EXPERIMENTAL ANALYSIS OF ADVANCED COOLING SOLUTIONS FOR CAVITIES OF MULTI-MW CW GYROTRONS

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ABSTRACT

The ongoing research and development of high-power fusion gyrotrons demands for an effective cavity cooling system for optimum gyrotron operation [1, 2]. Since the last decade, fundamental experimental research of advanced cooling techniques using mini-channels for high-power gyrotron cavities is carried out at KIT [3]. The test rig consists of the mock-up, 20 temperature sensors, two pressure sensors and the flow meter. The induction heater (6 kW maximal power) induces thermal loads on the cavity inner wall. An acquisition sub-system is implemented in the cavity cooling test system for visualization and recording of the measured values. A test mock-up that contains a cooling system based on 40 mini-channels, with geometry and materials identical to the real cavity of the 170 GHz 2 MW longer-pulse pre-prototype gyrotron, has been designed and integrated into the experimental set-up and systematically tested. The measured results, however, were shadowed by the experimental uncertainties and the comparison to the computed results, which in turn suffered from some uncertainty in the evaluation of the power deposited by the inductive heater, turned out to be difficult [4]. First improvements in the test set-up for the thermal-hydraulic investigation of a cavity cooling are already realized [5]. In order to increase the overall accuracy in the experiments and to eliminate potential uncertainties a set of improvements of the test set-up are implemented: (1) a new flowmeter with improved measurements accuracy, and (2) faster thermocouples, with reaction times < 0.1 s. Additionally a coating of the inner surface of the copper cavity with a Nickel layer of 100 µm thickness was introduced in order to increase the heat load. Further increasing of the induced heat flux in the inner wall of the mock-up will be achieved by increasing the available heating power, i.e. using an induction heater with 4 times higher nominal output power P_{out}, such as MINAC 24/40 (P_{out} = 24 kW). The obtained experimental results provide input to validate numerical models used for the cavity cooling optimization.
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