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Design study of superconducting TF coil concept with rectangular conductor layer winding with high manufacturability and insulation reliability for JA DEMO

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In this study, we focused on the layered winding concept, in which the conductor can be optimized for each layer by grading, and succeeded in the significant improvement of the conventional rectangular conductor winding concept. The radial plate (RP) system is the main proposal for the toroidal field (TF) coil of Japan's DEMO (JA DEMO), because of its performance in ITER. However, the RP system has a problem of cost increase due to its difficulty in fabrication. In recent years, the double pancake winding concept using rectangular conductors has been investigated as an alternative to the RP method, which has advantages over the RP method in terms of manufacturability and cost, but one of the problems of the conventional rectangular conductor concept remains the reliability of the insulation, i.e., the reduction of stress on the turn insulation.
In this study, taking advantage of the grading in the layered winding concept, the conductor arrangement and the conductor cross-sectional shape for each layer were investigated and optimized to reduce the stress on the insulation. As a result, lower shear stress on the insulation was achieved than the RP method. In addition, the current sharing temperature Tcs was calculated from the maximum magnetic field of each layer, and the amount of Nb3Sn strand was optimized to achieve a temperature margin of 1.5 K in each layer. As a result, we have developed a concept in which the amount of Nb3Sn wire can be reduced by up to 62% from the conventional RP method or the double pancake winding concept with rectangular conductors while maintaining the temperature margin by grading.

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