ON THE THERMO-MECHANICAL ISSUES INDUCED BY NEUTRON SWELLING INSIDE THE BACK-PLATE OF THE IFMIF TARGET ASSEMBLY

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Within the framework of the IFMIF R&D program and in close cooperation with ENEA-Brasimone, at the Department of Nuclear Engineering of the University of Palermo a research campaign has been launched to investigate the thermo-mechanical issues potentially induced by neutron swelling in the bolted connections of the IFMIF target back-plate.

The main aim of the research campaign has relied in the assessment of the maximum swelling volumetric strain that may be accepted in order to allow bolts to withstand thermo-mechanical stresses and work in safe conditions or to avoid unduly high torques to disconnect the bolts during remotely handled maintenance operations. To this purpose, attention has been focussed on the assessment of the dependence on the swelling volumetric strain of both the maximum equivalent stress state and the unscrewing torque within those bolted connections that are expected to be used in the IFMIF target back-plate.

A theoretical approach based on the Finite Element Method (FEM) has been followed and a well-known commercial code has been adopted to perform the study.

Since the swelling volumetric strains within the back-plate have not yet been assessed, a parametric analysis has been carried out, assuming significant values of these strains and evaluating for each of them, by means of a proper FEM analysis, the corresponding maximum equivalent stress state and unscrewing torque within the bolt. Swelling volumetric strains ranging from 0.001% to 0.1% have been considered for the study, since it is possible to foresee that the actual strains within the bolts of the IFMIF target back-plate should lie in this interval.

A realistic three-dimensional FEM model of a portion of the target back-plate pertaining to a single bolt has been set-up and it has been optimized by running a mesh independency analysis. In particular, a mesh composed of about 180.000 nodes, connected in tetrahedral elements has been selected, which allows numerical simulations to be carried out in about 2 days. Coarser meshes, allowing running time to be saved, have given not sufficiently accurate results along the thread profile. A contact model has been implemented between the thread surfaces of both the bolt and the plate and a perfect Coulombian interaction has been assumed between them. EUROFER has been considered as the reference structural material.

A uniform thermal field of 350 °C has been applied to the model to realistically simulate the operating temperature of the target back-plate. A realistic set of boundary conditions has been imposed to the nodes of the free faces of the modelled plate, to simulate the actual effects of the finite back-plate on the bolt thermo-mechanical performances.

The results obtained are presented and critically discussed.