BEAM DYNAMICS CALCULATIONS IN THE MULTI-BEAM GENERATOR CAVITY

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Abstract

In the previously designed, calculated and tuned structure of the compact generator-cavity the beam dynamics for the different geometry options has been calculated. The influence of injected beam parameters to the output power value has been overviewed. Also the geometry of the beam tubes and couple coefficient between cavity and the output waveguide has been optimized to reach the maximum output power value.

INTRODUCTION

The inductive output tube klystrod combine two superior characteristics of gridded tube and high-frequency klystron. A grid is used to provide simple control of electron beam. Cavity of klystrod couple bunches of modulated beam to the RF field. This combination makes a smaller, lower cost, high-frequency, high-power tube. To increase power of device without significant size change multiple electron beams coupled to one RF cavity.

RESONATOR TUNING

RF power is generated is multi-beam klystrod by drawing power from the electron beams, and storing it in cylindrical resonator, operating on TM020 mode at 2856 MHz. Beam drift tubes are located in maximums of electrical field. Electrical field distribution in resonator model is shown on figures 1 and 2.

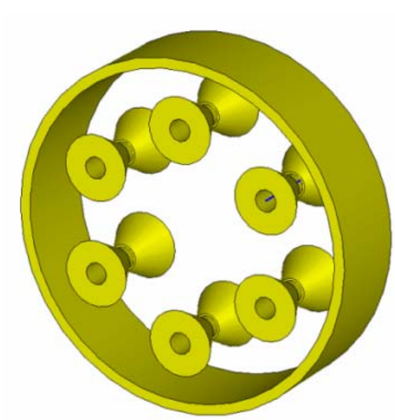

Figure 1: Resonator of multi-beam klystrod.

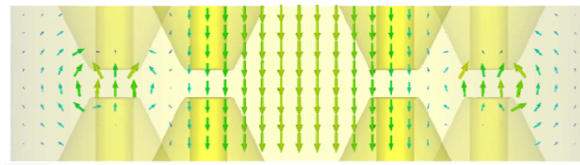

Figure 2: Electric field distribution in multi-beam klystrod resonator (side view).

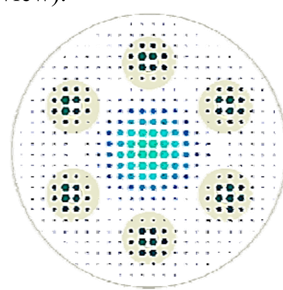

Figure 3: Electric field distribution in multi-beam klystrod resonator (top view).

For this resonator geometry, shunt impedance on the axis of each beam tube is 2.95 MOhm/m, which gives a total impedance of the model 17.7 MOhm/m.

WAVEGUIDE IRIS TUNING

For power input, standard waveguide 72.1mm x 34mm is used.

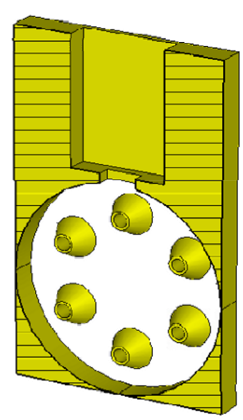

Figure 4: Multi-beam klystrod resonator and waveguide, connected by iris.

Maximum power transition from resonator to waveguide was acquired by tuning waveguide iris. On the figure 6 plot of normalized output port power over iris

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width il (output power was normalized to the maximum achieved output power). On the figure 5 iris geometrical parameters are shown.

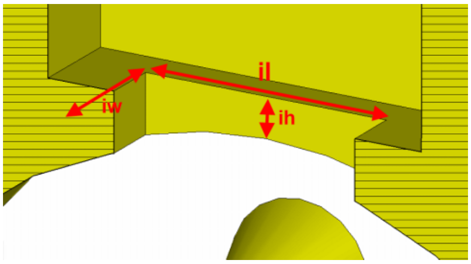

Figure 5: Iris geometrical parameters.

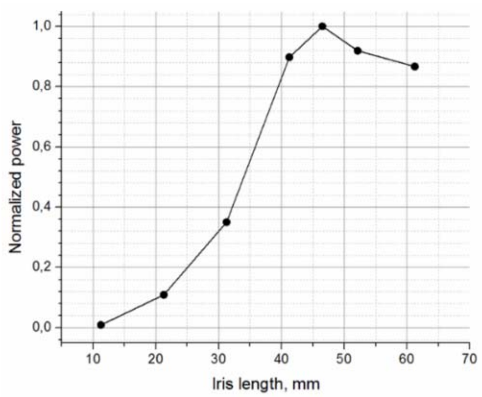

Figure 6: Normalized power over iris width plot.

Optimal iris parameters, which provide maximum output power, are presented in table 1.

Table 1 Iris parameters

ih	7.53 mm
iw	20 mm
il	46.5 mm

POWER OUTPUT TUNING

For power generation modulated electron beam is used. This beam is provided by electron gun with control grid, its parameters are shown in table 2.

Table 2 Electron beam parameters

Electron energy	$1 \cdot 10^5$ eV
Beam diameter	3 mm

In the table 3 parameters of beam modulation are presented. Explanation of bunch parameters can be found of the figure 7.

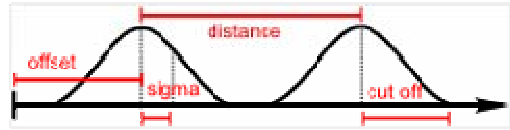

Figure 7: Beam bunches parameters scheme.

Table 3 Beam bunch modulation parameters set

Offset	0
Sigma	60 ps
Distance	350 ps
Cut off	70 ps

Output signal amplitude dependence of beam tube gap. Output power dependence of gap length g plot is presented on the figure 9.

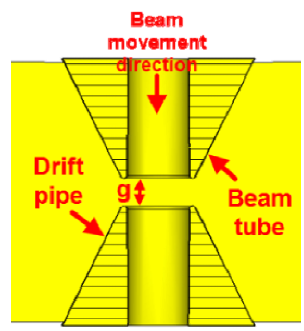

Figure 8: Resonator geometry parameters.

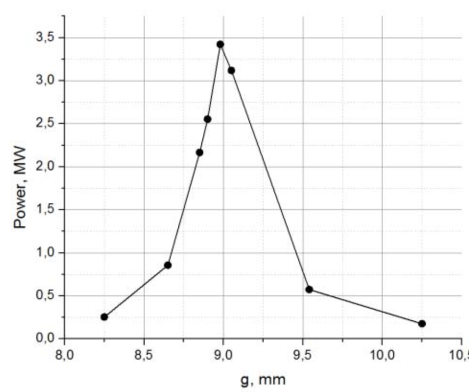

Figure 9: Output rms power over gap length g between beam tube and drift pipe plot.

After tuning, power generation was simulated. Electron beams with parameters, shown in tables 2 and 3 were launched to the centers of the beam tubes and coupled to the resonator RF field. From the resonator RF power was transmitted to the waveguide. This power was calculated shown on the figure 10. Klystrod reaches 90% output power level in 100 ns.

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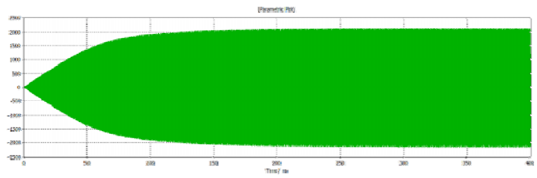

Figure 10: Multi-beam klystron output rms power over time plot.

Device efficiency was estimated by dividing output RF power on the electron beam bunch power. Presented parameters were achieved with total electron beams power of 4.3 MW. On the maximum output power level 3.4 MW of multi-beam klystrod efficiency is 73%.

KLYSTROD APPLICATION

Tuned multi-beam klystrod will be installed as a power source for electron accelerator. On the figure 11 presented a model of 8 cell acceleration structure, connected to the klystrod. Tuning of this accelerating structure is still in progress.

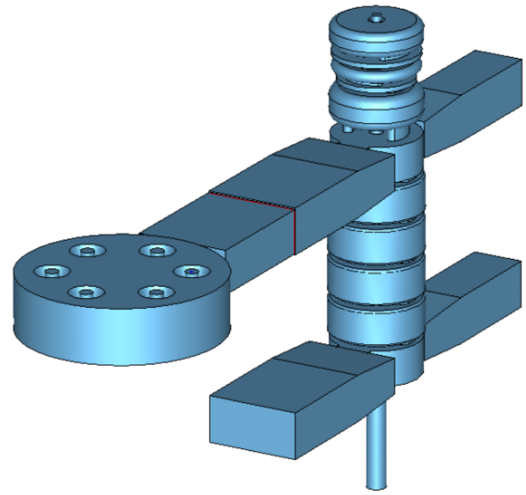

Figure 11: Multi-beam klystrod, connected to the accelerating structure.

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