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Ability to Study the Velocity Profile of a Composite Isothermal Jet

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Abstract - **The case of interacting jets or the interaction of a jet with a solid surface finds extensive application in practice. Various applications are realized in air conditioning, ventilation, combustion technology and others. In combustion engineering investigations, the research is conducted under isothermal conditions (without combustion) as a starting point. Obtaining a detailed picture of the velocity profile under isothermal conditions of a jet is a necessary prerequisite for research under combustion conditions. In the literature there are many studies of combustion processes implemented under different design geometries. One part of these solutions are implementations of more than one combustion device whose torches interact to form a composite combustion torch with useful properties for practice. From the study of the velocity profiles, the presence of circulation zones relevant to the quality of the combustion process can be supposed. The main factor observed in such studies is the geometric shape of the composite jet that is produced.**

***Keywords* – velocity profile, composite isothermal jet, injection nozzle, injection burner.**

I. INTRODUCTION

Controlling the shape of the free jet, and knowing its hydrodynamic effects, is particularly useful for practice. Multiple authors have published studies on different cases. The main areas in which the application of jets with a specific shape is noticeable are in firefighting and combustion technology. When we talk about for application in firefighting we are talking about equipment creating a flat water jet. There are several factors that are of fundamental importance here: the shape of the water jet; the angle of expansion of the jet and jet length. In combustion technology, the main application is the formation of a torch with a shape suitable for the particular application. In the literature, there are many studies of a rotated injection jet formed by four nozzles[1]. Other noticed studies are the interaction between two or three injection gas burners [2], [3], [4], [5], [6], [7]. Quantitative assessments have been created on the character of the heat exchange for which aerodynamic studies are a prerequisite. There are published results for merging axisymmetric gas jets [8], [9], [10], [15], [19], [20], [21], [22], [23]. Scientific developments have been noted with „connecting“ rotating jets, used in high power combustion. This type of organization of the combustion process is applicable in the power industry. The current research, is analysed a composite jet formed in a private structural-geometric case - by two injection burners whose axes are parallel or intersect at different angle[16], [17], [18]. The technical specifications of the gas injection burners used in the current research are shown in Table 1. The values apply when using propane-butane fuel at a pressure of 2 Bar.

The research was conducted under isothermal conditions, the injection torches in this case are injection nozzles where pressurized air flows at high velocity through a gas nozzle and injects air from the environment. Here after they will be called just nozzles.

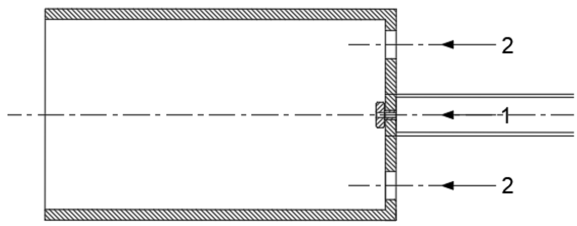

Fig. 1. Schematic diagram of the burner

Fig. 1 shows a schematic of the burner in section. With 1 is indicated the supplied air under pressure. With 2 indicates injected air.

TABLE 1
TECHNICAL DATA FOR GAS BURNERS

	Diameter of burner head D, mm		
	25	35	50
Heat workload Q, kW	3,7	6,3	28
Consumption of fuel m, g/h	265	450	2000
Gas nozzle diameter d, mm	0,35	0,5	1,2

II. METHODOLOGY OF THE EXPERIMENT

Two series of experiments were conducted:

The first set of experiments was conducted with parallel-axis nozzles according to the scheme in Figure 2. The resulting composite jet from the interaction of the two axisymmetric air jets is considered. The object of this series of experiments is to verify the reliability of the measurements. The results obtained in the present measurements are compared with experimental data from other authors as well as with results from computer simulations[3], [4], [11], [12], [13], [14].

Fig. 3 shows the experimental scheme, on the Fig. 4 is illustrated the adopted orientation of the coordinate system. The nozzles are positioned on a metal stand, allowing their

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free positioning in relation to each other - away or at an angle. Their position on the y-axis will not change.

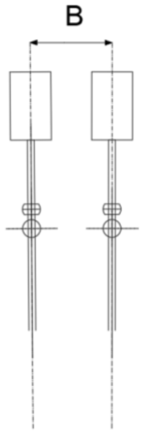

Fig. 2. Parallel arrangement of nozzles

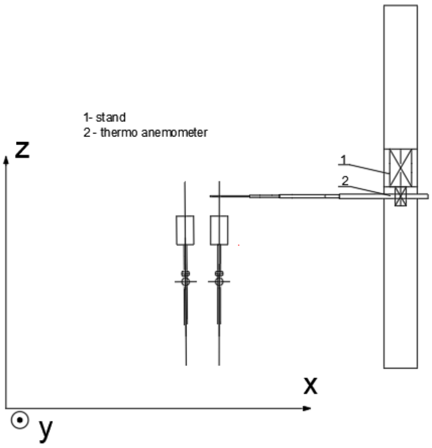

Fig. 3. Schematic of parallel speed measurement

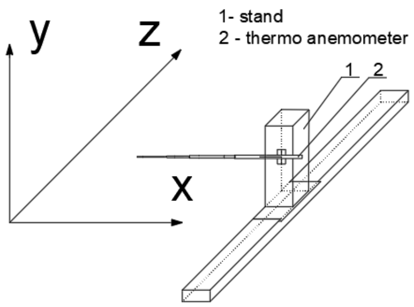

Fig. 4. Orientation of the coordinate axes relative to the stand

A thermal anemometer with a probe diameter selected according to the needs of the present measurements was used to measure the velocity. The measuring instrument is attached to a stand with a positioning device. It provides the ability to move along the x, y and z axes. The sensitive element is located in the plane of the nozzles axis, which in this case coincides with the yOz plane. Velocity profiles in a given section are obtained by sequentially measuring the velocity at specific points, moving the probe through a defined step b=20mm along the x-axis. The velocity profile for another section is learned by moving the stand along the z-axis and repeating the velocity measurement procedure. The velocity profile for a section spaced along the z-axis from the jets L-120 mm are shown in Figure 5.

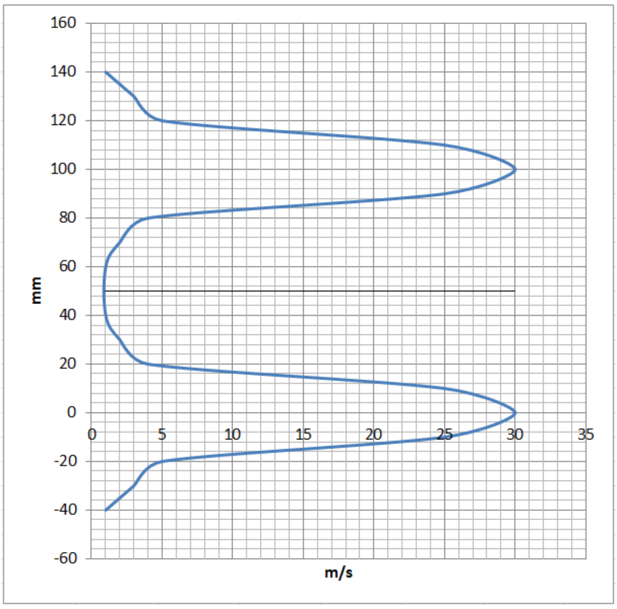

Fig. 5. Velocity profile for nozzles with parallel axes

III. Results

As expected, the velocity profile in this case has two nearly identical velocity maxima in the two nozzles axes. The results obtained in graphical form basically overlap with similar studies found in the literature. This is a reason to consider the measurement methodology correct. Also of interest will be the velocity profile along the Y-axis, just between the two nozzles.

The second set of experiments was conducted in nozzles with intersecting axes. Illustrated in Fig. 6. The nozzles are arranged in one plane. Their axes make an angle β, which for the particular measurement is equal to 45°.

Again, the interaction of isothermal air jets was investigated. The task is to get the velocity profile of the composite jet. In combustion theory and combustion engineering such studies are mandatory. Their results precede the real experiments on combustion processes.

Fig. 7 shows a schematic of the measurement. Includes thermoanemometer and coordinate tool. The thermoanemometer has a probe sized according to the specifics of the current measurements. The coordinate device allows positioning and holding the thermoanemometer at the correct measurement point. It also allows moving in the required direction for speed sensing. The selected measurement points were determined from a series of preliminary measurements. The results were obtained after conducting three series of measurements. Distances between measurement points are through 20 mm. At longer distances the speed profile is not displayed correctly.

The velocity profile at intersecting nozzles axes has lost the two velocity maxima, which have merged into one. An interesting fact in this case is that the maximum velocity is approximately twice that of parallel axes. The most likely reason for this is that the composite jet has "expanded" along its axis and acquired a sheet-like character.

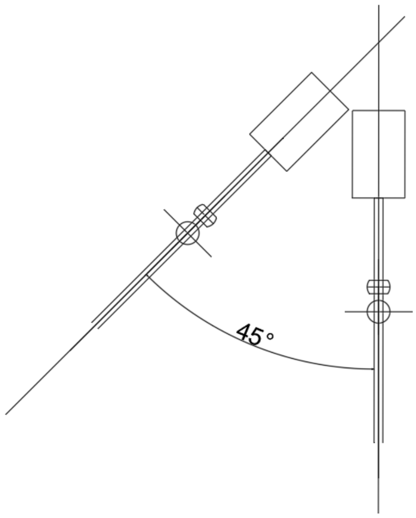

Fig. 6. Nozzles with intersecting axes

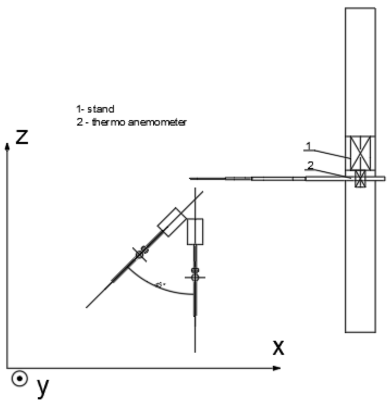

Fig. 7. Diagram for velocity measurement in nozzles with intersecting axes

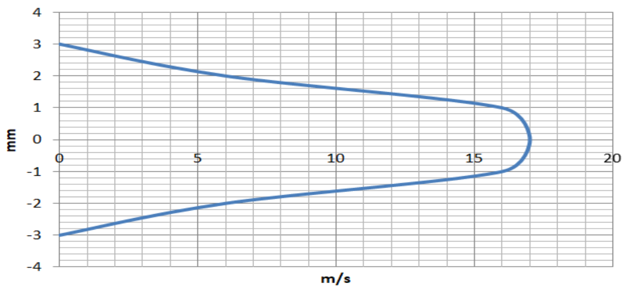

Fig. 8 Velocity profile in nozzles with intersecting axes

IV. Conclusion

The present experiments aim to show the possibility of an in-depth study of the velocity profiles of a composite isothermal (subsequently also with combustion) jet. A detailed study of the shape and size of the formed composite jet under different geometrical and mode parameters is to be carried out.

Obtaining a larger volume of experimental results will allow the formulation of some basic regularities and universal velocity profiles for different design configurations. They would help in creating combustion devices with a similar organization of the combustion process.

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