Development of a method to reconstruct modal forces on the EU ITER Test Blanket Module sets based on strain measurements and related procedure for validation of electromagnetic codes

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The EU ITER Test Blanket Module (TBM) sets, which consist of TBM box and shield, will be located inside the equatorial port #16 of ITER. One of the important objectives of the TBM program, starting from the first H-H phase, is the validation of the theoretical predictions of the structural behavior of the TBM set under thermal, mechanical and electromagnetic loads. High electromagnetic forces acting on the TBM sets, especially during off-normal operation, are one of the most demanding loading conditions. In order to estimate these forces, a force reconstruction method is proposed. The reconstruction is based on measurements of strain sensors on the attachment system, which connects TBM box and shield.

Due to the distributed characteristic of the electromagnetic forces, the forces are reconstructed in terms of modal forces. This approach as well as the use of modal forces to validate electromagnetic analyses is described in detail. In addition, the development of the modal models of the TBM sets required for the force reconstruction algorithms is explained.

A number of test cases has been defined that cover a wide range of ITER relevant excitations of the TBM sets due to electromagnetic forces. Based on the simulation of these test cases the influence of errors in the developed models on the accuracy of the reconstructed forces is evaluated. In this context, also the influence of the number of strain sensors is discussed. The determination of the sensor arrangements is based on a genetic algorithm. The requirements for the placement and installation of the strain sensors, which serve as input parameters for the genetic algorithm, are described.

Furthermore, the development of an experiment with a TBM box mock-up with a simplified attachment system to study the reconstruction of modal forces and the related validation of FEM codes is presented.