Experimental Investigation of the Breakdown Voltage of Nitrogen (N_2) and Sulfur Hexafluoride (SF_6) Gaseous Mixture

Using Experimental and Numerical Methods

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Abstract—This paper studies the breakdown voltage of a gaseous mixture of Nitrogen (N_2) and Sulfur Hexafluoride (SF_6). The study consists of both experimental and numerical methods. The comparison was conducted under various pressures, separation distance, and gases compositions. The results were measured using a pressurized dipole spark gap for the breakdown at a corresponding distance and were processed using an octave code that records the observed trend of the findings.

Keywords: Insulation Gases, Spark Gap, Voltage Breakdown

I. INTRODUCTION

Dielectric, or insulating, gases prevent electric discharge up-to a certain electric field level. They are used in multiple applications such as: Transformers, circuit breakers, and generally in HV pulsed power applications. Two of the most commonly used gases are Nitrogen (N_2) and Sulfur Hexafluoride (SF_6), the later having a relatively higher dielectric strength than the former. Paschen's law provides one of the most fundamental equations that describes the relation of the voltage breakdown between two electrodes and the gas pressure times the distance between the electrodes.

$$V_B = \frac{Bpd}{\ln(Apd) - ln\left[\ln\left(1+\frac{1}{\gamma_{se}}\right)\right]} \qquad (1)$$

where, V_B: breakdown voltage in volts, p: pressure in Pascals, d: gap distance in meters, γ_{se}: secondary-electron-emission coefficient, A: saturation ionization in the gas at a particular E/p, B: is related to the excitation and ionization energies. Notice that Eq (1) applies in uniform electric field conditions.[3]

A mixture of gases is used to optimize the breakdown voltage and corresponding pressure for numerous spark gap applications. Using only SF6 is a costly alternative, therefore mixing it with N2 would reduce the overall operating cost. This study will illustrate the optimum mixture composition.

When it comes to mixtures of different gases Paschen's law does not provide an equation that predicts the voltage breakdown; this is the goal of this paper through experimental testing.

Other papers and articles [1], [2] are using mathematical methods and approximations to estimate the dielectric strength of gas mixtures. As a continuation of these efforts this paper will present a series of experiments specifically on the mixture discussed and compare the results with the theoretical estimations.

II. METHODOLOGY

The experimental setup is presented in Figure. 1. It consists of a power supply, DC-AC converter, HV transformer, 2-stage voltage multiplier, and a spark gap. A HV Probe across the spark gap measures the voltage breakdown. The results are plotted based on the experimental output data. In addition, the experiment was done by varying the pressure, gas mixture percentage, and the distance between the electrodes.

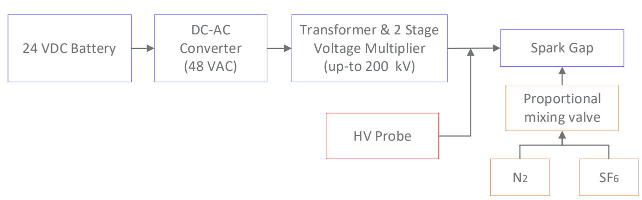

Figure 1. Experimental setup.

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