

# 一体化供热堆工程模拟机关键技术研究

## 摘要

一体化供热堆主要是用于满足工业供汽、核能供暖、海水淡化等需求的全新堆型，为解决一体化供热堆研发过程中的控制运行方案论证，工艺、控制和人机操作系统闭环设计验证，以及操作规程研发验证等综合性问题，需要研发一套适用于一体化供热堆的工程模拟机。本文基于一体化供热堆型号特点，开展了一体化供热堆工程模拟机关键技术的深入分析和研发工作，建立了一体化供热堆工程模拟机，并利用所研发的工程模拟机对供热堆运行控制方案进行了验证和优化。研究发现了一体化全自然循环反应堆降功率特有的惯性延迟特性，采用经过优化的控制系统可以有效缓解一体化供热反应堆功率线性变化瞬态工况下反应堆功率、一回路平均温度、二回路蒸汽压力等关键参数的周期性震荡。所研发的一体化供热堆工程模拟机为供热堆控制方案论证提供了有利的研究工具，为后续工艺、仪控闭环验证、操作规程研发验证提供了有利工具。

## 关键词

一体化供热反应堆；工程模拟机；实时仿真；DCS

## Abstract

The integrated heating reactor is a novel design intended to meet diverse energy demands, including industrial steam supply, district heating, and seawater desalination. To address key challenges in its development—such as verifying control strategies, conducting closed-loop validation of processes, instrumentation and control (I&C), and human-machine interface systems, and ensuring the correctness and practicality of operating procedures—a dedicated engineering simulator is essential. Building on the reactor's specific design features, this study analyzes key enabling technologies, develops an engineering simulator, and uses it to verify and optimize operational control schemes. The investigation reveals an inherent inertia-induced delay in power ramping unique to fully natural-circulation reactors. By applying optimized control system strategies, oscillations in reactor power, primary loop average temperature, and secondary loop steam pressure during ramp power change transients are effectively suppressed. The developed engineering simulator therefore serves as a powerful platform for evaluating control strategies, providing crucial support for closed-loop verification of processes and instrumentation, and refining operational procedures.

## Keywords

integrated heating reactor; engineering simulator; real-time simulation; distributed control system

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