The 27th Conference on Mechanical Engineering

Technion City, Haifa, Israel

May 19-20, 1998

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הכנס הישראלי ה-27
להנדסת מכונות
מאי 19-20 1998
קרית הטכניון, חיפה

הכינוס הישראלי ה-26
להנדסת מכונות

תכניה

22-21 במאי 1996
קרית הטכניון, חיפה

The 26 ISRAEL Conference
on Mechanical Engineering

Program

21-22 MAY 1996
TECHNION, HAIFA

I1.3 *The effect of small-scale forcing on large-scale structures.*
Sukoriansky S. - Ben-Gurion University, **Chekhlov A.** - Princeton University - U.S.A., **Galperin B.** - University of South Florida - U.S.A.

I1.4 *Computer visualization of unsteady vortices at a sudden expansion in a tube.*
Yakhot A., Shalman E., Herzenstein O. - Ben-Gurion University.

Session I2: FLUID MECHANICS - 22.5.96, 14:00-16:00

Chairperson: **L. Shemer, Tel-Aviv University**

I2.1 *Experimental study of the movement of an elongated bubble in a vertical pipe.*
Polonski S., Barnea D., Shemer L. - Tel-Aviv University.

I2.2 *Linear stability and long-time evolution of nonlinear gravity-capillary waves.*
Chamesse M., Shemer L. - Tel-Aviv University.

I2.3 *Instability of strong ionizing shocks in inert gases.*
Mond M., Rutkevich I., Toffin E. - Ben-Gurion University.

I2.4 *Effect of gas compressibility on a slug tracking model.*
Taitel Y., Barnea D. - Tel-Aviv University.

Session I3: FLUID MECHANICS - ATOMIZATION AND SPRAYS - 21.5.96, 11:00-12:30

Chairperson: **B. Greenberg, Technion**

I3.1 *An experimental study of an optimized plain-jet airblast atomizer in pulse mode and continuous mode.*
Harari R., Sher, E. - Ben-Gurion University.

I3.2 *Fuel atomization by flashing of a volatile liquid in a liquid jet.*
Zeigerson-Katz M., Sher E. - Ben-Gurion University.

I3.3 *Process-oriented population statistics: case study of plain-jet airblast atomizer in pulse mode; particle-size analysis.*
Hartmann D., Harari R., Sher E. - Ben-Gurion University.

Poster session I4: FLUID MECHANICS - 22.5.96, 11:00-12:30

Chairperson: **D. Pnueli, Technion**

I4.1 *Evolution of vortex rings.*
Kaplanski F., Rudi U., Tisler R. - Institute of Energy Research - ESTONIA.

I4.2 *Computational modelling of flow in a cavitator.*
Angelov M.S. - Higher Institute of Food Technology - Bulgaria.

I4.3 *Numerical and experimental modeling of interaction between a turbulent flow and an inlet.*
Antonov I. - Technical University of Sofia - Bulgaria, **Angelov M.S.** - Higher Institute of Food Technology - Bulgaria, **Lien H.** - Technical University of Sofia - Bulgaria.

I4.4 *Research upon the use of the double effect ventejectors for the transport of pulverulent medium.*
Samoila C., Benke V. - Transilvania University of Brashov - Romania, **Strul Moisa** - Ben Gurion University.

I4.5 *On resonance phenomenon in Soret-driven convection in horizontal layer of binary mixture under vertical vibration.*
Keller I. - Technion.

I4.6 *Particle motion in periodic shock waves.*
Goldstein A., Shuster K., Vainshtein P., Fichman M., Gutfinger C. - Technion.

I. S. ANTONOV, Ph.D.
Department of Mechanical Engineering, Technical University of Sofia, Bulgaria
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NUMERICAL AND EXPERIMENTAL MODELING OF INTERACTION BETWEEN A TURBULENT JET FLOW AND AN INLET

SYNOPSIS: There has been discussed a two-component flows of air and gas in ventilation devices. A two- velocity scheme of flow is used to realize the numerical method and an integral method of investigation is used. A comparison of numerical results and nature experiment is made for two conditions: over catching and not full catching. Conclusion is that the present model is precise and can use for engineer calculations.

NOTATION

Q_c - capacity in initial section
L - distance between outgoing section of jet and inlet
u_p - velocity of admixture
u_g - velocity of air
ρ_g - density of air
ρ_p - density of admixture
χ - concentration of admixture

1 INTRODUCTION

In ventilation devices to get rid of harmful substances out of working places, we use sucking devices. The local sources of pollution get evacuated by them. The applications of some methods of calculating such devices are given in [1] and others. A basic element when creating the model of sucking device is: the source of harmful substances is discussed as a rising convective flow, which is ejected out of sucking spectrum, created by a sucking apparatus. Some well-known works about this problem [1,2,3]etc., when developing a numerical model of the flow, discuss it often by method summing up the flows (superposition). All though the last given satisfying results, by a theoretical point of view it's not very precise. It has been presumed summing up a real turbulent jet flow to a potential one, created by an inlet (sucking) spectrum. In order to avoid this moment, in the present work, the flow is a whole one with variable quantity of motion and kinetic energy along its length. The change in those two parameters is caused by and is in function dependence of the inlet spectrum.

This was confirmed in our experimental studies [4,5]. In the so presented model the ungrounded summing up of the flows is avoided and it's presented a solution of complex interaction of jet and inlet spectrum, using the usual methods in the dynamics of real fluids.

2 BASIS OF THE NUMERICAL MODEL

There has been discussed a two-component flows of air-smoke gases. To realize the numerical model a two-velocity scheme of the flow is used and it's been accepted that velocities of two components do not coincide [6,7]. An integral method of investigation is used, based on the conditions of keeping mass contains, quantity of motion, kinetic energy. It's been accepted that quantity of motion and energy change in function of inlet action.

The numerical model is developed on the basis of following integral conditions:

- for keeping mass contains:

$$\frac{\partial}{\partial x}\int_0^\infty \rho_g u_p \chi y dy = 0, \qquad (1)$$

- for keeping quantity of motion:

$$\frac{\partial}{\partial x}\int_o^\infty \rho_g u_g^2 y dy + \frac{\partial}{\partial x}\int_o^\infty \rho_p u_p^2 y dy = 0, \qquad (2)$$

- for keeping kinetic energy of air:

$$\frac{\partial}{\partial x}\int_0^\infty \rho_g u_g^3 y dy = -2\int_o^\infty \rho_g \nu_{tg}\left(\frac{\partial u_g}{\partial y}\right)^2 y dy - 2\int_o^\infty u_g F_x y dy \qquad (3)$$

- for keeping kinetic energy of admixture:

$$\frac{\partial}{\partial x}\int_0^\infty \rho_p u_p^3 y\,dy = -2\int_0^\infty \rho_p \nu_{tp}\left(\frac{\partial u_p}{\partial y}\right)^2 y\,dy + 2\int_0^\infty u_p F_x y\,dy \qquad (4)$$

$$\frac{\partial}{\partial x}\int_0^\infty u_p \chi^2 y\,dy = -2\int_0^\infty \rho_g u_g \frac{\nu_{tp}}{Sc_t}\left(\frac{\partial \chi}{\partial y}\right) y\,dy\,, \qquad (5)$$

$$R_u = Sc_t R_p \qquad (6)$$

Equation (5) is an integral condition of higher order with no physical interpretation. Using equation (6) and Schmidt's turbulent number Sc_t we get the connection between diffusion R_u and by velocities R_p boundary layers. In the right side of equations (2), (3) and (4) stands correspondingly the changeable quantity of motion and flow energy. According to our experimental studies [4,5] they can be presented in the following:

$$I = I_1\left(1 + k_1 \bar{x}^n\right) \qquad (7)$$

$$E = E_1\left(1 + k_2 \bar{x}^m\right) \qquad (8)$$

In the system of equation (1÷5), the marked integrals are done using the similarity of cross velocity and concentration distribution of the kind:

$$\frac{u_g}{u_{gm}} = \frac{u_p}{u_{pm}} = \exp\left(-K_u \eta^2\right);$$

$$\frac{\chi}{\chi_m} = \exp\left(-K_\chi \eta^2\right); \qquad (9)$$

where $\eta = \frac{y}{x}$, $K_u = 92$ [6] $k_\chi = Sc_t k_u$

Having done the integrals after some revision and normalisation, we obtain the following system of equations:

$$A_{11}\chi_m \bar{u}_{pm}\bar{x}^2 = G_1 \qquad (10)$$

$$A_{21}\bar{u}_{gm}^2\bar{x}^2 + A_{22}\chi_m \bar{u}_{pm}^2 \bar{x}^2 = I_1\left(1 + k_1\bar{x}^n\right) \qquad (11)$$

$$\frac{\partial}{\partial x}\left[A_{31}\bar{u}_{gm}^3\bar{x}^2\right] = -A_{32}\bar{u}_{gm}^3\bar{R}_u - A_{33}\bar{u}_{gm}(\bar{u}_{gm} - \bar{u}_{pm})^2 + E_1\left(1 + k_2\bar{x}^m\right) \qquad (12)$$

$$\frac{\partial}{\partial x}\left[A_{41}\chi_m\bar{u}_{gm}^3\bar{x}^2\right] = -A_{42}\chi_m\bar{u}_{pm}^3\bar{R}_u + A_{43}\bar{u}_{pm}\left(\bar{u}_{gm} - \bar{u}_{pm}\right)^2\bar{x}^2 + E_1\left(1 + k_2\bar{x}^m\right) \qquad (13)$$

$$\frac{\partial}{\partial x}\left[A_{51}\chi_m^2\bar{u}_{pm}\bar{x}^2\right] = -A_{52}\chi_m^2\bar{u}_{pm}\bar{R}_u\,, \qquad (14)$$

in which the values of integrals are A_{ij} in presumed similarity [7]. Normalisation is done with the initial parameters of the flow. The system of equations (10÷15) is solved numerically using a suitable algorithm. The joint solution of (10÷15) comes to an equation regarding u_{gm} of the kind:

$$S_{38}\bar{u}_{gm}^9 + S_{37}\bar{u}_{gm}^8 + S_{36}\bar{u}_{gm}^7 + S_{35}\bar{u}_{gm}^6 + S_{34}\bar{u}_{gm}^5 + \ldots + S_{30}\bar{u}_{gm} + S_{29} = 0\,, \qquad (15)$$

where S_{ij} are complexes of constants [5].

RESULTS

Equation (15) is solved by the method of Newton. The determined u_{ij} is replaced consecutively in the rest equations and demanded quantities are determined. The initial concentration and velocities' components are used as input data. The following integral parameters of jet are results of solution: the change of maximum velocities components (u_{pm}, u_{gm}), concentration (χ) and borders of diffusion R_p and dynamic R_u jet boundary layers. Results of calculation about two conditions - over catching and not full catching are given on Fig.1 and Fig. 2.

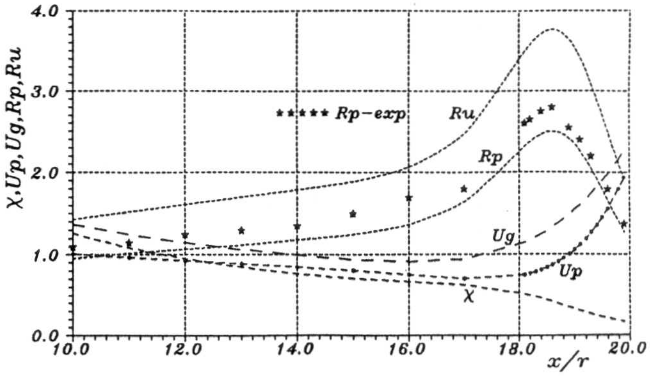

Fig.1. A case with over catching

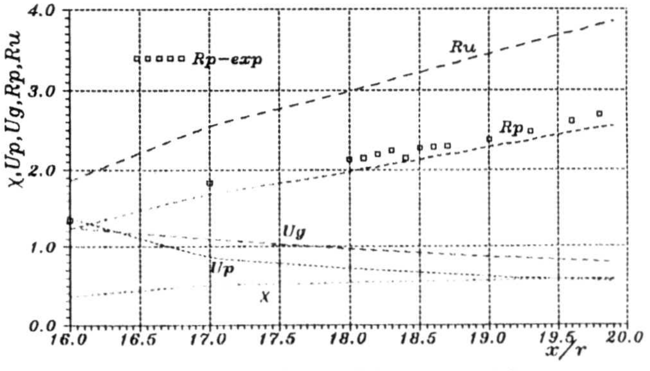

Fig.2. A case with not full over catching

The distance between outgoing section of jet and inlet is $\bar{L} = L/r_o = 20$ and the relation of capacities in initial section and in the inlet is $\bar{Q}_c = Q_c/Q_i = 3.8$ and 1.5. In the experiment the second component as an admixture is a smoke gas. To determine the diffusion border of two-component flow, some photo visual studies are done. We can make a comparison of numerical results and nature experiment. On fig .3 and fig. 4 is shown the case of described above conditions of outflow.

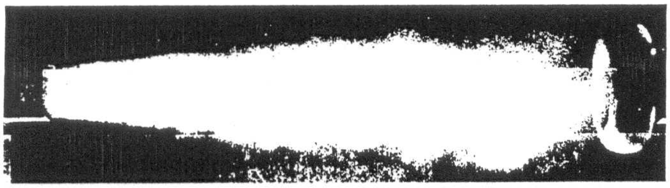

Fig. 3. Photo with over catching

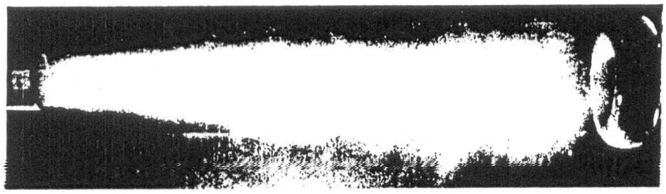

Fig. 4. Photo with not full catching

Some conclusions are drawn by checking with the experimental data:

-the presented model is precise and can be used for engineering calculations;

-the considerable contraction of diffusion boundary layer speaks about a great security in realising such devices. Being enveloped by a zone filled with air of environment, does no allow any harms to come out into the working places. This, of course, is possible when the sucking installation works in a condition of over catching or full catching.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the financial support and encouragement of Scientific Research Fund at the Bulgarian Ministry of Education.

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