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Comparative electromechanical study of different Nb3Sn CICC designs for tokamaks with FE simulations

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Several designs of Nb3Sn Cable-In-Conduit Conductors (CICCs) have been proposed so far for high-performance tokamak magnets. The Nb3Sn strands composing the conductors are submitted to mechanical stresses of electromagnetic (EM) and thermal origin, inducing local deformations and affecting the strands critical current carrying capability. Even though it is possible to test the conductors to evaluate their electrical performance, it is still not possible to predict them during the conceptual design phase. In the last ten years a numerical tool based on a finite element (FE) code simulations has been developed to simulate the mechanical behavior of the CICCs subjected to various types of loading. The main goal is to predict the electro-mechanical performance of the conductor in operation as a function of the design parameters such as the void fraction, the twist pitches and the conductor shape.
In this work, the numerical modelling of different conductors from the ITER, DTT, JT60 and DEMO projects is presented, describing the strands belonging to one sub-cable of the last cabling stage (the so-called petal, consisting of a few hundreds of wires). A study is carried out to highlight how the different design choices affect the cable electro-mechanical performance. A more detailed model of the ITER TF CICC is also presented, which describes all strands of the cable. The purpose of this study is to validate the 237-strands model describing the petal (which accounts for the action of the other petals on the analysed one) by comparison with the 1422-strands model of the whole cable. The detailed model including all strands proves useful for a deeper understanding of the mechanical phenomena occurring among the sub-cables during the conductor operation.

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