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Multiphysics Analysis of W7-X Control Coils

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The quasi-symmetric fivefold modular Wendelstein 7-X (W7-X) stellarator consists of three groups of coil systems, i.e. superconducting magnet, trim coil and control coil systems. The control coil system contains ten identical 3D shaped control coils (CC) situated behind the baffle plates of corresponding divertor unit, and is designated to rectify the error field and to sweep hot spots on the divertor target plates. The CC is wound from copper conductor with a square cross section of 16 mm x 16 mm and a water cooling hollow of \varnothing 8 mm. The control coil system was installed in W7-X in 2015, and the integral commissioning has been done in parallel with the completion of W7-X. During the operation phase (OP 1.2a) with limited plasma heating power, a leakage in one of the CC cooling water plug-in was found and dictates a detailed transient thermal analysis of CC to determine the allowable operation time without cooling water flow. The paper presents the transient thermal analysis and is followed by a detailed finite element mechanical analysis with the consideration of temperature gradient loads, dead weight and electromagnetic forces. Moreover, the transient thermal and mechanical performance of actively cooled CC to be intensively operated during state steady operation phase (OP 2) are also analyzed and evaluated with the same FE model.

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