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STABILITY ANALYSIS OF A SMR WITH LYAPUNOV METHODS

Light water SMRs cooled by natural circulation have intrinsic safety features that make them particularly interesting. The stability of these reactors, in which coupled neutronic, thermal and hydraulic phenomena coexist, has been satisfactorily studied for certain designs with different methods under normal and accidental conditions or after a scram.

This work addresses the study of stability from an alternative point of view. Starting from the simplified differential equations of the dynamics of a reactor with the peculiarities of a light water SMR reactor cooled by natural circulation, the characteristics that determine the evolution of the system over time are studied, and the Lyapunov methods for local and global stability are applied. The NUSCALE design reactor, with data obtained or estimated from public information, is taken as a reference, but the methods are universally applicable to other SMR of the same type.

As a result, local asymptotic stability has been verified by studying the responses to a step and a sinusoid of reactivity, and verifying that the eigenvalues of the equivalent reduced dynamic system are all negative. The global stability has also been tested by finding a valid Lyapunov function that involves the different state variables. Finally, it has been shown that the trajectories of the power and reactivity deviations in the phase plane converge towards the equilibrium state as a stable node.

This study does not replace other existing works, but rather reinforces and aligns with its conclusions.

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