_{g0} = T_{p0} = 323K; 373K, 473K$.

On fig. 1a-d are given the results of numerical solution damping of the maximum temperatures for the two phases of at different ambient temperature and the initial temperature of the flowing stream.

From what is shown in the figure follows:At increase of ambient temperature, the heat transfer of the jet is decreases, hence there is a weak damping of maximum values of the temperature of the two phases .This attenuation is proportional of the difference of initial temperature and jet medium temparature. For example at $T_{g0} = T_{p0} = 473K$ this difference decreases from $\Delta T = 185K$ to $\Delta T = 45K$, respectively for $T_{g0} = T_{p0} = 323K$ this difference decreases from $\Delta T = 45K$ to $\Delta T = 10K$.

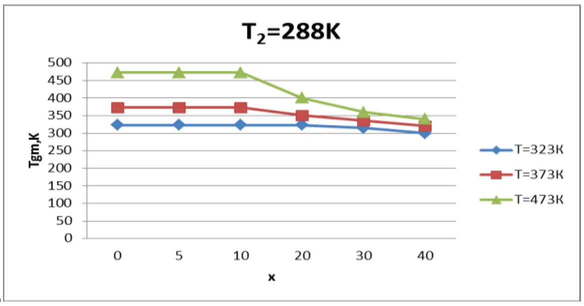

Fig.1a

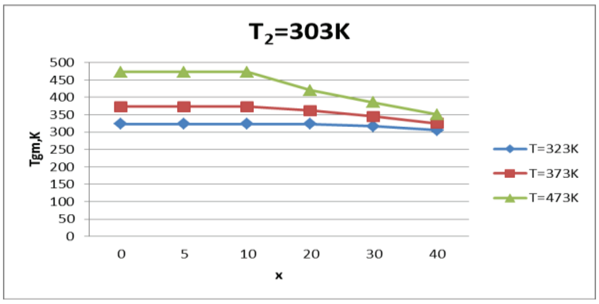

Fig.1b

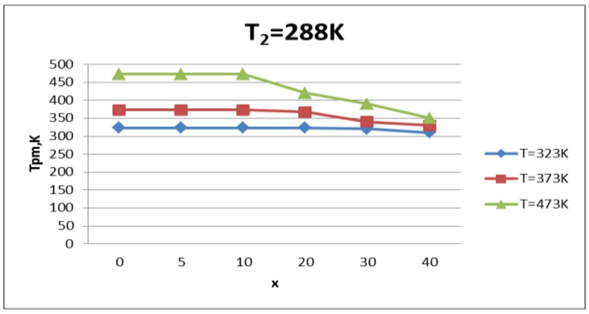

Fig.1c

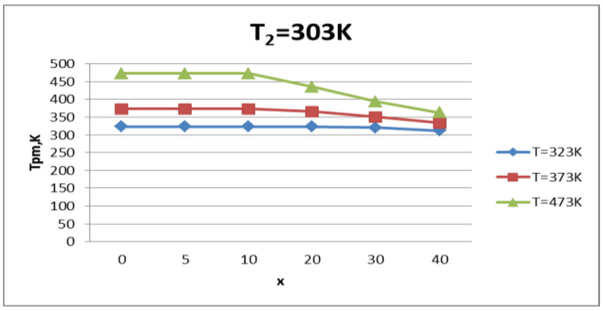

Fig.1d

Similar results currents close to the study are given in [1].

An important parameter of vertical jet is the extension at height of the flow. Software which is used allows calculating of typical thicknesses of flow boundary layer - the thickness of the boundary layer flow - on velocity Ru, temperature Rt and concentration R_p.

On fig. 2 a-c and 3a-c $\left(T_2 = 303K\right)$ are given thickness of boundary layer depending from the initial temperature $T_{p0} = T_{g0}$ and ambient temperature T_2.

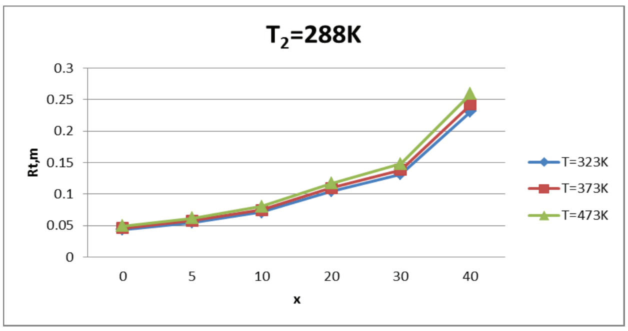

Fig.2a

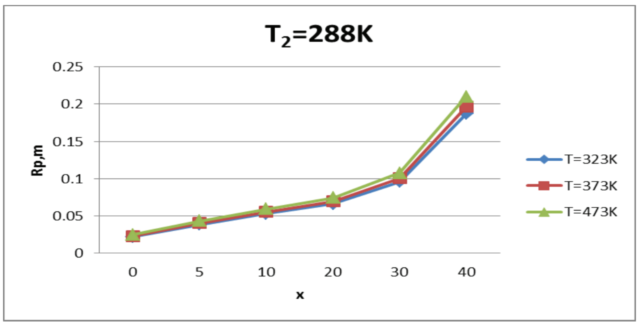

Fig 2b

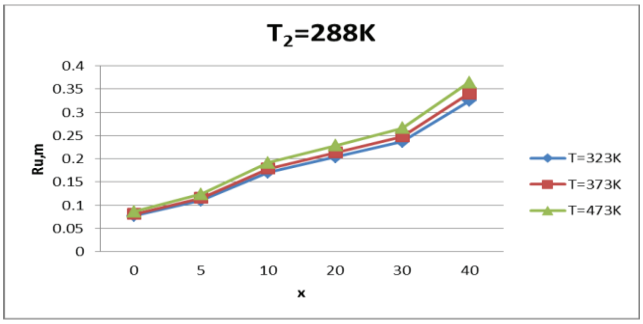

Fig.2c

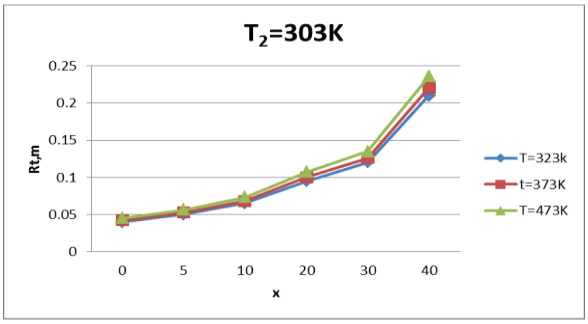

Fig.3a

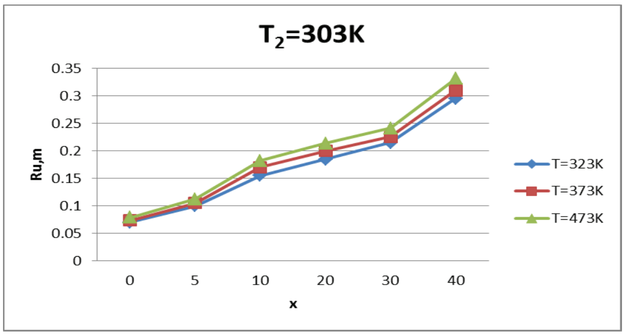

Fig.3b

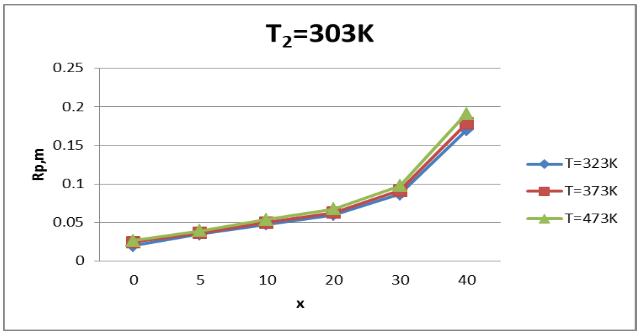

Fig.3c

The main conclusion is that the thickness velocity covers the other two:

$$R_u > R_t > R_p \qquad (1)$$

The result has great practical importance:

- At evacuation of contaminants and harmful is the main is thickness of impurity, since it may provide full suction of the corresponding suction opening (nozzle). This means that it can evacuate only the contaminated part of the jet.
- With the increase in the initial temperature of the plume its expansion is growing, as it is proportional to relationship $\frac{T_0}{T_2}$. The increase of T_0 obviously leads to a more rapid expansion of the jet.

Of course, this corresponds to that the more rapid decay of the maximum velocity given in Fig. 4a-d.

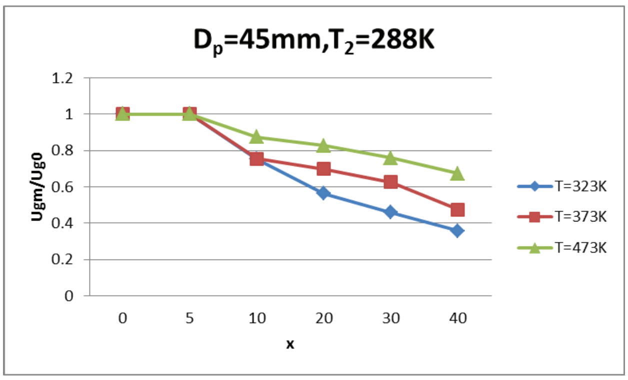

Fig.4a

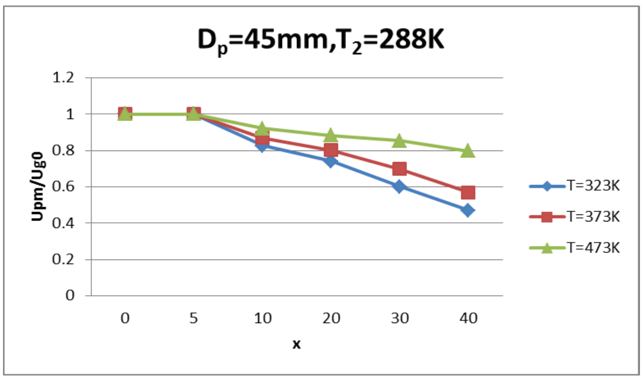

Fig.4b

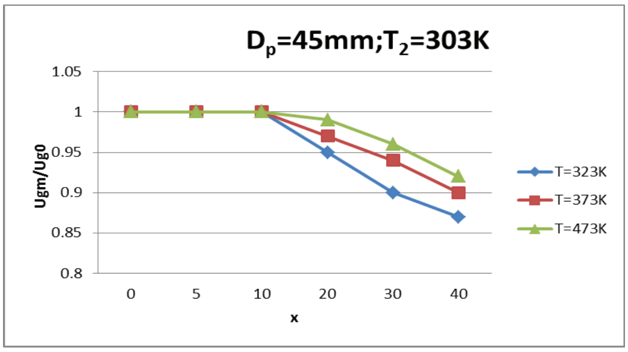

Fig.4c

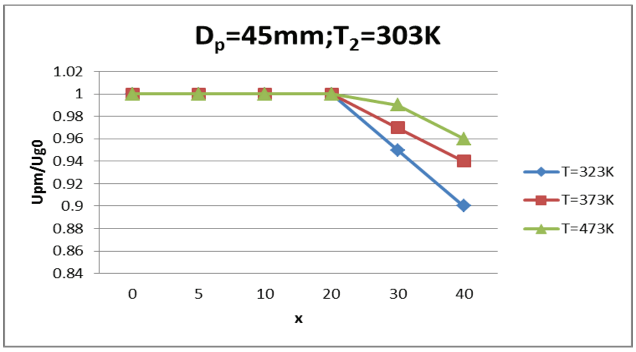

Fig.4d

The influence of the particle size of impurities with a spherical shape is given in Fig. 5a-c at difference diameter $D_p = 15,50,100\mu m$. It is obvious that D_p has minor influence on the parameters of concentration $\overline{\kappa_m} = \frac{\kappa_m}{\kappa_0}$. It is negligible also and the impact of the initial temperature.

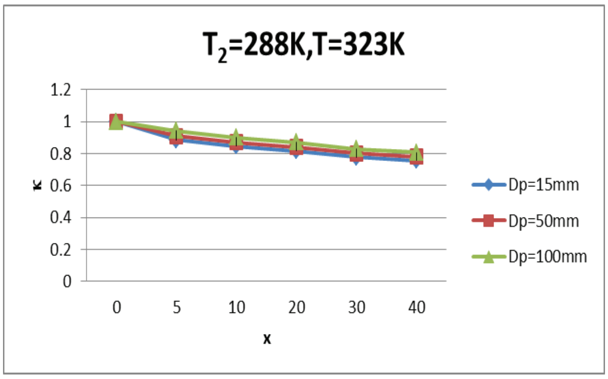

Fig.5a

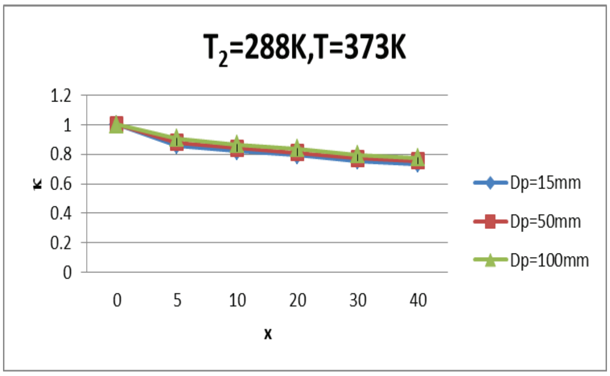

Fig.5b

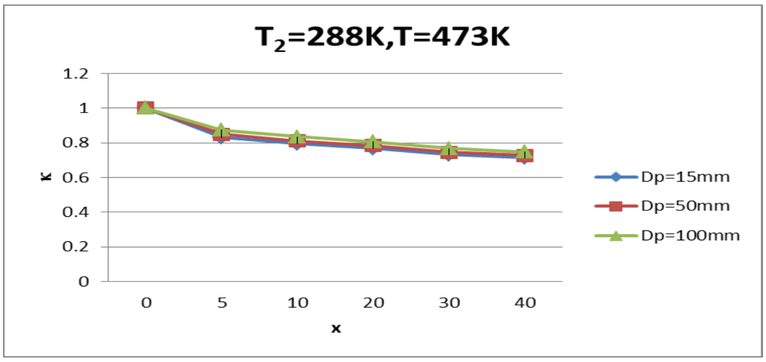

Fig.5c – Distribution of concentration at T2=288K, T=473K

Concentration influence at $\overline{U}_{pm}$ is weak (Figure 6a-c). From the figures is obvious it is described above effect of T_{g0} and T_{p0}.

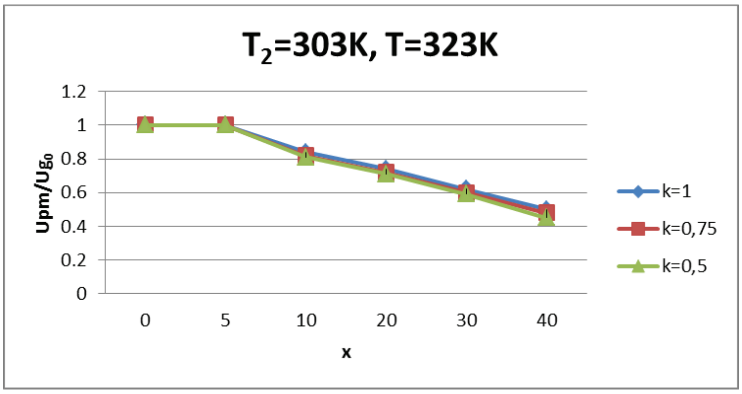

Fig. 6a – ***Distribution*** of velocity of phase of impurity at T_2=303K,T=323K

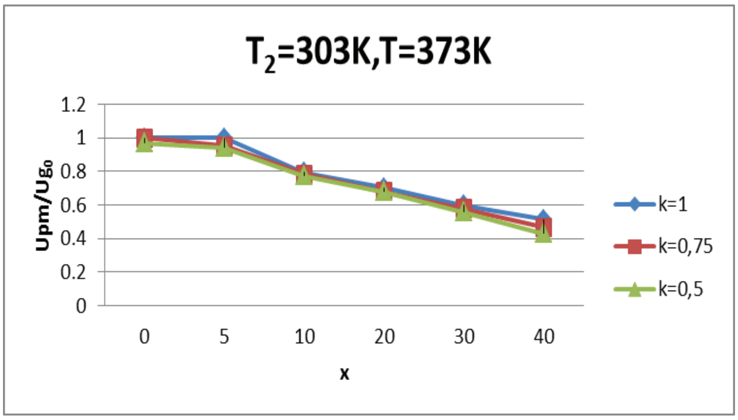

Fig. 6b – Distribution of velocity of phase of impurity at T_2=303K,T=373K

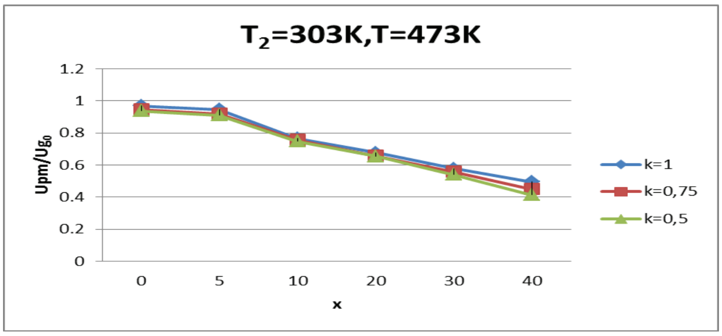

Fig. 6c – Distribution of velocity of phase of impurity at T2=303K,T=473K

CONCLUSION

The main conclusion of numerical simulation is the need to taking in mind the impact of the initial parameters: ambient temperature and the initial temperature of the jet. For sizing of current device for the evacuation of harmful substances it is necessary to calculate: the thickness of the respective boundary layers (at velocity, temperature, and impurities), the attenuation of the maximum temperature and velocity of the phases.

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This paper has been reviewed.