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核融合炉安全性確保のための対向機器健全性評価
Analyses on plasma facing components for safe operation of fusion reactors

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Introduction

Safety of fusion reactor must be assured before the construction of a fusion power demonstration reactor (DEMO). Operation of the reactor should be terminated passively and/or actively in cases of plasma and plant anomaly events. Previous studies [1, 2] for ITER concluded that in case of the ex-vessel Loss of Coolant Accident (ex-LOCA), temperature of plasma facing walls increases, thus impurities emitted from these walls eventually terminate the plasma operation. However, these studies cannot be directly applied for DEMO. One major difference between ITER and DEMO is amount of neutrons. Since DEMO will be a neutron-rich environment, influence of leaking neutrons to the operation of superconducting coils at ultimate-low temperature becomes more important as well as radiation damages. Neutronics as well as thermal analyses on blanket, divertor, and TF coil components were taken in order to compare time scales of these sequential phenomenon caused by ex-LOCA.

Numerical Models

Multi-layered heat transfer equation was solved for the thermal analysis on blankets. The equation was solved with considerations on latent heats in case of melting and vaporization. For the thermal analysis on divertor, calculations were focused on the tungsten tiles. Effect of ELM heat loads to the surface temperature was carefully examined for various size and frequency of ELM heat loads.

Neutronics calculations were taken by the 1-D neutron transportation calculation code ANISN with Fendl2.0 under the THIDA-package. Using this package, neutron heating as well as activation of materials were calculated. Thermal analyses on blankets and divertor were taken using these results. Besides, nuclear heating rates at the TF coil were analyzed as a function of residual coolant water in the shield.

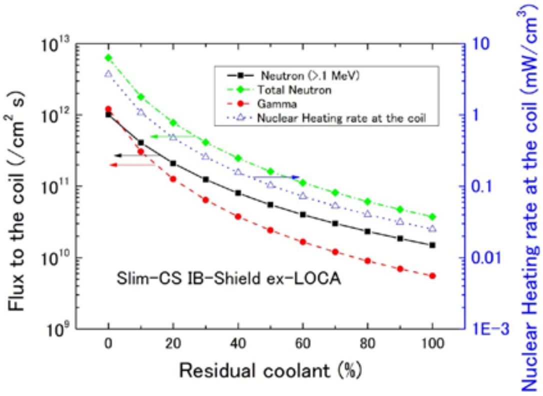

Fig. 1 Radiation flux and nuclear heating rate at the TF coil as a function of remaining coolant in the shield.

Results & Discussions

Thermal analysis on blanket showed that the steel-based structure materials would primarily reach its critical temperature. Analysis on divertor indicated that the frequency as well as the size of ELM heat loads is important for the achieving surface temperature.

Calculated radiation fluxes and nuclear heating rates at the TF coil were plotted in Fig.1. This figure indicates that the nuclear heating rate at the coil increases from 0.2 mW/cm^3 to 35 mW/cm^3 at a maximum. With this maximum nuclear heating rate, the TF coil would reach the Currie point within 10 seconds.

Summary

Thermal and nuclear analyses for blanket, divertor, and TF coil have been taken. Results indicated that a quench of the TF coil would possibly happen due to the increasing nuclear heat as a consequence of the decreasing shielding performance by ex-LOCA. Upgrade and integration of models are being processed.

[1] T. Honda and et al., Journal of Fusion Energy, **16**, 175 (1997)

[2] J.C. Rivas and J. Dies, Fusion Engineering and Design, *In Press*