BREAKDOWN CHARACTERISTICS OF AIR CONTAINING 0.125% OF SF_6 AT DIFFERENT GAP SPACING

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ABSTRACT

AC breakdown strengths of SF_6, air and a mixture of SF_6+Air containing 0.125% of SF_6 in non-uniform field were experimentally studied. The electrode gap spacing and the relative gas pressure were varied within the range of 5-25 mm and of 100-500 kPa respectively. In short gaps the breakdown voltages of the mixture and air have approximately similar and these values are below the breakdown voltage of pure SF_6. The experimental results have shown that the AC breakdown voltages of SF_6+air mixtures are higher than those of pure SF_6 and air above the range of pressure 250 kPa for 20 and 25 mm gap spacing. At this gap spacing SF_6+air mixtures show less degree saturation at high pressures.

INTRODUCTION

Sulphur-hexafluoride (SF_6) gas and its mixtures with other less expensive gases such as air, N_2 and CO_2 etc. are being investigated in recent years [1-3]. There are two basic reasons for carrying out such investigations. Firstly, the aims are to develop an insulating medium which is technically as well as economically attractive. The other reason is to obtain a better understanding of the breakdown mechanisms operating in SF_6, other compressed gases, and their gas mixtures. The breakdown characteristics of SF_6 gas mixtures in non-uniform field gaps under applications of direct and impulse voltages have been the subject of several studies [4]. A systematic and extensive study of breakdown characteristics of SF_6+air mixtures is still lacking. Earlier measurements have shown that the positive direct breakdown voltages of SF_6+air mixtures exhibit corona stabilization over a pressure range which depends upon SF_6 content of these mixtures, and is higher than the corresponding values for SF_6+N_2 and SF_6+CO_2 mixtures. Over the pressure range of 300 to 500 kPa, SF_6+air mixtures exhibited breakdown voltages which were generally higher than those for SF_6 alone or its mixtures with N_2 and CO_2. In the low pressure range, the breakdown voltages of positive and negative gaps have similar [5]. The negative impulse breakdown characteristics of SF_6+N_2 and SF_6+air mixtures are somewhat similar. In this case, an addition of SF_6 impurity to air causes an improvement in the negative impulse breakdown level for gas pressures of up to 300 kPa and lowers this level when pressure is increased above that value [6]. From the existing information it appears that SF_6+air mixtures show relatively less degree of saturation as compared to SF_6+N_2 mixtures. This is probably due to the presence of electronegative O_2 in the air. Because of the presence of chemically active oxygen in air, SF_6+air mixtures are technically less important as compared to SF_6+N_2. The objective of the present paper is to investigate the non-uniform field breakdown characteristics of SF_6, air and SF_6+air mixtures experimentally under alternating voltage.

EXPERIMENTAL SET-UP

Experiments were carried out using a rod plane electrode with a rod tip radius of 1 mm and plane disc diameter of 75 mm. All experiments were used over a pressure range extending from 100 kPa to 500 kPa and gap lengths ranging from 5 mm to 25 mm. Electrodes were mounted in a pressure vessel of 120 mm diameter and 600 mm length. In rod plane arrangement, the rod was connected to the high voltage supply while the plane was earthed. Before each series of tests, the electrodes were polished and cleaned thoroughly. The test vessel was first evacuated for at least two hours and then filled with the desired gas up to a relative pressure of 500 kPa. The gas mixture was left for at least 2 hours before test, for the purpose of obtaining a uniform mixture. For the 50 Hz AC tests with voltages up to 100 kVrms a high voltage transformer was employed. AC breakdown voltage was measured by means of a capacitive divider. The mean value of breakdown voltage and standard deviation were calculated by means of ten voltage applications.

TEST RESULTS

The breakdown voltages of SF_6, air and a mixture of 0.125%SF_6+air were measured up to a pressure of 500 kPa in rod plane gaps. All results were given in the range of 5-25 mm gap spacing separately in Fig. 1-6.

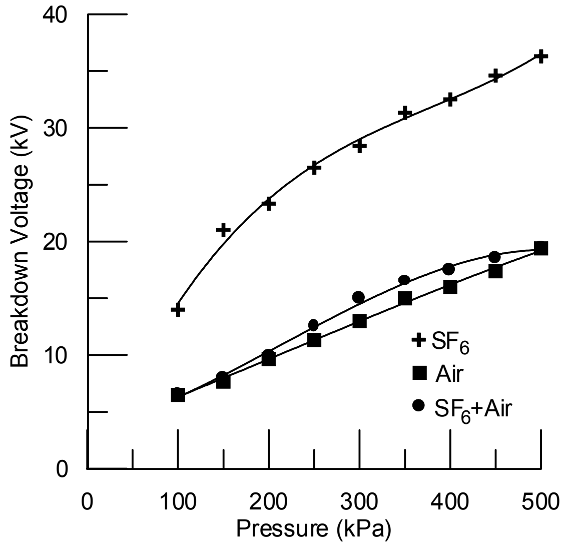

Figure1. Variation of breakdown voltage with pressure in air, SF_6, 0.125%SF_6+air for 5 mm gap spacing.

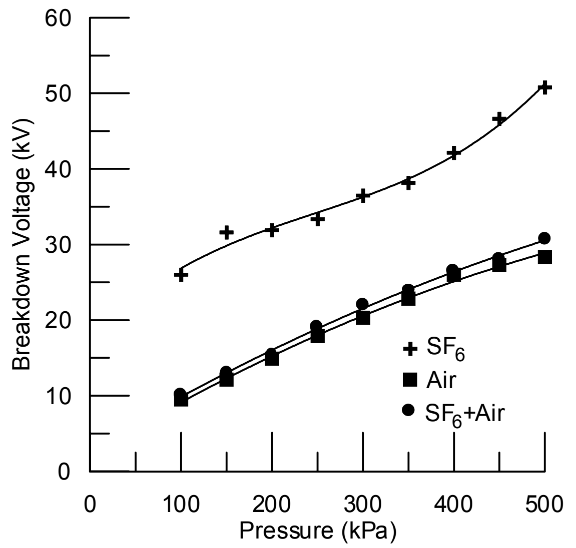

Figure 2. Variation of breakdown voltage with pressure in air, SF_6, 0.125%SF_6+air for 10 mm gap spacing.

Our results indicate that the AC breakdown voltages of 0.125%SF_6+air mixture increase linearly with pressure for 5, 10 and 15 mm gap spacing. For 20 and 25 mm gap spacing the breakdown voltage of mixture exhibit a saturation tendency above 400 kPa. At this pressure the breakdown voltage of air has same character that of mixture. As seen in figures 1-3 for 5, 10 and 15 mm gap spacing, the breakdown voltages of the mixture and air have approximately similar values. In these gaps, breakdown voltages of mixture were less than that of pure SF_6 at defined pressure range. Whereas in 20 and 25 mm gap spacing the breakdown voltage of the mixture is higher than that of pure SF_6 at above 250 kPa. For example, in short gaps the breakdown voltage of SF_6 is about 2 times that of air

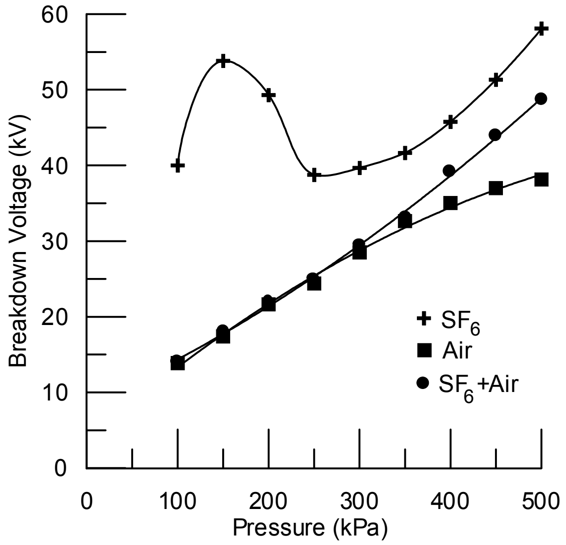

Figure 3.Variation of breakdown voltage with pressure in air, SF_6, 0.125%SF_6+air for 15 mm gap spacing.

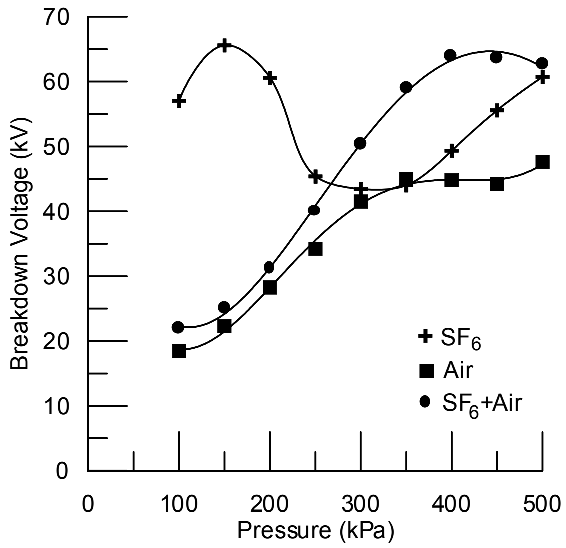

Figure 4. Variation of breakdown voltage with pressure in air, SF_6, 0.125%SF_6+air for 20 mm gap spacing.

and mixture at a pressure of 400 kPa, however at that pressure the breakdown voltages of mixture for 20 mm and 25 mm gap spacing were obtained 33% and 50% higher than that of pure SF_6 respectively. Even at the pressure range of 300-400 kPa the breakdown voltage of air is higher than that of pure SF_6 for 25 mm gap spacing. SF_6+air mixtures show relatively less degree saturation at high pressure as compared to SF_6+N_2 and SF_6+CO_2 but at higher pressure the breakdown voltages of SF_6+air mixtures are better than that of others [7, 8]. As seen in figures 3 to 5, the pressure p_m where the peak occurs in the breakdown voltage-pressure curve is about 150 kPa for pure SF_6. However its value is in the range of 400 kPa for SF_6+air mixtures.

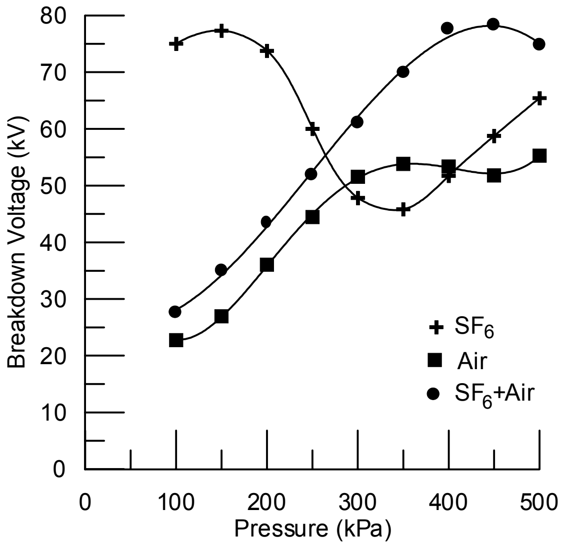

Figure 5. Variation of breakdown voltage with pressure in air, SF_6, 0.125%SF_6+air for 25 mm gap spacing.

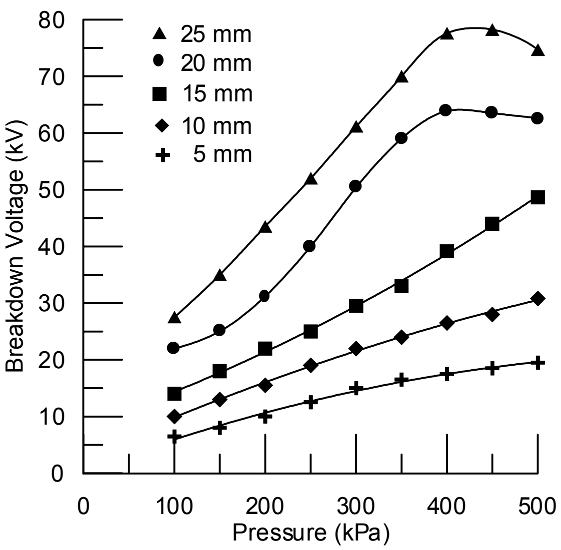

Figure 6. Variation of breakdown voltage with pressure in 0.125%SF_6+air for different gap spacing

CONCLUSION

Mixtures of 0.125%SF_6+air appear technically very attractive since such mixtures can have dielectric strength superior to that of pure SF_6 and air especially for 20, 25 mm gap spacing above the pressure of 250 kPa. In short gaps, the breakdown voltages of pure SF_6 and air have similar values. However a complete evaluation of air due to sparking is essential before this mixture is considered for possible applications in high voltage devices. This phenomenon is probably due to the presence of oxygen in the air and leads us to think of the use of such mixtures in high voltage apparatus.

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