Contribution ID: **56** Type: 海报展示

氦氙混合气体在平行槽道中的直接数值模拟与湍流普朗特数模型

摘要

氦氙混合气体被广泛应用于多种微型气冷核反应堆的设计中。然而，由于其普朗特数显著不同（约为0.2），氦氙混合气体的湍流流动与换热特性尚不完全明确。由于以往大多数湍流普朗特数模型的研究对象均为更低普朗特数流体（如液态金属，Pr<0.03）或更高普朗特数流体（如水，Pr»1），因此在为氦氙混合气体选择合适的湍流普朗特数模型方面仍存在挑战。直接数值模拟方法是湍流建模的基础，有助于湍流模型的构建。本文对平面通道内氦氙混合气体的流动与换热进行了直接数值模拟，雷诺数范围为 5600 至 13700，普朗特数范围为 0.2~0.3。同时，结合 SST k-ω 湍流模型，对几种湍流普朗特数模型进行 RANS 计算，并与直接数值模拟结果进行了对比。综合考虑雷诺数、普朗特数及壁面法向距离的影响，提出了一种三参数湍流普朗特数模型，以表征近壁面区域的变化规律。该模型还对特定湍流模型下湍流黏度的偏差进行了补偿，并给出了新模型在有修正与无修正情况下的对比结果。通过分析，提出了新模型的使用建议。

关键词

氦氙混合气体, 直接数值模拟, 普朗特数，槽道, 湍流普朗特数模型

Abstract

The helium-xenon gas mixture is used in various designs of micro gas-cooled nuclear reactors. The turbulent flow and heat transfer of helium-xenon is not well understood due to its distinct Prandtl number (~0.2). There is still challenge in choosing proper turbulent Prandtl number model for helium-xenon, since most previous turbulent Prandtl number models were investigated for lower Prandtl number fluids (liquid metals, <0.03) or larger Prandtl number fluids (water, »1). The direct numerical simulation method is fundamental in turbulence modeling and is helpful in formulating turbulence models. The flow and heat transfer of helium-xenon in a planar channel was simulated with the Reynolds numbers ranging from 5,600 to 13,700 and the Prandtl numbers of 0.2~0.3. Several turbulent Prandtl number models along with the SST k-ω turbulence model were also used and compared with direct numerical simulation method. By considering the effects of Reynolds number, Prandtl number and wall-normal distance, a three-parameter turbulent Prandtl number model was proposed to depict the near wall variations. It also compensated the deviation of turbulent viscosity from the specific turbulence model and show the comparison results between the new model with and without correction. Through analysis, usage suggestions for the new model were given.

Keywords

helium-xenon gas mixture, direct numerical simulation, Prandtl number, planar channel, turbulent Prandtl number model

Authors: Dr 舜琦, 王 (清华大学核能与新能源技术研究院); Prof. 宇, 吉 (清华大学核能与新能源技术研究院); Prof. 俊, 孙 (清华大学核能与新能源技术研究院); Prof. 玉良, 孙 (清华大学核能与新能源技术研究院)

Presenter: Dr 舜琦, 王 (清华大学核能与新能源技术研究院)

Session Classification: 海报展示

Track Classification: 海报展示: 海报展示