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EFFECT OF PYROLYSIS AND OXIDATION OF N-DECANE ON THE HEAT AND MASS TRANSFER CHARACTERISTICS OF HYDROCARBON FUELED SUPERSONIC FILM COOLING

Abstract

In our previous studies, we proposed a method to extend the cooling capacity of hydrocarbon fuel in a scramjet engine or a combined cycle engine through combining the regenerative cooling with supersonic film cooling, with the gaseous hydrocarbon fuel of the exit of regenerative cooling channel being used as the film coolant. Through basic analysis, the supersonic film cooling in the engine's combustor with hydrocarbon fuel as coolant was found to be a kind of flow with non-equilibrium reactions including the pyrolysis and oxidation of hydrocarbon fuel, the reactions will have significant effects on the mass and heat transfer characteristics of the cooling film. To investigate the effect of pyrolysis and oxidation of n-decane on the heat and mass transfer characteristics of hydrocarbon fueled supersonic film cooling, numerical model was established and has been validated by the experimental results. In order to describe the heat and mass characteristics of supersonic film cooling with non-equilibrium reactions precisely, a detail kinetic model of n-decane with 234 species and 1452 reactions was choose. The numerical study of supersonic film cooling which considers pyrolysis and oxidation of hydrocarbon fuel was carried out. The results indicate that the pyrolysis and oxidation of n-decane have due effects on the supersonic film cooling. On one hand, the pyrolysis reactions absorb heat and that is beneficial for improving the film cooling efficiency. On the other hand, the oxidation reactions release heat and the reactions will significantly disturb the flow and enhance the mixing by changing its thermophysical properties and that is bad for improving the film cooling efficiency. The overall effects of cracking reaction on the film cooling efficiency depends on the balance between the good effects and bad effects. The interaction mechanism between the flow, mass and heat transfer and chemical reactions has been studied further and the sensibility analysis has been made. The results of this paper can be a guidance of designing the supersonic film cooling using hydrocarbon fuel as coolant and it helps improve the cooling capacity of hydrocarbon fuel in a hydrocarbon fueled scramjet engine or combined cycle engine.