CALCULATION OF THE GUN AND COLLECTOR FOR ELECTRON COOLING SYSTEMS EX35 AND EX300

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Abstract

Results of the gun and collector simulation for the new developing electron cooling system EX-35 and EX-300 are presented. Gun microperveance is 2.5 mkA/V^3/2. Output transverse temperature of the electron beam is 0.1 eV.

1 INTRODUCTION

The new electron cooling systems EX-35 and EX-300 has been designed for the CSR Project (Institute of Modern Physics, IMP, China) [1] at BINP, Novosibirsk. The electron sources should provide the following parameters listed in Table 1

Table 1: Electron source parameters

Parameters	EX-35	EX-300
Energy of electrons, [keV]	4-35	10-300
Electron beam current, [A]	0.632-3	2.5-3
Magnetic field at gun region, [kG]	1.2-2.4	1.2-5

The electron sources are based on the guns with adiabatic acceleration electrodes. The guns are the same for both electron cooling systems. The main demand for electron source is to minimise additional transverse beam temperature that it should not exceed the cathode temperature of the beam 0.1 eV.

The collector should be able to dissipate an average power of up to 15 kW at 5 kV, and should have a relative current losses less than $3 \cdot 10^{-4}$ at 3 A.

2 ELECTRON GUN

2.1 Parameters of electron guns

The microperveance of the guns is 2.5 $A/V^{3/2}$. The diameter of the gun cathode is 2.5 cm. The guns are immersed in strong magnetic fields. To produce beam diameter 5 cm in cooling section the magnetic field reduces from cathode to cooling section, in this case magnetic expansion factor changed from 1 to 4 for EX35 and from 1 to 10 for EX300.

The main difference between electron sources for EX35 and EX300 is that for EX35 only one additional electrode is used with voltage of up to 35 kV and for high voltage EX300 the postaccelerating section of up to 300 kV is used. Also the magnetic systems in electron source are different because maximum magnetic fields are different too.

2.2 Magnetic systems for the guns for EX-35 and EX-300

The magnetic systems for electron sources were calculated by SAM code [3]. Because aperture of coils and magnetic shields is big enough in a gun region the special magnetic concentrator near cathode is used to increase magnetic field on the cathode. It permits to get necessary value of magnetic field on the cathode surface without increasing length of the magnetic system. The results of magnetic systems calculation are shown on Fig. 1 and Fig. 2. The pictures contain the axis magnetic field distribution along electron source.

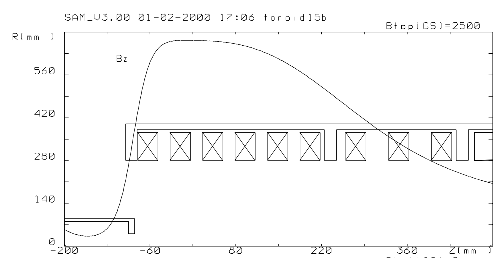

Figure 1: Calculation geometry of the magnetic system for gun of EX35 and axis field distribution.

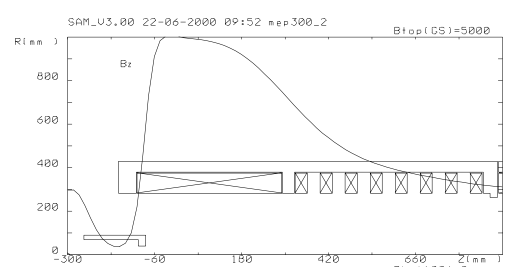

Figure 2: Calculation geometry of the magnetic system for gun of EX300 and axis field distribution

2.3 Calculation beam dynamics in the electron guns

Simulation of the beam dynamics in electron guns was made by SUPERSAM codes [4]. The calculation of additional transverse temperature for the wide range of parameters showed that the value of magnetic field in gun region should not be less than 1.2 kGs to get additional transverse temperature less than 0.1 eV. Figure 3 and 4 show the examples of calculation results for guns of EX35 and EX300 correspondingly for the case of maximum magnetic fields on the cathode. To decrease influence of electrostatic lens on the transverse temperature at the output of accelerating tube additional coil is placed at the tube output. Pictures contain axis distribution of electric and magnetic fields and axis distribution of potential. The beam trajectories are sparse to see beam structure. The current density distribution across beam is homogeneous enough.

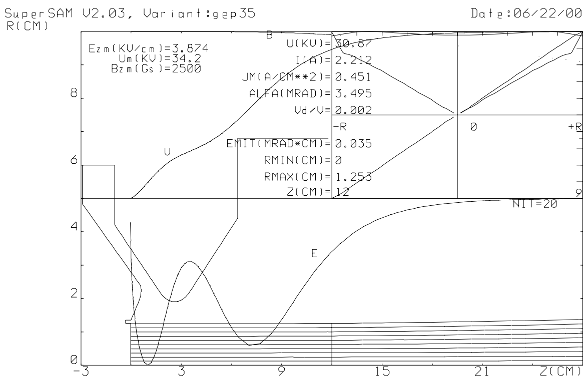

Figure 3: Results of calculation of electron gun for EX35. The beam trajectories, axis distribution of fields and potential are shown. At the right up corner of the picture the current density and angle dependencies in cross section at z =12cm are shown.

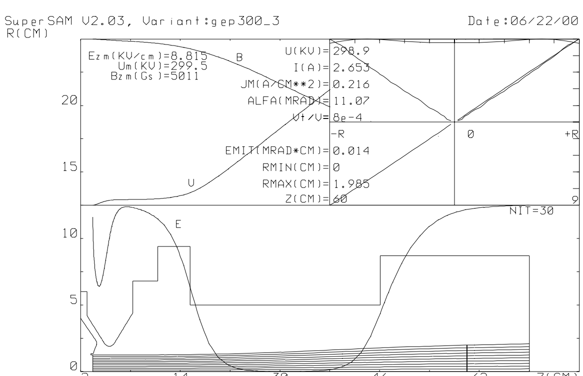

Figure 4: Results of calculation of electron gun for EX300. The beam trajectories, axis distribution of fields and potential are shown. At the right up corner of the picture the current density and angle dependencies in cross section at z =60 cm are shown.

The control electrode can has another potential than cathode, so there is a possibility to change size of emitter surface by switch on negative potential on focus electrode and so control the beam size without changing magnetic field. The Figure 5 shows the result of calculation of electron gun with negative potential on control electrode.

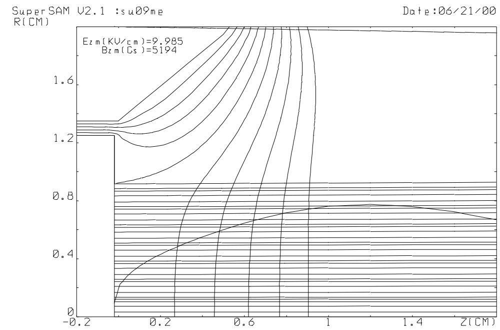

Figure 5: Decreasing of the emitting diameter at -2.5 kV voltage at the control electrode

3 COLLECTOR

3.1 Parameters of collectors

The collectors of both installations should be able to dissipate an average power of up to 15 kW at 5 kV. The shape of collector is the same for both cases. The high power beam in EX300 is deaccelerated by tube up to 10 keV. This tube is identical to accelerating tube used in electron source. The collector has sizes 18 cm in diameter and 17 cm long, and has cooling channels in its body. The differences are in the magnetic system for collectors because different magnetic fields are used in EX35 and EX300. The special suppressor electrode is used to catch slow secondary electrons.

3.2 Magnetic systems for the collectors EX-35 and EX-300.

The magnetic systems for collectors calculated by SAM code [3]. The special conical magnetic shield is used around collector body to produces special magnetic field distribution. The value of magnetic field near suppressor electrode is a half value of magnetic field on the cathode surface.

The results of magnetic systems calculation are shown on Fig. 6 and Fig. 7. The pictures contain the axis magnetic field distribution and force lines.

2.3 Calculation beam dynamics in the collectors

Simulation of the beam dynamics in electron guns was made by SUPERSAM codes [4]. The calculation shows that it is possible to reduce beam energy to 12 kWt at 4 kV. Figure 8 shows the result of collector simulation for EX300. There are beam trajectories, field and potential distribution along axis.

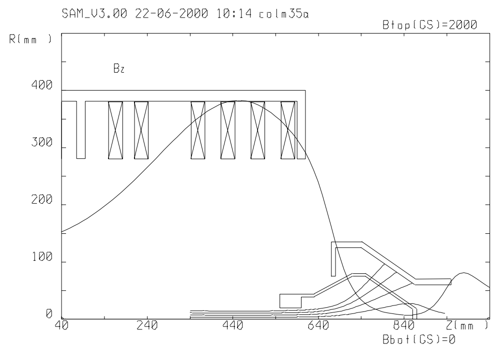

Figure 6: Calculation geometry of the magnetic system for collector of EX35 and axis magnetic field distribution and force lines

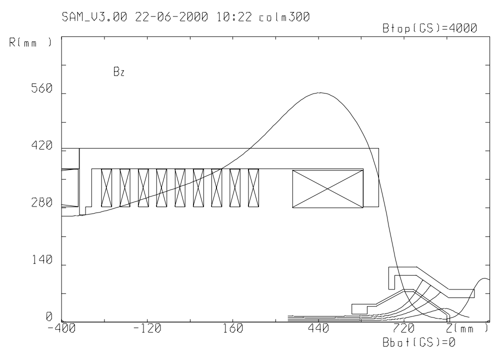

Figure 7: Calculation geometry of the magnetic system for collector of EX300 and axis magnetic field distribution and force lines

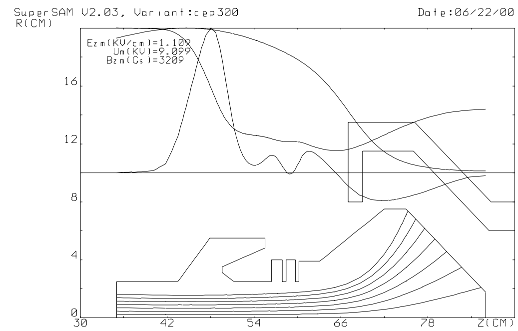

Figure 8: Results of collector calculation for EX300. There are beam trajectories, axis fields and potential distribution.

REFERENCES

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