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考虑发动机冷却通道固壁内耦合导热影响的低温甲烷超临界压力传热研究

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Study of Heat Transfer of Cryogenic Methane Under Supercritical Pressure with Consideration of Thermal Conduction in Engine Coo Channel Walls

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摘要

在考虑发动机冷却通道固壁内耦合导热影响的情况下,开展了低温甲烷在矩形冷却通道中的超临界压力湍流换热数值模拟研究;仔细分析了热流密度及管道几何形状对低温甲烷超临界压力下的流动和传热的影响;得到了流体速度、壁面温度、壁面热流密度等参数的详细变化情况以及Nusselt数的变化规律。计算结果表明:在考虑流固耦合作用时,上壁面施加的热流有一部分会通过固体壁面内的热传导,经由侧壁面传入超临界压力流体,并且随着热流密度的增加,经侧壁面传导的热流所占的比例也会随之增大;减小冷却通道内截面的高宽比,可以提高超临界压力下的换热效果,但流动压降会大大增加,因此冷却通道高宽比的选择需综合考虑传热与压力损失的影响,可以引入热性能参数作为参考;修正的Jackson&Hall对流换热关系式基本可以适用于本文中的各种工况。

关键词： 超临界压力传热 主动冷却 甲烷 流固耦合 数值模拟

Abstract:

Numerical simulation study is conducted of the heat transfer of cryogenic methane flowing inside a rectangular engine cooling channel under supercritical pressure with consideration of the coupled thermal conduction in the solid channel region. The effects of wall heat fluxes and cooling channel geometries on the fluid flow and heat transfer processes under supercritical pressure are carefully examined. Variations of the fluid velocity, channel wall temperature, wall heat flux, and Nusselt number are obtained and discussed. Results indicate that with consideration of the conjugate heat transfer in both the solid and fluid regions, a fraction of the heat flux imposed on the top channel surface is transferred into the cryogenic methane through the side walls. As the imposed wall heat flux increases, more heat can be thermally conducted into the side channel walls. Decreasing the cooling channel height/width aspect ratio leads to enhanced heat transfer, but the pressure loss also increases significantly. Therefore, the combined effects of the channel aspect ratio on both heat transfer and pressure loss has to be taken into consideration to obtain an optimum cooling channel design. The thermal performance parameter can be used as a reference in this regard. The modified Jackson & Hall coefficient is applicable to heat transfer prediction under supercritical pressure with acceptable accuracy under all tested conditions in this paper.

Keywords： supercritical pressure heat transfer positive cooling methane conjugate heat transfer numerical simulation

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