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NUMERICAL STUDY OF THE FUEL DROPLETS EFFECT ON COMBUSTION PROCESSES UNDER CONDITIONS TYPICAL FOR HYBRID ROCKET ENGINES

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The study of hybrid rocket engines in the era of orbital and suborbital flights has become more relevant than ever. This type of engines has several advantages over liquid and solid propellant rocket engines. The main disadvantage of such motors is their low specific thrust impulse. The usage of the low-melting fuels with low viscosity is considered as a promising way to solve this problem. In this case the fuel droplets from the liquid layer formed on the solid fuel surface are involved into the oxidizer stream due to the near wall shear layer instability [1,2]. In this work, the influence of the liquid fuel droplets on the combustion characteristics of a diffusion flame stabilized in the boundary layer of a high-speed oxidizer flow is studied. As a result of numerical simulations, two-dimensional distributions of characteristics were obtained of the oxidizer and gaseous fuel, droplet sizes and their number concentrations. Depending on the position of the droplet and its size, the local temperature near it decreases in the range from ≈50 K to ≈ 800 K (Fig.1).

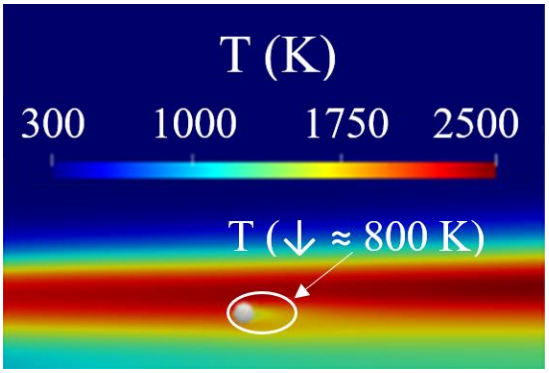

Fig.1. Two-dimensional temperature distribution. Initial droplet size 200 μm.

Depending on the size of the droplets, the characteristics of the system are changed. Thus, at small droplet sizes of ~50 μm, the liquid fuel evaporates completely. With an increase in the diameter of liquid fuel droplets, the evaporation fraction decreases and for droplets with a diameter of 100 μm, 150 μm, and 200 μm, it averages 0.9, 0.76, and 0.63, respectively.

If the ratio of the volume of droplets to the volume of gas in the system does not exceed 10^{-3}, then the quantitative concentration of droplets does not affect the fraction of droplet evaporation. For example, for 150 μm diameter droplets, the evaporation fraction for different number concentrations ranges from 0.76 to 0.77.

The effect of liquid fuel droplets on the diffusion flame stabilized in a boundary layer of a high-speed oxidizer flow consists in a local decrease of the gas temperature near the droplets, which also leads to a global decrease in the temperature of the flame front, as well as to its narrowing. An additional influx of gaseous fuel, as a result of droplet evaporation, leads to an increase in the gas temperature in the area under the flame front.

REFERENCES

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