ELECTRON-OPTICAL SYSTEM OF 200 kV GUN FOR THE VEPP-5 PREINJECTOR

V.E. Akimov, I.V. Kazarezov, G.I. Kuznetsov, M.A. Tiunov
Institute of Nuclear Physics, SB RAS, 630090, Novosibirsk, Russia, 11, Lavrentiev av.;
E-mail: I.V.Kazarezov@inp.nsk.su

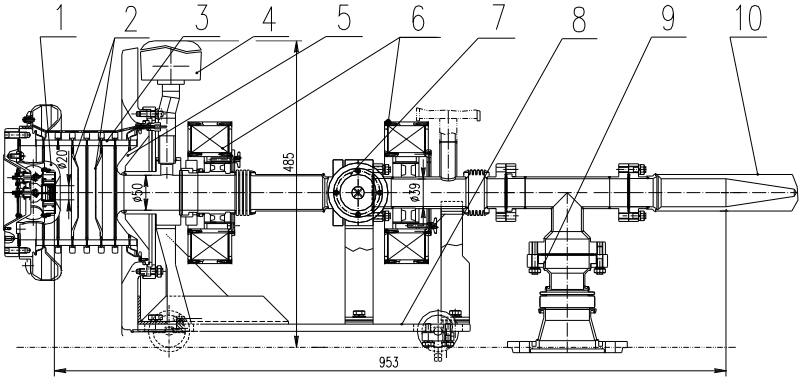
The electron gun with a new electron-optical system to match project parameters of the VEPP-5 preinjector is described. The gun produces the current with 10 A amplitude, pulse duration 2...3 ns at half-height and electron energy 200 keV. The gun has a dispenser cathode 20 mm in diameter and 100 mm spherical radius. The current control is performed by means of molybdenum equipotential grid with the cell size 0.4·0.4 mm and optical transparency of about 0.68. The experimental results obtained are in good agreement with project parameters.

PACS: 29.17.+w

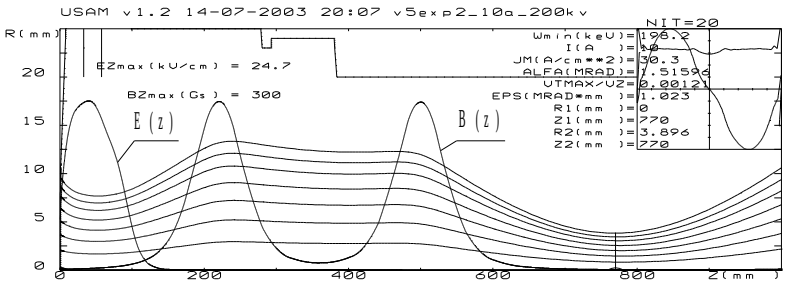
1. INTRODUCTION

In the Budker Institute of Nuclear Physics, SB RAS, Novosibirsk, according to the VEPP-5 preinjector project [1] a first version of its preinjector has been developed and put into operation [2]. To generate electron bunches, an electron gun operating at a stable mode of 200 kV, 2A current amplitude is used [3].

As an electron emitter, the 12.5 mm in diameter oxide cathode-grid unit based on the GS-34B valve is used [3]. This gun does not provide a required current and also is not durable enough, so a new electron source with enhanced parameters listed below has been constructed.



a



b

Fig.1. Electron gun:
General view (1 – cathode-grid unit with focusing electrode; 2 – electrodes; 3 – accelerating tube; 4 – ion pump; 5 – anode; 6 - magnetic lenses; 7 – gate; 8 – bed frame; 9 – vacuum channel; 10 – collector) (a); results of simulation (electric and magnetic field axial distributions, trajectories of electrons, at the right upper corner – current density distribution and phase portrait of the beam at the entrance to RF accelerator) (б)

Electron energy .....200 keV
Bunch current amplitude .....10 A
Pulse duration (at half-height) ..2...3 ns
Pulse repetition rate .....50 Hz
Beam emittance less than .....0.01 π cm rad
The cathode life-time is more than 10^4 hours.

In the paper the results of computer simulation, the electron gun design, and experimental data are presented.

2. OPTICAL SIMULATIONS

The sketch of the electron gun and its electron-optical system are presented.

The electron gun based on the accelerating tube along with focusing electrodes is manufactured on the

PROBLEMS OF ATOMIC SIENCE AND TECHNOLOGY. 2004. № 1.
Series: Nuclear Physics Investigations (42), p.128-130.

flange as one spear unit (1). A dispenser spherical cathode unit produced in "Thorium", Moscow [4], is used as an electron emitter. The cathode has the diameter 20 mm, spherical radius of 100.4 mm. The cathode allows 4-5 disassemblies of the gun and exposure on the air without its emission degradation. The control grid has spherical radius 100 mm, sell size 0.4·0.4 mm, width of crosspieces 0.06 mm, it is made of 100 μm molybdenum. The distance for the cold cathode-grid is 0.4 mm.

The accelerating tube (3) consists of 6 welded alumino-oxide ceramic rings with outer and inner diameters 150 mm and 135 mm respectively. The electrodes are made of Kovar, while the spacers of copper. The accelerating electrodes (2), which along with the focusing ones and anode are forming the electron-optical system, are fixed into the tube electrode recesses.

The beam transportation and its matching to the linear accelerate input is performed by means of two magnetic lenses (6). Nanosecond beam pick-ups (are not shown in Fig.1) allow recording a value and a shape of the current pulses with required time precision. Vacuum gate (7) installed between the gun and the linear accelerator permits one to fix on the preinjector the operational gun previously prepared and tested on the separated facilities. The gun and the vacuum channel are on the frame. Gun pumping during its activating phase is carrying through the vacuum channel (9) by additional pumps.

Simulations of the electron-optical system as well as of the cathode-grid unit have been made by the computer code UltraSAM [5] in electrostatic approximation. One of the alternatives of the beam propagation from the grid surface to the collector is shown in Fig.1,b. The current density on the grid is uniform. The initial electron energy is 0.17 keV. The aim was to minimize the beam emittance at the gun entrance. To simulate the separate cell of the control grid an axially symmetric model of a square sell with equal area was chosen. The full amount of such cells is about 2000. The cathode-grid gap in simulation was put 0.3 mm, taking into account a thermal drift of 0.1 mm. In Fig.2 one can see the results of computing. At the grid the electrical potential area is 7 kV/cm and the grid voltage is 0.17 kV.

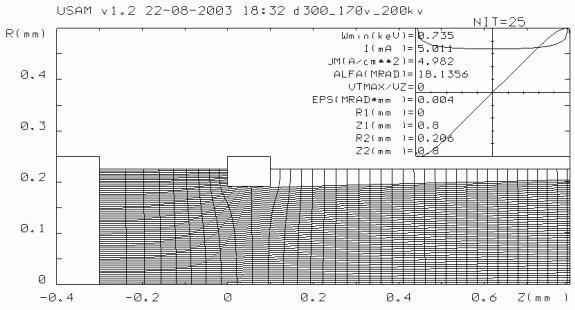


Fig.2. Results of simulation of the model of square grid cell. Between neighbor equipotential lines is 20 kV, trajectories of electrons, current density distribution and phase portrait of the beam at 0.8 mm from the grid (the right upper corner)

In Fig.3 the calculated dependences between cathode current, collector current and grid one and grid voltage are presented. One could also see the maximum relative spread of transverse velocities of electrons at the grid plane versus U_g. For these simulations a model of the cathode–grid unit described above was employed.

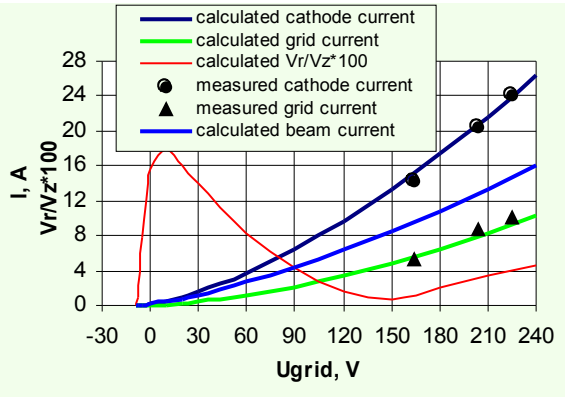


Fig.3. Results of simulations and measured VA plot of the new 200 kV gun for VEPP5 preinjector

3. EXPERIMENTAL RESULTS

The cathode supplies pulse current is up to 8 A at the heating power of 39 W, at 45 W it goes up to 16 A, at 54 W it is 26 A at the partially temperature limited mode.

In the test facility at the cathode voltage $U_к$=50 kV, the bias grid voltage was $1.02 \cdot 10^{-3}$ of cathode voltage. In this mode we had in the collector 1.2 of 1.75 A from the cathode, that was 0.685 of path current flow at grid optical transparency 0.68, that corresponds to 9.6 A at U_k=200 kV.

The measured cathode current and grid current for different grid voltages are presented in Fig.3. Measurements were performed at 50 kV on the cathode and were related to U_k=200 kV according to "3/2" law.

The measured cathode-grid capacitance on flange leads-in is 23 pF. The grid bias voltage at 200 kV of the anode one comprises 11…12 V and depends on gun heating power.

The thermal drift of the grid depends on the operating heating power. The gap between the cathode surface and the greed is 0.33…0.35 mm while 0.4…0.42 mm in cold condition.

The grid emission at 50 W of heating power is ~5 μA at the pressure $4 \cdot 10^{-6}$ Pa. When we use one pump of 10 l/sec capacity, the vacuum is $5 \cdot 10^{-5}$ Pa at 50 W of heating power.

CONCLUSION

The results of experimental testing of the new gun allow us to conclude that its parameters achieved are perfectly match to these required for the VEPP-5 preinjector project. When controlling systems are manufactured and tested in the operating mode, the electron source will be fixed on the preinjector.

The authors are very grateful to P.V.Logachev for fruitful discussion as well as to M.A.Batazova for her assistance in preparation of this paper.

REFERENCES

1. Physical project of the complex VEPP-5, Budker Institute of Nuclear Physics Novosibirsk, 1995.

2. M.S.Avilov, V.E.Akimov, A.V.Alexandrov, A.V.Antoshin, I.V.Kazarezov et al. Testing of the accelerating section of the preinjector Vepp-5 // *Proc.of XVII conference on charged particle accelerators, 17-20 October 2000. Protvino,* 2000, v.1, p.71-78.
3. V.E. Akimov, I.V. Kazarezov A.A. Korepanov et al. 200 keV electron beam pulse source for the complex VEPP-5 preinjector // *Voprosy Atomnoj Nauki i Tekhniki. Series: "Yaderno-fizicheskiye issledovaniya".* 2001, № 3, p.111-112.
4. I.G.Artyukh, M.V.Kalinin, B.Kh.Kantselson et al. Cathodes for electro-vacuum devices // *Zarubezhnaya radioelectronika.* 1998, № 5, p.72-77 (in Russian).
5. A.V. Ivanov, M.A. Tiunov. ULTRASAM - 2D Code for Simulation of Electron Guns with Ultra High Precision // *Proceedings of the EPAC2002, Paris.* 2002, p.1634-1636.

ЭЛЕКТРОННО-ОПТИЧЕСКАЯ СИСТЕМА 200 кВ ПУШКИ ДЛЯ ПРЕДЫНЖЕКТОРА VEPP-5

А.Е. Акимов, И.В. Казарезов, Г.И. Кузнецов, М.А. Тиунов

Описана электронная пушка с новой электронно-оптической системой, соответствующая проектным параметрам предынжектора VEPP-5. Пушка дает ток 10 А с длительностью импульса 2…3 нс на полувысоте и с энергией электронов 200 кэВ. Пушка имеет диспергируемый катод диаметром 20 мм и сферическим радиусом сферы 100 мм. Управление осуществляется посредством молибденовой эквипотенциальной сетки с ячейкой размером 0.4·0.4 мм и оптической прозрачности около 0.68. Экспериментальные полученные результаты находятся в хорошем соответствии с проектными параметрами

ЕЛЕКТРОННО-ОПТИЧНА СИСТЕМА 200 кВ ГАРМАТИ ДЛЯ ПРЕДИНЖЕКТОРА VEPP-5

А.Є. Акімов, І.В. Казарезов, Г.І. Кузнєцов, М.А. Тіунов

Описано електронну гармату з новою електронно-оптичною системою, що відповідає проектним параметрам передінжектора VEPP-5. Гармата дає струм 10 А с тривалістю імпульсу 2...3 нс на напіввисоті і з енергією електронів 200 кеВ. Гармата має диспергуємий катод діаметром 20 мм і радіусом сфери 100 мм. Керування здійснюється за допомогою молібденової еквіпотенційної сітки з коміркою розміром 0.4·0.4 мм і оптичною прозорістю близько 0.68. Експериментально отримані результати знаходяться у відповідності з проектними параметрами.