Preliminary design of powerful gyrotrons for IGNITOR and DEMO

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***Abstract*—Design development of continuous-wave 240 GHz gyrotron and 300 GHz gyrotrons with output power about 200-1000 kW for fusion research at advanced plasmas with intense magnetic field is presented. Main goal of such gyrotrons is application for EC complexes of IGNITOR and DEMO tokamaks. This paper includes task motivation and existing technical basis, results of calculation, design, technical requirements and pre-prototype experimental tests for main subsystems of gyrotron.**

I. Introduction

FOR some advanced fusion experiments at the next plasmas like IGNITOR and DEMO and promising technological applications RF sources with CW power near 200-1000 kW and frequency 240-300 GHz are requested [1]. In the framework of this project, the program for design of a 300 GHz gyrotron with high output power (up to 1000 kW) for operation in the continuous regime was implemented at IAP RAS.

II. Results

Gyrotron tube version with 200 kW output power could to be used together with 12 T liquid Helium free cryomagnet of SHI or JASTEC Company (Japan) [2] or its analogue with diameter of a “warm” aperture 100 mm. On the basis of the analysis of scientific and technical information the general design concept of the gyrotron has been developed and possible operating modes and the value of accelerating voltage have been chosen. Several possible operating modes were considered. Finally on the basis of the analysis of technical limitations the $TE_{22,8}$ operating mode have been chosen for 200 kW gyrotron tube version which will give us the possibility to check different scientific and technical solution. Accelerating voltages for this tube is 60 kV and beam current 20 A. The gyrotron tubes have the same principal design concept as the earlier developed 110-170 GHz gyrotrons (Fig1) [1] and in part the 300 GHz/4kW/CW gyrotron [2]. This includes the use of a quasi-diode gun with an impregnated or LaB_6 cathode, a build-in mode converter to transform cavity mode to wave beam with radial directed output, and an electron beam collector, all designed for CW operation. Using potential depressed collector (CPD) give us the possibility really improve gyrotron efficiency. Efficiency without CPD achieves 23.05 % without after-cavity interaction (ACI) [3], and 22.12 % with ACI. Efficiency with CPD and 0 % electron reflection is 39.6%, and with CPD and 1 % reflections 42.8 %. The mode converter includes a specially shaped waveguide end and three profiled mirrors to provide: low diffraction losses inside the tube, optimal RF power distribution over an output window; matching of the output wave beam to a transmission line. The TEM_{00} mode content at the tuber output **i**s 99.54 %. For the output window of 300 GHz/200 kW CW gyrotron will be used the CVD-diamond with near 80 mm diameter disks with small RF loses.

More powerful 300 GHz tube version needs 13 T cryomagnet with increased diameter of a “warm” aperture accelerating voltages near 80 kV and beam current 40-50 A. Particular properties of the 240 GHz gyrotron for DEMO were considered also. Results of this activity are summarized in this report.

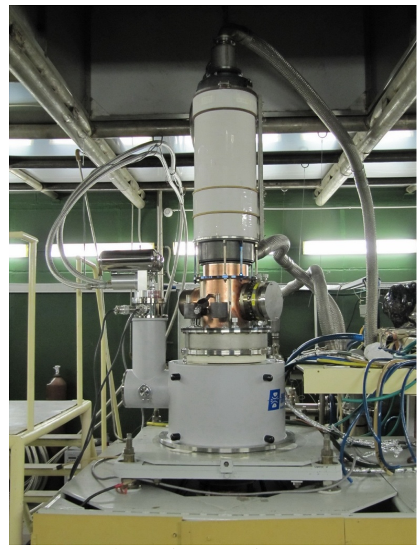

Fig. 1. Photo of 170GHz/1MW gyrotron

III. Summary

Design development of continuous-wave 240 ghz gyrotron and 300 Ghz gyrotrons with output power about 200-1000 kW for fusion research at advanced plasmas with intense magnetic field is presented. Main goal of such gyrotrons is application for EC complexes of IGNITOR and DEMO tokamaks. This paper includes task motivation and existing technical basis, results of calculation, design, technical requirements and pre-prototype experimental tests for main subsystems of gyrotron and auxiliaries. The 200 kw gyrotron setup also could be used as a part of a complex technological system for different applications

References

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