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Conceptual design of CRAFT TF coil heat treatment

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The Comprehensive Research Facility for Fusion Technology (CRAFT) project is a key pre-research project of the China Fusion Engineering Test Reactor (CFETR) device in China. The manufacture of a full-size CFETR toroidal field (TF) coil is one of the key sub-topics of the CRAFT project, which is completed by the Institute of Plasma Physics Chinese Academy of Sciences (ASIPP). A hybrid superconducting magnet structure will be used for the TF coil design, in which the high-field and medium-field windings are made of Nb₃Sn circle-in-square CICC, and the low-field winding is made of NbTi circle-in-square CICC. With a conductor operating current of 95.6 kA, a toroidal field of 6.5 T is generated and the peak field is 14.5 T. The CRAFT TF coil has a “D”-shaped profile. The shape of the Nb₃Sn coil is about 19.5m in length, and about 11.01m in width and the maximum height is 1.1m. The Nb₃Sn strands before heat treatment has excellent strength and toughness, which is good for coil winding, but the Nb₃Sn strands after heat treatment will cause performance degradation under the action of trace stress and strain. Therefore, the process of “wind and react” will be applied to the manufacture of TF Nb₃Sn coil. We plan to design a large-scale controlled atmosphere oven heat treatment system to complete the Nb₃Sn coil heat treatment. The effective temperature uniform zone size of the heating furnace is 20.1m in length, 11.5m in width and 1.5m in height. This article will define the process requirements for the heat treatment of the TF coil, introduce the structure and composition of the heat treatment system and the heat treatment process. The process must meet TF requirements for control of the reaction environment, the temperature and time constraints, and coil deformation constraint.

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