Effect of Beam Tunnel Geometry on Electron Beam Parameters for 42 GHz Gyrotron

Udaybir Singh[1], Nitin Kumar[1], Mukesh K Alaria[1], L P Purohit[2], Ashok K Sinha[1]
and
B. Piosczyk[3], M Thumm[3] and G Gantenbein[3]
[1] Gyrotron Laboratory, MWT Area
Central Electronics Engineering Research Institute (CEERI)
Council of Scientific and Industrial Research (CSIR)
Pilani, Rajasthan, INDIA-333031
[2] Department of Physics, Gurukul Kangri Vishwavidyalaya, Haridwar – 249404, INDIA
[3]Karlsruhe Institute of Technology (KIT), IHM, 76131 Karlsruhe, Germany
uday.ceeri@gmail.com , aksinha@ceeri.ernet.in

Abstract: *A triode type Magnetron Injection Gun (MIG) for a 200kW, 42GHz Gyrotron has been designed by using commercially available code EGUN. The design optimization of the beam tunnel has been done with the help of 3-D simulation software CST-Microwave Studio. This paper presents the effect of beam tunnel geometry on the electron beam parameters for 42 GHz gyrotron.*

Keywords: Gyrotron, Electron Gun, MIG, Beam Tunnel.

Introduction

Gyrotron is a high power, high frequency microwave device which produce coherent millimeter and submillimeter radiation. A 42 GHz 200 kW continous wave output power gyrotron is being to be developed for the electron cyclotron resonance plasma heating for the Indian TOKAMAK system through a multi institutional project. The triode type MIG with a modulating anode and an accelerating anode has been designed. The triode type MIG is preferable because of its own advantages though there are some complicacies in the fabrication and power supply [1]-[2]. Three computer codes (one commercially available code EGUN and other two are in-house developed) have been used for design and analysis of the MIG. After simulation, the electrical parameters of the electron gun have been evaluated by another in-house developed code MIGANS. Table 1 shows the optimized values of different parameters of the MIG. Here as beam tunnel the part of the drift section between the MIG gun and the cavity is considered which is occupied with a highly lossy structure as indicated in Fig. 1. The magnetic field is strongly inhomogeneous in this region so that the beam radius, axial and transverse velocity vary strongly [3]. Due to the highly lossy ceramic rings used in the beam tunnel and inhomogeneous magnetic field, various kinds of beam instabilities occur in the electron beam [4]. Based on the electron trajectories as obtained with EGUN the radial dimensions of the beam tunnel have been fixed. As shown in Fig. 1 and 2 the drift section between the MIG geometry and the cavity is equipped with two beam tunnels of different length.

The design optimization of the beam tunnel has been finalized with the help of 3-D simulation software CST-Microwave Studio [3]. The optimized length of the beam tunnel is 120mm. The efficient interaction of the electron beam with the rf field highly depends on the electron beam parameters. The effect of MIG geometry on the electron beam parameters has been already analyzed [5]. In this paper the study of the effect of the beam tunnel length on the electron beam parameters like transverse to axial velocity ratio of electron beam (α) and the maximum transverse velocity spread ($\delta\beta_{\perp max}$) is presented.

Effect of Beam Tunnel Geometry on Electron Beam Parameters

To see the effect of the beam tunnel length on the MIG parameters, the length of the beam tunnel has been varied in steps. Fig. 3 shows the variation of transverse to axial velocity ratio of the electron beam (α) with the change in the beam tunnel length. The value of the velocity ratio increases with increase in the beam tunnel length. Fig. 4 shows the variation of the velocity spread with the change in the beam tunnel length. The value of maximum transverse velocity spread (%) decreases with increase in the beam tunnel length. From Figs. 3 and 4 it is clear that with increase in the length of the beam tunnel the quality of the electron beam is improved.

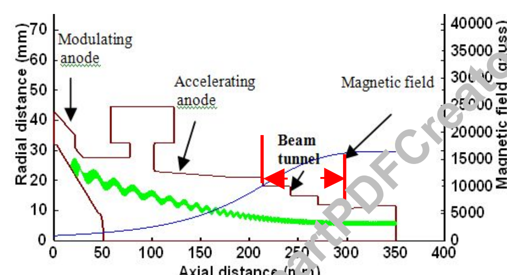

Fig. 1: MIG geometry with beam tunnel and beam profile.

Table 1: Different optimized parameters of MIG
(indicating the length of beam tunnel)

Cathode radius	22.6 mm
Slant length of emitting surface	7.0 mm
Slope angle of cathode	28 degree
Beam current	10.3 A
Beam voltage	65 KV
Modulating anode voltage	29 KV
Magnetic field at interaction region	1.65 Tesla
Compression ratio	14.84
Maximum transverse velocity spread (%)	2.65
Transverse to axial velocity ration of electron beam (α)	1.26
Length of beam tunnel	120mm

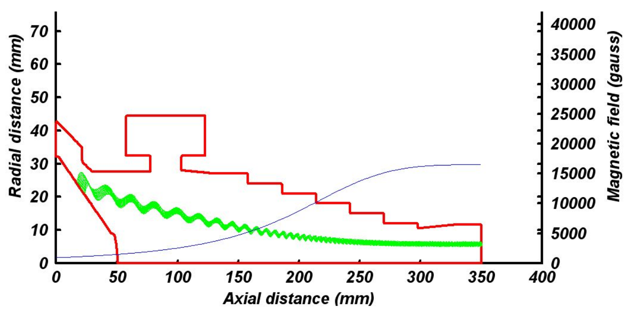

Fig 2: MIG geometry with beam tunnel and beam profile.

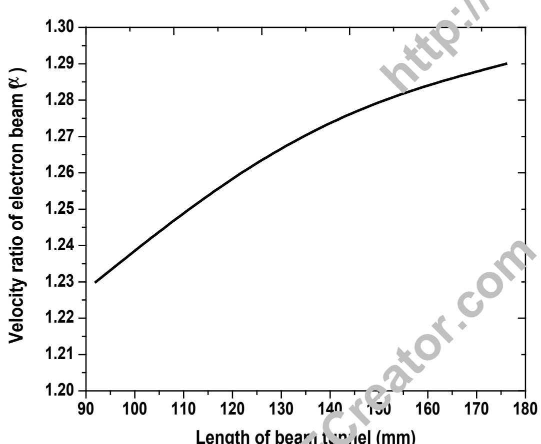

Fig. 3: Variation of velocity ratio of electron beam with beam tunnel length.

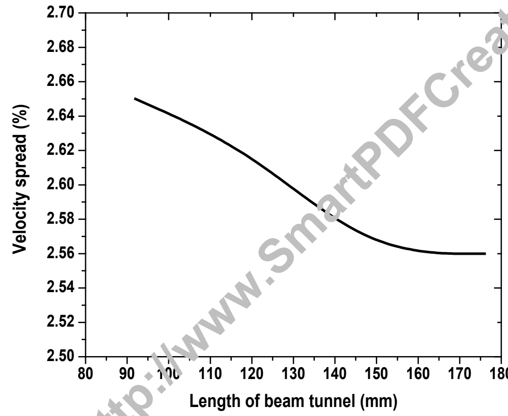

Fig. 4: Variation of maximum transverse velocity spread of electron beam with beam tunnel length.

Conclusion

In this paper the study of the beam tunnel length and its effect on beam parameters for a 42GHz, 200kW gyrotron has been presented. The value of velocity ratio (α) increases and the value of maximum transverse velocity spread (%) decreases with increase in beam tunnel length. This study shows that, with increase in the length of the beam tunnel the quality of the electron beam is improved.

Acknowledgement

Authors are grateful to the Director, CEERI, Pilani, for permission to publish this paper. Thanks are due to Dr SN Joshi, Dr V Srivastava, Dr RS Raju and team members for their continuous support and encouragement. Thanks are also due to DST for funding this project. Dr AK Sinha is grateful to DAAD for visit to FZK, Germany during which this work has been conceptualized.

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