Proposal of split and segmented-type helical coils for the heliotron fusion energy reactor

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Based on the successful progress of fusion relevant plasma experiments in the Large Helical Device (LHD), the conceptual design studies on the heliotron-type fusion energy reactor (FFHR) are being conducted. The present design gives the major radius of the helical coils of 14-18 m with the stored magnetic energy of 120-150 GJ [1]. A pair of continuous helical coils are wound with the toroidal pitch number m of 10, and the helical pitch parameter γ of 1.2-1.15. It was found in the previous studies that symmetry of magnetic surfaces is improved, without shifting the magnetic axis inward, as the current density of helical coils is increased at the inboard side while it is decreased at the outboard side [2]. This could be realized by splitting the helical coils in the poloidal cross-section. Here we also found that by lowering the γ value further to be about 1.0 together with split of helical coils, drastically larger spaces are obtained between the blankets and plasma. The properties of this new configuration are being examined with respect to vacuum magnetic surfaces (an example is shown in Fig. 1), confinement properties of alpha particles and electromagnetic forces. It should also be noted that by having split-type helical coils, RF waves and/or pellets can be injected through the helical coils from the outboard side (which corresponds to the higher magnetic field side).

For FFHR, 100 kA-class superconductors are required to be used at the maximum magnetic field of 13 T. As the third candidate in the present conductor selection, high-temperature superconductors (HTS) are considered with indirect-cooling scheme operated at the temperature range of 20-30 K [3]. Our proposal is to employ RE123-based coated-conductors and Fig. 2(a) shows a conductor design. HTS tapes are packed without transposition, and the bending strain is limited to be 0.05%. Good mechanical properties are secured also by using a stainless-steel jacket. The helical windings can be assembled with prefabricated half-pitch or one-pitch segments [3] (see Fig. 2(b)), which could drastically ease the construction process especially for the split-type helical coils.

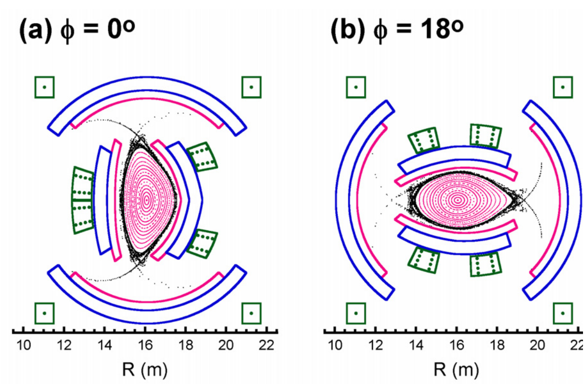

Fig. 1 Vacuum magnetic surfaces of FFHR-2S with split-type helical coils.

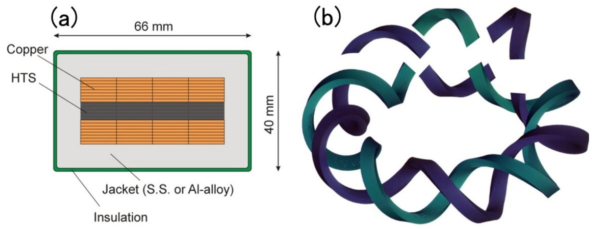

Fig. 2 (a) Conceptual design of a 100 kA-class HTS conductor and (b) illustrative image of (half-pitch) segmented helical coils.

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[2] K. Nishimura, M. Fujiwara, J. Phys. Soc. Japan **64** (1995) 1164.
[3] G. Bansal et al., Plasma and Fusion Research **3** (2008) S1049.