Study of the Initial Air-Fuel Mixture Temperature Effect on Ethane Flame Heat Release Rate Pulsation

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One of the problems of low-emission combustion chambers of gas turbine engines and power plants is the instability of their operation due to high-amplitude self-oscillations of gas pressure in the flame tube. High-amplitude pulsations of pressure and velocity occurred in the combustion chamber arising as a result of instability lead to fluctuations in engine thrust, flame blowout or flashback, as well as increased vibration load on the engine design components. These vibrations lead to increased heat transfer and thermal stresses of the flame tube, increased gas erosion of turbine blades, low- and high-cycle fatigue of design components, as well as a decrease in the accuracy of control systems. Flame heat release rate pulsations can be caused by changes in laminar flame speed, fuel composition, and changes in the environment. Experimental and numerical studies show that the initial air-fuel mixture temperature has a significant effect on the intensity of heat release rate pulsations in the flame front. An increase in the initial air-fuel mixture temperature at the combustion chamber inlet can lead to an increase in the amplitude of heat release pulsations, which can affect combustion efficiency and process stability. Therefore, studying the influence of the initial air-fuel mixture temperature on heat release rate pulsations in the flame front is of practical importance for optimizing the operation of burner devices, reducing pollutant emissions of harmful substances and increasing the efficiency of thermal processes.

The work carried out a computational study of the influence of the initial air-fuel mixture temperature at the model burner device on the heat release rate pulsations during ethane combustion. The combustion processes were simulated using the LES turbulence modeling approach with the Flamelet Generated Manifold combustion model. The pulsation amplitude of the speed of the air-fuel mixture at the inlet was 10%, the pulsation frequency varied in the range from 150 to 600 Hz.

As a result, the dependences of heat release pulsations on the frequency of the supplied mixture speed pulsations at initial temperatures of 300K, 400K and 500K were obtained. It is shown that when the initial temperature of the mixture changes, the peak values of heat release pulsations change their frequency and amplitude.

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