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THERMAL STATE OF THE COMBUSTION ZONE IN STABILIZER-TYPE BURNER DEVICES WITH THREE-DAY FUEL SUPPLY

Summary. *This article presents the results of a study examining the dependence of the thermal state of the active combustion zone on the characteristics of a microtorch burner with a multi-row fuel feed and variable heat output. An analysis is made of the influence of these characteristics on the temperature field distribution in the longitudinal cross-section of the flame stabilizer, the average enthalpy temperature distribution, and the temperature non-uniformity coefficient along the channel.*

Key words: *micro-jet burner, computer modeling, average enthalpy temperature, flat flame stabilizer.*

Introdaction. Various modifications of stabilizer-type microtorch burners are characterized by improved stabilization properties, a high degree of combustion zone homogenization, and low pressure losses across the burner. This paper examines a modification of such devices with a multi-row fuel supply system, which are designed for use at various values of the excess air coefficient, and examines the situation with a time-varying heat output of a power plant, typically observed during the operation of furnaces, drying units, and other fire-technical facilities. Mathematical and computer modeling are widely used to study fuel combustion processes [1-24]. In the presented paper, the operating processes of a new modification of microtorch burners were studied using computer modeling.

The burner devices discussed in this article are designed using a modular principle. Connecting a certain number of burner modules allows for the required power output. A single burner module was considered for the simulation. Each burner module consists of a flat flame stabilizer located in a channel at a distance from the channel walls. Fuel supplied to the flame stabilizer enters one of three sections (I, II, and III), separated from each other. Each section delivers fuel gas at a specific excess air ratio within a specified range. A three-row system of circular holes is located on the side surfaces of the flame stabilizers, through which gas is fed directly into the oxidizer flow for combustion. This fuel supply system allows for the regulation of the fuel mixture composition in the flame stabilization zone.

The results of studies of the thermal state of the combustion zone for a situation of variable heat output of the equipment are shown in Fig. 1-5.

The temperature field in the longitudinal section of the flame stabilizer when fuel gas is supplied to different rows of gas supply holes is illustrated in Figure 1. The data presented indicate that the presented fields differ significantly quantitatively. Thus, a higher fuel supply row number generally corresponds to a lower temperature level. The tendency for temperature to increase downstream of the recirculation zone is more pronounced, the lower the row number. The highest temperatures for the first and second fuel supply rows are observed at the channel outlet and are 1777°C and 1718°C, respectively. For fuel supply to the third row of gas supply holes, a high temperature occurs in the recirculation zone along the stabilizer. The latter is explained by a significant reduction in the range of the fuel jets due to reduced fuel consumption and the consequent formation of a rich combustible mixture in the recirculation zone.

The fields of mean square temperature pulsations when fuel is supplied to different rows of gas supply holes are shown in Figure 2. As can be seen, the temperature fluctuation pattern is qualitatively similar for fuel delivery to the first and second rows of gas-injection ports, and differs significantly for fuel delivery to the third row. Specifically, a relatively low temperature fluctuation level is observed in the central zone of the channel width, some distance from the stabilizer end. However, when fuel is delivered to the first and second rows, the level of these fluctuations decreases downstream. The width of this zone downstream increases, encompassing the entire channel width. When fuel gas is delivered to the third row of gas-injection ports, the temperature fluctuation level in this central zone, on the contrary, increases downstream, while its width in the initial section of the channel remains virtually unchanged and is smaller than the channel width.

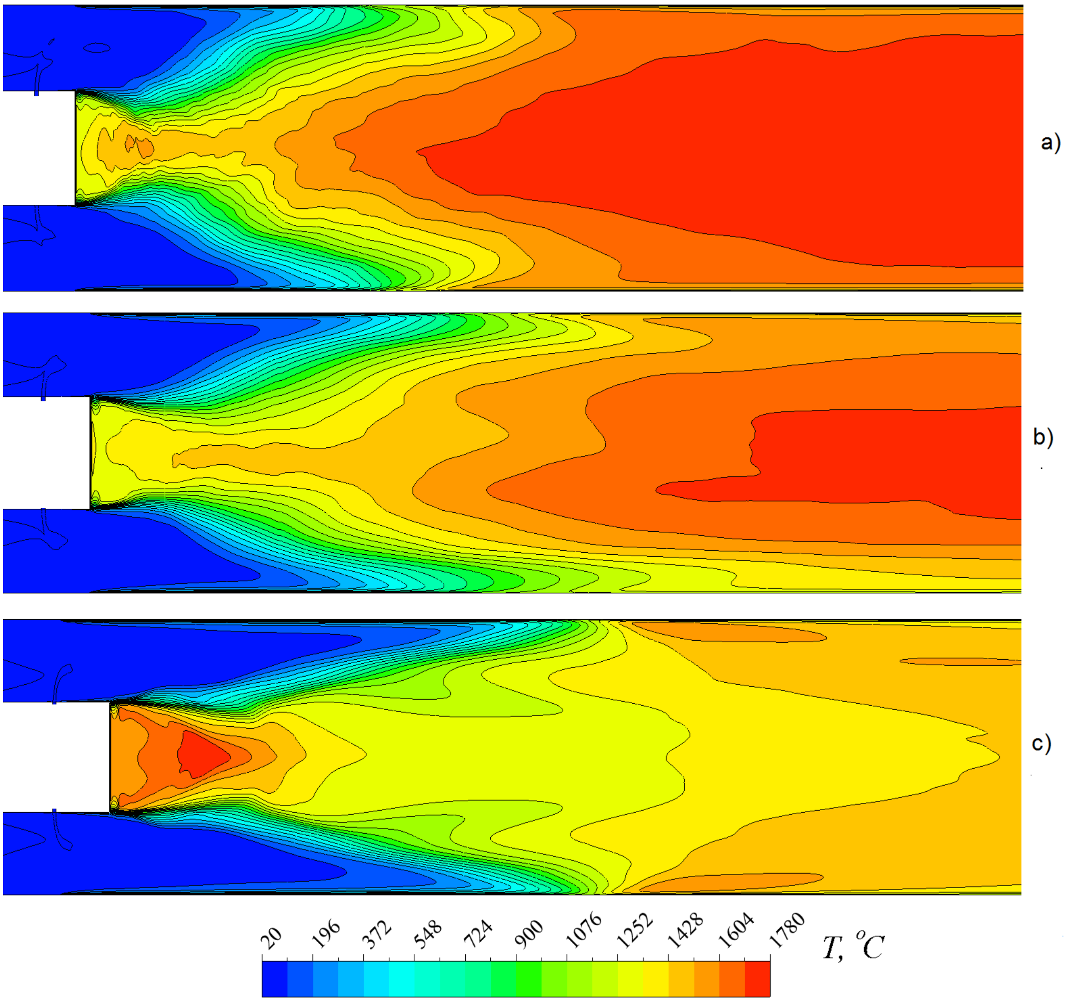

Fig. 1. Temperature field *T* in the longitudinal section of the flame stabilizer passing through the axis of the gas supply holes, when fuel is supplied to the first (a), second (b) and third (c) sections under conditions of variable heat output of the equipment

When fuel is delivered to the first and second rows of gas inlet ports, relatively large zones with high temperature fluctuations are observed behind the return flow zone in the subregions corresponding to the inter-stabilizer channel. Pulsation values in these zones exceed 600°C. Higher levels occur when fuel is delivered to the first row. A significantly different picture is observed when fuel gas is delivered to the third row of gas inlet ports. Here, the zone of relatively high pulsations includes two long, narrow bands that extend beyond the recirculation zone toward the channel walls. The velocity fluctuation level in these zones is significantly lower than when fuel is delivered to the first and second rows of gas inlet ports.

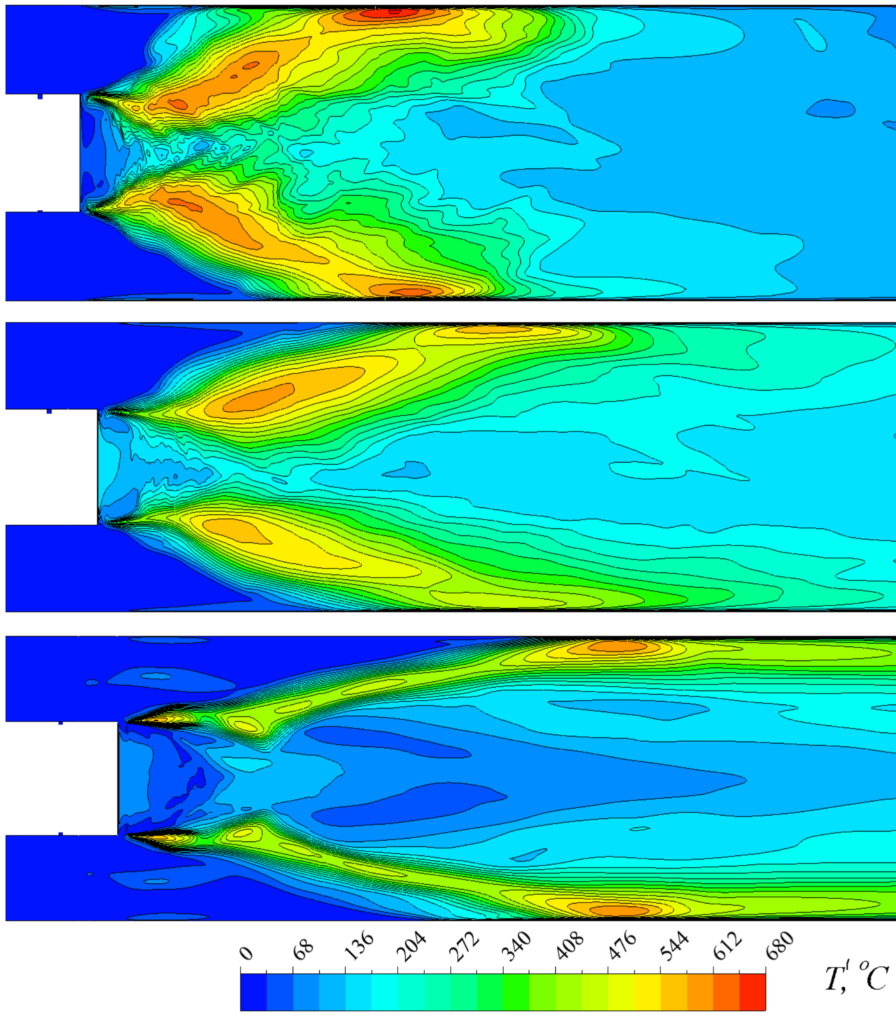

Fig. 2. Field of mean square temperature pulsations *T′* in the longitudinal section of the flame stabilizer passing through the axis of the gas supply holes, when fuel is supplied to the first (a), second (b) and third (c) sections with variable heat output of the equipment

The distribution of the average enthalpy temperature T^e along the channel is illustrated in Fig. 3. According to the data obtained, overall, excluding a small section along the flame stabilizer, a higher row number corresponds to a lower temperature T^e value. Regarding the nature of the temperature T^e change along the flow, its practically constant values are achieved at the smallest distance from the stabilizer end for fuel supply to the first row, and at the greatest distance for the second row.

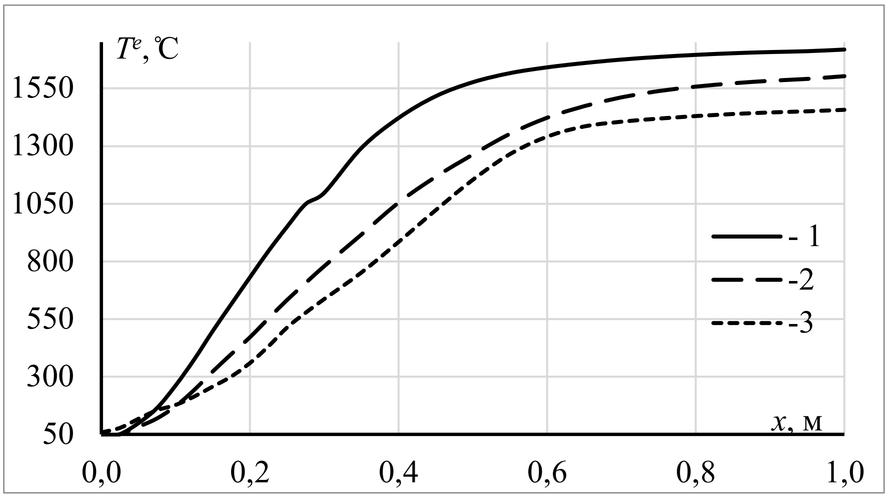

Fig. 3. Distribution of the average enthalpy temperature To along the length of the channel behind the flame stabilizer, when fuel is supplied to the first (1), second (2) and third (3) sections with variable heating capacity of the equipment

The temperature distribution along the x -axis when fuel is supplied to different sections is shown in Figure 4. Note the presence of extreme temperature values in the recirculation zone for the three fuel delivery situations considered. The most pronounced temperature extreme occurs for the third fuel supply row and is least pronounced for the second row. The temperature correlation on the x - axis for different fuel supply sections at a certain distance from the stabilizer end becomes the same as for the average enthalpy temperature.

Regarding the variation of the temperature non-uniformity coefficient γ along the channel length, it generally has the lowest values when fuel is supplied to the first section, somewhat higher values in the second section, and the highest values in the third section Fig. 5.

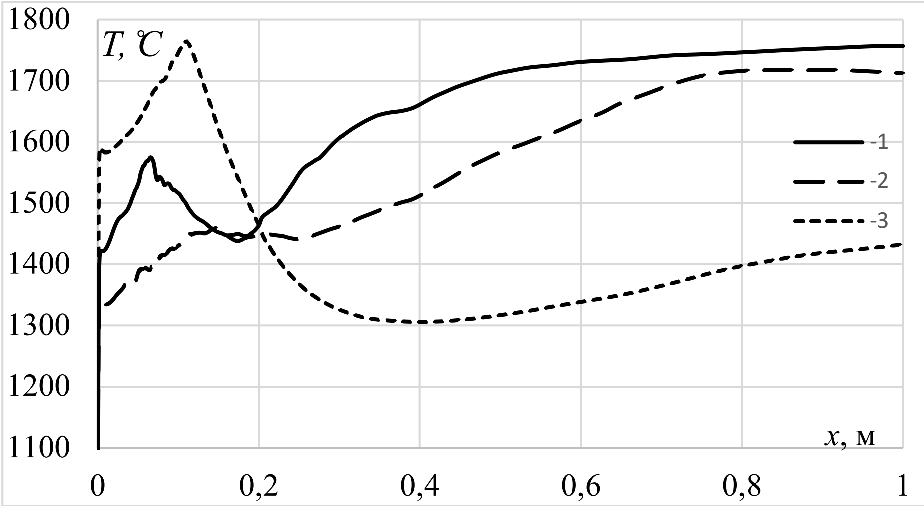

Fig. 4. Distribution of temperature *T* along the length of the channel behind the flame stabilizer on its axis in the plane passing through the axis of the gas supply holes, when fuel is supplied to the first (1), second (2) and third (3) sections with variable heat output of the equipment

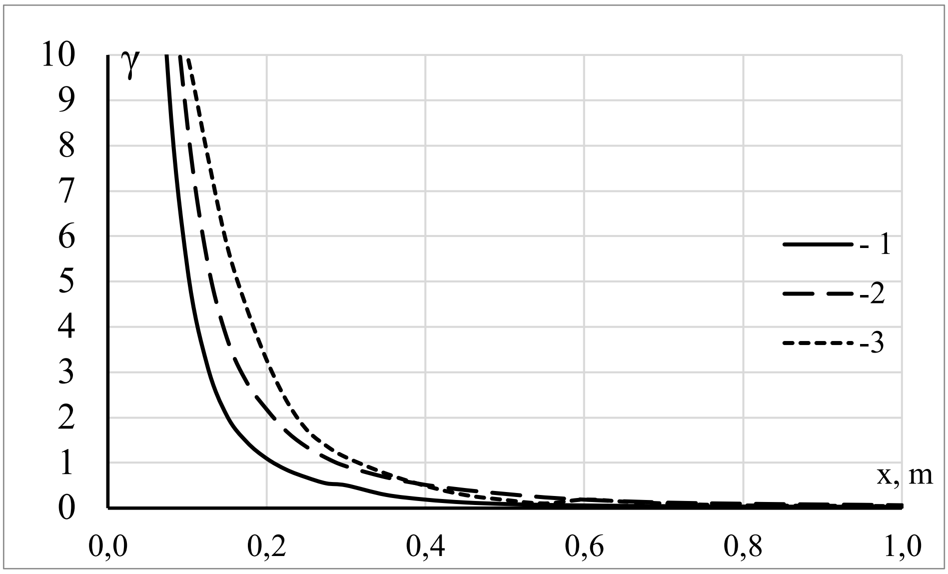

Fig. 5. Distribution of temperature non-uniformity γ along the length of the channel behind the flame stabilizer, when fuel is supplied to the first (1), second (2) and third (3) sections with variable heat output of the equipment

A relatively sharp change in γ occurs up to the coordinate $x \approx 0.25$ m. After this, an asymptotic decrease in γ is observed.

Conclusions. Studies of the dependence of the thermal state of the active combustion zone on the burner device characteristics with variable equipment heat output have shown that higher fuel row numbers correspond to lower temperatures, and the tendency for the temperature to increase downstream of the recirculation zone is more pronounced than lower row numbers. Regarding the mean enthalpy temperature, the data obtained indicate that higher row numbers correspond to lower temperatures. If we consider the nature of the mean enthalpy temperature change downstream, its nearly constant values are achieved at the shortest distance from the stabilizer end for the first row, and at the greatest distance for the second row.

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