2 MW, 170 GHz Pre-Prototype Coaxial-Cavity Gyrotron for ITER

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Abstract

A 2 MW, CW, 170 GHz coaxial-cavity gyrotron for electron cyclotron heating and current drive in the International Thermonuclear Experimental Reactor (ITER) is under development in cooperation between European Research Institutions (EGYC). The design of critical components like electron gun, beam tunnel, cavity and quasi-optical (q.o.) mm-wave output system has been studied in a short-pulse coaxial gyrotron (pre-prototype) at Forschungszentrum Karlsruhe (FZK). This 170 GHz pre-prototype gyrotron was originally designed for operation at reduced cathode voltage due to the limited field strength of the superconducting magnet at FZK (max. B = 6.7 T). Now an additional normal conducting (NC) coil was installed to achieve magnetic fields up to the nominal value of 6.87 T, and the shape of the MIG anode has been adjusted for operation at the nominal accelerating voltage of U_C = 90 kV. In agreement with expectations, the increase of the magnetic field by using the NC-coil resulted in a shift of the excitation region of the $TE_{34,19}$ coaxial-cavity mode to higher values of the cathode voltage U_C. Around the nominal value of the magnetic field a maximum mm-wave output power P_{out} of about 1.8 MW with an efficiency of almost 28 % (non-depressed collector operation) at I_b=75 A has been obtained, in good agreement with results of numerical simulations, if 15% total internal losses (ohmic, diffraction, dielectric, after cavity interaction, window absorption) are taken into account. The operation of the gyrotron with a new beam tunnel with longitudinally corrugated copper rings resulted in a significant improvement of operation stability and purity of single-mode operation over a very broad parameter range. In these experiments the conversion efficiency of the q.o. output coupler to the fundamental Gaussian $TEM_{0,0}$ mode was only approximately 80 % and the amount of internal stray radiation losses was about 8%.
To improve the performance of the q.o. mode converter system a novel scalar diffraction integral optimization code has been implemented. The obtained inner surface contour of the launcher is quite sophisticated but technically feasible. Calculations show a very high conversion efficiency (97 %) of the launcher into the Gaussian mode. The new improved launcher antenna together with a suitable mirror system has been fabricated and tested at low power. These measurements showed a very good agreement with the calculations. Then the new q.o. output coupler has been integrated into the gyrotron. Currently high power tests are being performed. First experiments showed 2 MW output power at almost 30 % efficiency (without depressed collector).

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