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Prediction of departure from nuclear boiling in the first wall of WCCB blanket for CFETR

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The Water Cooled Ceramic Breeder blanket(WCCB), which employs the operating conditions of Pressurized Water Reactor(PWR), namely inlet/outlet temperature of 285/325℃ and pressure of 15.5MPa, is being comprehensively researched in the Institute of Plasma and Physics Chinese Academic of Sciences. As an important component of the Water Cooled Ceramic Breeder blanket(WCCB), the first wall faces the plasma directly. It removes away the high heat flux and nuclear volumetric heat by coolant water flowing through the internal cooling passages. The departure from nuclear boiling(DNB) is the typical crisis in the reactor which uses water as coolant, especially for PWR, because it can make the water near heated wall dry out, at which point the local temperature can have a excursion exceeding the limits and the integrity of the structure is damaged. The DNB can easily happen in the first wall(FW) channel for the reason that the enhanced radial transport and edge-localized modes(ELMS) in the fusion reactor can increase the heat flux as high as several MW/m2. Therefore, the investigation on the departure from nuclear boiling is necessary.
In this paper, the DNB is numerically analyzed by the CFD approach, which has the capacity of solving the Eulerian two-phase equation with Rensselaer Polytechnic Institute (RPI) wall boiling model. Responding to the excursion of heat flux, the main issue concerned is to determine the ultimate heat flux when the boiling instability happened during the normal operation, indicating the DNB occurs. Furthermore, the influence of different structure design on DNB is also investigated. The FW containing the parallel channels is modeled, in which the velocity of each channel is obtained from the previous thermal hydraulic analyses on the blanket under the normal condition, namely the heat flux of 0.5MW/m2. Besides, the detailed flow behavior and distribution of two-phase are also revealed. All these results are beneficial for the further safety operation of fusion reactor.

Eligible for student paper award?

Yes

Author: Dr JIANG, Kecheng (Institute of Plasma Physics Chinese Academy of Science;University of Science and Technology of China)

Co-authors: Dr LI, Min (Institute of Plasma Physics Chinese Academy of Science); Dr MA, Xuebin (Institute of Plasma Physics Chinese Academy of Science;University of Science and Technology of China); Dr HUANG, Kai (Institute of Plasma Physics Chinese Academy of Science); Prof. LIU, Songlin (Institute of Plasma Physics Chinese Academy of Science)

Presenter: Dr JIANG, Kecheng (Institute of Plasma Physics Chinese Academy of Science;University of Science and Technology of China)

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