Vertical non-isothermal turbulent jet flowing over a flat opening

Rositsa Velichkova

***Abstract**: In current work is solving integral conditions for the quality of movement with taking into account Archimedes forces and equation for conversation of heat content. In dependence for define on the width of the stream is used initial value of the temperature and also is use that the flow is non-isothermal. The results which are given are from the results of numerical calculations of the parameters.*

Key words: *integral condition, non-isothermal turbulent flow, numerical investigation*

INTRODUCTION

According [1] and [2] is adopts the term "slight non-isothermal" where the temperature of the jet and the environment $\left(T_{ok} \approx T_1\right)$ are assimilate. This acceptance does not correspond to the nature of the flow and decrease its comprehensiveness.

In the work is consider a relatively accurate integral solution and it is assume that the for flow is important initial ratio of temperature $\theta = \dfrac{T_1}{T_{ok}}$. Thus is neglecting the influence of variable temperature difference $\Delta T_m = T_m - T_{ok}$. This leads to some uncertainty, but it can be ignore by using of several successive iterations. In fact, acceptance provides a steady rise because $b_{real} < b$.

According [3] for the width of the jet is assuming:

$$\frac{db}{dx} = 0,22\left(1+0,5a\right) \tag{1}$$

where a is define as:

$$\theta_1 = \frac{T_1}{T_{ок}};\; a = \frac{\Delta T_m}{\Delta T_1}\frac{\Delta T_1}{T_{ок}} = \frac{\Delta T_m}{\Delta T_1}\left(\theta - 1\right) \tag{2}$$

where $\Delta T_m = T_m - T_{ok}; \Delta T_1 = T_1 - T_{ok}$, T_m - maximal temperature at height of the jet.

Expression for a can be simplify as follows: ΔT_m is replace with $\dfrac{\Delta T_1}{\Delta T_0} = \theta_1$. This means increasing in the width of the jet with a constant coefficient $1+0,5a \rightarrow 1+0,5\left(\theta_1 - 1\right)\theta_1 = const.$, this coefficient is always bigger than the real one because $\Delta T_m < \Delta T_1$ but the flow is non-isothermal. Expression for $b = f\left(x\right)$ takes the form:

$$\frac{db}{dx} = 0,22\left[1+0,5\left(\theta_1 - 1\right)\theta_1\right] \tag{3}$$

Equation 10 is integrate::

$$b = 0,22k_1x + const. \tag{4}$$

where $k_1 = \left(\theta_1 - 1\right)\theta_1$

Parameter a is define from initial conditions:

At $x = 0; b = b_0; const. = b_0$

$$b = b_0 + 0,22k_1x \tag{5}$$

This expression is divide on b_0 and equation is obtain in dimensionless expression b:

$$\bar{b} = \frac{b}{b_0} = 1 + 0,2\overline{k_1x} \tag{6}$$

The equation for the quality of movement is obtain:

$$1,485abg = \frac{d}{dx}\left(u_m^2 b\right) \tag{7}$$

Equation (7) after differentiation leads to the expression:

$$G_1 b = b2u_m + u_m^2 \frac{db}{dt} \tag{8}$$

where: $G_1 = 1,985abg = 14,5ba$; $\frac{db}{dx} = 0,22k_1$

And substituting in (8) and taking into account the expression for $\bar{b}$ from equation (6) is obtain:

$$0,22k_1\bar{x}u_m^2 + \left(1+0,22k_1\bar{x}\right)u_m - 7,28a\left(1+0,22k_1\bar{x}\right) = 0 \tag{9}$$

Decision for (9) according u_m leads to the expression:

$$u_{m1,2} = \frac{-b \pm \sqrt{b^2 + 6,4b}}{0,44k\bar{x}} \tag{10}$$

The positive roots of (10) gives decay of the maximum velocity of non-isothermal vertical jet.

The equation for conservation of the heat content has the form:

$$\Delta T_m = \frac{\Delta Q_0}{\rho_1 \rho_g g u_m f B_2} \tag{11}$$

With equation (12) is define the decay of the maximum temperature difference in the jet.

On the basis of the result of (12) can be make possible correction in the expression for b (12) and if it is necessary to solve the second approximation of the problem.

NUMERICAL RESULTS

Based on the above equations are made numerically solution for define of the basic parameters of the flow, velocity, temperature, and width of the jet. Fig. 1 shows the decay of velocity of the jet at different value for parameters θ. It is see that with increasing of the initial temperature difference θ maximum values for u decay slowly and the reason for that is the bigger lift force.

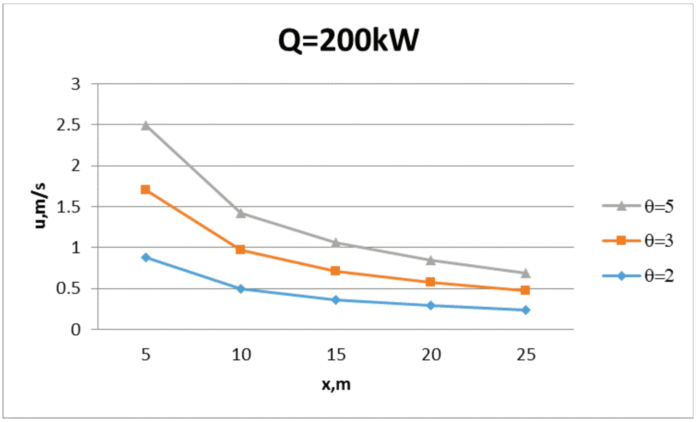

Fig.1

The maximum temperature of the stream decreases relatively rapidly when θ

increasing. The reason for that heat exchange is increase with the environment. The extension of the jet (Fig. 3) and to be expected depending on (8) becomes larger with increase of θ.

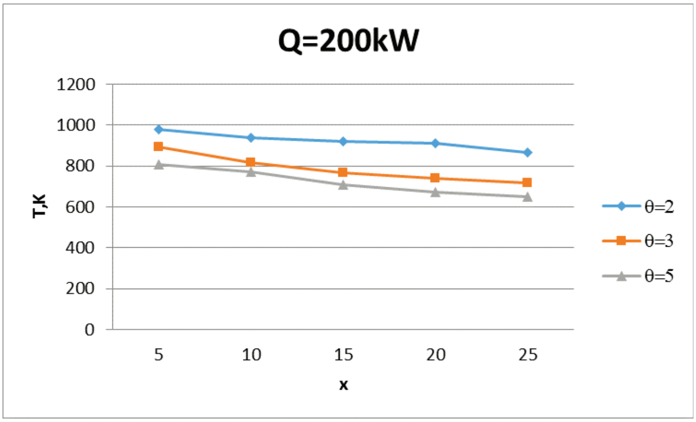

Fig. 2

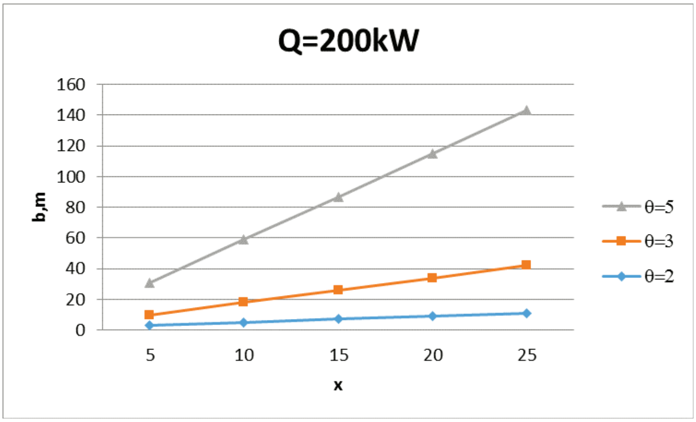

fig.3

On fig. 4 ÷ 6 is give an effect of the initial power of the heat source at change of T_m. As shall be expect with increasing of θ, velocity u_0 decreases more slowly. The increase of θ, as mentioned above reduces T_m.

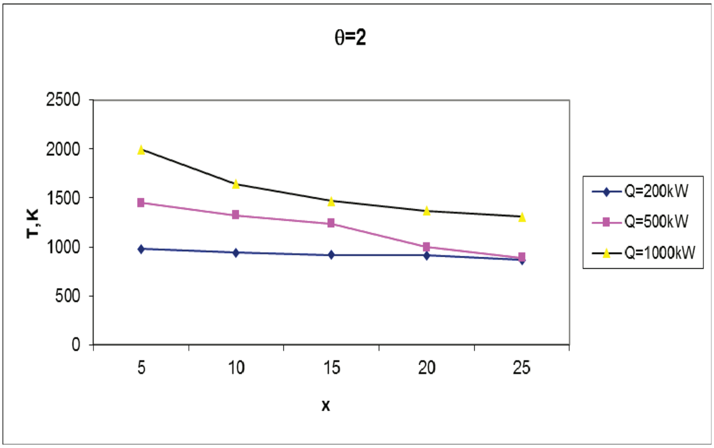
θ=2
2500
2000
1500
1000
500
0
T,K
5
10
15
20
25
x
Q=200kW
Q=500kW
Q=1000kW

Fig. 4

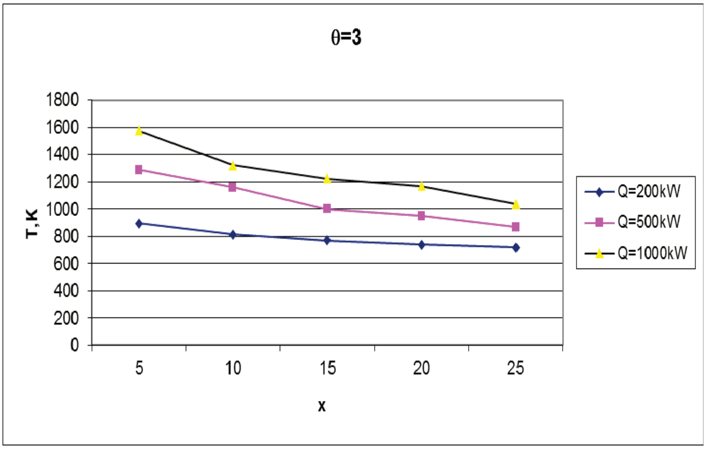
θ=3
1800
1600
1400
1200
1000
800
600
400
200
0
T,K
5
10
15
20
25
x
Q=200kW
Q=500kW
Q=1000kW

Fig. 5

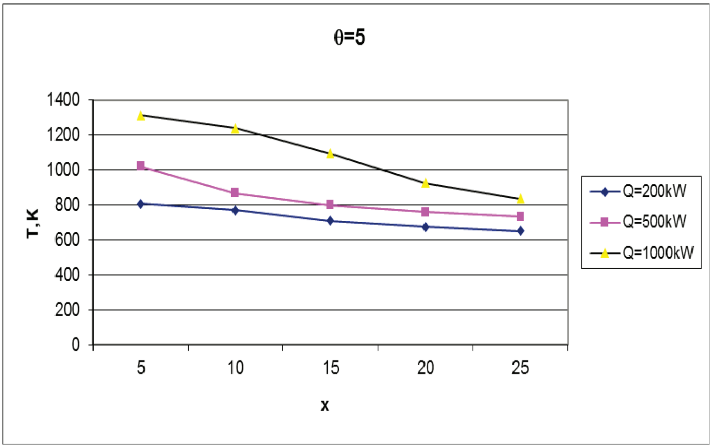

Fig.6

CONCLUSION

In the current article is develop integrated method which allows relatively rapid analysis of non-isothermal vertical jet. Through this method is taking into account the influence of initial parameters. In this case are investigate the influence of Q_0 and θ. The results which are analyse for the main parameters can be use to investigate such flow in engineering practice.

LITERATURE

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[2] Abramovich G.N. Theory of turbulent jets, M. 1984
[3] Velichkova R., Integral model of vertical non-isothermal flat rate, Scientific paper of University of Ruse 2012 under review

Contacts:
Assoc. prof. PhD Rositsa Velichkova, department Hydroaerodynamics and hydraulic machines, Technical university of Sofia phone 02 965 3443, e-mail: rositsavelichkova@abv.b

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