25/2019(ii)

Modelling of Electron Gun for long life Application

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***Abstract*- A low perveance electron gun has been modelled/ designed for helix traveling wave tube (TWT) for long life application with an additional accelerating anode in the electron gun geometry. This pierce type convergent electron gun consists of M-Type dispenser cathode, electrically isolated beam focusing electrode and three isolated anodes has been designed using commercial software EGUN and CST-PS following Vaughan synthesis approach. For confined flow of the electron beam along the interaction structure (helix) of the TWT, periodic permanent magnet (PPM) focusing system has also been suitable modelled.**

I. INTRODUCTION

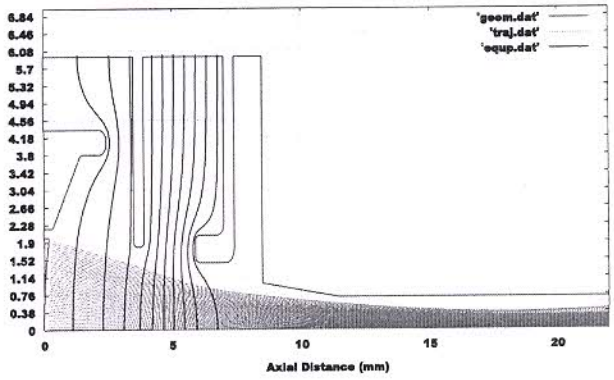
Electron gun is the source of electron beam in a helix TWT and its performance, that is current density, decreases with time due to degradation of cathode performance for long hour operation. Thus, the performance of the TWT decreases with time, and hence, to recover the performance or to improve beam current density, an isolated accelerating anode is introduced between BFE and ion barrier anode. Adjustable potential of the accelerating anode improves beam current density with nominal change in beam optics under the same magnetic focussing structure.

Pierce type electron gun has undergone several evaluations with time under modern state-of-the-art of design concepts depending the applications. For long life application low perveance electron gun with enhanced current density has always been emphasized and has been achieved using multiple electrodes with suitable potentials in the vicinity of the cathode. These electrodes control/ shape the required beam optics with suitable magnet focussing structure to confine the electron beam along the interaction structure, for instance, the helix slow-wave structure [1]-[3].

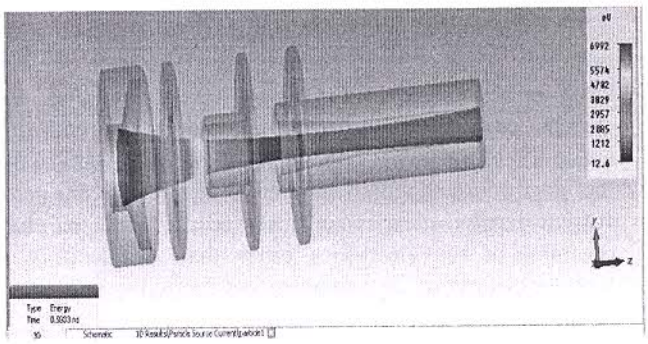
The electron gun, under study, has been modelled in commercial soft-ware packages, namely, EGUN [4] and CST [5] to get the required beam optics for long life application. Among the multiple electrodes, the accelerating electrode, place between BFE and Anode-2, controls beam current density. In this paper author have presented the effect of accelerating electrode potential on beam current density and beam optics, which can be regulated to enhance beam current with time by suitable increasing potential with time.

II. DESIGN OF ELECTRON GUN AND FOCUSING SYSTEM

The basic beam optics and cathode emission current density, define in pierce electron gun are calculated from Vaughan synthesis [3], by giving appropriate beam parameters. The gun geometry obtained from analytic approach with two electrode between cathode and Ground anode is fed in the EGUN and optimization is carried out to get the desired beam parameters like perveance, waist radius and laminarity [1]-[3]. The optimized EGUN result is shown in Fig. 1(a), and validated with CST-PS is shown in Fig. 1(b) are agreeing closely.



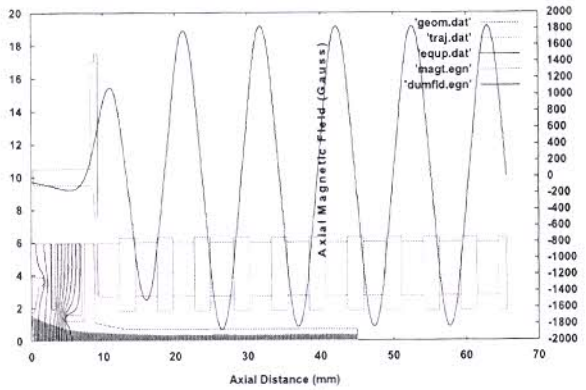
(a)



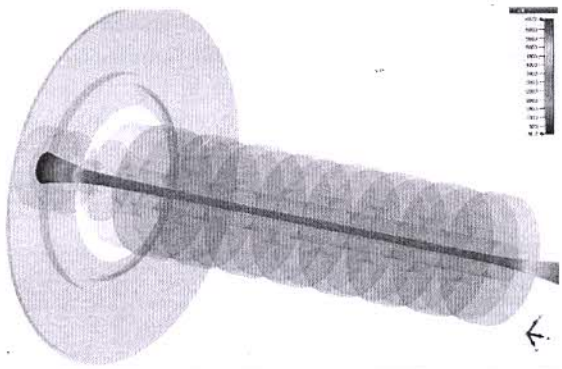
(b)

Fig. 1. Simulated electron gun trajectory in a) EGUN and b) CST-PS.

To compensate the space charge forces and to achieve laminarity of the beam, PPM design is optimized in Magfld-EGUN [4] using magnetic pole piece, nonmagnetic spacer and samarium-cobalt as permanent magnet to minimize beam scalloping. The PPM design is further validated with CST-PS. The trajectories of two software with magnetic field are shown in Fig. 3a-3b and have peak axial magnetic field of 1800 Gauss and scalloping comes out to be less than 5%.



(a)



(b)

Fig. 2. Trajectory with magnetic field (PPM) in (a) EGUN, (b) CST-PS.

III. RESULTS AND DISCUSSION

The electron gun has been optimized/ modelled for electrodes geometry, position and potential w.r.t cathode for required beam optics (Table-1). As discussed in Section-1, that the current density, emitted from cathode decreases with time and hence life of the TWT, one needs to keep provision to increase the electrode potential with time to increase beam current or current density. It has been observed that with the change in potential of the electrodes other than accelerating anode, without disturbing the geometry and focussing structure, beam optics changes rapidly and hence performance of the TWT. However, with the change in potential of the accelerating anode, there is significant increase in beam current without affecting beam optics beyond sensitive limit (Table-1) (Fig. 1).

Moreover, a minimal additional potential, typically -4 V for present study, of BFE w.r.t cathode helps to converge the beam (Table-2). Thus, keeping geometry, position and potential of the electrodes constant, one can increase beam current with time by increasing accelerating anode potential with time.

Table 1. Effect of accelerating anode potential over nominal volt

Accelerating anode Voltage (Volt)	I_0 (mA)	r_z (mm)	Z_w (mm)	Scalloping (%)
1800	129.8	0.4125	13.29	8.972
1830	132.24	0.4105	13.49	7.03
1850	133.84	0.4095	13.59	5.72
1900	137.9	0.4075	13.89	2.69
2000	146.15	0.396	14.52	1
2100	154.48	0.379	15.15	7.71
2200	163.13	0.384	15.78	13.04

Table 2. Effect of BFE potential over nominal volt

BFE Voltage (Volt|)	I0 (mA)	rz (mm)	Zw (mm)	Scalloping (%)
0	133.01	0.4005	13.99	13.99
-4	131.2	0.4065	13.59	7.27
-7	129.8	0.4115	13.29	8.97
-10	128.5	0.4175	12.96	10.9
-15	126.35	0.4255	12.42	13.22
-20	123.97	0.4335	12.15	16.12
-200	65.34	0.4	7.4	52.47
-400	33.33	0.4	2.6	61.24
-600	16.35	0.39	2.13	66.63
-800	6.65	0.38	1.49	67.62
-1000	1.7	0.36	1.121	74.15
-1200	1.04	0.16	0.584	57.57
-1300	0	0	0	100

IV. CONCLUSION

A low perveance electron gun of PPM focusing system with confined flow for high power Ku band space TWT has been designed and simulated using EGUN code and CST-PC. For the enhancement of life of space TWT voltages of accelerating anode has been tuned to get the effect of the change of beam current, helps to balance the beam current when cathode current density starts to decrease.

ACKNOWLEDGMENT

Authors are thankful to Director CEERI for granting permission to present this work.

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