Technical sciences

UDC 536.24:533

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STUDY OF TORCH STABILITY IN MICROJET CYLINDRICAL BURNERS OF STABILIZER TYPE

Summary. *The article presents the results of experimental studies of stable combustion of gaseous fuel in stabilizer-type burners. It is proven that stable combustion is achieved by forming a zone of reverse currents in the stabilizer's feed areas. The stabilization conditions for "lean" and "rich" breakdown are established.*

Key words: *stabilizer-type burners, reverse flow zone, reverse flow zones of the stabilizers' after edge, relative distance of gas supply holes, excess air*

coefficient.

Considerable attention is paid to the study of various aspects of combustion of gaseous fuel in micro-jet burner devices [1-14].

In most cases, flame stabilization in stabilizer-type burners is achieved through the use of various aerodynamic methods. Stability of operation in these devices is achieved due to the formation of reverse flow zones of the stabilizers' after edge. These zones ensure continuous ignition of the fuel.

The experimental studies of combustion stability, carried out in this work for smooth cylindrical stabilizer burner devices, were carried out on the experimental stand shown in Fig. 1.

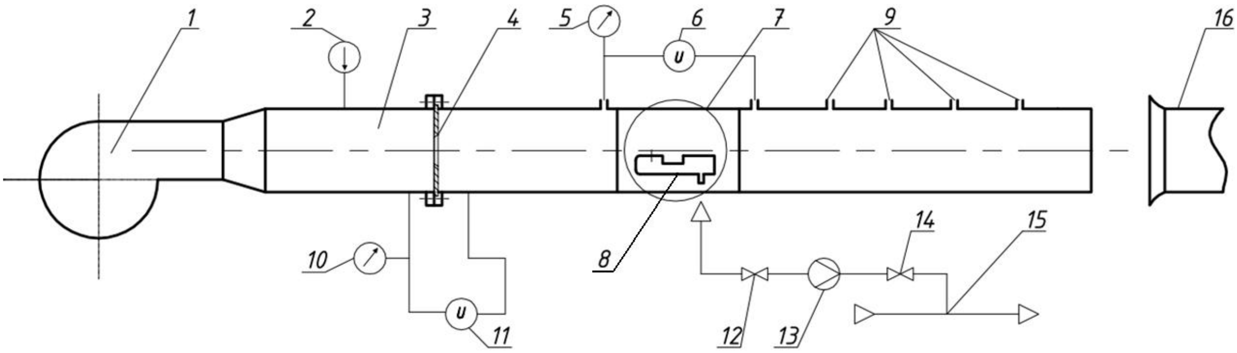

Fig. 1. Experimental setup diagram:

1 – fan; 2 – thermometer for measuring air temperature; 3 – initial section; 4 – narrowing device; 5 – pressure gauge for measuring pressure at the inlet to the measuring section; 6 – differential pressure gauge for measuring resistance of the cylindrical modules under test; 7 – working section equipped with access for gas analysis sampling probes and measuring equipment, as well as a spark plug; 8 – cylindrical stabilizer; 9 – nozzles for sampling along the torch length; 10 – pressure gauge for measuring pressure in front of the diaphragm; 11 – differential pressure gauge for measuring pressure drop across the diaphragm; 12 – regulating gas valve; 13 – gas flow measuring diaphragm; 14 – shut-off valve; 15 – gas main; 16 – inlet to the gas exhaust tract

From fan 1, air is supplied to initial section 3, which is additionally equipped with narrowing device 4. Temperature of incoming air is measured by thermometer 2. In the diagram, the fan is equipped with frequency controller, which can change air flow without using damper. After initial section, air is supplied to working section 7, lined with refractory material. To perform measurements in the torch, the working section is equipped with differential pressure gauge 6 to determine pressure drop in the module, which is being tested. The design of the stand allows for quick replacement of cylindrical modules 8 under test. Gas path is equipped with pressure gauge and differential pressure gauge to measure gas pressure before diaphragm and pressure drops on diaphragm. Electric igniter with voltage of 27 V is used to ignite the mixture.

During torch ignition, "lean" and "rich" breakdown, the limits of stable burner operation are determined by the excess air coefficient depending on its velocity. Dependencies $\alpha_{ign} = f(U_{air})$, $\alpha_{max} = f(U_{air})$, $\alpha_{min} = f(U_{air})$ are found as follows. The main air supply compressor is switched on and the minimum air flow through the burner is set in accordance with the capabilities of the control system or obtained during the burner adjustment tests. The auxiliary igniter is ignited according to the corresponding program. The air and gas flow through the auxiliary igniter is set based on the adjustment tests results. Voltage is applied to the igniter plug. Gas is supplied to the burner device under test until the flame appears behind the stabilizers. The gas flow to the burner $\left(V_G\right)^{ign}$ at the moment of torch ignition is determined. Ignition operations, "lean" and "rich" torch breakdowns are performed with a gradual change in the air flow through the main burner. The "lean" breakdown boundary α_{max} is determined as follows. The auxiliary burner is switched off. The gas flow rate is gradually reduced until the flame breaks off and the flow rate is fixed $V_G^{\min}$. The characteristics of the "rich" breakdown - α_{min}, are determined after the main flame is ignited behind the stabilizer by gradually increasing the gas flow rate with the auxiliary burner switched off. As a rule, the fact of occurrence of strong pulsations is accepted as a criterion of the "rich" breakdown.

The results of the experiments, presented in Fig. 2 – 4, were obtained for the following initial data: stabilizer diameter $d_{st} = 33\cdot10^{-3}$ m; channel diameter $D = 53\cdot10^{-3}$ m; diameter of gas supply openings $d = 2\cdot10^{-3}$ m; absolute temperature of gas and air was 293.15 K; blockage coefficient of the channel flow section $k_f = 0.3$.

Fig. 2 shows the dependence of the excess air coefficient α_{max} on the "lean" flame failure on the air velocity at the inlet of the burner device. As can be seen, with an increase in air velocity, the value of α_{max} decreases, i.e. flame stabilization on the "lean" failure worsens.

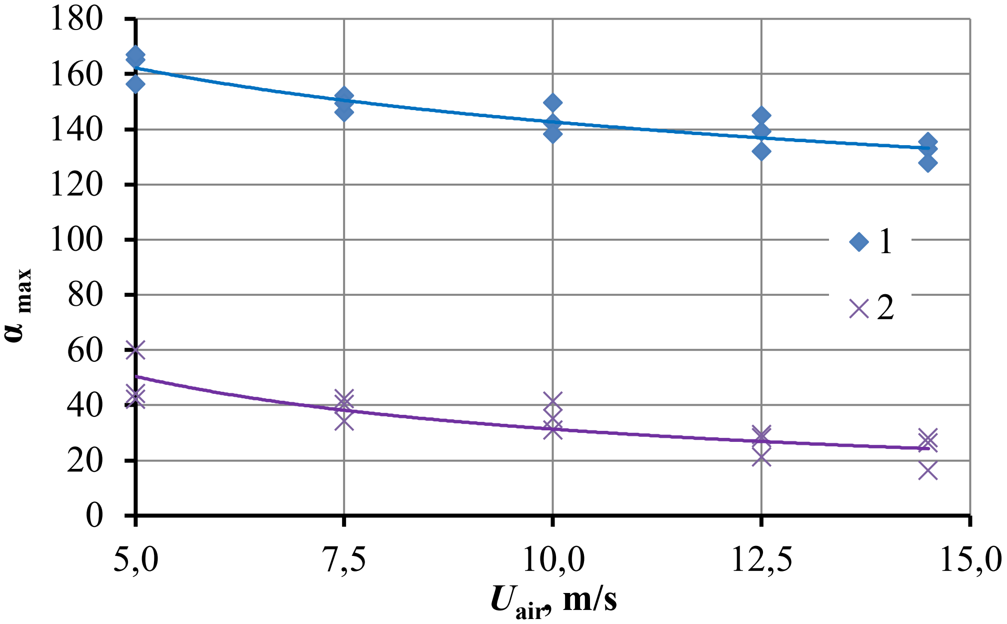

Fig. 2. Experimental dependence of the excess air coefficient α_{max} at a “lean” breakdown on the air velocity at the inlet to the burner device for different values of the relative pitch of the gas supply openings S/d: 1 – S/d=3.2; 2 – S/d=6.5

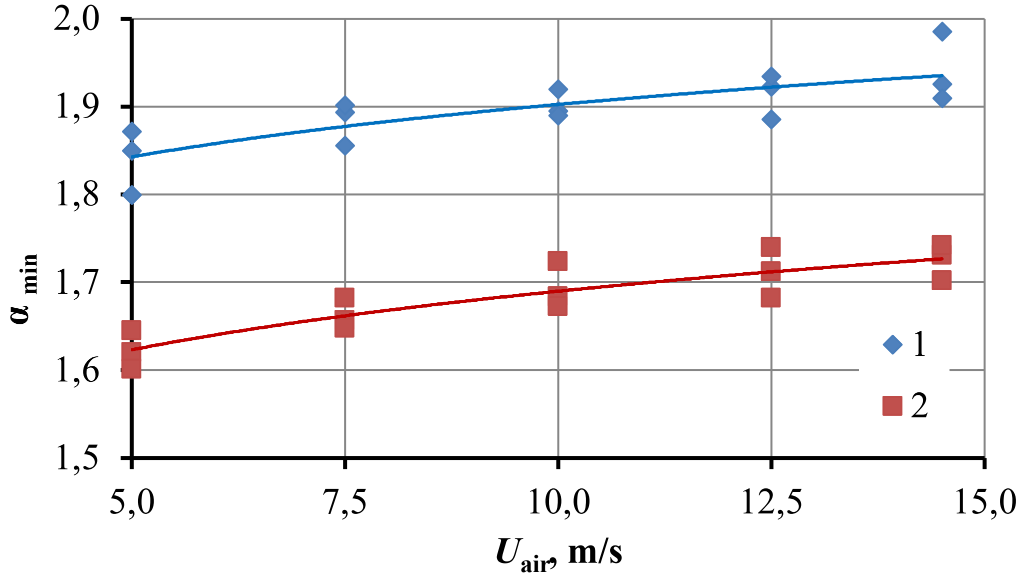

Fig. 3. Experimental dependence of the excess air coefficient α_{min} at a “rich” breakdown on the air velocity at the inlet to the burner device for different values of the distance from the gas supply openings to the breakdown edge of the flame stabilizer L_1: 1 – L_1 = 0.015 m; 2 – L_1 = 0.03 m

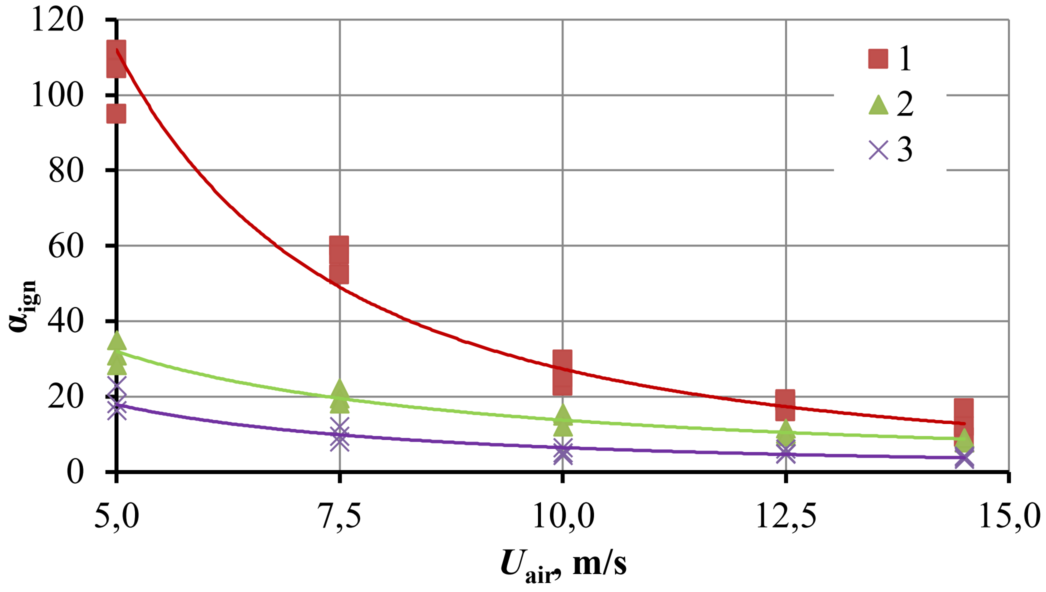

Fig. 4. Experimental dependence of the excess air coefficient in ignition mode α_{ign} on the air velocity at the burner inlet for different values of the relative pitch of the gas supply holes *S/d*: 1 – *S/d* = 4.0; 2 – *S/d* = 5.0; 3 – *S/d* = 6.5

As for the influence of the relative step of the gas-feeding holes *S/d* on the values of the excess air coefficient α_{max}, then larger *S/d* correspond to smaller values of α_{max}. In other words, flame stabilization at a "lean" breakdown improves with a decrease in the relative distance between the gas-feeding holes. This is due to the fact that with an increase in S/d, the depth of penetration of gas jets into the air flow increases, and a smaller amount of fuel gets into the zone of reverse flows behind the stabilizer. This circumstance causes a deterioration in the breakdown characteristics of the burner device.

Fig. 3 shows the experimental dependence of the excess air coefficient α_{min} at a "rich" breakdown on the air velocity at the burner inlet. According to the data obtained, the stability of the flame at a "rich" breakdown worsens (α_{min} increases) with an increase in the air velocity and with a decrease in the distance L_1 from the breakdown edge of the flame stabilizer to the gas supply holes. As for the starting characteristics of the burner devices under consideration, as can be seen from Fig. 4, they correlate in a certain way with the breakdown characteristics at a "lean" breakdown, and worsen with an increase in the air flow velocity and the value of S/d.

Thus, the flame stability at a "lean" breakdown increases with a decrease in the relative distance between the gas supply holes. The effect of the relative step of the gas supply holes on the values of the excess air coefficient α_{max}, then larger values of the relative step of the gas supply holes correspond to smaller values of α_{max}. This is due to the fact that with an increase in S/d, the depth of penetration of gas jets into the air flow increases, and a smaller amount of fuel gets into the zone of reverse flows behind the stabilizer. This circumstance causes deterioration of the breakdown characteristics of the burner device.

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