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NUMERICAL STUDY ON N-DECANE HEAT TRANSFER UNDER SUPERCRITICAL PRESSURE IN REGENERATIVE COOLING CHANNEL

Abstract

Scramjet is a promising power system for hypersonic vehicle, and the core technology of supersonic combustion in scramjet has achieved significant progress in recent years. However, the thermal protection of combustion chamber needs further attention for the sake of long-time safe flight. Regenerative cooling is the ideal technique for scramjet thermal protection. The cold hydrocarbon fuel is heated to supercritical state flowing through the cooling channels before injected into the chamber, taking excess heat from solid wall. In order to obtain in-depth understanding of supercritical heat transfer characteristics of hydrocarbon fuel in regenerative cooling process, numerical heat study on turbulent flow and conjugate heat transfer was conducted. Real-fluid equation of state was used to evaluate the thermal-physical properties of n-decane fuel under supercritical pressure, with fuel slight cracking effect considered using proportional production distribution (PPD) chemical mechanism. The accuracy of numerical methods was fully validated by experiment results. Multiple geometry of regenerative cooling channels were investigated and compared, including smooth square channel and channel with spoiler structures. The pressure effect on fuel thermo-physical properties and heat transfer was also evaluated. The results indicated that, the secondary flow induced by spoiler structure has significant impact on the fuel temperature distribution, and the heat transfer efficiency of cooling channel has remarkable enhancement. This work has a benefit to develop the CFD assessment method for the regenerative cooling schemes of scramjet thermal protection device.