Thermo-mechanical design of the SINGAP accelerator grids for ITER NB Injectors (P3-B-406)

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The SINGle Aperture - SINgle GAP (SINGAP) accelerator for ITER neutral beam injector foresees four grids for the extraction and acceleration of negative ions, instead of the seven grids of the Multi Aperture Multi Grid (MAMuG) reference configuration. Optimized geometry of the SINGAP grids (plasma, extraction, pre-acceleration, and grounded grid) was identified by CEA Association considering specific requirements for ions extraction and beam generation referring to experimental data and code simulations.
This paper focuses on the thermo-hydraulic and thermo-mechanical design of the grids carried out by Consorzio RFX for the design of the first ITER NB Injector and the ITER NB Test Facility. The cooling circuit design (position and shape of the channels) and the cooling parameters (water coolant temperatures, pressure and velocity) were optimized with thermo-hydraulic and thermo-mechanical sensitivity analyses in order to satisfy the grid functional requirements (temperatures, in plane and out of plane deformations). A complete and detailed thermo-structural design assessment of the SINGAP grids was accomplished applying the structural design rules for ITER in-vessel components and considering both the reference load conditions and the maximum load provided by the power supplies.
The design required a complete modelling of the grids and their support frames by means of 3D FE and CAD models. The grids were finally integrated with the support and cooling systems inside the beam source vessel.
The main results of the thermo-hydraulic and thermo-mechanical analyses are presented. The open issues are then reported, mainly regarding the material properties characterization (static and fatigue tests) and the qualification of technologies for OFHC copper electro-deposition, brazing, and welding of heterogeneous materials.