

反应堆工程

高温气冷堆蒸汽发生器传热管断裂事故进水量分析

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收稿日期 2008-1-17 修回日期 2008-3-24 网络版发布日期: 2009-5-20

摘要 模块式高温气冷核反应堆是一种安全性好、发电效率高的先进核反应堆。蒸汽发生器传热管断裂导致一回路进水的事故对于高温气冷堆是特有的, 可能导致高温石墨燃料和构件与水发生化学反应, 引起放射性物质释放和大量可燃爆气体产生的严重后果。对此事故进行深入分析对于验证高温气冷堆的固有安全性有着重要意义, 而事故过程中的进水量对事故后果严重性有非常重要的影响。本工作以清华大学核能与新能源技术研究院设计的10 MW高温气冷堆(HTR-10)为例, 针对蒸汽发生器传热管两种典型位置下的单管、双管双端(2A)断裂, 使用热工水力系统分析程序RETRAN-02模拟分析了断管进水过程。分析表明, 进水量与断管位置、断管数目、破口面积有关。入口段断裂进水量比出口段断裂进水量更大。断管处破口面积越大、断管数目越多, 进水量越大。HTR-10泄放系统可有效排空蒸汽发生器内存留的水和蒸汽, 以免其大量进入一回路。

关键词 [高温气冷堆](#); [传热管断裂](#); [进水](#)

分类号 [TL334](#)

Analysis on Water Ingress Mass in Steam Generator Heat-Exchange Tube Rupture Accident of High-Temperature Gas-Cooled Reactor

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Abstract The module high-temperature gas-cooled reactor (HTGR) is an advanced reactor with high safety and high efficiency in electric power generation. The steam generator heat-exchange tube rupture accident which will result in the water ingress to the primary circuit of reactor is an important and particular accident, and it may result in chemical reaction of graphite fuel and structure with water causing severe results with massive release of radioactive isotopes and production of explosive gaseous in large quantity. The analysis of the water ingress accident is significant for verifying the inherent safety characteristics of HTGR. The seriousness of the accident consequence is affected directly by the amount of water ingress mass. The 10 MW High-Temperature Gas-Cooled Reactor (HTR-10) designed by the Institute of Nuclear and New Energy Technology of Tsinghua University was selected as an example of analysis, and the 2-area (2A) broken (or double-ended breakup) single and two heat-exchange tubes at the inlet and outlet of steam generator were simulated respectively by RETRAN-02, a general-purpose thermal-hydraulic system analysis program. The amount of water ingress mass is related with the broken position, the broken area and the number of broken tubes. The amount of water ingress mass at inlet of steam generator is more than that at outlet. The greater the broken area or the number of broken tubes, the larger is the amount of water ingress mass. The water in steam generator could be drained effectively by the HTR-10 emptier system, so it will prevent the primary circuit of reactor from water ingress due to water leakage from steam generator.

Key words [high-temperature](#) [gas-cooled](#) [reactor](#) [broken](#) [heat-exchange](#) [tube](#) [water](#) [ingress](#)

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