NUMERICAL INVESTIGATION ON THE INFLUENCE OF INSERT MISALIGNMENT ON THE INSERT LOADING OF A 170 GHz, 2 MW COAXIAL-CAVITY GYROTRON

Parth C. Kalaria[1], Marc George[1], Stefan Illy[1], Konstantinos A. Avramidis[1], Gerd Gantenbein[1], Sebastian Ruess[1,2], Manfred Thumm[1,2], and John Jelonnek[1,2]

[1]Institute for Pulsed Power and Microwave Technology (IHM),

[2]Institute of High Frequency Techniques and Electronics (IHE),

Karlsruhe Institute of Technology (KIT), Karlsruhe

ABSTRACT

Gyrotrons are used as efficient, high-frequency RF sources for Electron Cyclotron Resonance Heating and Current Drive (ECRH&CD) in fusion plasma experiments. As an example, in total ten 140 GHz, 1 MW Continuous Wave (CW) hollow-cavity gyrotrons are completely installed and are being operated successfully to fulfil the total ECRH requirement of the Wendelstein 7-X (W7-X) stellarator in Greifswald (Germany) [1]. For the ITER tokamak in Cadarache (France), twenty-four 170 GHz, 1 MW CW gyrotrons are planned for a total ECRH&CD power requirement of 20 MW, launched to the plasma. In Europe, a 1 MW 170 GHz hollow-cavity gyrotron and a 2 MW 170 GHz coaxial-cavity gyrotron have been developed for ITER [2]. Compared to the hollow-cavity design, an additional longitudinally corrugated insert is placed at the cavity center in the case of the coaxial-cavity design. The slightly tapered corrugated-insert significantly controls the mode competition and reduces the effects of space-charge during the start-up, which allows high-power gyrotron operation in a very high-order operating mode.

During the gyrotron operation, the inner cavity wall and the coaxial insert are heated by the generated RF wave. The increase in temperature results in deformations of the cavity wall and the insert, which further modifies the frequency of the generated RF wave and the total heat flux. In the ref. [3], the performance of the insert cooling system of a 170 GHz, 2 MW coaxial-cavity gyrotron is systematically studied using the developed multi-physics simulation approach for CW gyrotron operation. The results confirm that a gyrotron equipped with a perfectly aligned coaxial insert made of Glidcop, having the same cooling system as the existing insert can operate trouble-free under the foreseen conditions. However, a perfect alignment cannot be guaranteed at each time-point during gyrotron operation. A misaligned insert results in a loss of the axial symmetry of the heat flux, which leads to a non-uniform temperature field and to insert-deformation.

In this talk, the applied multi-physics simulation model to study the influence of the axial insert misalignment on the insert cooling efficiency will be presented. A misalignment of the foreseen insert, provided it does not exceed 200 µm (which is the electromagnetic limit the excitation of the desired operating mode), is far from resulting in water boiling or plastic deformations and the gyrotron is still capable of proper operation.

Acknowledgement

This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission. Parts of the simulations presented in this work have been carried out the Marconi-Fusion super-computer facility.

References

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