Status of the 10 MW 140 GHz, CW ECRH System for the Stellarator W7-X

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Electron cyclotron resonance heating (ECRH) has proven to be one of the most attractive heating schemes for stellarators, as it provides net current free plasma start up, heating and non-inductive current drive. Extensive measurements on stellarators at IPP Garching provide a solid physical and technological basis. Therefore, ECRH will be the main heating method for the Wendelstein 7-X stellarator (W7-X) now under construction at Greifswald/Germany. A 10 MW ECRH system with continuous wave (CW) possibilities operating at 140 GHz will be built up to meet the scientific goals with inherent steady-state capability at reactor relevant plasma parameters. A prototype gyrotron with an output power of 1 MW was developed in collaboration between European research laboratories and European industries [1]. The gyrotron is equipped with a single-stage depressed collector for increasing the efficiency, an optimized quasi-optical mode converter and a CVD-diamond window. The prototype gyrotron has been successfully tested with an output power of 0.89 MW at a pulse duration of 3 minutes and 0.54 MW for about 15 minutes. The specified value of Gaussian beam output power exceeding 0.9 MW has been obtained for about 1 minute. The corresponding pre-prototype tube (0.74 MW, 100 s) has started to operate at its site in Greifswald. Another prototype gyrotron has been developed at CPI which has generated 0.5 MW at a pulse duration of 700 s. The ten gyrotrons will be arranged in two subgroups symmetrically to a central beam duct in the ECRH hall. The RF-wave of each subgroup is combined and transmitted by a purely optical multi-beam waveguide from the gyrotrons to the torus. The combination of the five gyrotron beams to two beam lines each with a power of 5 MW reduces the complexity of the system considerably. The single-beam- as well as the multi-beam waveguide mirrors and the polarizers are being manufactured. Cold tests of a full size uncooled prototype line delivered an efficiency exceeding 90%. The microwave power is launched to the plasma through 10 CVD-diamond barrier windows and in-vessel quasi-optical plug-in launchers allowing each 1 MW RF-beam to be steered independently. The polarization as well as the poloidal and toroidal launch angle can be adjusted individually to provide optimum conditions for different heating and current drive scenarios.

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

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