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High Voltage

ORIGINAL RESEARCH

Investigation of impact of DC component on breakdown characteristics for different electric fields under composite AC & DC voltage

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Abstract

The valve side of the converter in the high-voltage direct current is subjected to mixed voltages such as composite AC & DC voltage. In this study, the effects of the homogeneity of electric field on breakdown voltage were investigated for different ±DC component amplitudes of the composite voltage. The field efficiency factor was calculated using mean and maximum field strengths for all of them. Variation of breakdown voltage of air was examined under the composite AC & DC voltage for different ratios ±DC. As one result of the study, the breakdown occurs at the positive half-wave of the AC voltage despite −DC voltage being applied due to positive corona discharge pulses. This breakdown point is named as the polarity change point. The breakdown voltage increases with the decrease of DC voltage component up to polarity change point in non-uniform electric field. In less uniform electric field, the AC breakdown voltage was measured slightly higher than the DC breakdown voltage. In less uniform electric field, as the ratio of the applied AC voltage to DC voltage increases, the breakdown voltage gradually approaches the AC breakdown voltage. This result is similar to the result obtained for the +DC component in non-uniform electric field experiments.

1 | INTRODUCTION

The use of high-voltage direct current systems has become more relevant by the development of new technology, increasing power capacity, and increasing customer demand. Nowadays, power electronic equipment in power transmission systems has been increasing due to the need for AC to DC conversion [1, 2]. In practice, tests of electrical insulation material are only applied for a single type of voltage wave shape. But in real operation, the insulation systems are stressed with the electric field formed by the sum of different voltage shapes. Therefore, it should be essential to perform tests under composite voltage to ensure the reliability of an insulation system. For example, the breakdown voltage is significantly different in a non-uniform field under −DC or +DC because of the polarity effect on electrical discharge [3]. So, breakdown behaviour under the composite voltage resulting from the combination of AC with +DC or −DC will be different. Therefore, testing insulation systems under composite voltage will increase their reliability and safety in the service conditions.

Mixed voltages are formed by the combination of two voltages having different wave characteristics. The voltage generated is called 'combined' or 'composite' voltage, depending on the way the stress components are applied to the test object [4]. A composite test voltage is produced by connecting two different test voltages to one terminal. In this application, two different voltages are superposed and composite voltage is applied to test objects by a single point [4]. In recent years, many studies have been carried out on insulation performance investigations under composite or combined voltages [5–9]. However, these studies are much less compared to studies performed for a single voltage type (only AC, only DC or only impulse voltage), so there is a gap in the literature on this subject due to laboratory facilities, the application of different voltage types at the same time and the difficulties of the protection elements. As in this study, there is no study investigating the breakdown voltage of air under composite AC & DC voltage for different ±DC voltage amplitudes. Contributing to this gap in the literature increases the motivation to work. In recent years, the investigation with experimental studies under composite AC & DC high voltage has accelerated. There are some studies for different application fields such as electrical treeing, breakdown and partial discharge measurements for different insulation materials, etc. [2, 10–15].

Li et al. performed the experiments of breakdown voltage in air under composite voltage for different gap spacings with the rod-plate electrode system. They emphasised that the positive corona discharge pulse before breakdown much affects the breakdown voltage under composite AC & DC voltage [16]. Zhang et al. performed the experiments of corona inception voltage in air to investigate the impact of composite AC & DC voltage on corona discharge characteristics with the rod-plate electrode system. They found that the minimum corona inception voltage occurs under a certain combination of AC and DC voltage in the same conditions and electrode systems [17].

The aim of this study is to examine the impact of DC component of composite AC & DC voltage on breakdown voltage in less uniform and non-uniform electric fields. In this study, sphere–sphere, rod–plane and needle–plane electrode systems are used in the experiments to create different electric fields.

The maximum field strength values of the electrode systems for all gap spacings were calculated using Finite Element Method (FEM). The field efficiency factor was calculated using mean field strength and maximum field strength for all of them. Firstly, breakdown experiments are carried out under the only +DC, only −DC and only AC for each electrode system. Later, the DC voltage having a certain amplitude is applied to electrode system, then AC voltage is superimposed on this fixed valued DC voltage and AC voltage is increased until breakdown in the electrode system. Thus, the breakdown voltage is obtained under the composite AC & DC voltage for different electric fields and the impact of DC component is examined on the breakdown voltage.

2 | MATERIAL AND METHOD

2.1 | Breakdown tests and test setup

In this study, breakdown tests in air were carried out in less uniform and non-uniform electric fields under composite AC & DC voltages. In these experiments, sphere–sphere electrodes for less uniform electric field, rod–plane electrodes and needle–plane electrodes for non-uniform electric field were used at the different gap spacings. For the rod–plane electrode systems, rod electrodes with two different diameters of tip curvature were used. The diameters of these electrodes are 1 and 6 mm. Thus, non-uniform electric fields of different intensities with different electrodes were obtained. It is well known that pollution or oxide layers on the electrode surface affect breakdown behaviour.

Before the experiments, the electrode surfaces were cleaned against all kinds of dirt with isopropyl alcohol and polished with polishing material to remove micro-protrusion. The electrode systems used for less uniform and non-uniform electric field experiments are shown in Figure 1.

Used electrode systems were modelled with simulation software based on FEM. The electrode systems shown in Figure 1 were used to draw the model. Then, maximum electric fields were calculated for different gap spacings with created FEM model.

The field efficiency factors were calculated using mean field strength and maximum field strength according to Equation (1). E_0 and $E_{\max}$ are uniform field strength in a parallel-plate capacitor and maximum electric field for the same gap spacing, respectively. η is field efficiency factor.

$$E_{\max} = \frac{1}{\eta} E_0 \tag{1}$$

The composite AC & DC high voltage experimental setup established at TU Ilmenau in Germany is shown in Figure 2. The schematic of the experimental circuit is shown in Figure 3. 50 and 30 kV test transformers were used for the DC and AC sides on the test setup, respectively. Composite voltage was generated by connecting AC and DC voltage sources in parallel to the electrode systems. But, in order to prevent these voltage sources from affecting each other, they were connected with the decoupling elements. C1 and R3 elements seen in Figure 3 are coupling capacitance and coupling resistance, respectively. A resistor with high resistance was chosen as a decoupling element so that the DC voltage is minimally affected by the AC voltage.

The breakdown voltage value and wave shape were recorded using the trigger feature of the oscilloscope. A breakdown signal recorded with the trigger feature is shown in Figure 4 as an example.

The peak value of the applied composite voltage at the point where the breakdown occurred was taken as the measured breakdown voltage. Breakdown voltage wave shapes were recorded with Yokogawa DLM 2024 oscilloscope via

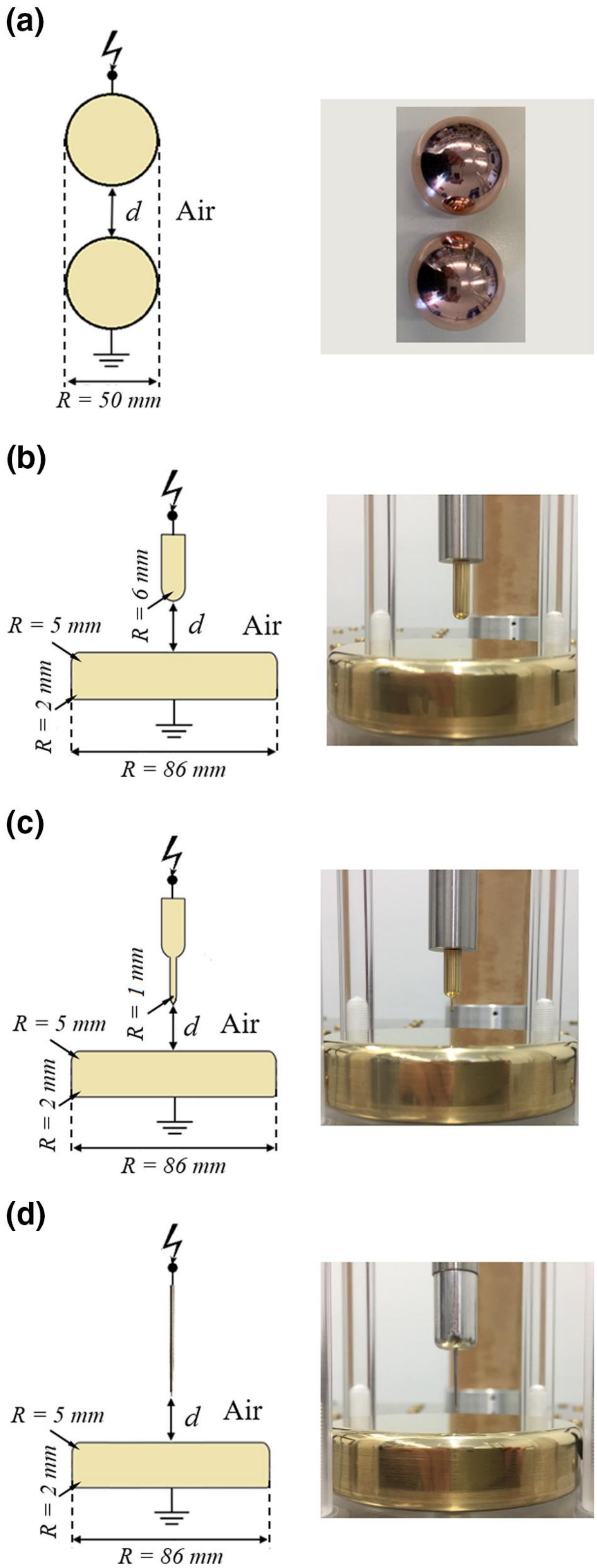

FIGURE 1 Electrode systems used in experiments of less uniform and non-uniform electric fields. (a) Sphere—sphere, (b) Rod (R = 6 mm)—plane, (c) Rod (R = 1 mm)—plane, (d) Needle (R = 88 μm)—plane

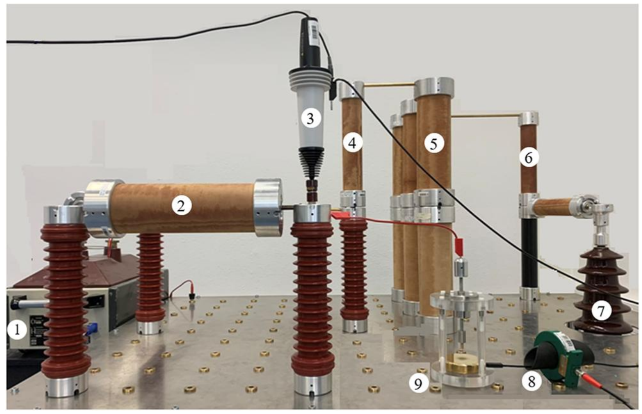

FIGURE 2 Composite AC & DC high voltage experimental setup 1: 50 Hz test transformer, 2: Coupling capacitance, 3: RC voltage divider, 4: Coupling resistance, 5: Smoothing capacitance, 6: Rectifier, 7: 50 Hz test transformer, 8: Pearson current monitor, 9: Equipment under test (EUT)

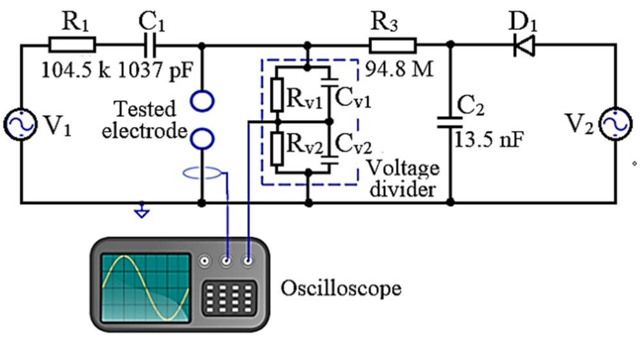

FIGURE 3 Circuit scheme used for the generation of the composite AC & DC high voltage experiments

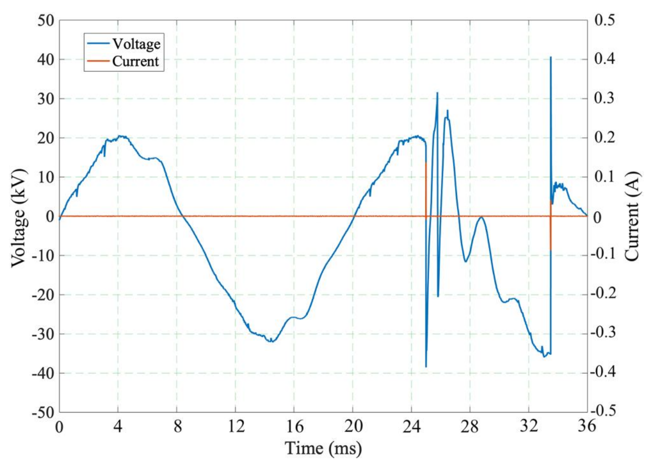

FIGURE 4 Breakdown signals recorded with the trigger feature

using Testec TT-HVP 2739 capacitive-resistive voltage divider. The division ratio of the capacitive-resistive voltage divider used is 1000:1. The oscilloscope has a bandwidth of 200 MHz and a sampling rate of 2.5 GS/s. An example of an applied test voltage with superimposed AC on DC voltage is shown in Figure 5. In this composite voltage, U_{DC} and peak value of U_{AC} are 10 and 5 kV, respectively.

2.2 | Determination of breakdown voltage with Weibull distribution

Statistical methods are often used to evaluate the results of high-voltage experiments [18–22]. For example, the breakdown voltage of a spark gap is determined by an applied voltage that is increased until the breakdown occurs. If the test is repeated several times, it can be noted that an 'exact breakdown voltage' does not exist, and the breakdowns occur at different voltages [3]. The Weibull distribution is an important method, especially in determining breakdown voltage on high-voltage techniques [3, 19, 21]. The Weibull cumulative distribution function ($F(x)$) is given in Equation (2), where x_0, x_{63} and δ are location parameter (lower extreme value), 63% quantile and shape parameter, respectively.

$$F(x) = 1 - e^{-\left(\frac{x - x_0}{x_{63} - x_0}\right)^{\delta}} \quad (2)$$

The Weibull exponent can be found from Equation (3) easily, where the coordinates z_1 and z_2 are two points on the straight line.

$$\delta = \frac{\log\left\{\frac{\ln[1 - F(z_1)]}{\ln[1 - F(z_2)]}\right\}}{\log\frac{z_1}{z_2}} \quad (3)$$

Determination of breakdown voltage using Weibull distribution is shown in Figure 6 as an example. Here, the value corresponding to 63% as a probability is the Weibull distribution (63% quantile) of breakdown voltage.

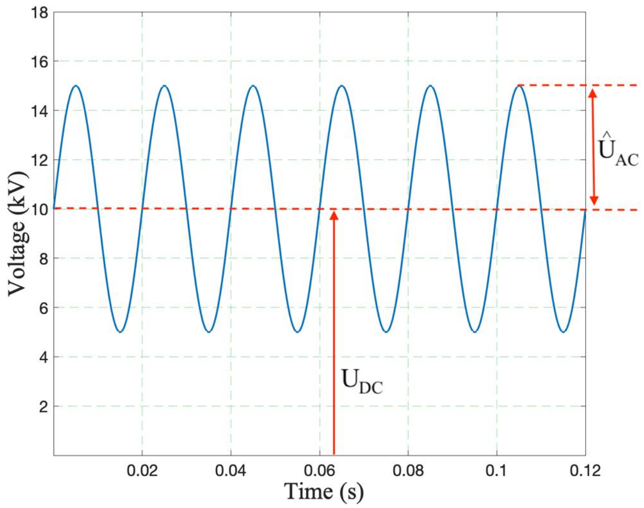

FIGURE 5 Composite AC & DC test voltage applied to equipment under test (EUT)

3 | RESULTS

3.1 | Breakdown in less uniform electric fields

In this section, breakdown experiments performed under composite AC & DC voltage at 50 mm diameter sphere–sphere electrode system were explained. Experiments were carried out for 3, 5, 7, 9, and 10 mm gap spacings. The maximum, minimum and arithmetic average values of the ambient conditions measured during these experiments are shown in Table 1. For all these gap spacings, the efficiency field factor has been calculated using FEM and is 0.972, 0.957, 0.910, 0.900, and 0.897, respectively. The variation of the breakdown voltage in less uniform electric field according to different +DC and −DC values is shown for 3, 5, 7, 9, and 10 mm in Figure 7.

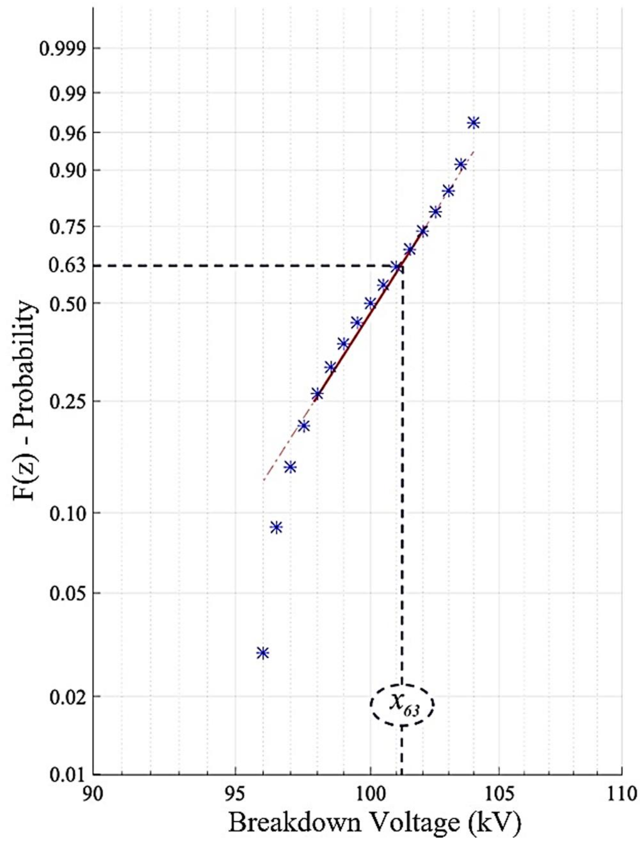

FIGURE 6 Probability paper plot for the Weibull distribution of breakdown voltage

TABLE 1 Ambient conditions during the experiments in less uniform electric field

Parameter	Min. value	Max. value	Arithmetic mean value
Relative humidity (%)	29.5	38.8	33.5
Room temperature (°C)	20.6	24.8	22.5
Air pressure (mmHg)	709.3	730.2	723.3

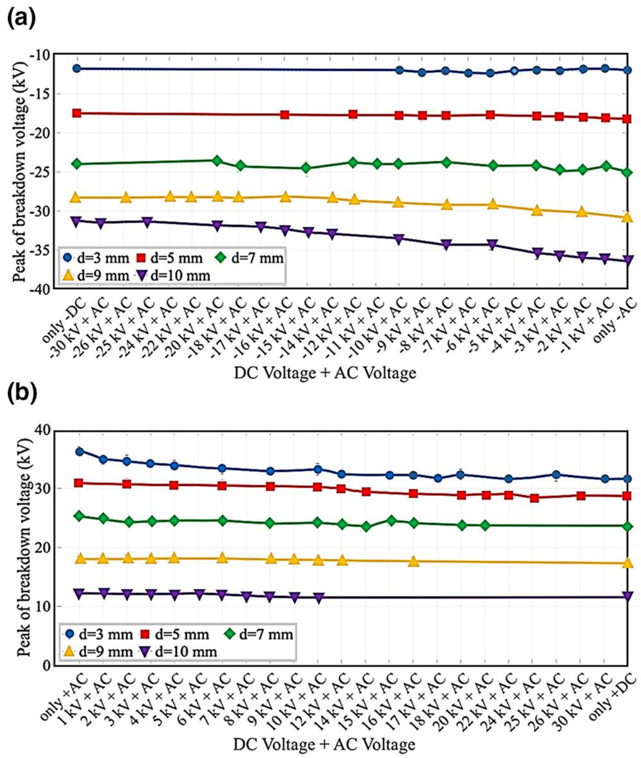

FIGURE 7 Variation of breakdown voltage with different +DC and −DC voltage component amplitude values of composite AC & DC voltage for five gap spacings in less uniform electric field (a) −DC component, (b) +DC component

In the less uniform electric field, experiments are repeated at least 20 times for AC voltage since some of the breakdowns are on the positive polarity and some on the negative polarity. Positive and negative voltage values were taken into consideration within themselves. But they are almost equal to each other as absolute value. In these experiments, the breakdown voltage under the AC voltage is slightly higher than the breakdown voltage under ±DC. The difference between AC and ±DC is clearly seen on the 9 and 10 mm gap spacing, however, it is almost equal for 3, 5, and 7 mm. Here, the breakdown voltage increases for both polarities as the DC voltage decreases at 9 and 10 mm. As the ratio of applied AC voltage to DC voltage increases, the breakdown voltage gradually approaches the AC breakdown voltage. If we ignore the small differences at 3 and 5 mm, the breakdown voltage is not remarkably changed according to the variation of ±DC voltage at these gap spacings.

3.2 | Breakdown in non-uniform electric fields

In this section, breakdown experiments performed under composite AC & DC voltage with three different electrode systems at 5, 10, and 15 mm gap spacings were explained. The two different rods, needle and plane electrodes were used in non-uniform electric field experiments. The rod and needle electrodes are at high potential in these systems,

TABLE 2 Ambient conditions during the experiments in needle–plane electrode system

Parameter	Min. value	Max. value	Arithmetic mean value
Relative humidity (%)	32.6	39.7	37.1
Room temperature (°C)	23.7	25.9	24.9
Air pressure (mmHg)	714.9	724.3	719.8

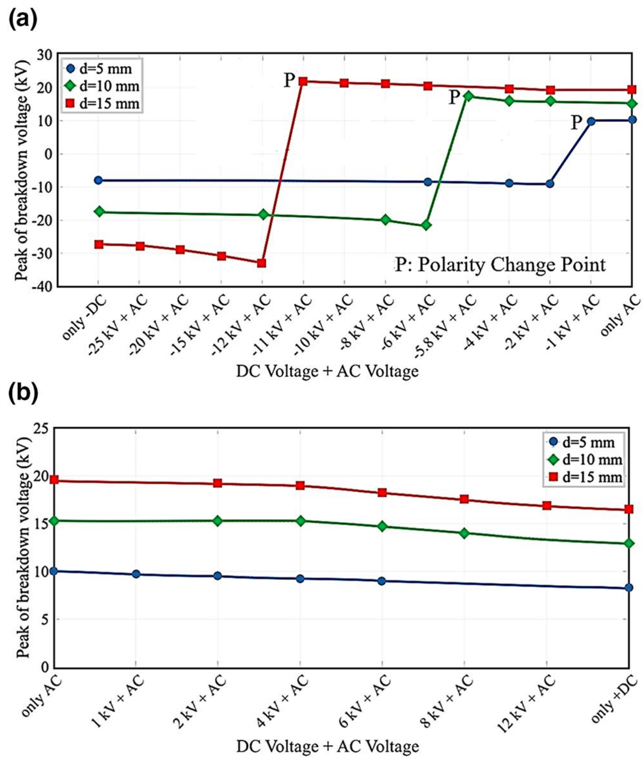

FIGURE 8 Variation of breakdown voltage with different +DC and −DC voltage component amplitude values of composite AC & DC voltage for three gap spacings at the needle–plane electrode system (a) −DC component, (b) +DC component

while the plane electrode is grounded. The used electrode systems are shown in Figure 1. Rod electrodes with two curvature diameters 1 and 6 mm are used for rod–plane electrode systems. The maximum, minimum, and average values of the ambient conditions measured during these experiments with needle–plane electrode system are shown in Table 2.

The tip diameter of the needle electrode was measured using Scanning Electron Microscope (SEM). The geometry of needle electrode was drawn using this radius value in the FEM. For all these gap spacings, the efficiency field factor has been calculated using FEM and is 0.027, 0.015, and 0.011, respectively. The breakdown voltage variation for needle–plane electrode system according to different +DC and −DC values is shown for 5, 10, and 15 mm in Figure 8.

Breakdown voltage experiments were carried out for four different +DC and −DC voltages at 5 mm gap spacing, four different +DC voltages and six different −DC voltages at 10 mm gap spacing and five different +DC voltages and 10 different −DC voltages at 15 mm gap spacing apart from only AC and only ±DC. The breakdown voltage under −DC is much higher compared to +DC and AC at 10 and 15 mm. At 5 mm, the breakdown voltage under −DC and AC is slightly higher than the +DC. The important difference in these experiments is that the breakdown voltage rises up to a certain negative value. Above this value, breakdown occurs in the positive polarity of AC even though a negative DC voltage is applied. For 15, 10, and 5 mm, the breakdown occurs at the positive polarity of the AC voltage at 11, 5.8 and 1 kV −DC voltage, respectively and this value can be called polarity change point (Figure 8). In this polarity change point, breakdown voltage decreases as absolute value, but it is greater than breakdown voltage at only AC. It is clearly seen that the breakdown voltage increases with the decrease of negative DC voltage at 10 and 15 mm gap spacings up to the polarity change point. As the ratio of applied AC voltage to DC voltage increases for +DC side, the breakdown voltage gradually approaches the AC breakdown voltage above the polarity change point.

The maximum, minimum, and average values of the ambient conditions measured during these experiments with rod (R = 1 mm)-plane electrode system are shown in Table 3.

The tip radius of the rod (R = 1 mm) electrode was measured by SEM. The tip structures of these electrodes were checked by a photo taken in the SEM. Finally, the rod (R = 1 mm) electrode geometry was drawn using this radius value in the FEM. For all these gap spacings, efficiency field factor has been calculated using FEM as 0.122, 0.070, and 0.049, respectively.

The variation of the breakdown voltage for rod (R = 1 mm)–plane electrode system according to different +DC and −DC values is shown for 5, 10, and 15 mm gap spacings in Figure 9.

In Figure 9, at 10 and 15 mm gap spacings, the −DC breakdown voltage is much higher compared to +DC and AC. At 5 mm, AC breakdown voltage is slightly high than −DC and +DC breakdown voltage. As shown in Figure 8, the breakdown voltage increases with decreased −DC voltage up to a certain value. Above this value, breakdown occurs in the positive polarity of AC despite −DC voltage being applied. It is clearly seen that the breakdown voltage increases with the decrease of the negative DC voltage at 15 mm. For 15, 10, and 5 mm gap spacings, the breakdown occurs at the positive polarity of the AC voltage at 8, 4.7, and 2 kV −DC voltage, respectively. In this polarity change point, breakdown voltage decreases as absolute value. It is lower than AC at 15 mm and almost equal at 5 and 10 mm. At 15 mm, as the ratio of applied AC voltage to DC voltage increased for +DC side and above the polarity change point, the breakdown voltage gradually approaches the AC breakdown voltage. The maximum, minimum, and average values of the ambient conditions measured during these experiments with rod (R = 6 mm)–plane electrode system are shown in Table 4.

For all these gap spacings, the efficiency field factor has been calculated using FEM as 0.442, 0.284, and 0.213, respectively. The variation of the breakdown voltage for rod (R = 6 mm)–plane electrode system according to different +DC and −DC values is shown for 5, 10, and 15 mm gap spacings in Figure 10. In Figure 10, at 15 mm, the −DC breakdown voltage is much higher compared to +DC and AC. AC breakdown voltage is greater than +DC for all gap spacings. At 5 and 10 mm, −DC breakdown voltage is slightly high

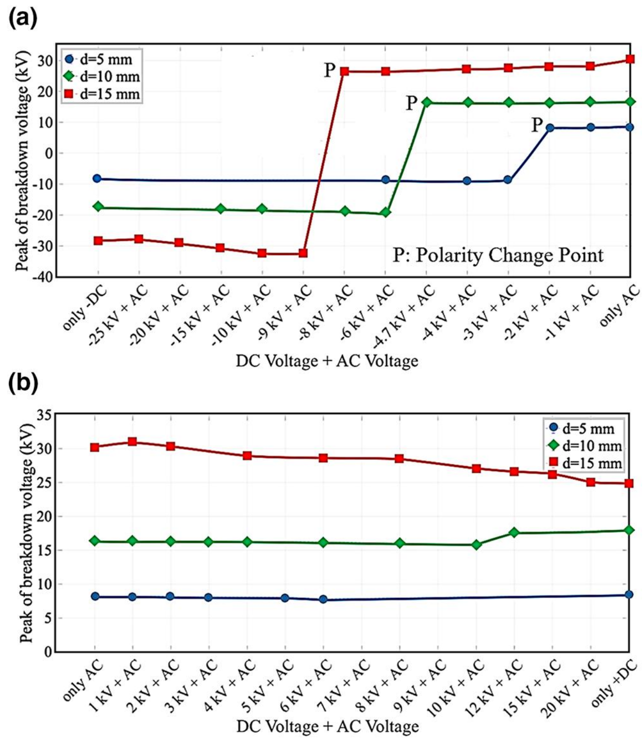

FIGURE 9 Variation of breakdown voltage with different +DC and −DC voltage component amplitude values of composite AC & DC voltage for three gap spacings at the rod (R = 1 mm)–plane electrode system. (a) −DC component, (b) +DC component

TABLE 3 Ambient conditions during the experiments in rod (R = 1 mm)–plane electrode system

Parameter	Min. value	Max. value	Arithmetic mean value
Relative humidity (%)	35.6	41.5	38.6
Room temperature (°C)	22.2	24.8	24.2
Air pressure (mmHg)	712.3	715.4	714.2

TABLE 4 Ambient conditions during the experiments for rod (R = 6 mm)–plane electrode system

Parameter	Min. value	Max. value	Arithmetic mean value
Relative humidity (%)	28.6	41.3	35.6
Room temperature (°C)	21.9	24.7	23.7
Air pressure (mmHg)	715.1	722.1	717.1

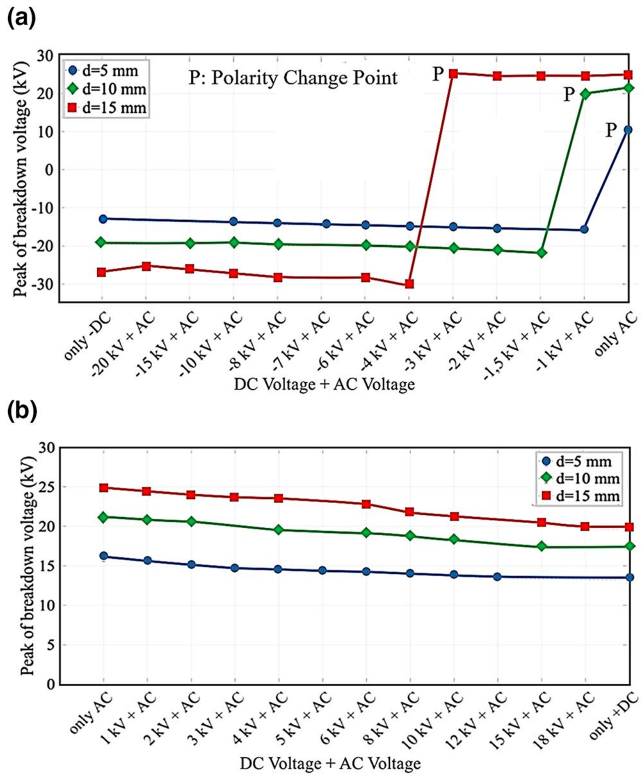

FIGURE 10 Variation of breakdown voltage with different +DC and −DC voltage component amplitude values of composite AC & DC voltage for three gap spacings at the rod (R = 6 mm)–plane electrode system (a) −DC component, (b) +DC component

than +DC. As shown in Figures 8 and 9, the breakdown voltage increases with decreased −DC voltage up to a certain value. Above this value, the breakdown occurs in the positive polarity of AC despite the −DC voltage being applied. However, this is not valid at 5 mm in this electrode system, unlike the previous two electrode systems. For 15 and 10 mm, the breakdown occurs at the positive polarity of the AC voltage at 3 and 1 kV −DC voltage, respectively. In this polarity change point, breakdown voltage decreases as absolute value. It is lower than AC at 10 and 15 mm. Above the polarity change point and on the +DC side, the breakdown voltage gradually approaches the AC breakdown voltage, as the ratio of applied AC voltage to DC voltage increases at all gap spacings.

4 | DISCUSSION

The breakdown voltage is closely related to the ambient conditions during the experiments. The variation of the electrode geometry, gas pressure, temperature, humidity, type of gas, and field distortions significantly influences the breakdown voltage in many cases [3]. The impact of air pressure, temperature, and humidity can be described by an air-density correction factor k_1 and by an air-humidity correction factor k_2. Breakdown voltage at the air conditions in which the experiments were carried out is described in Equation (4), where V_{bd0} is breakdown voltage in standard atmospheric conditions.

$$V_{bd} = V_{bd0} \cdot k_1 \cdot k_2 \tag{4}$$

The air-humidity correction factor (k_2) in Equation (4) differs for DC, impulse, and AC voltage [23]. This value can be described as follows:

$$k_2 = k^w \tag{5}$$

k is a parameter dependent on the type of test voltage. It can be obtained as a function using the following equations [23]:

$$k = 1 + 0.014 \cdot \left(\frac{h}{\delta} - 11\right) - 0.00022 \cdot \left(\frac{h}{\delta} - 11\right)^2 \tag{6}$$

$$1\frac{\mathrm{g}}{\mathrm{m}^3} < \frac{h}{\delta} < 15\frac{\mathrm{g}}{\mathrm{m}^3} \quad \text{for DC}$$

$$k = 1 + 0.012 \cdot \left(\frac{h}{\delta} - 11\right) \tag{7}$$

$$1\frac{\mathrm{g}}{\mathrm{m}^3} < \frac{h}{\delta} < 15\frac{\mathrm{g}}{\mathrm{m}^3} \quad \text{for AC}$$

In Equation (6) and (7), h and δ are absolute humidity of air (g/m^3) and relative air density, respectively. In Equation (5), the exponent w is tabulated as a function of the parameter g (Equation 8), which gives the ratio of the breakdown voltage V_{bd} and the specific voltage drop of a positive streamer discharge, where U_{50} and L are 50% discharge voltage (measured or estimated) at the actual atmospheric conditions (kV$_{\mathrm{peak}}$) and minimum discharge path (m), respectively.

$$g = \frac{U_{50}}{500L\delta k} \tag{8}$$

It is $w = 1$ close to $g = 1$, for $g < 0.2$ and $g > 2$ the exponent w decreases to 0. Thus, we can accept this parameter as 1 in this study.

We calculate the breakdown voltage through these equations by the maximum, minimum, and average of ambient parameters during all experiments. As a result of these calculations, it has been seen that the AC breakdown voltage can be 1%–3.5% higher than the DC breakdown voltage for all experimental conditions. The influence of air humidity is negligible for negative streamer discharges [3]. The experimental results that we have obtained are consistent with this calculated information. As the ratio of applied AC voltage to DC voltage increases for all the experiments, the breakdown voltage gradually approaches the AC breakdown voltage. This behaviour exhibited by the breakdown voltage can be clearly seen in 9 and 10 mm for less uniform electric field experiments in Figure 7. These evaluations were only made considering the air conditions of the laboratory where the experiments were carried out. The breakdown voltage depends on many parameters such as frequency, vertical or horizontal electrode system, surrounding objects, etc.

The polarity change points and efficiency factor of electrode systems in the non-uniform electric field are shown in Figure 11 for all electrode systems and gap spacings. The efficiency factors of electrode systems in Figure 11b were calculated using E_0 and E_{max} obtained by FEM.

In recent years, electrical characteristics of solid and liquid insulation were investigated under composite AC & DC voltage [2, 10–15]. Li et al. examined the experiments of breakdown voltage in air under composite voltage with only −DC for only non-uniform electric field with a single radius of curvature rod electrode [16]. In this study, different from Ref. [16], breakdown characteristics of air were examined on less uniform and non-uniform electric fields under composite AC & DC voltage with negative and positive polarity DC.

Also, two different radius of curvature rods and needle electrodes as high potential electrodes for non-uniform electric field experiments were used. It can be considered that the corona discharge pulses before breakdown are the critical factors affecting the breakdown voltage under composite AC & DC voltage [16]. Since the space charge produced by the positive corona discharge promotes the growth of the streamer, the breakdown occurs at positive polarity of AC with these produced positive discharge pulses. The formation of the corona discharge pulses is closely related to the homogeneity of the electric field. Pre-discharges or corona discharges occur easier for tips, edges, and conductors with a small radius.

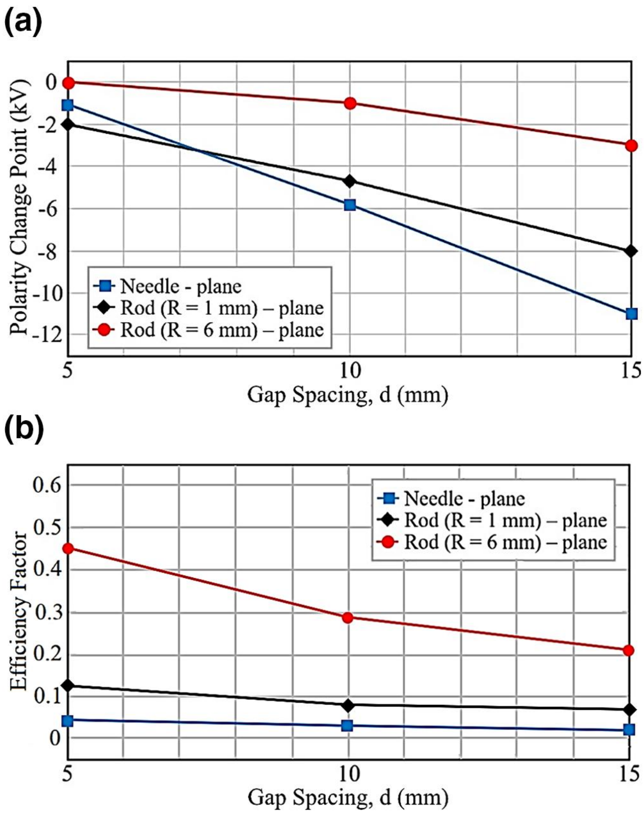

FIGURE 11 (a) Polarity change points and (b) efficiency factor of electrode systems in the non-uniform electric field

As the gap spacing between the electrodes increases and the radius of curvature of the HV electrode used decreases, the homogeneity of the electric field decreases. As the homogeneity of the electric field decreases, the polarity change point starts to be higher −DC voltage. There is no polarity change point for rod (R = 6 mm)–plane electrode system at 5 mm because the homogeneity of the electric field increases with increasing radius of curvature and decreasing gap spacing. An initial electron has to be provided on a very small surface on the needle electrode for negative polarity. Space charges form a barrier in front of the electrode, which prevents the electron's exit. So, the discharge needs a higher voltage to overcome this barrier.

When AC voltage is superimposed on −DC voltage, the space charges, which create a barrier, increase due to the AC voltage. Thus, they cause the breakdown voltage to rise up to the polarity change point. Above the polarity change point, the breakdown voltage decreases as absolute value and breakdown begin to occur at the positive polarity of the AC voltage.

5 | CONCLUSION

This study carried out breakdown voltage tests in air under composite AC & DC voltage with different ratio DC components for four different electrode systems. The measured breakdown voltage was evaluated using the Weibull distribution. The breakdown voltage behaviour of air in less uniform and non-uniform electric fields was investigated under the composite AC & DC high voltage. As a result of this study, carried out to evaluate the DC component of composite AC & DC voltage on the breakdown voltage of air, the following information was obtained:

- In less uniform electric field experiments, AC breakdown voltage is slightly higher than DC. The breakdown voltage gradually approaches the AC breakdown voltage with the ratio of AC voltage to DC voltage increased.
- In non-uniform electric field experiments, the breakdown voltage increases with decreased −DC voltage up to a certain value. Above this −DC voltage, the breakdown occurs at the positive polarity of the AC voltage despite −DC voltage being applied. Above the polarity change point, the breakdown voltage gradually approaches the AC breakdown voltage.
- In non-uniform electric field experiments, AC breakdown voltage is higher than +DC breakdown voltage except for gap spacing of 10 mm for rod (R = 1 mm)–plane electrode systems. The breakdown voltage gradually approaches the AC breakdown voltage as the ratio of applied AC voltage to DC voltage increases on the +DC side.
- As a result of the experiments, it was seen that the polarity change point is closely related to the homogeneity of the electric field. As the homogeneity of the electric field increases, the polarity change point starts to be lower −DC voltage.

In order to better understand the impact of environmental parameters on breakdown voltage under composite AC & DC voltage, this study can be continued with experimental studies in larger gap spacings.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Author elects to not share data.

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