THE FLAT CORONA TRIODE AND INTERMEDIATE SHIELDS IN ELECTROSTATIC GENERATORS

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Abstract
A design and principle of the flat corona triode functions is described. This construction allows to leak the current of corona triode through the intershield of the electrostatic generator. The influence of the intershields on the parameters of electrostatic accelerators is discussed. Calculations of position and number of the intershields ensuring the maxima voltage of electrostatic generator are presented. Experimentally was demonstrated that using two intershields increases the voltage of the generator up to 60%.

1 INTRODUCTION

The corona triode is used for voltage stabilization in the electrostatic accelerators with the positive polarity of the terminal. In this case the intermediate shields are not used so they prevent passing of the current of corona triode at the terminal. Nevertheless, A.V. Almazov had realized the voltage stabilization of electrostatic generator with the intermidiate shields by corona triode [1]. In order to allow passage of corona triode current through intermidiate shield it was made aperture in the screen. The aperture was arrange in the place of hitting of the corona current to the shield. The metallic disk with gasket of semiconductive rubber was positioned in this aperture. About ten points were seated on the edge of disk. That flat disk with the points A.V. Almazov has named as a flat corona triode. If the corona triode current passes to the disk of flat triode the voltage of disk relatively to the intermediate shield will change. It results in the beginning corona current from flat corona triode points to the terminal. The availability of semiconductive rubber gasket results in the small current leak from flat triode to intermediate shield voltage. Then there are not a sparking between the intermediate shield and the disk of flat triode. But that flat corona triode was not working long as the resistance of the semiconductive rubber was decreasing gradually. The reproduction of that rubber was failed. Therefore we have elaborated new construction of flat corona triode in order to increase the voltage of the EG-8 accelerator.

2 FLAT CORONA TRIODE

Scheme of construction of the flat corona triode is illustrated in Figure 1. The grid 1 of flat corona triode is fixed in the aperture of the intermediate shield 2 by means of flange 3. Disk with the points 4 is installed inside of the grid by means of isolator 5. Disk is connected to grid by means of leak resistor 6. The points are fixed in the disk so that the space between the end of points and the external surface of grid is equal about 0.6 mm.

The magnitude of leakage resistance R can be found in the following way. The time constant RC of the disk with the points must be not greater than the time constants of the terminal and intershield, which have the magnitude about second. Assuming that capacity C of the disk is equal to

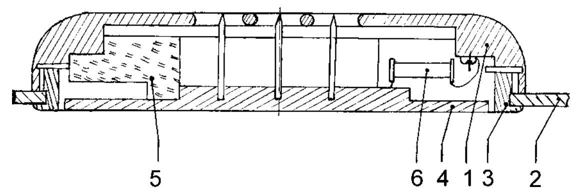

Figure 1: Schematic view of the flat corona triode.
1 - grid; 2 - intershield; 3 - flange; 4 - disk with points; 5 - isolator; 6 - leak resistor.

10 pF it is obtained that $R < 1\ s / 10\ pF = 100\ G\Omega$. In order to not make worse the quick-action of corona triode the leakage resistance R must be by one order of magnitude larger than internal resistance 1/S of corona triode. Here S is the steepness of corona triode equal about 15 μA/kV [2], therefore $R > 10/15 \cong 0.7\ G\Omega$. We believe that through leakage resistance must pass not more 0.1 of average current of corona triode. Usually the average current is equal to 10 μA by average voltage at the grid of flat triode about 2 kV. Hence it follows that $R > 2kV/0,1{*}10\mu A = 2\ G\Omega$. In consequence of these appraisals it is obtained that value of the leakage resistance should fall within the range from 2 to 100 GΩ.

The small value of voltage at the points of flat corona triode allows to decrease (less than 1 mm) isolating gap between the disk and the intershield. In this case the availability of the flat triode has not influence on the electric strength of the gap between tank and intershield. In our case the thickness of the flat triode is equal to 24 mm and radius of protuberant part is equal to 20 mm. Generally, the thickness of flat triode must be as high as possible to decrease drift time of ions to terminal which is proportional to square of a distance [3]. But it should not decrease the electric strength of gap between the terminal and shield.

3 INTERMEDIATE SHIELDS

Long and successful exploitation of the stabilization system of the electrostatic generator EG-8 is made vital consideration of question concerning the choice of number of the intershields and their optimum disposition.

Voltage of electrostatic accelerator with one intershield U_1 is a sum of the voltages of two isolating gaps:

$$U_1 = E\,[r \ln(r_1 / r) + r_1 \ln(R / r_1)], \quad (1)$$

where E is the electric field at the terminal and at the outside of intershield; r is the radius of terminal; r_1 is the radius of the first intershield; R is the radius of tank. If intershield is at the optimum position then the value of U_1 will be maximum and for this position the first derivative $dU_1/dr_1 = 0$. This condition yields

$$R / r_1 = \exp(1 - r / r_1). \quad (2)$$

This equation permits to determine optimum position of the intershield. For example, if we take $r_1 / r = e = 2.72$ then we receive the ratio $R / r_1 = 1.88$. Similarly, for several intershields we can write:

$$r_2 / r_1 = \exp(1 - r / r_1)$$
$$r_3 / r_2 = \exp(1 - r_1 / r_2) \quad (3)$$
....
$$R / r_i = \exp(1 - r_{i-1} / r_i),$$

where i is the number of the intershields. Equations (3) can be used to calculate the terminal voltage U_i for the case of several intershields. These data are summarized in Table 1. The achieved terminal voltages of two identical accelerators type of MP - 6 and MP - 7 are

Table 1: Dependence of maximum voltage of the electrostatic generator U_i/ER and the position of shields on the number of intershields.

i	R/r_i	R/r	U_i/ER	U_i/U_0
0	2.72	2.72	0.368	1.00
1	1.88	5.10	0.531	1.44
2	1.60	8.17	0.626	1.70
3	1.45	11.9	0.688	1.87
4	1.37	16.2	0.732	1.99

equal -11 MV and +16 MV respectively [4]. It can be seen that maximum electric field of negative polarity is smaller than the electric field of positive polarity at the same conditions. The ranges of ratios of tank radius to terminal radius R/r, where the intershields can be used, may be determined from assuming that this decreasing of voltage is accounted by the corona current from negative electrode. This is illustrated by Figure 2 where the curves are calculated using Equation (1). It can be seen that utilization of electrostatic accelerators with the ratio $R/r < 1.45$ is purposeless because of arising of corona from the terminal. Use of intershields is purposeless also in the range $1.45 < R/r < 2.3$ where the corona arises from tank. In the range $2.3 < R/r < 4.3$ it is expedient to use one intershield and in the range $R/r > 4.3$ it is necessary to use two intershields. From the Table 1 it can be seen that third shield always results in corona from tank, as ratio R/r = 1.45 and in this case the corona arises always.

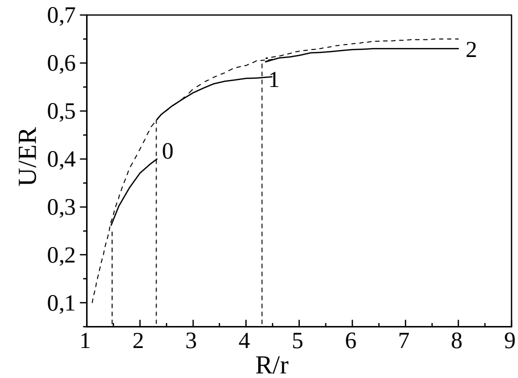

Figure 2: Dependence of voltage U/ER of electrostatic generator with optimum disposition of the intershields on the ratio R/r. 0 - without any shields; 1 - with one shield; 2 - with two intershields. The broken line shows the range where a corona from tank occurs.

Electrostatic accelerator with two shields has the ratio R/r = 8.17 at maximum voltage but in spite of increasing of terminal radius about R/r = 5 the voltage decreases only by 1.5 %. Electrostatic accelerator of Institute of Nuclear Physics of MSU has two intershields. But with flat corona triode only one external intershield is used because of spark between tank and external shield. That is why the using of internal shield is not necessary.

4 CONCLUSION

Utilization of the flat corona triode with one intermediate shield in accelerator allows to raise the terminal voltage. Using the flat corona triode allows to decrease voltage oscillations of the exit of constant current amplifier of the stabilization system. It testifies the improvement of ion beam stability caused by increasing of the terminal capacity by intershield.

The above described consideration has qualitative character in order to understand the regularities which influence to choice of number and disposition of intershields. It is necessary to use experimental data of electrical strength of corresponding isolating gaps in order to solve that problem correctly.

5 REFERENCES

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