COMPARISON OF EXPERIMENTAL DATA AND NUMERICAL SIMULATION OF LARGE TURBULENT STRUCTURES IN DIFFUSION FLAMES

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Multiple temperature fluctuations during the diffusion combustion of different fuels are related to the turbulent flow in flame. In the work (Loboda et al., 2014), it is reported that the temperature spectrum contains pronounced maxima which have different frequencies for different fuels due to the movement of gaseous fuels along the flow with their further combustion (Loboda, Reyno, 2011).

This work presents the experimental studies of temperature fields during the combustion of fuels, numerical simulation of diffusion combustion of diesel fuels, and comparison of the turbulence scale with experimental data by frequency temperature spectra and the scale of temperature inhomogeneities.

Liquid fuels were used as the test fuels: petroleum, kerosene, diesel fuel, and ethanol. The mass of the fuel varied from 20 to 50 g. The fuel was burned in a tank 0.15 m in diameter. The JADE J530SB thermal imaging camera with a narrow bandpass filter (2.5-2.7 microns) was used as the recording instrument which was selected based on the analysis of the flame emission spectrum (Loboda et al., 2015). The flame emission coefficient was corrected by black body radiation and flame temperature measurements using a BP type thermocouple with a junction diameter of 50 μm and a time constant of 0.1 s.

Using the approach described in (Loboda et al., 2014), a flame temperature spectrum was obtained applying FFT. The scale of temperature inhomogeneities was determined by the frame-by-frame processing of the experimental data.

In the mathematical formulation of the problem, it was assumed that the flow in the considered area was axisymmetric; the movement of fuel was characterized by laminar, transitional, and turbulent flow regimes; combustion rate in turbulent diffusion flames was determined both by chemical kinetics and turbulent mixing of processes.

The following results were obtained:

1. The turbulence scale obtained experimentally was in good quantitative agreement with numerical simulation.
2. Temperature fluctuations are related to the turbulence of the flame flow, and the characteristic frequencies of the temperature spectrum are due to the scale of turbulent eddies.
3. The initial area of the flame is characterized by the maximum turbulent fluctuations.
4. Microvolume fuel combustion takes place in the main area of the flow at the external boundary of the jet.
5. In the aftercombustion zone, the main factor determining the combustion mode is the breakdown of turbulent eddies.

References

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