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THE STRUCTURE OF THE FLOW IN MICROJET BURNERS WITH VARIABLE AIR -EXCESS COEFFICIENTS

Summary. *Numerical studies of the flow structure in stabilizer-type burners with three-row fuel supply are performed. The influence of the design and operating parameters of the fuel supply system on the flow pattern in burner devices is analyzed.*

Key words: *burner devices, CFD modeling, flame stabilizer, three-row fuel supply*

This article is devoted to the consideration of flow patterns in micro-flare burner devices with a three -row fuel gas supply. These devices are intended for operation at various values of the air excess coefficient. The creation of this promising modification of burners leads to the need for comprehensive studies of their working.

The final technological result of the burners work is largely determined by the laws of the flow in them. Therefore, special attention is required by the study of the aerodynamics of these burners. For the research the computer simulation method was used, which is becoming increasingly widespread for the study of such processes [1-20].

Computer modeling was carried out using the Fluent package. At the same time, due to the geometric symmetry of the fuel module and the symmetry of physical processes regarding the axis of the interstabilizer channel, the area corresponding to half the module was subject to consideration (Fig.1).

The simulation was performed using the following initial data: $B_{\mathrm{st}} = 0.03$ m; $B_{\mathrm{c}} = 0.075$ m; $L_{\mathrm{c}} = 1.3$ m; $L_0 = 0.1$ m; $L_{st} = 0.2$ m; $d = 2.5 \cdot 10^{-3}$ m. The distance L_1 between the stabilizer tear-off edge and the first, second and third rows of gas supply holes $L_1 = 10 \cdot 10^{-3}$ m; $20 \cdot 10^{-3}$ m; $30 \cdot 10^{-3}$ m; the coefficient of blockage of the channel flow area $k_{\mathrm{f}} = 0.4$ ($k_{\mathrm{f}} = B_{\mathrm{st}}/B_{\mathrm{c}}$); air velocity at the channel inlet $U_{\mathrm{in}} = 10$ m/s; turbulence intensity Tu in the channel inlet section $Tu = 3\%$. Natural gas was used as a fuel, air as an oxidizer.

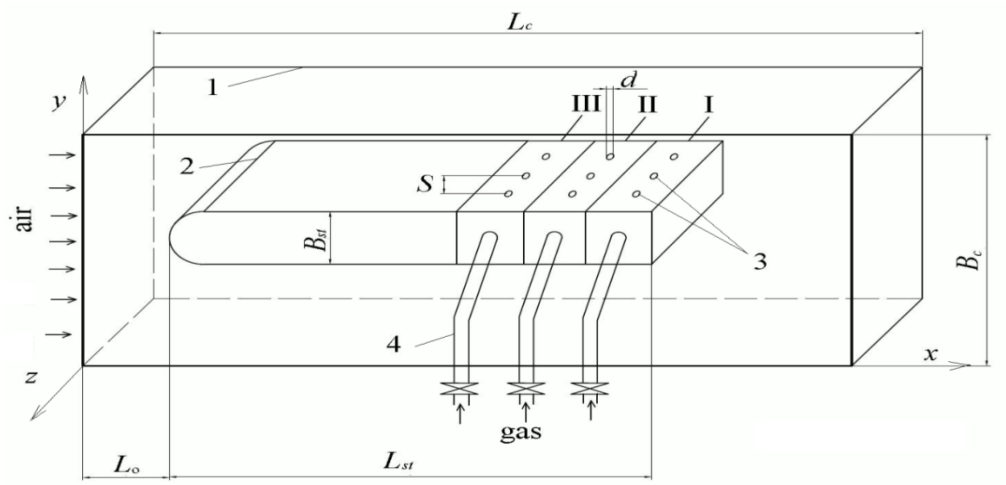

Fig. 1. Scheme of the module of the burner device of the stabilizer type with a three-row fuel gas supply: 1 – flat channel; 2 – flame stabilizer; 3 – gas supply holes; I, II, III – gas supply sections with different values of the relative pitch of the holes, corresponding to different values of the excess air coefficient

The proposed burner with a three -row jet fuel supply consists of separate modules. The necessary power of such devices is ensured by recruiting a certain number of modules. In a separate module, a flat flame stabilizer 2 is placed in the channel 1 (Fig. 1). Fuel gas is brought to the flame stabilizer through one of the three separate sections I, II, III. In the first section, the gas is supplied with an excess of air α equal to 1.1, in the second section at $\alpha = 1.3$ and in the third - at $\alpha = 1.5$. Each section corresponds to the system of round gas supply holes 3 located on the side surface of the stabilizer. Through these holes, fuel gas enters to the stream of the oxidizing agent directly for burning.

The task of the first stage of the research was to determine the rational design parameters of the fuel supply system of the proposed burners. This task was specified as follows. In area after the stern of the flame stabilizer, favorable conditions for mixture formation necessary for stabilizing the torch must be ensured. Such favorable conditions were considered to be those under which in the zone of reverse currents behind the flame stabilizer the average concentration of methane is equal to the average value between the upper and lower concentration limits of ignition.

During the research to determine the rational design parameters of the fuel supply system, the following results were obtained. The rational value of the relative pitch of the gas supply holes S/d increases with the increase of the fuel supply row number, and the diameter of these holes decreases. Thus, for $\alpha = 1.1$, the rational values of the diameter and relative pitch are $d = 4.3 \cdot 10\text{-}3$ m and $S/d = 3.72$. For $\alpha = 1.3$, these are $d = 4.2 \cdot 10\text{-}3$ m and $S/d = 3.81$; for $\alpha = 1.5$, these are $d = 4.1 \cdot 10\text{-}3$ m and $S/d = 3.90$, respectively.

The obtained data allowed us to analyze the flow patterns in the proposed burner with rational geometric parameters of the fuel supply.

The results of CFD modeling conducted at the next stage of the research allowed us to identify the following patterns. The flow structure is qualitatively similar when fuel is supplied to different sections of the burner. In the area after the stern of the flame stabilizer, a vortex structure is formed, responsible for the stability of combustion. With distance from the end of the stabilizer, an acceleration of the flow is observed, caused by the expansion of the gas due to combustion. Downstream, the high-speed zone covers an increasingly large part of the channel cross-section. In this case, the maximum speeds in this zone increase downstream and are reached on the stabilizer axis.

The analysis of the flow pattern indicates the presence of certain quantitative differences in the fuel supply to different sections of the burner. The length of the reverse flow zone behind the stabilizer increases with the distance of the gas supply holes from the tear-off edge of the stabilizer. Thus, it is 70.2 mm, 73.0 mm and 103 mm for the first, second and third fuel supply sections, respectively. It is noteworthy that the difference in the values of the reverse flow zone length for the first and second fuel supply sections is insignificant. However the length of this zone for the third fuel supply section increases significantly.

With respect to the region located at some distance from the stabilizer end, where the flow acceleration occurs, its characteristics depend on the row number of the gas supply holes. Namely, the greater the row number, i.e. the farther the gas supply holes are located from the tear-off edge of the stabilizer, the lower the flow begins the specified acceleration. In this case, in a fixed cross-section of the flow, the highest speed corresponds to the first fuel supply section, and the lowest to the third. This circumstance for the flow speed on the stabilizer axis is illustrated in Fig. 2.

The nature of the specified speed on the stabilizer axis for different fuel supply sections also has its own characteristics. With an increase in the row number at a greater distance from the tear-off edge of the flame stabilizer, the speed values do not change.

At the same time, the differences in the values of this velocity for different fuel supply sections behind the reverse flow zone downstream first increase and then acquire an almost constant value.

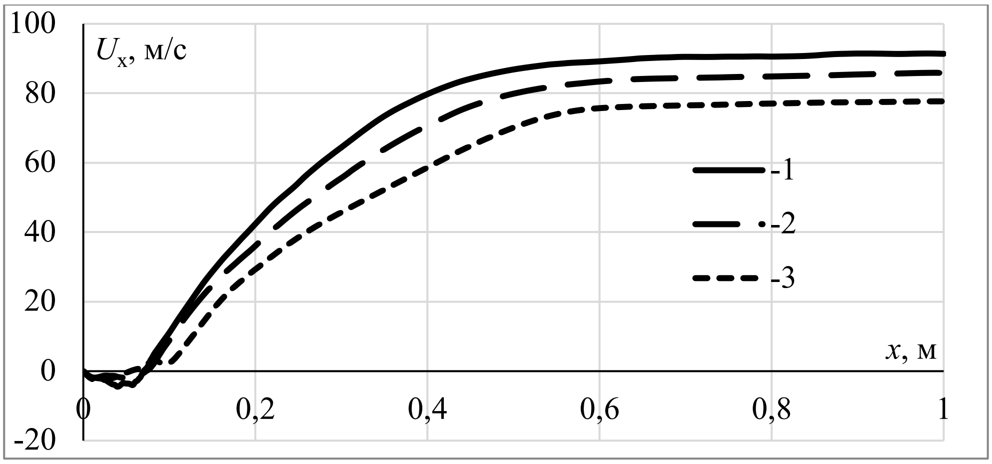

Fig. 2. Change of the speed U_x on the stabilizer axis passing through the axis of the gas supply holes for the reacting flows at: 1 – α=1,1; L_1=40·10^{-3} м, 2 – α=1,3; L_1=50·10^{-3} м, 3 – α=1,5; L_1=60·10^{-3} м.

Conclusion. For stabilizer-type burning devices with three -row fuel supply, focused on use at different values of the air excess coefficient, a complex of studies of the flow structure was carried out. The rational constructive parameters of the fuel supply system were determined, in which in the area after the stern of the flame stabilizer the favorable conditions for the mixture necessary to stabilize the torch are ensured.

A comparative analysis of the characteristics of the current during the supply of fuel in different sections was carried out. It is shown that the structure of the current is of a qualitatively similar nature for different rows of gas supply holes. However, there are certain quantitative differences. Namely, with the removal of fuel supply from the tear-off edge of the flame stabilizer, the length of the reverse flow zone behind the stabilizer increases, its acceleration begins.

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