PRESENT STATUS AND FUTURE PROSPECTS OF HIGH POWER CW GYROTRON DEVELOPMENT AT KIT

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ABSTRACT

In the previous decades, electron cyclotron resonance heating and current drive (ECRH&CD) has been established as important method to support the operation of the major plasma fusion experiments, like the stellarator Wendelstein 7-X (W7-X) in Greifswald, Germany (which is now under preparation for the third experimental campaign), or ITER, currently under construction at Cadarache, France. High frequency (100 – 200 GHz), high power (~ 1 - 2 MW) gyrotrons are the unique RF sources which meet the challenging requirements of those applications. Optimum current drive efficiencies for the prospected Demonstration Power Plant DEMO may require even higher frequencies (> 200 GHz), multi-MW levels of output power together with enhanced efficiency, while frequency-tunability of the RF sources would be favourable for plasma stabilization.

KIT, together with its EU partners, is currently working on several projects related to the design, optimization, construction, and testing of gyrotrons for plasma fusion applications. This includes an upgrade of the 140 GHz gyrotron for W7-X to achieve a continuous wave (CW) output power of 1.5 MW (instead of the present 1 MW); the industrial CW tube is already manufactured and under testing at the new Fusion Long Pulse Gyrotron Laboratory (FULGOR) at KIT. In addition, investigations are ongoing to stabilize the output frequency of the W7-X tubes using a PLL control system and to operate the original W7-X gyrotron at higher frequency (175 GHz) and reduced output power (~ 500 kW) to use it as an RF source for collective Thomson scattering (CTS) plasma diagnostics.

Further optimization and experimental testing of the EU 1 MW, 170 GHz gyrotron for ITER and theoretical and experimental investigations on 2 MW-class coaxial cavity gyrotrons are conducted, where KIT already achieved a record output power value of 2.3 MW at 170 GHz for millisecond pulses. In addition, intensive design and construction work is performed on multi-frequency gyrotrons relevant for DEMO, targeted for a maximum frequency of up to 240 GHz. In the context of efficiency enhancements for future power plants, investigations on multi-stage depressed collectors are ongoing, with the goal to set up a first short pulse experiment to verify the expected capabilities of this new type of gyrotron collector.

Within the research and development activities described above, KIT is investing in the development of advanced design tools and components research; to maintain a proper test environment for future gyrotrons the test facility FULGOR has been set up at KIT and now started operation. Among other relevant components, it will comprise a 10 MW (90 kV, 120 A) CW power supply capable to operate with multi-stage depressed collectors and a high-field cryogen free superconducting magnet.

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