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圆管内组分热扩散对氦氙流动换热的影响研究

摘要

氦氙混合气体作为空间堆冷却工质，在温度梯度影响下会出现热扩散现象，导致氦氙混合不均匀。现有氦氙流动换热相关研究均将氦氙作为一种纯气体，不考虑混合不均匀的问题。但氦气、氙气性质差异大，混合不均匀对流动换热特性可能存在较大影响。本文以 Taylor 的氦氙流动换热实验为基础，基于 Fluent 针对圆管内氦氙在温度梯度的热扩散影响下的混合均匀性分布以及对流动换热的影响开展研究。结果表明在 Taylor 的工况下，热扩散对氦氙流动换热的影响并不明显。进一步分别针对不同加热段热流密度、入口混合均匀性，探究截面上氦氙分布变化以及对氦氙流动换热的影响。结果表明热流密度越高、加热段长度较短的情况下，热扩散对氦氙混合均匀性及流动换热带来的影响越大。

关键词

氦氙混合气体；流动换热；组分输运；热扩散

Abstract

Helium-xenon gas mixture is used as the coolant of space nuclear power plants. Under the influence of temperature gradient, thermal diffusion will lead to uneven mixture of helium-xenon. Current studies on helium-xenon flow and heat transfer regard helium-xenon as pure gas, without considering the problem of uneven mixing. However, the properties of helium and xenon are very different, and the non-uniform mixing may have a great influence on the characteristics of flow and heat transfer. In this paper, based on Taylor's experiment, the mixing uniformity distribution of helium-xenon and the flow and heat transfer characteristics in a circular tube under the influence of thermal diffusion are studied based on Fluent. The results show that the influence of thermal diffusion on helium-xenon flow heat transfer is not obvious in Taylor's working condition. Further, the variation of helium-xenon distribution and its influence on helium-xenon flow and heat transfer are investigated according to the different heat flux and inlet mixing uniformity respectively. The results show that the higher the heat flux and the shorter the length of the heating section, the greater the influence of thermal diffusion on the mixing uniformity and flow and heat transfer characteristics of helium-xenon gas mixture.

Keywords

Helium-xenon gas mixture; Flow and heat transfer characteristics; Species transport; Thermal diffusion

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