

加热圆管内氦氙分布影响因素及其对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致扩散现象，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下分离的影响因素以及对流动换热的影响开展研究。结果表明温度梯度下氦氙分离主要受热流密度、来流雷诺数以及来流温度的影响，热流密度越大、来流雷诺数越小、来流温度越低，氦氙分离越明显。同时圆管上游的弯管形式对圆管内的换热无明显影响。由于氦氙分离主要存在于近壁面区域，加热促使氦气在壁面处聚集，反而抑制了热致扩散，导致氦氙分离程度有限，对管内换热影响无明显影响。

关键词

氦氙混合气体；组分运输；热致扩散；流动换热

Abstract

Helium-xenon gas mixture is used as the coolant for space nuclear power plants. Under the influence of temperature gradients, thermal diffusion occurs, leading to an uneven mixture of helium and xenon. Existing research on helium-xenon flow and heat transfer treats the mixture as a pure gas, ignoring the issue of uneven mixing. However, due to the significant differences in the properties of helium and xenon, the uneven mixing may have a considerable impact on the flow and heat transfer characteristics. This paper is based on Taylor's helium-xenon experiment and uses Fluent to study the factors influencing the separation of helium and xenon in a circular tube under temperature gradients and its impact on flow and heat transfer. The results show that the separation of helium and xenon under temperature gradients is mainly affected by heat flux density, inlet Reynolds number, and inlet temperature. When the heat flux density is high, the incoming flow Reynolds number is low, and the incoming flow temperature is low, helium and xenon are more easily separated. Meanwhile, the form of the upstream elbow in the circular tube has no significant effect on the heat transfer within the tube. Since the separation of helium and xenon mainly occurs in the near-wall region, heating causes helium to accumulate at the wall, which instead suppresses thermal diffusion, resulting in a limited degree of separation and no significant impact on the heat transfer within the tube.

Keywords

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

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