DISTRIBUTION OF TURBULENT SHEAR STRESSES PROFILES IN FREE JET FLOW

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Abstract The flow turbulence influence on momentum and heat transfer processes on surfaces. In many cases this process of intensification is realized by use free and impinged jets. The strong velocity gradient in shear layer of free jet created between jet and environment is able to generate high turbulent flow. So free jet can be an easy way to use it as a source of turbulent flow to intensifying transport phenomena on surface. To recognize mechanism of production of turbulence in free jet the shear stress distribution were measured. This information can be useful to verify possibility to use for calculations as simple model of turbulence as possible in case of turbulent flows with high production of turbulence.

INTRODUCTION

A large number of papers described flow characteristics of free and impinging jets. These kinds of jets have a wide application in engineering. The papers e.g. [1,2] give many information concern the structure of the free jets, and processes occurring in the free jets flow e.g.[3]. Many papers show influence of free jet on heat transfer process in case of impinging jets [4]. Recently more complex phenomena occurring in the free and confined jets have been investigated. In [5] the authors analyzed the propagation of the jet flowing from the ventilation system. A few papers describe the effect of changes in the structure of the free jet due to externalities. The papers describes the changes in the structure of a jet, the potential core length and the size of the coherent structures due to the impact of eccentrically located in the nozzle ring. Another papers described the impact of the impinging jet on momentum transfer process on the porous surface. Experimental research provide new information that is used as boundary conditions for numerical simulation. Nevertheless new information concern shear stress distributions in free jet are useful for description of flow transport properties and for direct verifications of turbulence models e.g. [6].

The experimental setup gives possibility to measure data for analysis of coefficient of correlations between uv and product of u_{rms} times v_{rms} . The relations between gradient of average velocity axial component and uv correlation which represents turbulent shear stress in jet flow will be analyzed also.

EXPERIMENTAL APPARATUS

Open wind tunnel was used to perform experimental investigations. Turbulent flow was generated by a free round jet issued from round nozzle diameter of 0.06 m and 0.15 m. Jet velocity at nozzle outlet was change to get constants value of velocity U_x in distance x from nozzle outlet. This get possibility to get turbulent flow with the some velocity bat with different turbulent structure. For this conditions level of turbulence in the jet axis change in wide ranges for the some velocity. The Constant Temperature Anemometer TSI IFA 300 was used to measure average flow velocity and turbulent flow characteristics. Distribution of local turbulent shear stress distributions in flow was measured by means of X probe connected to CTA. Measured signal was digitally collected and processed by used Thermal Pro 5.0 computer program.

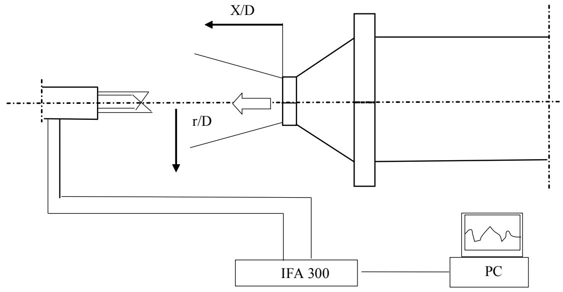

Figure 1. Sketch of the experimental setup.

RESULTS OF EXPERIMENTAL INVESTIGATIONS

The measurements were made in the axisymmetrical jet, not swirled and unstimulated flowing out from the round nozzle to unbounded environment. The measurements were made for local velocity 16 m/s, which correspond to the Reynolds numbers at nozzle outlet 32000. The air temperature was maintained on the level of 20^{o}C.
Distributions of average axial velocity component and uv correlation as a function of flow turbulent shear stress in free jet for different distances from nozzle outlet section is presented in Figure 2.
As it is visible in Figure 2a velocity profile is change from very flat jet velocity distribution in jet core to very narrow mixing region when velocity rapidly drop down. When distance from jet outlet increase flat core of jet decay and mixing region of jet increase. Because of this radial velocity gradient in mixing region get lower as it is possible to observe finally at distance x/D=10.
The relation between flow shear stress and velocity distributions is analyzed. The average velocity profile is correlated with distribution of *uv* correlation which represents the turbulent shear stress. In Figure 2a *uv* correlation is exactly located in jet mixing region where rapid changes of velocity occur.

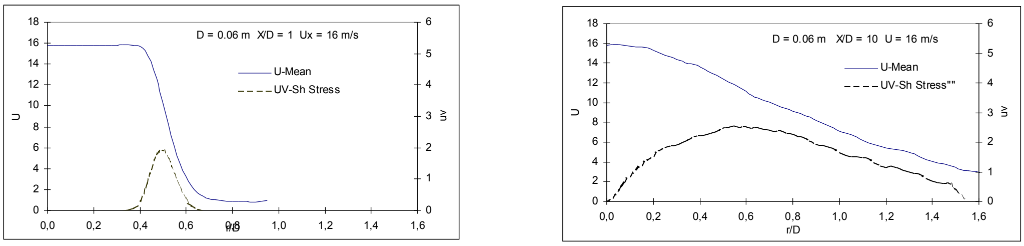

Figure 2. Distributions of the axial component of velocity U_x and u'v' correlation in free jet for different distances from nozzle outlet s of x as a function of x.

In Figure 3 there are presented distributions of radial time average velocity component and *uv* correlation together with distributions of turbulent fluctuations of u_{rms} and v_{rms} components as an example.

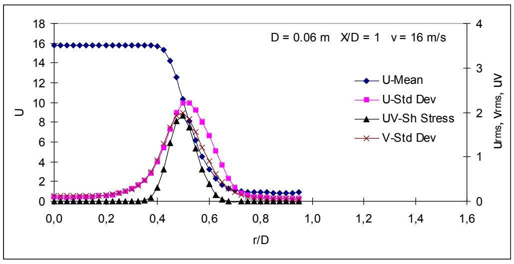

Figure 3. Distributions of the axial component of velocity U_x and *u'v'* correlation in comparison with distributions of turbulent fluctuations components u_{rms} and v_{rms} in free jet at distance X/D=1 from nozzle outlet

SUMMARY

The results of presented investigations show strong correlation between gradient of average velocity and distribution of *uv* correlations. This information about distributions of turbulent share stress can be used for direct verification of turbulence models. Presented experimental studies have delivered important information about the nature of flows with strong mixing regions which are a main source of turbulent structures generation. This kind of turbulent flows are difficult to numerical solution and need many experimental data for verification numerical simulations.

References

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