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Impact of the Neutral and Impurity Transport model on Divertor Heat Load in Fusion Demonstration Reactor

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In tokamak-type fusion devices, it is essential to reduce the heat load on the diverter plates caused by power exhaust from the hot core plasma. This is particularly crucial in a demonstration (DEMO) reactor, where power exhaust three times that of ITER is expected. In previous studies, the divertor plasma characteristics were analyzed by the integrated diverter code SONIC [1] and operating scenarios and wall shapes to reduce the heat load were proposed.

Concurrently, in the SONIC code, several numerical models have been implemented/improved: the radiation transport/absorption model [2], more precious atomic and molecular data [3], elastic collision for neutral particles [4], and kinetic thermal force model for impurity transport [5] (referred as new models hereafter). The impacts of these new models on the DEMO divertor plasma have been individually investigated. Therefore, their synergistic effects and impacts on the operation window, especially the divertor heat load, are not clear yet. This study aims to investigate the impacts of new models on the divertor heat load control in DEMO reactors.

Numerical simulations of the diverter plasma for JADEMO are performed by the SONIC with new models. Following Ref. [6], the exhaust power from the core region of 250 MW(equivalent to the fusion power of 1.5 GW) and the radiated power of 175 MW due to the Ar puffing (80% of the exhaust power) are assumed as a reference scenario. The impurity radiation power and the electron density at the mid-plane in the Scrape-Off layer (SOL) are varied. Numerical results without and with new models under the above conditions are compared to investigate the impact of new models on the divertor heat load and the divertor operation window.

Figure 1 shows the peak heat load on the outer divertor as f_{rad}, which is a function of the impurity radiation fraction on the exhaust power. In $f_{rad} > 0.6$ of the modelOFF case, where the new models are switched off, the heat load is below 10 MWm!", which is the desired level in the engineering design. On the other hand, taking into account the new models (model-ON), the heat load increases, especially in f_{rad}<0.7, it exceeds 10 MWm!".

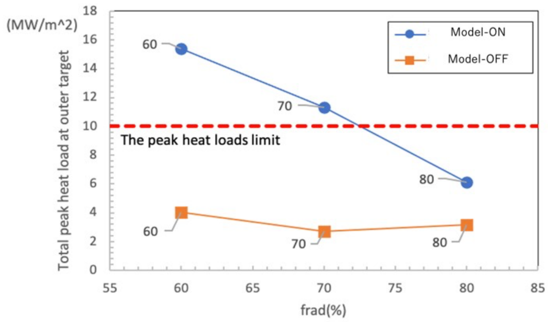

Fig. 1 The peak heat load against f_{rad} in the outer divertor

The increase in heat load may be explained by the influence of the impurity thermal force model. The new thermal force model affects the impurity transport and then the impurity radiation distribution. The impurity radiation in the Scrape-off Layer becomes low, and therefore the divertor heat load is increased.

In this study, introducing the new models results in an increase in the heat load on the divertor. The result suggests that the divertor plasma designs in the viewpoint of the divertor heat load need to be reassessed under somewhat more stringent conditions than the previous study. The result of other parameter dependence, such as the mid-plane density, exhaust power, etc., and a detailed analysis of the impact of each new model on the operation window for the divertor heat load will be discussed in the presentation.

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