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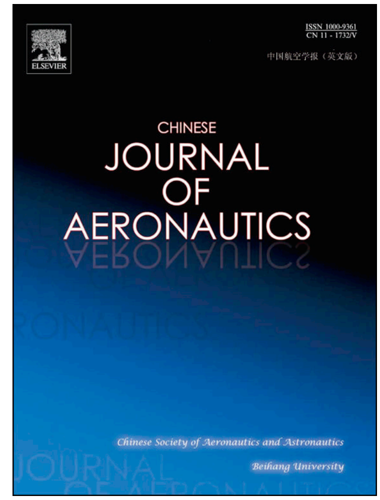

Full Length Article

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Numerical investigation of pyrolysis effects on heat transfer characteristics and flow resistance of n-decane under supercritical pressure

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Abstract

Pyrolysis of hydrocarbon fuel plays an important role in the regenerative cooling process. In this article, a Two-Dimensional (2D) numerical model is proposed to investigate the pyrolysis effects on the heat transfer characteristics and flow resistance of n-decane under supercritical pressure. The one-step global pyrolytic reaction mechanism consisting of 19 species is adopted to simulate the pyrolysis process of n-decane. The thermophysical and transport properties of the fluid mixture are computed and incorporated into the numerical model for simulation. Comparisons between the current predictions and the open published experimental data are carried out and good agreement is achieved. In order to better understand the complicated physicochemical process, further investigations on the turbulent flow and heat transfer coupled with pyrolysis in a tube have been performed under various operating conditions. The results indicate that the pyrolysis intensively takes place in the high fluid temperature region. The occurrence of the heat transfer deterioration would lead to increasing n-decane conversion at the beginning of the heated section. It is found that the pyrolysis could improve the heat transfer deterioration and promote the heat transfer enhancement. Meanwhile, pyrolysis gives rise to an abrupt increase of flow resistance. The mechanisms of the physicochemical phenomena are also analyzed in a systematic manner, which would be very helpful in the development of the regenerative cooling technology.

Keywords: Supercritical pressure; n-decane; Pyrolysis; Convective heat transfer; Flow resistance

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1. Introduction[1]

Scramjet engines suffer from extremely harsh thermal circumstances, and thus thermal protection to the scramjet engine is becoming a major consideration for hypersonic aircraft. Regenerative cooling has been considered as the most effective and practical method.[1,2] The successful implementation of this application can lead to greatly improved coolant quality on one hand, and the desired atomization for further efficient combustion on the other hand.[3]

Hydrocarbon fuel is normally injected into the cooling channel under supercritical pressure. During the regenerative cooling process, the hydrocarbon fuel transfers from subcritical to supercritical state as being continuously heat-