Contribution ID: **88** Type: **not specified**

Analysis of an actively-cooled coaxial cavity in a 170 GHz, 2 MW gyrotron using the multi-physics tool MUCCA

Monday, 17 September 2018 11:00 (2 hours)

Continuous Wave (CW) gyrotrons are the key elements for electron cyclotron resonance heating and current drive in present machines and future fusion reactors. In the frame of the EUROfusion activities, a 170 GHz, 2 MW short-pulse (ms) coaxial gyrotron existing at Karlsruhe Institute of Technology (KIT) is being upgraded for operation at longer pulses (100 ms - 1 s). In the coaxial gyrotron, the resonant cavity is made by a hollow cylindrical resonator and a coaxial inner insert, which permits increasing the gyrotron output power by enhancing the mode selectivity of the cavity. A forced flow of pressurized subcooled water, passing around the resonator as well as through the insert, is used to keep the cavity cooled.

The MUlti-physiCs tool for the integrated simulation of the CAvity (MUCCA) has been recently developed in collaboration between Politecnico di Torino and KIT. MUCCA is applied here to the analysis of the cavity of the upgraded 170 GHz, 2 MW coaxial gyrotron, to assess the evolution of its working point, starting from cold conditions, when different cooling configurations are considered for the resonator. An iterative procedure is adopted, where thermal-hydraulic and thermo-mechanical simulations are first performed on both resonator and insert with the commercial software STAR-CCM+, evaluating the mechanical deformation. The deformed cavity shape is then used as input in the electro-dynamic module EURIDICE to evaluate the heat load on the cavity wall, which becomes in turn the driver of the thermal-hydraulic analysis in the following time-step.

The main results of the MUCCA simulations are presented in terms of evolution of temperature, heat load, and deformation of the heated surface of the resonator and insert in the first seconds of operation. It is shown that the cavity behavior evolves towards a stable operation, with a maximum temperature strongly dependent on the cooling configuration.

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Session Classification: P1

Track Classification: Plasma Heating and Current Drive