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Study Experimental on Corona Losses in Conductors

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دراسة تجريبية حول فاقد الكورونا في الموصلات

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الملخص:
تم إجراء دراسة تجريبية لتحديد جهد بدء ظاهرة الكورونا **(Corona Inception Voltage)** وجهد انطفائها **(Corona Extinction Voltage)**، إضافةً إلى فاقد القدرة الناتج عن الكورونا في الموصلات العارية المستخدمة في خطوط نقل وتوزيع الطاقة الكهربائية.
كما تضمنت الدراسة إجراء محاكاة لظاهرة الكورونا، شملت تصميم نموذج تجريبي بسطح مستوٍ **(Flat-Surfaced Artificial Plane)** لتمثيل الظروف المحيطة بالمجال الكهربائي حول الموصلات.
وتم تحليل فاقد الكورونا بهدف تقييم مدى تأثير نوع الموصل مقارنةً بحجمه (قطره)، حيث شملت الدراسة موصلات مصنوعة من النحاس والألومنيوم والفولاذ. وقد تم اعتماد قطر الموصل كمعيار أساسي للمقارنة بين الحالات المختلفة.
وأظهرت النتائج التجريبية أنه، بالنسبة لنفس نوع المادة، فإن فاقد الكورونا يتناسب طردياً مع مربع قطر الموصل، مما يشير إلى أن قطر الموصل يُعد عاملاً حاكماً في تحديد مقدار الفاقد مقارنةً بنوع المادة.

الكلمات الدالة: فاقد قدرة الكورونا، أنواع مختلفة من الموصلات، قياسات الكورونا.

Abstract
The inception voltage, extinction voltage, and power loss resulting from coronas on bare conductors used for energy distribution and transmission lines are experimentally investigated in this work. Corona simulations include the construction of a flat-surfaced, artificial planet. To determine whether the conductors' kinds or sizes are more significant, we examined the corona losses. The diameter of the conductor—which might be copper, aluminum, or steel—is the basis for the inquiry. For the same class of materials, the experimental results show that corona losses are proportional to the square of the conductor diameter.

Keywords: Corona Power Losses, Different Type of Conductors, Corona Measurements.

1. Introduction
When gases are at or near atmospheric pressure, a phenomenon termed corona conduction occurs. Coronas, particularly those occurring near power transmission lines, may generate both audible and radio-frequency noise. Power lines across densely populated areas result in energy loss and

provide health hazards to people owing to their impact on air pollution, ozone, and nitrogen oxides [1]. Consequently, it is an essential factor in the design of high voltage apparatus. The insulation of motors, transformers, and capacitors is compromised due to the prolonged impacts of corona discharge [2].

It results in ozone formation, purple light, electromagnetic interference, power loss, and loud noise in transmission lines. Therefore, while designing and building an overhead power line, it is necessary to take into account the conductor surface quality, size, distance to ground, and other conductors in order to avoid these negative impacts [3–4].Since alternating current (AC) voltage is more efficient than direct current (DC), it is used in electrical transmission. The periodic shift in the applied field's direction under ac and its impact on the space charge that remains after the discharge during previous half-cycles are the primary distinctions between ac and dc corona. It is possible to see streamer corona, positive glow, and negative glow in a corona trichel pulse.

The effects of ac corona on different sized and kinds of conductors are investigated in this study. To achieve this, the ideal corona cage is built. The metals steel, copper, and aluminum are put through their paces. All bare conductors have their corona inception and extinction voltages and currents shown at these voltage levels. Corona power loss is also calculated using established experimental formulas.

Experimental Procedure

The source of this alternating current was a generator capable of producing 400 kilovolts of power. A flawless steel cage with a completely level surface is used in the trials. The corona cage is 10 cm in diameter and 25 cm in length. Its thickness is one millimeter. To measure current, a ring is placed in the center of the corona cage. The conductor that was taken out of the ring after it was connected to the corona cage has a measuring device attached to it. The wires that are already fastened to the cage are linked in series with a Fluke 187 digital multimeter and a 102.6 Ω measurement resistor to measure current. The outcomes are then recorded using the oscilloscope. Figure 1 depicts the fundamental scheme of the Corona measuring system.

Gradually increasing the applied voltage until it reaches the lowest level where constant corona may occur is used to determine the corona origin voltage. In order to measure the corona inception voltage, the current voltage is increased by 10%. The voltage was then reduced to the point where the corona noise became inaudible. Simultaneously, as the analyzer and control unit observed, the harmonics began to decrease. This is why, in order to see the precise levels of the corona's genesis and elimination voltages, the rate of increase is configured to 500 V/s.

The same parameters were employed in every outdoor trial: room temperature of 22.0C and ambient pressure of 756 mmHg. A single conductor is used for the clearing in each experiment in the series. 2.12 mm and 4.27 mm aluminum conductors have been selected. Steel conductors are utilized in conductor diameters of 2.20 mm and 4.23 mm. Copper conductors with diameters of 1.72 mm and 2.65 mm are used.

Experimental Results

Experimental findings for several types of conductors are conducted individually for each conductor diameter. The experimental outcomes for aluminum, steel, and copper conductors are summarized in Table 1. The inception and extinction voltages of corona rise with an increase in conductor diameter. For all types of conductors, currents observed at these voltage levels rose with the diameter of the conductor. For each kind of conductor, the observed corona extinction voltages were lower than the corona inception voltages. Currents recorded at corona initiation and extinction thresholds rose with the augmentation of conductor diameter for both aluminum and copper conductors. Nevertheless, for steel conductors, currents recorded at corona initiation and extinction levels decreased as conductor diameter increased.

Corona initiation and extinction voltages for steel and aluminum conductors differed substantially for the same diameters of the conductors.

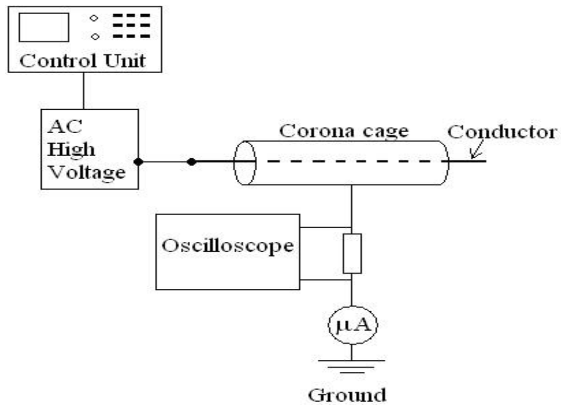

Figure (1):Principle scheme for corona measuring system

Calculation Of Corona Power Loss

To calculate ac corona power losses, a number of empirical formulas have been put forward. Transmission line fair weather corona losses are often calculated using Peterson's experimental approach;

$$P_c = \frac{3.73K}{(D/r)^2} f.V^2 \quad \frac{kW}{km} \qquad (1)$$

D and r represent the spacing of phase conductors and their radius, respectively, whereas V denotes line voltage and f signifies frequency. The ratio of the operating voltage V to the corona onset line voltage V0 establishes the factor K.

Corona onset voltage is calculated as,

$$V_o = E_o.r \ln\left(\frac{D}{r}\right) \quad KV_{peak} \qquad (2)$$

Here E0 is calculated by the empirical formula

$$E_o = 30\delta\left(1 + \frac{0.3}{\sqrt{\delta r}}\right) \quad \frac{KV_{peak}}{cm} \qquad (3)$$

where r is the radius of the conductor in centimetres. δ = 1 at standard pressure and temperature. [3].

Corona power loss estimates are computed using the experimental data for corona inception voltage and corona extinction voltage, which are shown in Table 1. Table 2 presents the findings. According to Corona power loss estimates, power loss rises with cable diameter. Equation (1) shows that power loss increases empirically as the applied voltage to the conductor increases. Additionally,

Table 1 shows that corona extinction and initiation

Conductor type	Iev (Current µA)	Uev (Extinction Voltage KV)	Uiv (Inception Voltage KV)	Iiv (Current µA)	Uev (Extinction Voltage KV)
Copper (r=2.65 mm)	42.30	9.91	10.47	44.81	9.91
Copper (r=1.72 mm)	9.30	7.60	8.61	13.40	7.60
Steel (r=4.23mm)	25.14	11.36	13.52	27.12	11.36
Steel (r=2.20mm)	47.78	6.33	6.94	56.94	6.33

Aluminum (r=4.27 mm)	40.62	8.97	10.05	45.75	8.97
Aluminum (r=2.12 mm)	33.79	8.18	9.07	10.13	8.18

voltages rise with conductor diameter. Therefore, corona power loss increases with applied voltage and conductor diameter for the same phase conductor separation.

Table (2): Corona power loss calculations

Conductor type	PCloss (at Uiv)	PCloss (at Uev)
Aluminum(r=2.1 mm)	983.886	890.389
Aluminum(r=4.25 mm)	6202.534	5540.848
Steel (r=2.1 mm)	754.494	686.002
Steel (r=4.25 mm)	8360.744	7025.004
Copper (r=1.72 mm)	570.060	503.267
Copper (r=2.68 mm)	2088.645	1977.145

Conclusion

Corona extinction and inception voltages under AC voltages are to be shown to vary with conductor diameter and type in this experiment. Corona inception and extinction voltages are shown to rise with increasing conductor diameter. Furthermore, it has been shown that the variance in corona extinction and inception voltage is size and type of conductor dependent. No matter the diameter of the wire, corona starts to form at applied voltage levels greater than the extinction voltage. The empirical formula proposed by Peterson is used to calculate the corona power loss. The results show that when the applied voltage and conductor diameter increase, corona losses also climb.

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