Breakdown Voltage Calculation for Gases with Nonuniform Fields of an Accelerator by Base Method

K.A.Rezvykh, V.A.Romanov

Abstract

The method for calculating the breakdown voltage of gas insulating the gaps in accelerator has been developed. A new model of insulation system element is proposed according to the results of tests for the EG-2.5 Van de Graaff accelerator, IPPE (Fig. 1). Complete enough set of causes (factors) for the gas breakdown has been defined based on the experimental and calculated study. The calculation method includes the combination of some analytical equations coupled with the results of a special experiment with breakdown. A conclusion is made based on the comparison of experimental and calculated findings for the EG-2.5, MP and FN accelerators and other insulation structures that the accepted element model and the used dependencies of the breakdown voltage on the main factors are adequate to the gas discharge nature of different gases. Since the calculation error is within of the limit for the input data, the method described allows to predict the breakdown voltage for insulation gaps of accelerator with accuracy of 1-5%.

The breakdown voltage is calculated accurately enough if the value of the breakdown gradient is obtained from the procedure described above and relates to the given special conditions. It can be stated that the element model accepted for the insulation system and the set of the breakdown factors considered are adequate for the nature of the gas discharge. The old concept according to which the breakdown gradient can be found from generalized data obtained by other experiments seems to be not satisfactory, since it involves different surface conditions and uses an incomplete set of the breakdown parameters. The method is valid for different gases. As a rule the total error of calculations does not exceed the error limits of the input data. So the calculation accuracy is achievable within some per cent for the high-voltage accelerators.

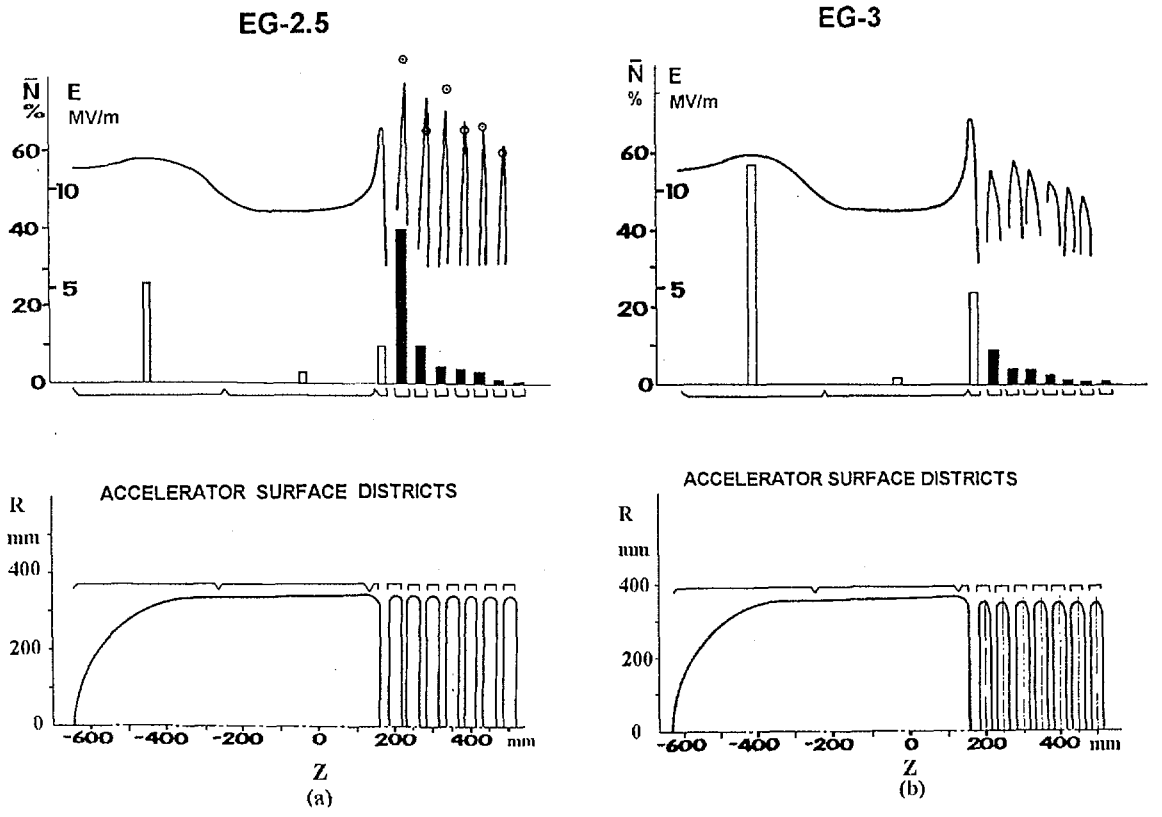

Fig. 1. The distribution of the potential gradient E (full line) and the mean number $\overline{N}$ of the breakdown marks (□) along the electrode surfaces for two modifications of the EG-2.5 accelerator [13]. (a) EG-2.5 with hoops of the circular cross section, (b) EG-3 with hoops of the twice oriented oval cross section. Both insulating systems consist of two elements: the terminal top ($z \leq -250$ mm) and the junction of the terminal and the column ($z > 112$ mm). Accelerator dimensions in mm. The terminal potential (U_{calc}) is equal to 2,5 MV at the field calculation.

° – the potential gradients corresponding to the variation (within ± 3 mm) of the 350 mm external radius for the first, second, etc. hoops;

– the terminal number of spark marks on the surface districts;

■ – the hoop number of spark marks on the surface districts