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Steady state thermal-hydraulic analysis of the MITICA experiment cooling circuits

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The MITICA (Megavolt ITER Injector Concept Advancement) experiment [1] is the full scale prototype of the Heating and Current Drive Neutral Beam Injectors for ITER, to be built at Consorzio RFX (Padova). The injector is designed to deliver about 17 MW neutral beam of deuterium particles, obtained from a precursor beam of negative ions accelerated to 1 MeV. The MITICA components will be subjected to heat loads between 2 and 19 MW and heat fluxes up to 20 MW/m^2, during one hour beam pulses, thus setting demanding requirements for a reliable active cooling.

The high heat fluxes on the accelerating grids due to stray particles, the temperature control required for optimal cesium deposition on plasma grid and plasma source walls, the highly concentrated load on the back plate due to back streaming ions, and the delicate RF drivers, make the MITICA beam source [2] a very challenging system in which the correct prediction of the flow rate partitioning and coolant temperatures are mandatory. The beam line components [3] also deal with severe heat loads, high coolant temperature and pressure, and like the beam source, are subjected to regulatory limits.

Several analyses have been carried for optimizing the cooling circuits. The thermo-hydraulic behavior of each cooling circuit under steady state condition has been investigated by using one-dimensional models. Complex geometries whose hydraulic behaviors are not available in literature have been studied by detailed three dimensional CFD models and then their characteristic curves (pressure drop vs. mass flow rate) have been included in the one-dimensional models as concentrated pressure drop elements to fully characterize the circuits. The models have been used as versatile tools in order to improve and modify the cooling circuits' layout during the design. The final results, obtained considering a number of optimizations for the cooling circuits, show that all the requirements in terms of flow rate, temperature and pressure drop are properly fulfilled.

References

[1] V. Toigo, et al., Progress in the realization of the PRIMA neutral beam test facility, Nuclear Fusion **55** 083025

[2] D. Marcuzzi, et al., "Final Design of the Beam Source for the MITICA Injector", to be presented at this conference

[3] M. Dalla Palma, et al., "Design and R&D for manufacturing the beamline components of MITICA and ITER HNBs", in press, doi:10.1016/j.fusengdes.2015.06.092