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Thermo-hydraulic analyses and fatigue verification of the Electrostatic Residual Ion Dump for the ITER HNB

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In the ITER Heating Neutral Beam Injector (HNB) the remaining charged particles after the neutralization process will be removed by an Electrostatic Residual Ion Dump (ERID) where electrostatic fields are used to deflect the ions that are so dumped on to five panels, each one composed of 18 separate CuCrZr Beam Stopping Elements (BSEs).
The thermal loads applied on panels were calculated for full beam-on power and for the most severe beam conditions (3 mrad beam core divergence and 30 mrad beam halo divergence) taking into account also possible off-normal conditions due to possible variation of the gas throughput in the Neutraliser channels that can affect the heat fluxes on the ERID.
A customized finite element (FE) code was developed to allow parametric and coupled solid-fluid simulations in the sub-cooled boiling conditions expected in the swirl flow of cooling channels. The model was used to verify the expected temperature at the inner cooling channels and at the external surface, the pressure drop, the Critical Heat Flux (CHF) and bulk boiling.
Thereafter, thermo-mechanical analyses and fatigue verifications of the ERID panels were undertaken with non-linear material properties by using elasto-plastic properties of CuCrZr and by considering the most demanding condition produced by breakdown and beam-on/off cycles during the operation. The thermal results produced by transient thermo-hydraulic analyses were applied as body load onto the mechanical model to calculate stress and strain fields. The analysis results were post-processed for the fatigue verification by evaluating local effects and creep-fatigue interaction.

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