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槽道内氦氙混合气体 **RANS** 模拟的计算模型适用性研究

摘要

小型气冷核反应堆系统多以氦氙混合气体为循环工质及堆芯冷却剂。在推荐混合比下，其普朗特数（Pr）可低至 0.2。雷诺时均模拟（RANS）方法依赖湍流模型与湍流普朗特数（Prt）模型，已有研究重点关注 Prt 模型对氦氙换热的影响，对湍流模型适用性的讨论还不深入。本文采用 RANS 方法研究槽道内氦氙气体流动换热，并与直接数值模拟（DNS）结果对比，依次开展湍流模型与 Prt 模型适用性研究，阐明湍流模型和 Prt 模型对 RANS 结果的影响。结果表明，SST k-ω 模型是槽道流的优选湍流模型，当前的 Prt 模型仍需改进才能更好满足氦氙的换热计算。建议针对氦氙流动换热的 RANS 分析中应同时考虑湍流模型和 Prt 模型的组合。

关键词

雷诺时均模拟；DNS 标准数据；RANS 计算模型

Abstract

Small gas-cooled nuclear reactor systems almost regard the helium-xenon mixture (He-Xe) as the cycling working fluid and reactor core coolant. With the recommended mixing ratio, the Prandtl number (Pr) of He-Xe is as low as 0.2. The RANS method is the main method on the CFD computation of nuclear engineering, which needs the turbulence model and Prt model. Previous studies have focused on the effect of Prt model on He-Xe heat transfer, but the applicability of turbulence model has not been deeply discussed. In this paper, the RANS method is used to study the flow and heat transfer of He-Xe in a parallel channel, and the applicability of turbulence model and Prt model is studied in order to clarify the influence on the heat transfer simulation. The results show that the SST k-ω model is the preferred turbulence model for the channel flow, and existing Prt models still need to be improved to satisfy the heat transfer simulation of He-Xe. It is proposed that the combination of turbulence model and Prt model should be considered in RANS analysis of He-Xe flow and heat transfer.

Keywords

Reynolds-Averaged Numerical Simulation; DNS standard Data; RANS Models

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