Recent Results of the 1-MW, 140 GHz, CW Gyrotrons for the Stellarator W7-X

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The development of gyrotrons with 1-MW output power at the Forschungszentrum Karlsruhe in collaboration with EURATOM Associations and Thales Electron Devices for continuous wave (CW) operation at 140 GHz is linked with the construction of the new superconducting Stellarator Wendelstein 7-X at the Institute of Plasma Physics (IPP) Greifswald, Germany.

The gyrotrons are equipped with a diode-type magnetron injection gun, a $TE_{28,8}$-mode cavity, an advanced quasi-optical mode converter system, an output RF-window with a single edge-cooled "chemical vapour deposited (CVD)"-diamond disk and a single-stage depressed collector (SDC) for energy recovery [1]. After the construction and test of two prototype gyrotrons, seven series gyrotrons had been ordered.

The first series tube [2] tested at the Forschungszentrum Karlsruhe yielded a total output power of 980 kW with an efficiency of 31% (without SDC) in short pulse operation and of 920 kW in pulses of 180 s (efficiency of 45% at depression voltage of 29 kV). The directed output power was 906 kW. The pulse length at full power (1 MW) is limited at Forschungszentrum Karlsruhe by the available power supply. At reduced electron beam current, it is possible to operate at longer pulse lengths. At an output power of 570 kW (electron beam current of 29 A), the pulse length was increased to 1893s. There was no physical reason for a limitation of this pulse: the pressure increase during the pulse was less than a factor of two and ended up at a very low value in the 10^{-9} mbar range. The tube was delivered to IPP Greifswald for tests at full power and up to 30 minutes pulse length. The directed RF output power yielded 870 kW at a total output power of 920 kW in 30 min. pulses. Again, no indications for a limitation in pulse length was found.

The second series tube was delivered to Forschungszentrum Karlsruhe in November 2005. Up to now, this tube could only be tested in short pulse operation. At the design value of 40 A for the electron beam current , an output power of 960 kW was found in very short pulse operation (1 ms), and 1200 kW at 50 A, both in very short pulse operation (1 ms). For these output powers rather high acceleration voltages were necessary (85 to 86 kV). Unfortunately, mode jumping and excitation of the neighbouring mode occurred for increased pulse length. For 3 ms, the accelerating voltage had to be decreased and the output power was reduced to about 800 kW at 40 A beam current.

Long pulse operation with this tube and further investigations on ode competition will start in February. The experimental results will be included in the paper.

References:

[1] G. Dammertz et al., IEEE Trans. Plasma Science 30 (2002) 808-818
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