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Research on modeling and simulation of the primary coolant system for China Experimental Fast Reactor

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Based on the structure and physical characteristics of primary coolant system (PCS) of China Experimental Fast Reactor (CEFR), a series of reasonable mathematical and physical models were set up. A set of stable and highly effective numerical methods were used to solve the models. Then the real-time thermal-hydraulic analysis codes for PCS of CEFR have been developed with modular method by using FORTRAN programming language. The codes have been merged into SimExecTM real-time simulation platform and could be linked to the modules of other systems.

The models include the basic thermal-hydraulic model of coolant, the heat transfer model of fuel pellet, the heat thermal model of intermediate heat exchangers (IHX), the model of primary pump, the flow friction and heat transfer correlations, the thermo-physical properties, etc. "Control body"method was put forward in the set of models and Gear method was applied to solve the thermal-hydraulic model of coolant and heat transfer model of fuel pellet. Quasi-newton iteration method was used to solve the flow rate distribution equations. The model and numerical method in this research contribute to the accurate and effective of calculation to meet the requirement of real-time simulation.

The design parameters of CEFR were used to validate six different steady-state conditions from 26.5%FP to 100%FP by this code, and the steady-state calculation of the reactor main vessel cooled system was also finished and the results were compared with the datum obtained by the references. Thus the validity and applicability of this code was proved. The normal operation conditions were calculated and validated by the manual of PCS of CEFR. The reactivity insertion accident, the loss of coolant accident and the loss of heat sink accident were also simulated. The results showed that the trend of simulation curves for the steady and transient conditions are reasonable, which are in accordance with the actual physical process. The real-time characteristics of the code were analyzed and could meet the simulation requirements.

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