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Further Development of the W7-X Magnet System FE Global Model in Preparation for Enhanced Operation Phase

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The Wendelstein 7-X (W7-X) stellarator equipped with a large cryogenic magnet system (MS) [1] has been extended for the long pulse operation at the Max-Planck-Institute for Plasma Physics in Greifswald, Germany. If the main focus of mechanical engineers during first two experimental campaigns was on the static structural strength of the MS, the issue of component cyclic behavior is addressed now. Therefore in parallel to the W7-X completion process, the MS global finite element model (FEM) and its postprocessing have been developed further to consider the effect of winding pack (WP) embedding (EB) process on coil stiffness and deformations as well as on planar coil case pins and bolts plastification. The updated post-processing routine predicts now how many electromagnetic cycles with particular loading patents could be safely withstood with required margins by the system components after cool down-warm up cycles.
The procedure of implementing the EB effect in the ANSYS® global FEM is based on the death/birth feature of particular elements, special fixation algorithm and careful check of the unavoidable artificial stress level.
The paper focus is on the structural cyclic behavior modelling of the W7-X magnet system components. Several related issues are addressed, such as:
1). Specific features of winding pack embedding modelling;
2). Reasonably simplified modeling of multiple pins and bolts in the FE global model;
3). Accurate prediction of plastic strain and stress levels using detailed local pin/bolt FEMs;
4). Influence of WP embedding on mutual coil displacements, stress levels, number of cycles and sensor signals to be monitored in the nearest future.
In addition, lessons learned so far are also briefly summarized.

[1] V. Bykov, J.Zhu, et al, Cyclic behavior of Wendelstein 7-X magnet system during first two phases of operation, IEEE Trans. Applied Superconductivity, Volume: 30, Issue: 4, page(s): 1-5, June 2020

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