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Advanced Structural Analysis of Wendelstein 7-X Magnet System Weight Supports

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The Wendelstein 7-X (W7-X) optimized stellarator is presently under final stage of assembly at the Max-Planck-Institut für Plasmaphysik in Greifswald. The goal of W7-X is to verify that the advanced stellarator magnetic confinement concept is a viable option for a fusion reactor.

The coil system consisting of 70 superconducting coils of seven different types is supported by a massive central support structure (CSS), and thermally protected by the cryostat. The magnet system weight is borne by supports which are bolted to the cold CSS. The CSS is supported by 10 so-called cryo-legs that penetrate through the cryostat wall to the warm machine base. The design of the cryo-legs incorporates glass-reinforced plastic tubes to guarantee relatively small thermal conductivity for low heat flux to the cryostat. In order to ensure free thermal shrinkage of the magnet system and to reduce stresses in the cryo-legs, sliding and rotating bearings are used as interfaces to the machine base. Tie rods between the machine base and the warm ends of the cryo-legs prevent toroidal movements of the magnet system with respect to the torus axis, as well as a horizontal shift due to any non-symmetric loads.

During assembly of the W7-X magnet system some important measurement results have been collected and analyzed. In particular, the assembly of the magnet system introduced some imperfections in the vertical position of the cryo-legs causing considerable additional internal stresses which were not considered during the design stage. In addition, trim coils were installed at a later stage which were not planned originally when the magnet structure was designed. The loads induced by them are not cyclic symmetrical, therefore, the previously used method to analyze one magnet system module with periodical boundary conditions is not applicable. Consequently, a model of the complete magnet system including all five modules was created and analyzed with respect to the mentioned goal.

Fatigue analyses of the cryo-legs under the new cyclic loads applied on top of the approximately 100 t static weight has been performed in order to evaluate the life time. The paper presents the progress in structural analyses of the W7-X magnet system under the as-built conditions, loads due to the trim coil operation, and results of the weight support life cycle analysis.

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