Study of Breakdown Voltage Phenomenon in SF_6-N_2 gas mixture with Spacers

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Abstract

Gas Insulated Substations (GIS) have been used for more than three decades in power systems due to their reliability, ease of maintenance, and low ground space requirements. Gas Insulated systems require solid insulating materials to provide mechanical support for conductors. Hence the spacers used in GIS should be precisely designed to realize more or less uniform field distribution along their surfaces. GIS occupy an important position in the power system. Insulating spacers are important parts in GIS. GIS have been used for many years as a means to provide safe and reliable high volt-age electrical systems. Normally, the problems connected with the use of these systems are few, especially when lower voltage levels are considered. The aim of this work is to study the breakdown voltage (BDV) phenomenon on 10% Sulphur Hexa Fluoride(SF6) and 90% Nitrogen(N2) gas mixture with Poly Methyl Metha Acrylate (PMMA) spacers.

Keywords: *Breakdown voltage, spacers, SF6-N2, Gas Insulated Systems*

1. Introduction

The rapid urbanization and over population make expanding the transmission network very challenging due to the right of way problem and the limited amount of space available. There are also many issues with conventional air-insulated substations, including pollution by salt or dust, meteorological difficulties, and safety concerns. To overcome these problems, underground cable and gas-insulated substations (GIS) are needed to replace conventional transmission lines and substations.

SF_6 gas is considered to be greenhouse gas. Hence it cannot be used without gaseous mixtures. Only a small content of SF_6, about 10% is used with nitrogen gas about 90% as mixture in GIS.

The metal particle material affects the flashover voltage on spacer only under high gas pressure and high surface electric field of metal particle. The flashover voltage is almost the same when the iron or aluminum particle is attached, and is higher when the copper particle is attached [7]. GIS occupy an important position in the power system. Insulating spacers are important parts in GIS. The use of compressed gas as the insulating medium has made it possible to use compact equipment compared to that with air insulation [l-4]. The particle contamination on the spacers is one of the causes for the partial discharges which in turn cause the insulation failure. The particle contamination inside the GIS may occur because of the manufacturing process, from mechanical vibrations, moving parts of the system such as breakers. It can also be from the negligence during the maintenance inside the GIS or from corrosion or decomposition of the metallic products. A critical part in the development of GIS is support spacers. Surface flashover shows a strong sensitivity to metallic particle contamination of the spacer surface. A free conducting particle, moving near a spacer, under AC ramp voltages close to the particle crossing voltage, may initiate a breakdown [5].

Spacers are the weakest links in GIS, in addition to metallic particles. Spacers are used to support and insulate high voltage conductors in GIS. In the presence of a metallic particle, the breakdown strength of an SF6 test gap bridged by an alumina filled epoxy spacer is drastically reduced. The discharge always involves the particle [6]. The effect of conducting particle on spacers subjected to High Voltage is studied in Air Insulated system. The humidity did not influence the flashover voltage of the spacer as long there was no condensation. On the other hand, the gas pressure and the condition of the epoxy surface play significant roles in the flashover voltage [8]. In an electrical system, breakdown occurs when the insulation is lost. Insulation between electrodes can be solid, liquid, and gaseous. A breakdown strength of an insulation is determined by its ability to withstand a voltage. Various types of media, including solids, liquids, and gases, have been studied extensively in order to understand the breakdown phenomenon between electrodes. As per the International Electrotechnical commission (IEC), the standard electrode configuration used for the purpose are plane-plane, point-plane, rod-plane and sphere-plane.

2.Experimental Set up

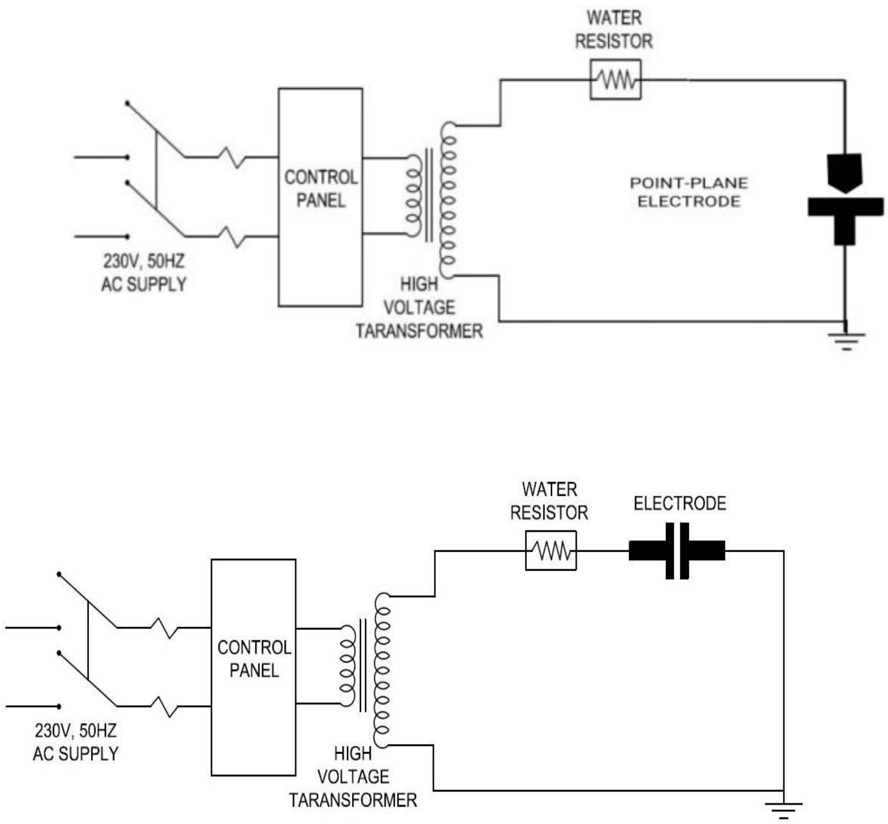

Figure 1. Circuit diagram of the experimental set up

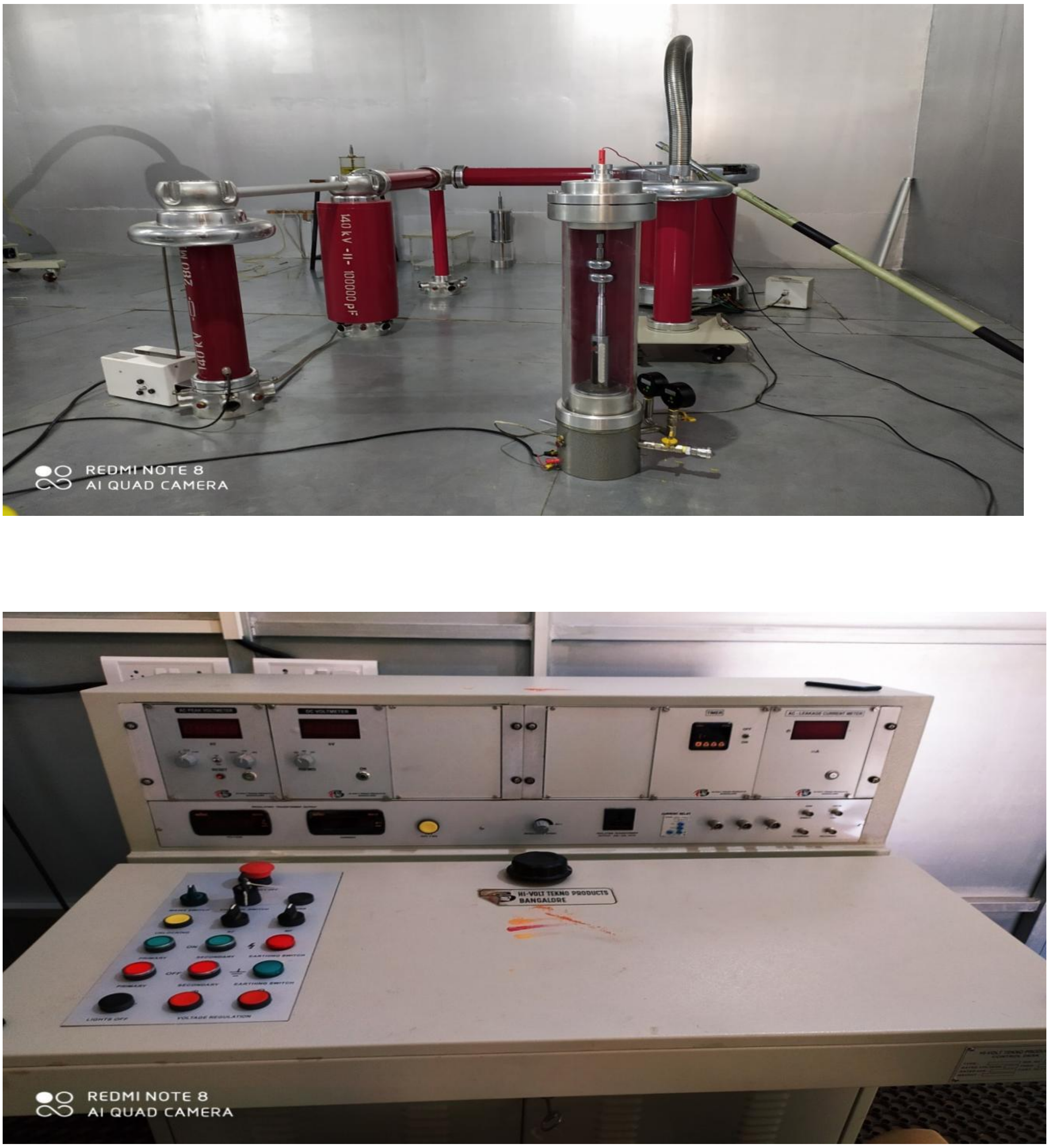

Figure 2. Laboratory experimental set up

3.Experimental Procedure

1. Output terminal of the high voltage transformer is connected to the gas chamber through water resistor.
2. Place the different electrodes in gas chamber in their proper position.
3. Now the main supply is switched on from control panel.
4. Voltage is increased using increase button from the control panel till the Breakdown occur.
5. Distance between the electrode increases in each step
6. Before placing the next different electrodes in gas chamber, proper discharging is done through grounding rod.

4. Results and Discussion

Table 1. Variation of BDV under AC on PMMA spacers in SF6/N2 gas mixture for different pressure (Plane-Plane)

Electrode Spacing(mm)	BDV at 0.1MPa pressure (KV)	BDV at 0.2MPa pressure (KV)	BDV at 0.3MPa pressure (KV)
5	22.75	27.93	29.81
8	38.56	41.12	49.32
10	44.95	51.42	54.58
12	59.88	62.97	71.11
15	63.14	66.45	70.12
18	72.62	78.19	81.11
20	77.58	80.11	89.98

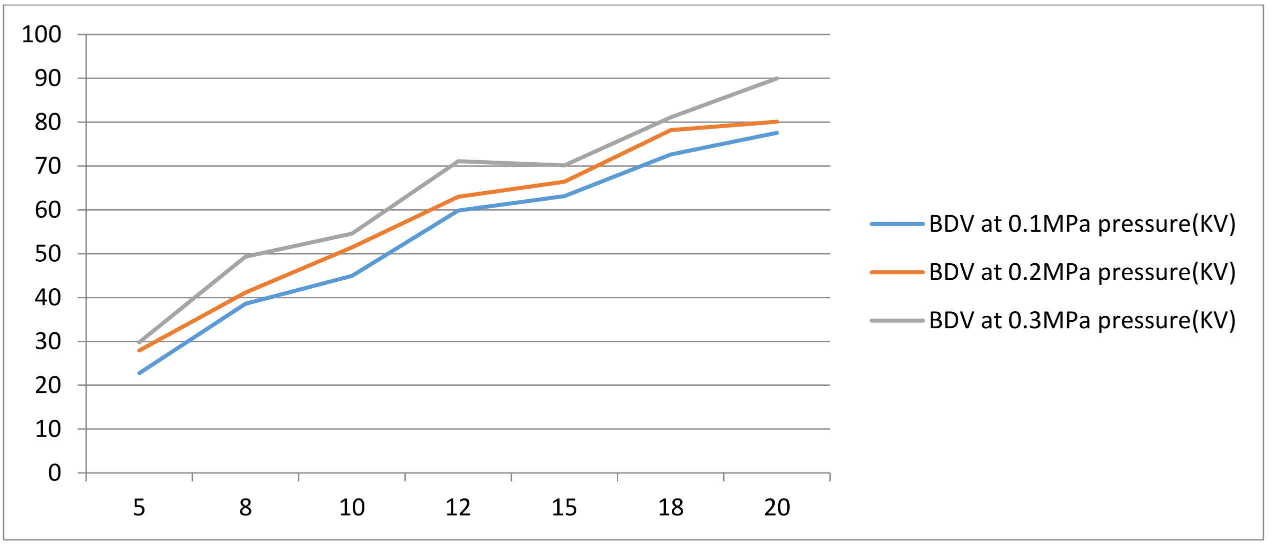

Figure 3. Variation of BDV under AC on PMMA spacers in SF6/N2 gas mixture for different pressure (Plane-Plane)

Table 2 Variation of BDV under AC on PMMA spacers in SF6/N2 gas mixture for different pressure (Sphere-Plane)

Electrode Spacing(mm)	BDV at 0.1MPa pressure (KV)	BDV at 0.2MPa pressure (KV)	BDV at 0.3MPa pressure (KV)
5	29.05	32.43	38.68
8	33.62	38.16	40.45
10	41.12	44.26	54.74
12	49.33	54.12	59.84
15	54.87	58.78	61.02
18	60.32	64.45	71.79
20	66.67	70.54	75.96

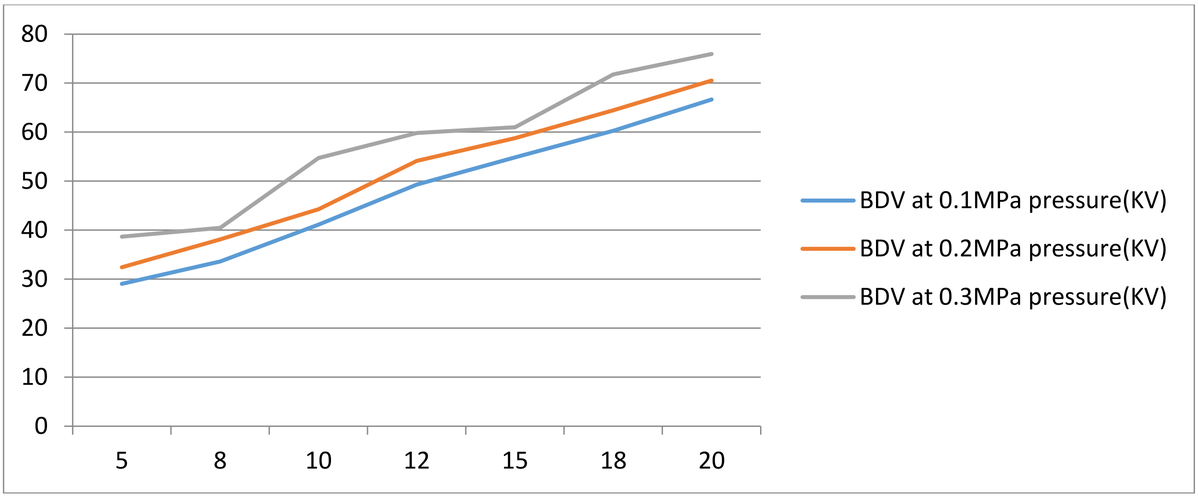

Figure 4 Variation of BDV under AC on PMMA spacers in SF6/N2 gas mixture for different pressure (Sphere-Plane)

Table 3. Variation of BDV under AC on PMMA spacers in SF6/N2 gas mixture for different pressure (Rod-Plane)

Electrode Spacing(mm)	BDV at 0.1MPa pressure (KV)	BDV at 0.2MPa pressure (KV)	BDV at 0.3MPa pressure (KV)
5	26.62	32.74	39.39
8	29.11	34.12	42.74
10	33.19	38.77	44.17
12	35.69	40.64	47.44
15	37.56	40.59	42.87
18	40.59	44.20	49.25
20	45.25	47.63	50.33

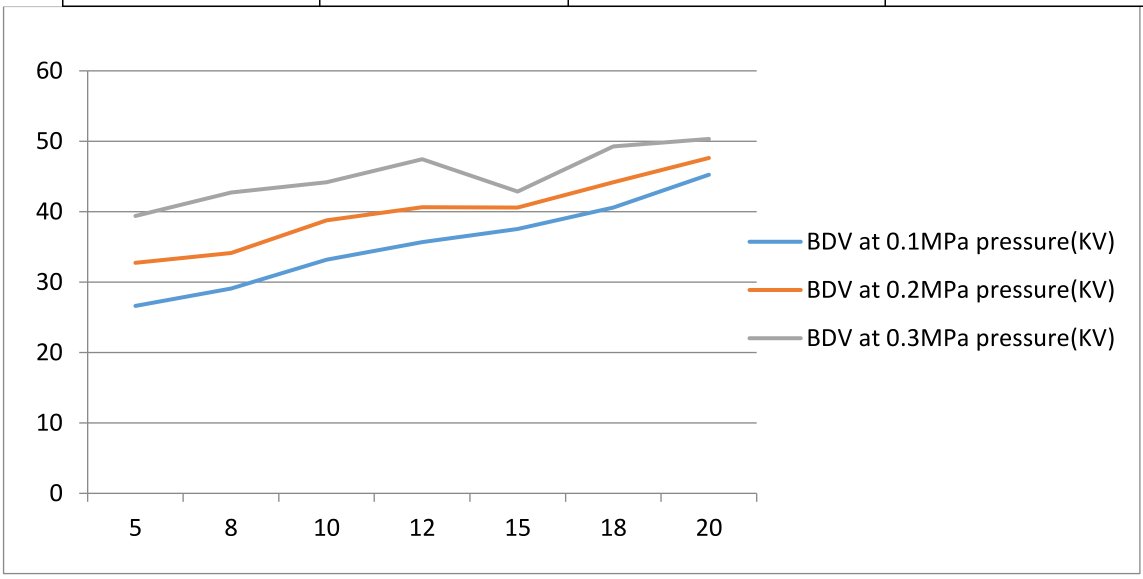

Figure 5 Variation of BDV under AC on PMMA spacers in SF6/N2 gas mixture for different pressure (Rod-Plane)

The BDV characteristics of spacers subjected to HVAC in SF6/N2 gas mixture increases over electrode spacing. The BDV is high at high pressure(0.3MPa) and low at low pressure(0.1MPa). The BDV is high for uniform electrode when compared to that of non uniform electrode. The BDV of Point Plane configuration is less when compared to that of Sphere Plane electrode configuration.

5.Conclusions

Based on the observations from the experiments conducted with different electrode configurations (plane-plane, sphere-plane, and rod-plane) with conducting particle on spacer reveal that the breakdown voltage decreases when compared to that of without particle subjected to high voltage AC. The BDV phenomenon shows high for uniform electrode when compared to that of non-uniform electrode. The BDV of rod-plane electrode configuration is less when compared to that of sphere plane configuration. The conducting particle influences on the BDV subjected to HVAC. The experiments can be extended to study the BDV phenomenon on gaseous mixtures with conducting particle on spacers.

6.Acknowledgement

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