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EXPERIMENTAL AND NUMERICAL INVESTIGATION OF FLOW REACTION AND HEAT TRANSFER WITH SUPERCRITICAL HYDROCARBON FUEL

Abstract

With the increase of flight Mach number, the thermal protection problem of the Scramjet which caused by combustion inside of it and aerodynamic heating, becomes more serious. When the flight Mach number exceeds 7, the total temperature of the combustion chamber can reach 3000K and the regular material without active cooling cannot work continuously for a long time. Structural thermal protection is one of the key technologies for Scramjet. This topic comes from the need of the research on Scramjet heat protection technology. Regenerative cooling is one of the effective ways to solve this problem.

Firstly, Decane as a single component substance is chosen as the working fluid. A test bed is set up for the heat transfer in a tube and a series of experiments on different conditions are carried out. The experimental results are obtained in order to make the verification of the numerical simulation model. It can be seen that a significant enhanced heat transfer occurs in the section near the tube inlet, this is because in this area, the flow field transitions from the laminar state to the turbulent state. When the wall temperature reaches approximate 750K, there is another short and less obvious heat transfer enhancement. When the wall temperature reaches near 1050K, there will be the second heat transfer enhancement. Analysis based on the experimental phenomena is performed.

Secondly, the mathematical model and the reaction mechanism are selected reasonably. The simulation method of hydrocarbon fuel flow reaction and heat transfer are established. Through the comparative research, RNG k-ε flow model, SRK equation of state, one-step fragmentation reaction and the two-dimensional axisymmetric model are selected in the simulation. The comparison between computation and experiment shows that reasonably good results can be obtained by means of this numerical method.

Finally, the above-mentioned method is applied on the simulation of a kind of endothermic hydrocarbon fuel (EHF) and the simulation result is compared with the data published in open literature. The computational results agree well with the experimental data.

The analysis of heat transfer for both decane and EHF demonstrates that the computational method in this study has good accuracy.