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Conference Article

Simulation of the Flow Over the Burner Device with the Counter Twirled the Principle of Flame Stabilization in Comsol Multiphysics

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Abstract

Stable burning of a moving air-fuel mixture is possible with equal flow rates and flame propagation. To do this, use special technical solutions. First of all, they strive to turbulize the flow in the combustion zone, which intensifies the process of heat and mass transfer, improves the mixture formation and increases the speed of flame propagation. For flow turbulization, blade vanes or bluff bodies located in the front device of the flame tube are used. Behind these elements there is a zone of reverse currents with a reduced static pressure, which creates the ejection of gas by an annular jet flowing out of the blade vortex. With such aerodynamic recycling, the burning fuel is transferred to meet the incoming fresh portions of fuel. Due to the heat of the combustion products sucked to the root of the flame, heating, evaporation (in the case of liquid fuels) and ignition of fresh portions of fuel occur.
The article presents the results of numerical modeling of isothermal air flow on a microflame burner with a counter-swirling current. A 3-D model of the burner, a grid of the model, a simulation area, pressure and velocity contours are presented. The zones of recirculation flow formation are determined. The most optimal angles for setting the blades for stabilization characteristics are shown. The influence of the size of the recirculation zones on the formation of nitrogen oxides is indirectly analyzed, in view of their dependence on the residence time in the combustion zone.

Keywords: microflame burner, counter-swirling current, burner;

1. Introduction

Stable burning of a moving air-fuel mixture is possible with equal flow rates and flame propagation. To do this, use special technical solutions. First of all, they strive to turbulize the flow in the combustion zone, which intensifies the process of heat and mass transfer, improves the mixture formation and increases the speed of flame propagation. For flow turbulization, blade vanes or bluff bodies located in the front device of the flame tube are used. Behind these elements there is a zone of reverse currents with a reduced static pressure, which creates the ejection of gas by an annular jet flowing out of the blade vortex. With such aerodynamic recycling, the burning fuel is transferred to meet the incoming fresh portions of fuel. Due to the heat of the combustion products sucked to the root of the flame, heating, evaporation (in the case of liquid fuels) and ignition of fresh portions of fuel occur. [1-5].

The article presents the results of numerical modeling of isothermal air flow on a microflame burner with a counter-swirling current. A 3-D model of the burner, a grid of the model, a simulation area, pressure and velocity contours are presented. The zones of recirculation flow formation are determined. The most optimal angles for setting the blades for stabilization characteristics are shown. The influence of the size of the recirculation zones on the formation of nitrogen oxides is indirectly analyzed, in view of their dependence on the residence time in the combustion zone.

2. Material and method

Figure 1 shows an isometric view of the 3-D model of the burner. The burner consists of an input register consisting of two tiers of blade devices. The first "outer" tier has blades (register) 1 with an angle of 60º (large), the second level has blades (register) with an angle of 60º relative to the angle of register 1.

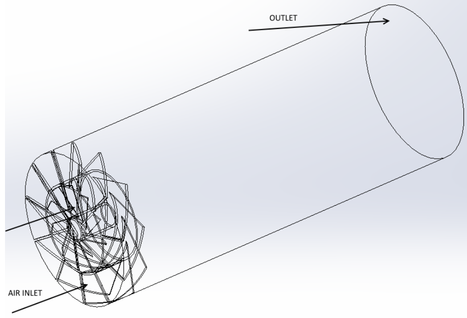

Fig. 1. Isometric view of the burner

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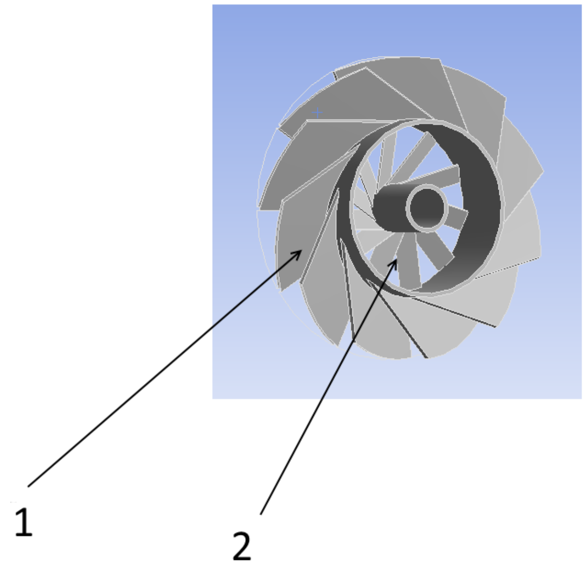
Figure 2 shows a General view of the input register. The register consists of two levels of blades. Modeling parameters are presented in table 1.

The model of turbulence k-ε realizable, which according to [6] is the most optimal solution, was used in the simulation. In the simulation, only the air velocity was changed.

Table 1. Initial parameters

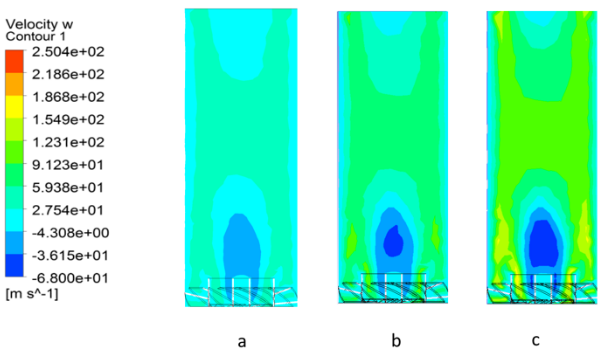
Air velocity, m/s	Initial temperature of oxidizer (air)/fuel, K	Number of tetrahedral elements in the simulated area
40-120	400	200000



1 – upper tier of blades, 2 – lower tier of blades
Fig. 2. General view of the blade device (input register)

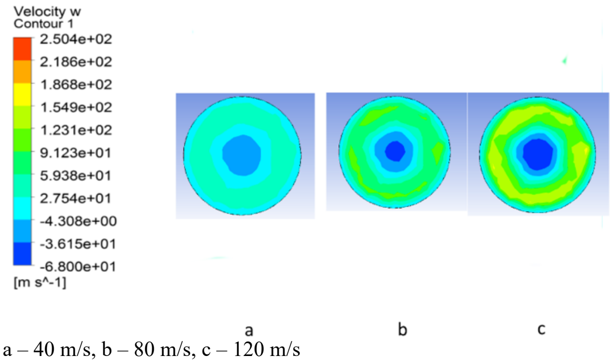
3. Results and discussion

Figure 3 shows the results of numerical simulations at different speeds. The contours of blue and dark blue represent the reverse flow zones. At a speed of 40 m/s, the reverse flow zone has a size of 1 caliber. The speeds in them are 36 m/s. With increasing speeds, an increase in strong reverse speeds is noticeable at a constant size of the reverse flow zone. At a speed of 80 m/s there is a spot with a strong reverse flow while maintaining the size of the recirculation zone. The same process occurs when the speed is increased to 120 m/s.



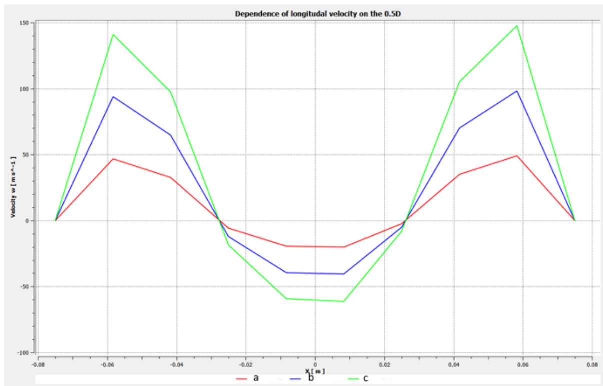
a – 40 m/s, b – 80 m/s, c – 120 m/s
Fig. 3 Velocity contours at different inlet velocities of air

Figure 4 shows the transverse velocity distribution at a distance x=0.5 D (0.5 caliber). As can be seen from the figure with increasing velocity rate in the central part of the burner grow "spot" with a strong reverse flow. This fact indicates the possibility of high flame stabilization on the one hand, on the other hand, the developed central zone leads to the concentration of a large amount of fuel, the creation of local zones of high temperatures and an increase in the concentration of nitrogen oxides at the outlet of the burner.



a – 40 m/s, b – 80 m/s, c – 120 m/s
Fig. 4. Velocity flows in the cross-section at a distance of 0.5 caliber (x=0.5 D)

Figure 5 shows the velocity distribution over the cross section at a distance of x=0.5 D. As can be seen from the figures, with the increase in velocity in the peripheral areas, the speed increases, and the speed increase has a steep increase. At minimum (40 m/s) speeds growth of longitudinal speeds has more flat dependence. The size of the recirculation zones at a distance of x=0.5 D does not change with increasing speed and is 0.3 D.



a – 40 m/s, b – 80 m/s, c – 120 m/s
Fig. 5. Distribution of longitudinal velocities across the cross section at a distance of 0.5 caliber (x=0.5 D)

4. Conclusions

The following conclusions can be drawn from the analysis:

1. Regardless of the flow rate, the recirculation zone behind the input register has a constant size.;
2. The presence of a Central recirculation zone in terms of flame stabilization is an advantage, since it provides a sufficient temperature regime to maintain the flame at different loads (fuel surplus coefficients);
3. Further development of the study may be the analysis of the effect of pre-mixing of the fuel-air mixture on stabilization.

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State the funding sources that have supported the work (name of the founder and project number). Specify the role of the funder in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

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