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Experimental study of interaction of isothermal jet with suction opening

Ivan Denev, Petko Tsankov, Rositsa Velichkova

***Abstract**: In current work is analysed the results of own experiments on the reaction of a turbulent jet with suction opening. It is given a geometry of the flow and characteristics distinction of the flow rate and amount of movement. It is made a comparison with the distribution of free turbulent jet leakage at the same initial conditions.*

***Key words:** turbulent jet, suction opening, flow rate*

INTRODUCTION

The use of local exhaust ventilation is the safest option for cleaning the air of harmful emitted in different technological processes. Industrial local exhaust ventilation provide controls on capture, targeting and removal of contaminated air flow from working areas and ensure clean breathing zone of the operators of the machines. Harmful particles falls in the supply air stream and with it are directed towards the suction opening [2].

In current work are processed experimental data of the distribution of isothermal turbulent jet and the influence that has the existence of a suction opening.

SUMMARY

The aim of this work is to analyze the results of own experiments on the interaction of a turbulent jet with suction opening. It is given a geometry of the flow and characteristics distinction of the flow rate and amount of movement. It is made a comparison with the distribution of free turbulent jet leakage at the same initial conditions.

For this purpose was developed test-rig for conducting an experiments for interaction of turbulent jet with suction opening, shown at fig. 1. The study area is further increased for better performance.

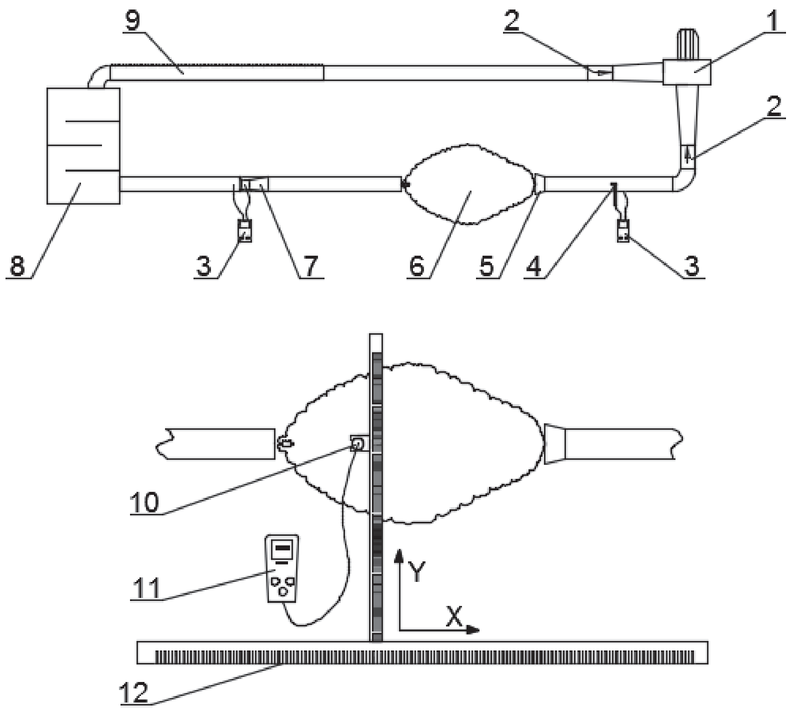

Fig. 1 Scheme of test-rig for experimental study

It is used high pressure fan (1) fitted with regulators on compressed and intake flow rate(2) respectively on discharge and suction sections. Supply additional flow rate can be regulate by inverter connected to the fan. The suction flow rate Qs is measured by the velocity tube (4) which is tared by the suction nozzle (5). Reading is via a differential pressure gauge (3). Supercharger flow rate Qn is measured by Venturi tube (7) and a differential pressure gauge (3). To reduce error at reading of flow rate due to highly turbulent nature of the flow is built calming chamber (8), which allows smoother supply of the jet through the discharge section. The controller of the length of pipe (9) is serves to correct the distance L between the suction and discharge sections, which allowed a greater number of research and implementation of the three types of captures of the turbulent stream of the suction opening (incomplete, complete, and extra complete capture). Velocities of flow in the measuring zone (6) are reading by an anemometer (10) which is mounted on a coordinating device (12). It allows the exact positioning of the measuring probe on the axes X and Y. Velocities are reading by using multifunction device Testo 435-4 (11).

First is done a measuring the distribution of velocity at free isothermal turbulent jet. On fig. 2 are shown the experimentally obtained profile of the stream, compared with the theoretical one [1]. From the receiving result it can see that the error in measurement is in the range of 5-10%.

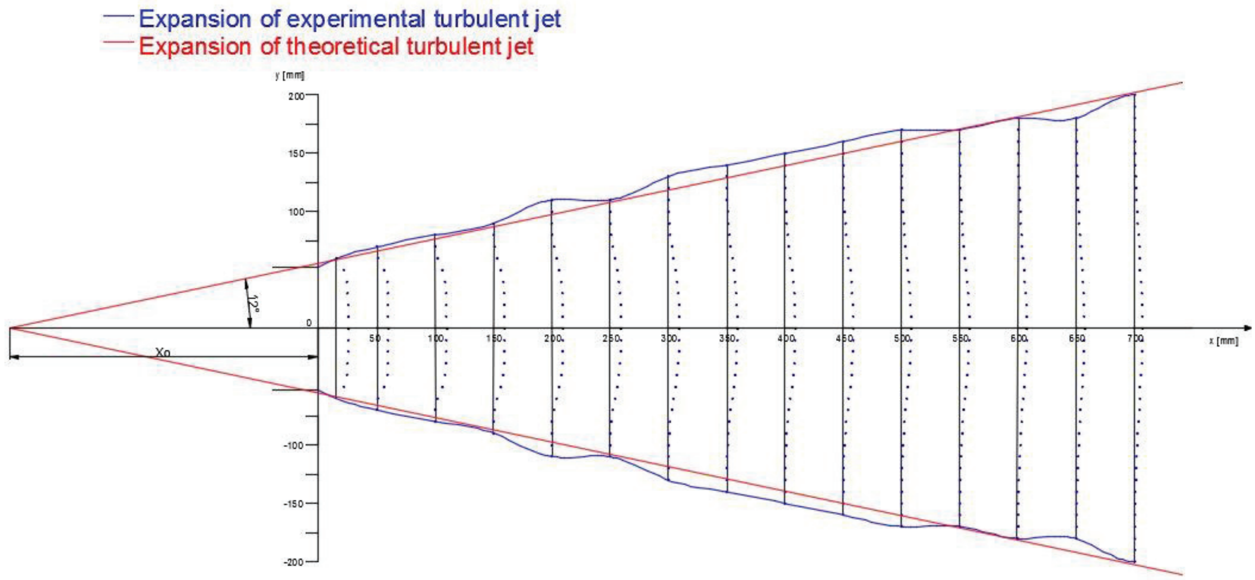

Fig. 2. Velocity profile of theoretical and experimental study of free turbulent jet

On fig. 3 and 4 are shown the velocity profile of interaction of turbulent jet with suction spectrum in terms of flow rates Qs = 2Qn where: Qs - flow rate measured in suction section; Qn – flow rate measured in discharge section.

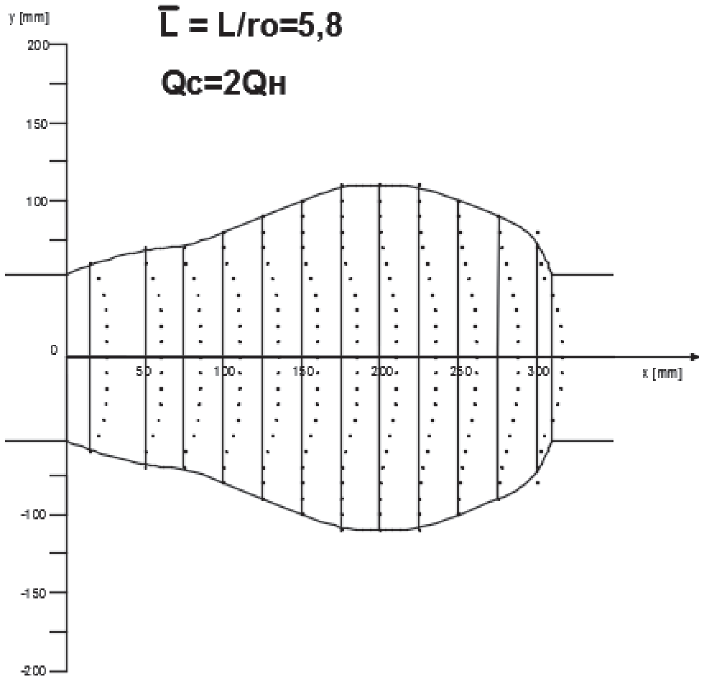

Fig. 3. Velocity profile of turbulent jet which is interact with suction opening at Qc=2Qn; $\bar{L} = \frac{L}{r_0} = 5{,}8$

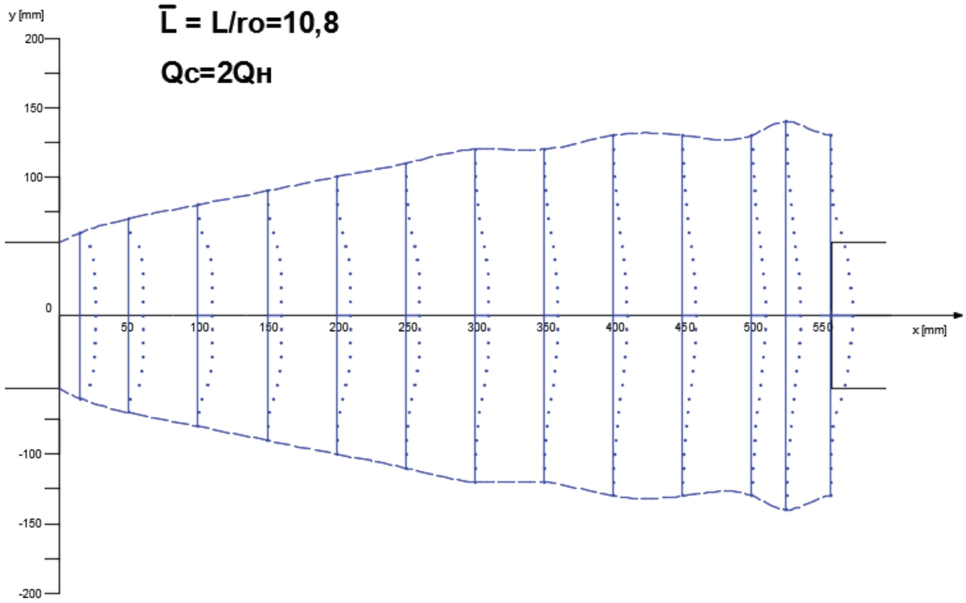

Fig. 4. Velocity profile of turbulent jet which is interact with suction opening at Qc=2Qн; $\bar{L} = \frac{L}{r_0} = 10{,}8$

From velocity profiles of jets are clearly shown the influence of the dimensionless length $\overline{L}$ on the type of suction. $\overline{L}$ is the ratio of the distance between suction and discharge section and the radius of the pipe. Obviously at $\overline{L} < 10$ has a full suction of supply jet while $\overline{L} > 10$ has incomplete suction.

It is made and comparison of turbulent jet interacting with the suction opening and free turbulent jet at equal initial conditions. The profiles of the two streams are shown in fig. 5.

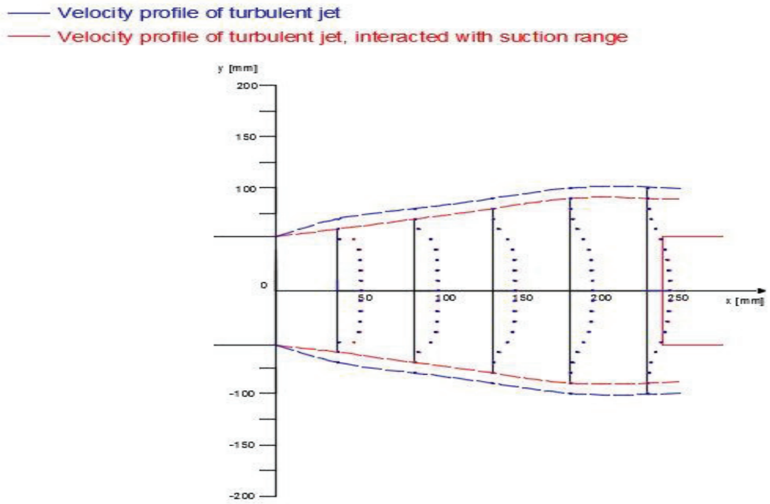

Fig. 5. Comparison of velocity profiles of free turbulent jet and a jet which interact with suction opening

The profile of the free turbulent stream is wider than that of the stream at presence of the suction opening. Thus ejecting air from the environment at free stream turbulence is more than the jet under the influence of suction spectrum. This is determined by the fact that the flow rate calculated for the different sections of the jet with free turbulent jet have higher values as compared with that in the presence of the suction opening (Fig. 6).

For the flow rate in each section according [3] we can write:

$$Q = 2\pi \int_0^{\delta} urdr = 2\pi u_{\max} \delta^2 \int f\eta d\eta \qquad (1)$$

where: r – radius of the jet in current section;
u – velocity of the jet in the section;
δ – thickness of the boundary layer in the section.

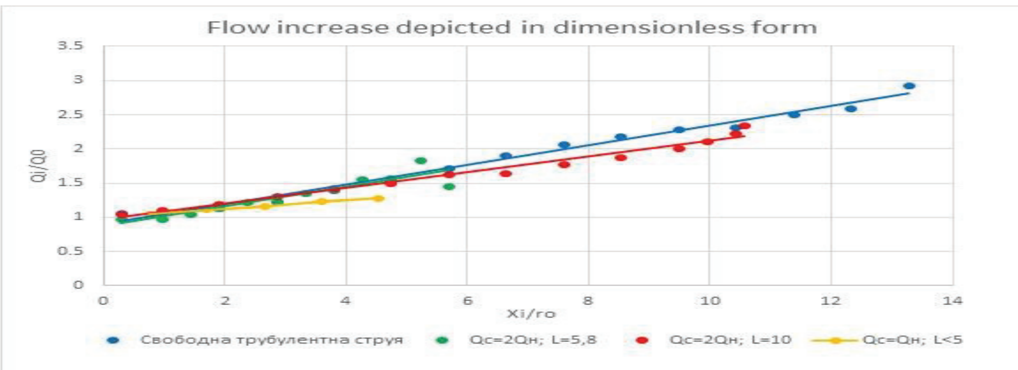

Fig. 6. Change of the flow rate along the flow

In the case of interaction of the jet with the suction opening for the amount of movement is interesting a sharp increase in the area of influence of the exhaust shown in fig. 7. The amount of movement can be expressed by equation (2) and a free turbulent jet is kept constant over the entire length:

$$\pi\rho u_0^2 r_0^2 = 2\pi\rho \int_0^{\delta} u^2 rdr = const. \qquad (2)$$

Increasing of amount of the motion at the presence on suction opening is explain from interaction of turbulent jets with suction spectator and increasing the velocity of leakage of suction devices.

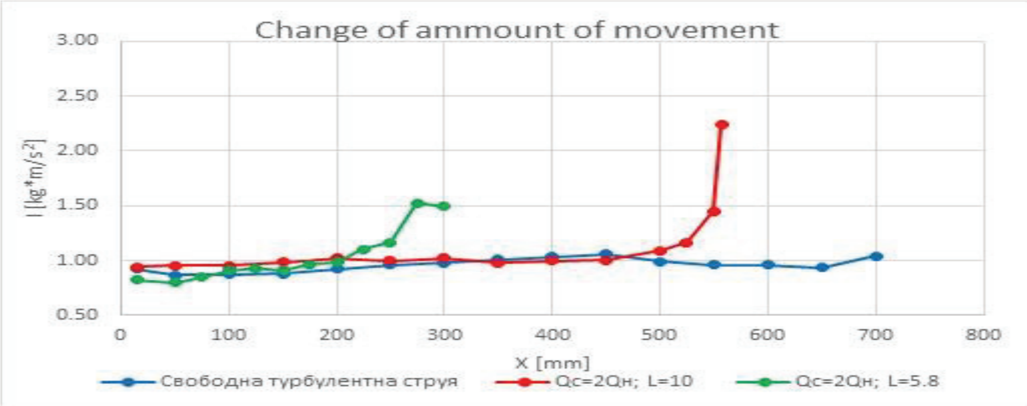

Fig. 7. Change of amount of movement along the jet

CONCLUSION

The analysis of results obtained from the experimental study of the interaction of a turbulent jet with suction opening indicates a specific case of increasing the amount of motion in the area of the suction opening and the lower flow rate compared to the free turbulent flow. This study confirms initial expectations based on overview [3], [4]. This is a prerequisite for further consideration of the issue and its various options, including numerical modelling with CFD product.

Literature

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Contacts:

PhD student Ivan Denev, Department of Hydroaerodynamics nand hudraulic machines, Technical university of Sofia, e-mail: ivan_denev.eng@abv.bg ;

Senior assist. prof. Petko Tsankov, PhD, Faculty of engineering and pedagogy of Sliven, Technical unibersity of Sofia e-mail: ptsankov@abv.bg ;

Assoc. prof. Rositsa Velichkova, PhD, Department of Hydroaerodynamics nand hudraulic machines, Technical university of Sofia e-mail: rositsavelichkova@abv.bg

This paper has been reviewed.