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トカマク原型炉の先進ダイバータ概念設計における物理および工学要素の検討
Investigation of physics and engineering issues in advanced divertor design for tokamak Demo reactor

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Handling of an extreme exhausted power to the divertor is the most important issue for the fusion reactor design. Recently, magnetic configurations of *advanced divertor* such as super-X divertor (SXD) and snowflake divertor (SFD) has been proposed for a Demo reactor in order to reduce the target heat load by increasing connection length ($L_{//}$) and magnetic flux expansion. Magnetic configurations of the SXD and SFD divertors were investigated for an ITER-size Demo reactor, SlimCS (R = 5.6m, a = 2.1m, I_p = 17MA) [1], as shown in Fig.1. It was found that $L_{//}$ is increased 1.4-1.8 times, while the divertor size is comparable to the conventional divertor. Physics and engineering issues for the advanced divertor, particularly for SXD, are investigated.

This SXD geometry is compact, compared to other SXD proposals with the long-divertor leg and extending to outboard. Formation and control of the plasma detachment near the SX null are the important issues for the Demo application. Effect of the SXD magnetic configuration on the divertor detachment is investigated, using the divertor simulation code, SONIC. Since the field line length and the flux expansion near the SX-null are strongly increased with the magnetic flux ratio ($f_{SX} = [\Psi_{SX} - \Psi_{ax}]/[\Psi_s - \Psi_{ax}]$) as shown in Fig. 2, enhancements of the radiation power and plasma detachment are the important issues of the compact SXD design. Calculation mesh was generated, and the result will be shown for the first time.

Arrangement of the divertor coils is the important engineering issue for the Demo application. It was found that the divertor coil currents are decreased comparable to or less than the plasma current by installing inside TFC (interlink) as shown in Fig. 1. For the Demo advanced divertor, the divertor coil arrangement is restricted by structural design such as the divertor cassette, vacuum vessel, and neutron and thermal shieldings, as well as by the coil currents and size. At the same time, it will be designed for the divertor replacement. The divertor coil arrangement, inside and outside of TFC and their combination, is investigated from these engineering viewpoints. Advantages and issues of the Demo advanced divertor mainly for SXD are discussed.

[1] N. Asakura et al. Trans. Fus. Sci. Tech. **63** (2013) 70.

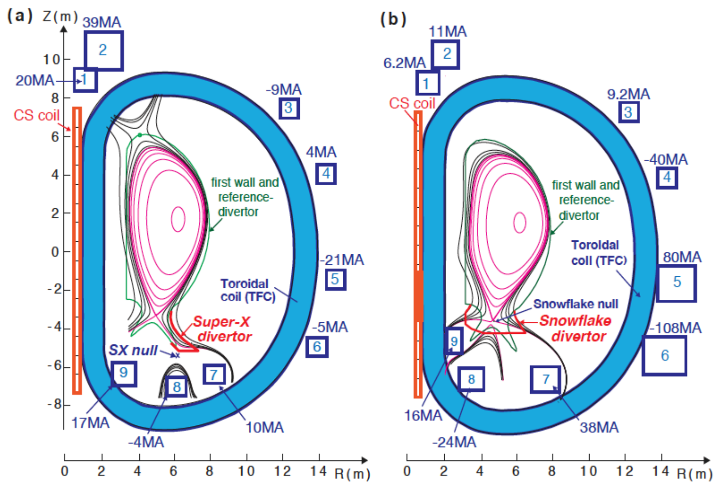

Fig. 1. Plasma equilibriums and divertor geometries for (a) super-X divertor (SXD) with R_{SX} = 6.0 m, f_{SX} = 0.95, and (b) snowflake divertor (SFD). Locations of three divertor coils are arranged inside TFC. PFC current distributions are described.

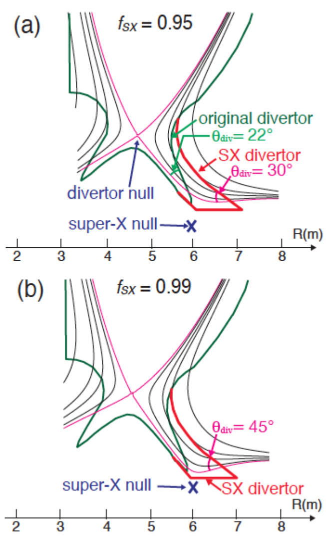

Fig. 2. Magnetic configurations for SXD: (a) f_{SX} = 0.95, (b) f_{SX} = 0.99. SOL field lines correspond to Δr^{mid} = 0, 1, 3, 5, 10 cm, and the reference divertor and extended SXD are shown.