Contribution ID: **4** Type: **not specified**

Mechanical analysis of the DEMO TF with 2D and 3D models: homogenized and fully detailed – comparison of accuracy

Thursday 4 May 2023 16:15 (30 minutes)

The most common type of models used to analyzed the design of the toroidal field (TF) coils of tokamaks rely on the homogenized mechanical properties of the winding pack (WP). Such approach simplifies the model and reduces the computational time at the cost of introduced simplifications, the main one being the loss of information on the stress and strain fields inside the WP. In this work a fully detailed 3D model of the DEMO TF coil was developed as well as a homogenized model, and the results of the two models were compared to judge the accuracy/error of the homogenization approach.
The Lorentz forces were computed with a global electromagnetic model, developed in Ansys APDL based on the scalar potential approach (SOLID96+Sourc36 elements). For the detailed model, the circular strands based on the WP#4 TF design by CEA were approximated by finite number of rectangles –due to limitation of the Sourc36 elements. The necessary number of rectangles that approximate the circular strands was found based on a parametric study. Additionally, a method of computing the EM force densities, unavailable directly for Solid96 elements, was proposed allowing easy transfer of the results to the mechanical model.
As the homogenized model does not provide relevant information from the WP, the usual method accepted in the community relies on a detailed 2D model. Such model was developed as well and its results were compared to the fully detailed 3D model to evaluate the error introduced by 2D modeling, especially looking at the stress levels in the conductor's jacket and its insulation.
The computational cost of both the EM and mechanical models was analyzed in details, having a16 CPU workstation as the hardware. Computing times and RAM requirements were analyzed for the Ansys software. Further perspectives of running nonlinear mechanical models with ˜10e6 elements and larger on the state-of-the art workstations were discussed.

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Session Classification: Mechanical modelling - 2