Design Studies on a 1.0-1.3 MW, Long Pulse, Start-up Gyrotron for ITER

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Abstract: *In this work, the initial design concept of a 1.0-1.3 MW, long pulse gyrotron operating at 127.5 GHz, for plasma start-up*

Introduction :

Gyrotrons and their variations, popularly known as gyro-devices, are microwave and millimetric wave sources that provide very high powers ranging from long pulse to continuous wave (CW) for various technological, scientific and industrial applications [1,2,3]. Gyrotrons are exclusively employed for electron cyclotron resonance heating (ECRH), current drive, start-up (pre-ionization) and stabilization of plasmas in thermonuclear fusion reactors [1,2]. We, here, give the recent progress of our research work on the design of a 127.5 GHz, 1.0-1.3 MW, CW Gyrotron for plasma start-up in the ITER. Recent works at MIT and elsewhere [4, 5] suggest that a start-up Gyrotron delivering a power level around 1 MW (long pulse to CW) can be realized for the ITER. But the operating frequency chosen in these works [4, 5] was 120 GHz for the start up of plasma in ITER. However it has been corrected to 127.5 GHz since the diamond window for the transmission is resonant at 170 and 127.5 GHz respectively. This facilitates a 1.48 mm thick CVD Diamond window which is resonant at both these frequencies. In this context, it is to be noted that 1 MW CW, 170 GHz Gyrotron is being employed for ECRH in ITER. As a logical extension of their work, we have started searching for a Gyrotron that is capable of delivering power in excess of 1.0 MW preferably long pulse to CW for plasma start-up in ITER at 127.5 GHz. The operating mode chosen should support an advanced dimpled-wall quasi-optical (q.o.) launcher and smooth surface phase correcting mirrors. This will reduce the technical complexities connected with high diffraction losses (stray radiation) inside the device. In this paper, the recent results on this specific Gyrotron are presented. In this work, the design studies on a 1.0-1.3 MW, CW Gyrotron operating in the $TE_{24,8}$ mode with radial output collection is presented. Design constraints and starting currents are computed considering $TE_{24,8}$ as the main operating mode along with major competing neighbors. Cold-cavity design and self-consistent computations are also carried out. A triode type magnetron injection gun along with necessary magnetic guidance system is designed. The true beam information obtained from the MIG simulations has been used to study the RF-behavior of such a device and to investigate the start-up scenario and current neutralization processes. These studies have strongly suggested that it should be possible to realize such a long pulse start-up Gyrotron for ITER.

Design Studies :

The design goals and specifications of this start-up gyrotron are presented in Table I.

Table I: Design Goals & Specifications

Frequency	127.5 GHz (earlier it was 120 GHz)
Output Power	» 1.0-1.3 MW, CW
Efficiency	» 35 % (without depressed collector)
Beam Parameters (I_b/U_b/a)	40-50 A/ 75-80kV/ 1.30-1.35
Cavity Type	Conventional Hollow
Q_{Diff}	» 1000

Wall losses	< 2 kW/cm^2

After the mode selection process, one may chose either $TE_{24,8}$ or $TE_{24,7}$ as the operating mode. However, we have presented the r

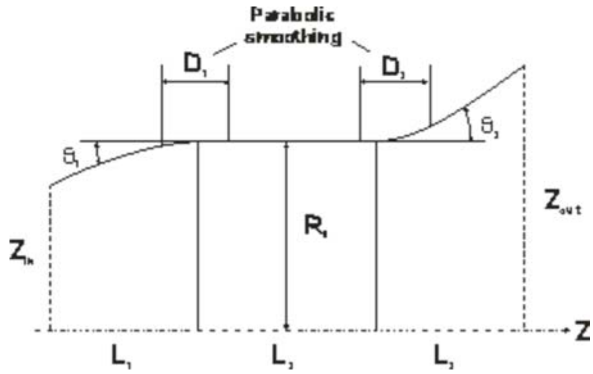

Fig. 1 Cavity geometry for $TE_{24,8}$ (L_1=12 mm, L_2=16 mm, L_3=18 mm, q_1=2.3°, q_2=0.0°,q_3=3.0°)

By suitably choosing a three-section weakly tapered conventional cavity geometry the cold cavity design and the computation of tl

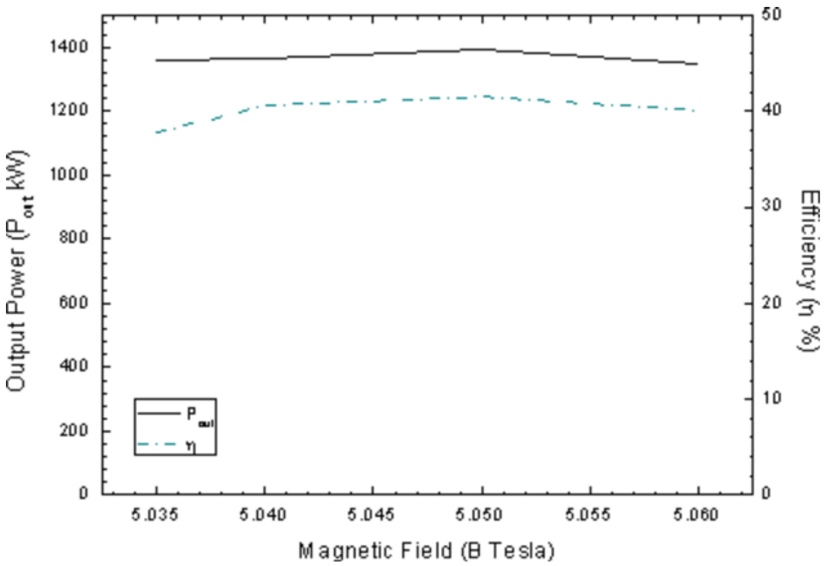

Fig. 2 Self-consistent simulation results for a $TE_{24,8}$ mode gyrotron.
Here, I_b = 42 A, U_b = 80 kV, and a = 1.30.

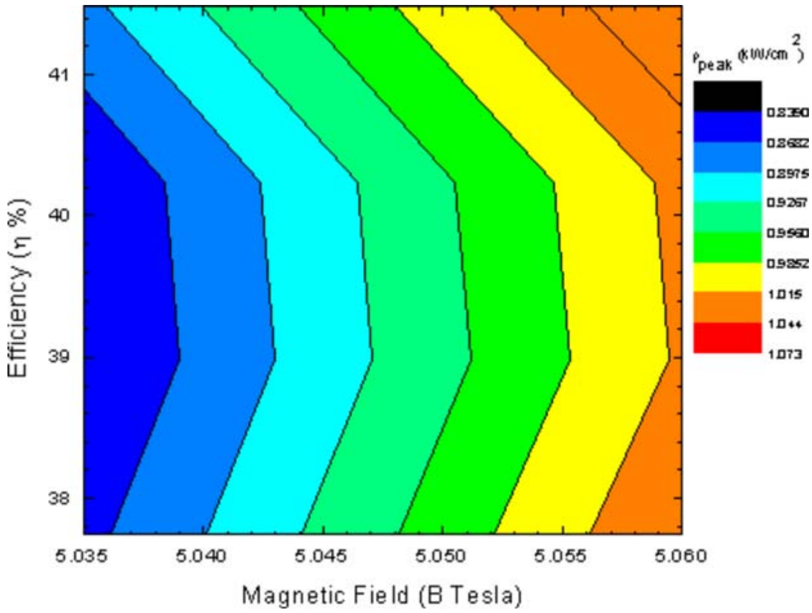

Fig. 3 Random contours of peak wall loading for a $TE_{24,8}$ mode gyrotron.
Here, I_b = 42 A, U_b = 80 kV, and a = 1.30.

Concluding Remarks :

We have presented design studies and RF-behavior of a 1.0-1.3 MW, Long Pulse Gyrotron operating in the $TE_{24,8}$ mode and with r

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