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Scaling analysis and design for the test model of water-cooled ceramic breeder blanket

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In Chinese Fusion Engineering Test Rector (CFETR), blanket is a key component, responsible for producing and transporting tritium, energy conversion and output, so its safety is of particular concern. The water-cooled ceramic breeder blanket (WCCB) is one of three candidate blankets for CFETR. To confirm safety of WCCB, sufficient data are required to estimate the thermal-hydraulic state and response in the blanket during postulated accidents. Due to strict test conditions and the complexity of WCCB structure, the expense of direct experiments is so great that it is inevitable to design a simplified and scaled-down model instead of the prototype for experiments with some appropriate scaling techniques. In this paper, based on same working fluid—water, full-temperature and full-pressure test conditions, scaling analysis is used. On one hand, the top-down scaling analysis is adapted to preserve the system dynamic responses. On the other hand, the bottom-up scaling analysis is adapted to preserve effective local phenomena. Through that, the characteristic time ratio group and the relation of important parameter ratios are established. The design scheme of reduced height and the number of flow channels is adopted, and the prototype blanket's structure is reasonably simplified to reduce difficulties of manufacture. Finally, scaling distortions of designed model are quantified, and verify that model can satisfy engineering application requirements. The test section can competently reproduce the thermal-hydraulic behaviors in WCCB.

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