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TEMPERATURE REGIMES OF STABILIZER BURNERS UNDER APPLICATION OF THERMO-BARRIER COATINGS ON DIFFERENT PARTS OF THEIR SURFACE

Abstract: *The article contains the results of studies of thermal barrier coatings to improve the reliability and durability of the stabilizer burner devices. Using thermal barrier coatings, flame stabilizer temperature levels should be reduced to the specified allowable values.*

Keywords: *thermo-barrier coatings, burner devices, heat state, mathematical modeling*

Introduction

The use of thermo-barrier coatings is one of the effective ways to improve the reliability and durability of stabilizer-type burner devices [1-5]. The use of these coatings is intended, first of all, to provide the required heat state of the burner devices walls. In particular, with the help of thermo-barrier coatings, the temperature levels of flame stabilizers should be reduced to the given permissible values.

Thermo-barrier coatings can be applied to different parts of the burner devices surfaces. It is of interest to conduct a comparative analysis of the effectiveness of different localizations of coatings to provide required heat state of the burner devices.

Formulation of the problem and research methodology

A micro jet burner device with flat flame stabilizers equipped with special cooling systems was considered (fig. 1). As a coolant in these systems, natural gas was used, which is subject to further combustion.

Studies were carried out for three variants of the localization of thermo- barrier coatings on the outer surface of the flame stabilizer (fig. 2). Namely, for option a) corresponding to the coating on the stabilizer surface including the niche cavity (zones I, II, III), the lateral surface of the stabilizer adjacent to the end (zone IV) and the end surface (zone V); for variant b) corresponding to the location of the coating in zones IV-V, and variant c) in zone V (in fig. 2 the coating area is indicated by a bold line).

A step-by-step simulation technique was used when solving a problem that meets this physical situation [6]. The solution is based on the URANS approach using the FLUENT software. The work performed verification of turbulent transfer models, the results of which substantiated the use of the RNG k-ε turbulence model.

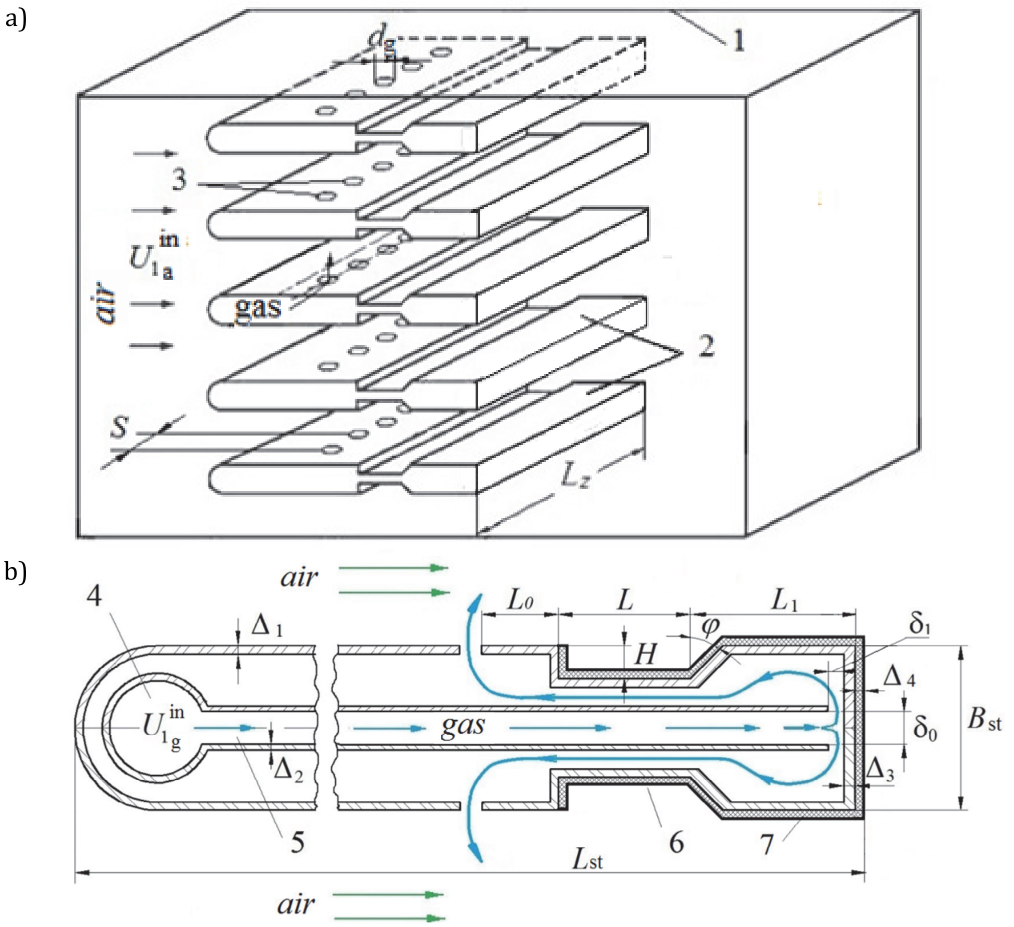

FIGURE 1. *Scheme of the stabilizer burner device (a) and its cooling system (b): 1 – a flat channel, 2 – flame stabilizers, 3 – gas supply holes, 4 – gas supply manifold, 5 – channel for cooling gas, 6 – niche cavity, 7 – coating*

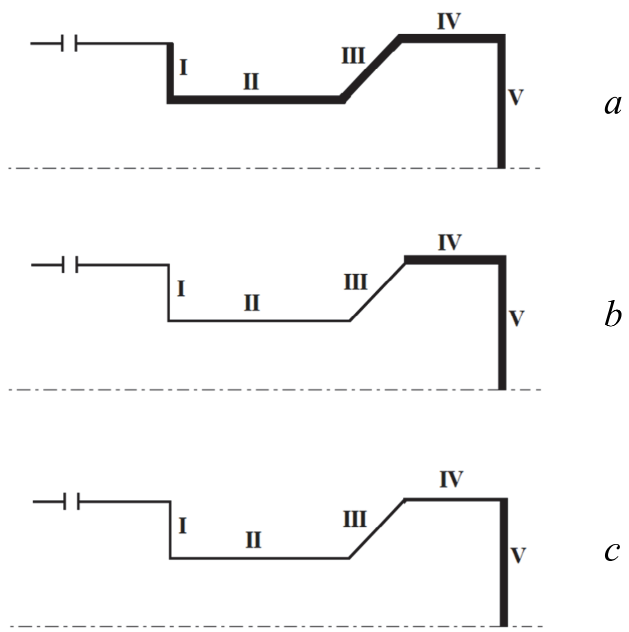

FIGURE 2. *Schemes of localization of coatings on the outer surface of flame stabilizers: a), b), c) investigated localization variants, I-V – numbers of zones*

A wide range of studies of the transfer processes in stabilizer burner devices in the presence and absence of thermo-barrier coatings with different localization of their application and various values of the boiler unit load was carried out. The computer simulation was carried out with the following values of the initial parameters: natural gas rate G = 200 m^3/h, which corresponds to 100% of the boiler load; the excess air coefficient was 1.1; the gas temperature at the inlet to the cooling system t_{in}^{g} = 15°C; air temperature at the inlet to the burner device t_{in}^{a} = 20°C; the wall material of the flame stabilizer is doped steel; blockage coefficient of the channel cross-section k_f = 0.3; diameter of gas supply holes d = 0.004 m; the relative step of the arrangement of the holes S/d = 3.33; length of the stabilizer L_{st} = 0.225 m; width of the stabilizer B_{st} = 0.030 m; L_0 = 0.016 m; L = 0.024 m; L_1 = 0.033 m; Δ_1 = 0.0015 m; Δ_2 = 0.001 m; Δ_3 = 0.002 m; δ_1 = 0.003 m; δ_0 = 0.006 m; δ = 0.003 m; coefficient of heat conductivity of the coating material λ_c = 0.8 W/(m·K); the thickness of the coating is Δ_4 = 0.0013 m.

Particular attention is paid to the consideration of the situation when the load N of the boiler unit is 20%. This is because in this case the cooling conditions are the least favorable due to the low consumption of the cooling agent (natural gas). Studies have shown that when the boiler load is equal to 20%, in the situation of the absence of thermo-barrier coatings, the temperature of the outer surface of the flame stabilizer exceeds the permissible value of 550°C in area of stalling edge.

Figure 3 shows the characteristic results of the studies performed for the conditions corresponding to the presence of thermo-barrier coatings at different localization of these coating on the outer surface of the flame stabilizer for N = 20%. As can be seen from Figure 3, for different coating localization, the nature of the temperature change along a fragment of the outer surface of the flame stabilizer is generally similar (lines 4, 5, 6). Namely, on the end surface of the stabilizer the temperature increases with moving off from the center to the stalling edge where this temperature reaches its maximum value. Further along the lateral surface of the stabilizer, adjacent to the stalling edge, and along the surface of the niche cavity, the temperature of the flame stabilizer decreases generally.

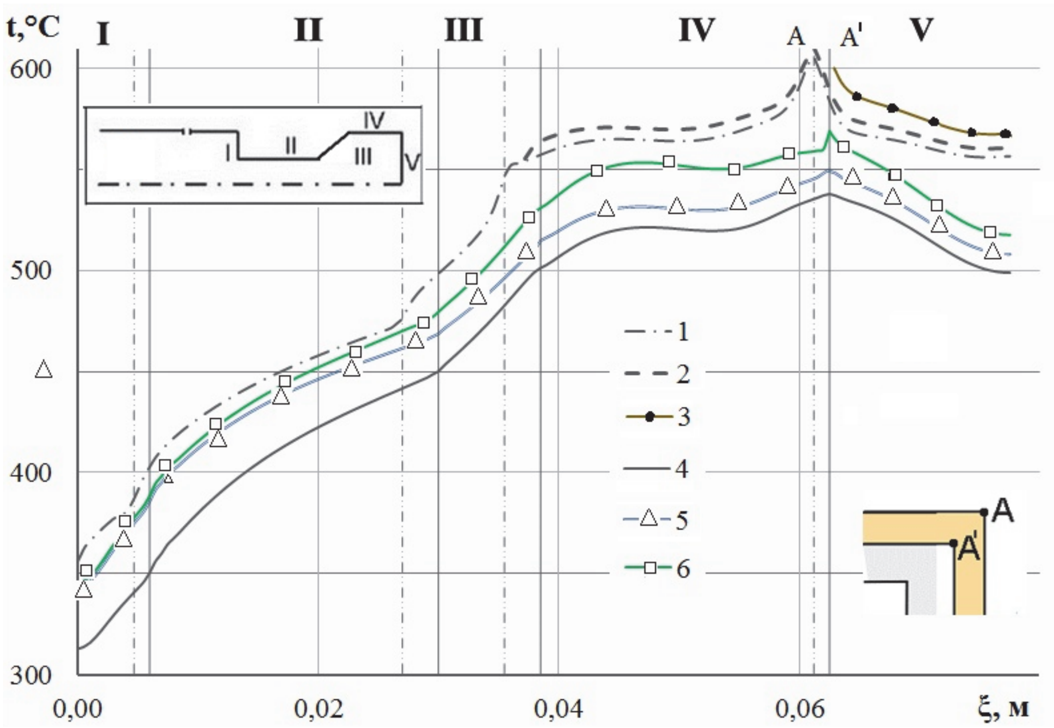

***FIGURE 3.** Temperature distribution along a fragment of the outer surface of the coating (1, 2, 3) and the wall of the flame stabilizer (4, 5, 6) with a relative load of the boiler 20% for different variants of coating localization: 1, 4 – variant a); 2, 5 – variant b); 3, 6 – variant c)*

The temperature levels on the outer surface of the stabilizer are somewhat different with different localization of thermo-barrier coatings. The temperature level turns out to be the lowest for the variant of localization of the coating a), which corresponds to the largest area of coating application, and the highest for variant c) with the smallest value of this area.

It is also noteworthy that the differences in the temperatures of the flame stabilizer for different coating localizations somewhat change along its outer surface. For the variants of localization of the coating *a*) and *b*), these differences are most significant in the niche cavity region, where in variant *a*) the coating takes place and in variant *b*) it is absent. Other picture is observed when comparing the temperatures of the outer surface of the flame stabilizers for options *b*) and *c*). Here, on the contrary, in the area of the niche cavity, these differences are the smallest, since in both of these variants in this area no coating is applied.

With different localization of thermo-barrier coatings, the maximum temperatures observed at the stalling edge of the flame stabilizer also differ. At the same time, this maximum temperature turns out to be lower than acceptable only for coating localization variants *a*) and *b*). Thus, it is possible to recommend for practical use the variant of coating localization *b*) as less costly in terms of the consumption of the coating material.

Conclusions

Based on the studies performed, the expediency of using thermo-barrier coatings to ensure the required heat state of stabilizer burners has been established. According to the results of a comparative analysis of the effectiveness of different localizations of coatings on the outer surface of flame stabilizers, recommendations for their use are proposed.

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