DESIGN AND EXPERIMENTAL RESULTS OF 160 KV DC ELECTRON SOURCE

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Abstract

A portable high voltage D.C. electron source was developed for use in environmental clean up with nominal beam parameters 160 kV, 15 mA. Different approaches were investigated. Experimental results seem encouraging and show a satisfactory device performance which is to be tested in the field.

1. Introduction

Zapit Technology, Inc. was formed as a Schonberg Research Corporation spin-off company to commercialize it's electron beam toxic waste destruction system [1]. The latter is an on-site hazardous waste destruction system for the vapor-phase treatment of volatile organic compounds found in the air, soil, and groundwater.

Schonberg Research Corporation designed and built the electron beam tube for this system with the following parameters: 160 kV, 15 mA. The subject of the research and development is not innovative [2], [3], but comprised several essential features: compact size, easy repair ability of the tube, and, therefore, offering a unique product at a low cost. The beam power is low compared to some commercial radiation facilities, but in a number of applications the small size, weight, and cost of the equipment could be a major requirement to practically apply the system.

One of the main problems, which could arise in such a development, due to the high power density dissipated in a window foil, is a beam exiting into atmosphere. One would strongly desire to obtain "flat" distribution of the beam current density over a window area and avoid hot spots to reduce risk of damaging a window and increase the lifetime of the device.

2. Design Aspects and Experimental Results

One of the electron tubes built at SRC is shown on Fig.1. In the picture one could not see the window foil, as it is protected with the aluminum plate. The tube is made out of stainless steel, the window support is a perforated copper plate. A tungsten wire thermionic cathode is used in order to regulate the electron flow and density distribution, a semi-spherically shaped grid is placed in front of the cathode.

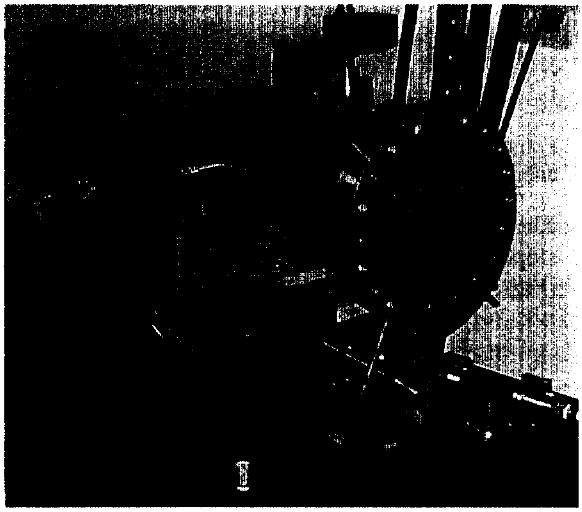

Figure 1: The experimental set up with 160 kV tube.

In order to calculate the electron trajectories in the tube, we have generated a computer code which uses the results of a SUPERFISH field plot to present beam dynamic in graphical form. Results of the simulations in a grid-anode gap using each of the codes is shown in Fig.2.

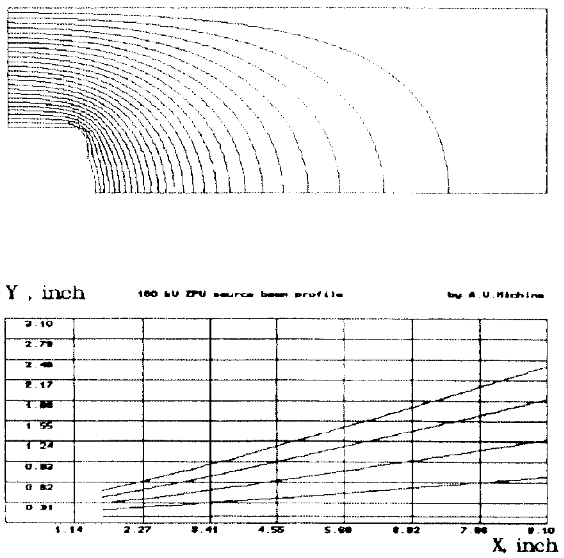

Figure 2: Equipotential lines and beam trajectories in grid-anode gap.

The beam spot size on the window and the beam slope are quite sensitive to the grid curvature radius (Fig. 3).

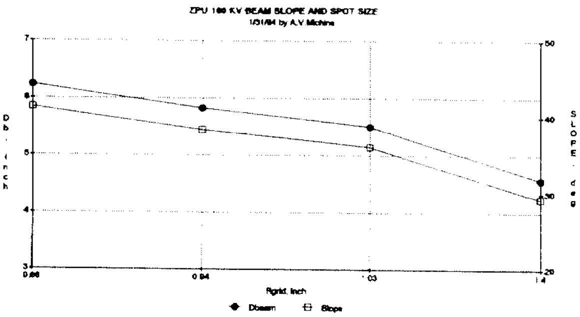

Figure 3: Beam spot diameter and slope vs. grid radius of curvature.

The cathode-to-grid distance is also very important to get even distribution of beam current density on the window.

At low energies, it is quite important to maintain a limited value of heat dissipated in the window foil due to beam absorption. The beam losses are high at 160 kV [4], [5] and would create a foil heating problem, which is illustrated in Fig. 4.

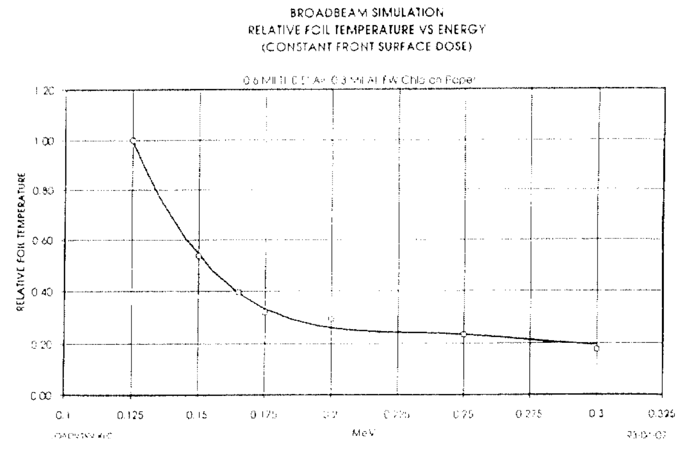

Figure 4: Relative foil temperature vs. beam energy.

This plot was made using TIGER code which was provided by Sherm Farrel (RPC). One would not want to reduce the voltage below 160 kV as beam losses would rise dramatically. Normally, beam current density on the foil is maintained below 0.2 mA/cm^2 for commercial units [3]. The normal life time for 15 to 100 micron thick titanium foil is thousands of hours, with a total acceptable dose of 10^6 Mgy. Total beam losses in the tube before getting the electron beam out to the atmosphere could go as high as 50% of the total beam power, so water and air cooling is provided.

The tube has been tested under continuous operation and demonstrated satisfactory performance.

Beam current density distribution at the exterior of the window is shown in Fig. 5 inside the vacuum chamber which is very close to the theoretically predicted value. Currently, the installation is in use in the field and the technique is being determined for vapor detoxification [6].

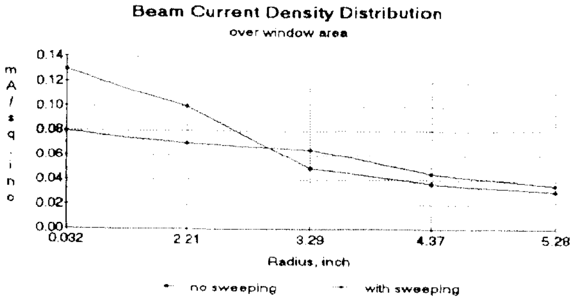

Figure 5: Experimentally measured beam current density distribution behind the window (air).

3. Conclusions

The beam characteristics obtained are in good accordance with designed values. We think that serial manufacturing of the unit for industrial application is feasible. However,we need to run the unit continuously in a steady state condition to determine it's lifetime. This was not possible due to a very tight schedule and some adjustments to the design during the experimental tests. The foil operating conditions are acceptable and lie below the critical values mentioned above.

4. Acknowledgments

The authors appreciate the support and suggestions provided by Roger Miller from SLAC and helpful consulting by Sherm Farrel, RPC Industries.

5. References

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