Contribution ID: **64** Type: 口头报告

HTR-PM 正常工况一回路典型核素化学形态和化学反应研究

摘要

核素的化学状态会极大地影响其在多组分和多相系统中的行为，包括吸附、解吸、沉积、扩散、迁移和化学反应。根据世界上第一个鹅卵石床模块化高温气冷堆示范电站（HTR-PM）的设计和运行参数，在热力学框架和新开发的二维投影相图下，研究了 HTR-PM 正常运行条件下一次回路中 14 种典型核素的化学状态和潜在反应。利用相关矩阵定量分析了影响化学态的因素，包括温度、压力和杂质元素（C、H、O 和 N）的数量。结果表明，温度对核素化学态的影响最大，而压力和 N 含量的影响可以忽略不计。在 C 和 O 对典型核素化学态的影响之间发现了一种镜像对称关系。这种对称性所导致的相界在很大程度上受到次要元素化合物的化学状态和含量的影响。该研究系统地提供了典型核素在 HTR-PM 一次回路中的化学状态和反应，对研究先进核能系统中裂变产物的行为具有重要意义。所开发的技术和方法也广泛适用于多组分和多相化学系统。

关键词

HTR-PM 化学形态化学反应吉布斯自由能二维投影相图相关性分析

Abstract

The chemical states of nuclides significantly affect their behaviors in multicomponent and multiphase systems, including adsorption, desorption, deposition, diffusion, migration, and chemical reactions. Based on the design and operating parameters of the world's first pebble-bed modular high-temperature gas-cooled reactor demonstration power plant (HTR-PM), the chemical states and potential reactions of 14 typical nuclides in the primary circuit under normal operating conditions of HTR-PM were investigated under a thermodynamic framework and a newly developed two-dimensional projected phase diagram. A correlation matrix was used to quantitatively analyze the factors influencing the chemical states, including the temperature, pressure, and amount of impurity elements (C, H, O, and N). The results showed that the temperature had the greatest effect on the chemical states of the nuclides, while the pressure and N content had negligible effects. A mirror-symmetry relationship was discovered between the effects of C and O on the chemical states of typical nuclides. The phase boundary caused by this symmetry was largely influenced by the chemical states and contents of the compounds of minor elements. This study systematically provides the chemical states and reactions for typical nuclides in the primary circuit of HTR-PM, which is of great significance for research into the behaviors of fission products in advanced nuclear energy systems. The developed technologies and methods are also widely applicable to multicomponent and multiphase chemical systems.

Keywords

HTR-PM, Primary circuit, Chemical states and reactions, 2D projected phase diagram, Correlation analysis, Mirror symmetry relationship

Author: 郭, 静霓 (北京市清华大学核能与新能源技术研究院)

Co-author: Prof. 谢, 锋 (清华大学)

Presenter: 郭, 静霓 (北京市清华大学核能与新能源技术研究院)

Session Classification: 核能科学与工程

Track Classification: 03 口头报告: 核能科学与工程