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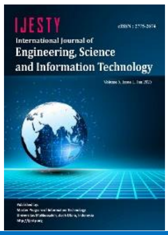

Corona Discharge Detection Analysis on Aluminum and Iron Conductors by Point Field Electrode Method

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Abstract

Currently, Southeast Asia's highest primary energy usage is in Indonesia. Electrical infrastructure like transmission and distribution will be directly responsible for the high energy use. More distribution electrical networks will be in place due to the growing demand for electricity. So, the more significant the electrical disruptions that arise. Corona is one type of electrical disruption in the medium voltage network system. Corona is caused by a partial release of electrical charge, meaning the charge does not entirely pass through both conductors. The surrounding air experiences dielectric stress, producing noise, purple light, and a characteristic smell. Corona's appearance may seriously affect electrical equipment. Additionally, there are other ways to identify the appearance of corona, including using the senses of sight, smell, and hearing. The hearing approach involves utilizing a sound-capable sensor to detect corona. By taking pictures of the location of the corona, one can use sight to detect it. On the other hand, an ozone gas sensor is used in the scent approach. The author attempted to use the method of scent in this investigation. An ozone sensor will record corona disruptions that occur at the delivery site. Oxygen can be broken down into ozone because the air around the corona may ionize the surrounding air.

Keywords: *Ozone Sensor, Corona Effect, Corona Losses, Corona Detection.*

1. Introduction

Indonesia ranks fifth in the Asia Pacific after China, India, Japan, and South Korea, and it has the highest primary energy consumption in Southeast Asia. The Asia Pacific region has experienced the second-largest economic growth in the world since 2006, accounting for 29 per cent of the global gross domestic product, according to the United Nations Economic and Social Commission for Asia and the Pacific [1], which is based on the GDP growth rate in recent decades. Energy consumption is broken down into energy types and sectors [2]. As a result, electricity takes precedence over other forms of energy, and as the times change, so will the need for it. The government will make residential electrical customer groupings simpler. This proposal will create three distinct categories of power customers. First, 450 VA and 900 VA supported client groups. Second, there are customer groups of 1,300, 2,200, 3,300, and 900 VA without subsidies; they will be merged to form a customer group of 4,400 VA. Third, customers with 4,400–12,600 VA will have their electricity pooled into 13,000 VA, while those with 13,000 VA or over would lose power. The goal of this strategy is to deliver power following demand. Furthermore, this policy strategy aims to absorb an additional 40 GW increase in power capacity in 2025 [3] [4] [5].
According to the Ministry of Energy and Mineral Resources, Indonesia is expected to require 457 TWh of energy in 2025. Table 1, Projected Energy Needs in Indonesia, indicates that as the country's population grows, so will its energy requirements. Eighty-two million people are expected to use electricity in Java, Bali, Sumatra, and Eastern Indonesia by 2025. Due to the growing demand for power, there will be numerous interruptions to the 20 KV medium voltage distribution system. In the distribution cable channel, partial discharge is one of the distribution disturbances. Partial discharge is a phenomenon that happens when dielectric stress damages a tiny portion of insulation in a high-voltage environment. It is called "partial" because the jump does not span the space between the two insulated electrodes [6].

Electrical disturbances produce an electric spark known as a partial discharge. It happens when the high-voltage insulation of the stator windings in generators and motors has a hollow in the surface or a highly irregular electric field. The manufacture and installation procedure, heat damage, winding contamination, or movement of the stator rods during operation can all cause this PD pulse [7].
There are three categories of partial discharge:

1. Partial Internal Discharge
   Occurs as a result of a cavity gap in the conductor or its insulating material that
2. Partial Discharge on the Surface
3. Discharge Arching

Table 1. Energy demand projection until 2025 (Source: ESDM, 2016)

Detail	Unit	2020	2022	2024	2025
1.Energy Consumption					
Indonesia	TWh	315.3	366.0	424.9	457.0
Java Bali		228.2	260.8	297.5	317.7
West Indonesia		36.4	43.6	52.2	56.4
Sumatera		50.7	61.7	75.2	82.9
2. Customer					
Indonesia	Millions	74.7	78.0	81.1	82.6
Java Bali		46.7	48.3	49.8	50.6
East Indonesia		13.0	14.0	14.9	15.3
Sumatera		15.0	15.7	16.4	16.7
3. Capita Per Consumtion					
Indonesia	KWh/Capita	1,173.0	1,333.3	1,517.1	1,616.5
Java Bali		1,466.3	1,646.2	1,846.6	1,956.0
East Indonesia		439.7	775.2	903.3	965.8
Sumatera		539.0	1,030.9	1,228.5	1.339.8

Before the breakdown voltage happens, several processes can cause corona losses. A hissing sound on the conductor is the first sign of corona creation. Purple or violet light then appears, followed by an electric jump or flash, also known as breakdown voltage or voltage jumping to another electrode. In this instance, the cubicle's corona effect may cause the insulator to burn or lose effectiveness. Although the Corona effect is frequently discussed in many research studies, not all can forecast when it will occur. As a result, the corona effect requires specific and in-depth study in cubicle research.
Corona detection utilizing sound as noise has been studied using the LPC and Euclidean Distance approaches with accurate pure hissing noises caused by corona discharge. Both the data that was evaluated and the data that was collected had an average accuracy result of 97.78% [8]. Other research uses convolutional neural networks (CNNs), long short-term memory (LSTM) techniques, or a combination of both CNNs and LSTMs to detect disturbances in cubicles. Time and frequency domain analysis is performed, and the success rate in differentiating between corona and non-corona cases during the validation, testing, and trial phases is assessed. For time domain analysis, the LSTM approach produced 97.3%, 98.4%, and 92.4%, whereas 1D-CNN generated success rates of 98.3%, 98.4%, and 93.9%. 1D-CNN-LSTM is the most effective technique, with success rates of 99.3%, 98.4%, and 98.4%. The success rates of 1D-CNN in the frequency domain analysis were 100%, 95.8%, and 95.8%.
Prior studies have used sensors placed near the corona source to detect corona on circuit breakers; however, the distance was not explained, and the measurement results indicated that the maximum corona hiss frequency value (157 dB) occurred at the maximum ozone value, which was 22.6 ppb[9]. The findings demonstrate that corona can result in the formation of ozone gas [10][11] and hissing noises around corona disturbances, which are incredibly upsetting to human hearing [12][13][14]. Other research attempts to identify the corona process in copper conductor medium at the plane point electrode by detecting the place of corona occurrence. According to the data, corona may be detected from the start of the hissing sound process to the breakdown voltage [15]. Therefore, the findings of the previous investigation showed that the maximum ozone level at 21 KV was 1425 ppb, or 8.65 KW, if the calculation results were matched. The results of the computation of corona losses at a voltage of 9.5 KV were 0.233 KW, while the lowest after corona was achieved from testing at a voltage of 9.5 KV with a maximum ozone of 125 pbb. The graph modelling and test results demonstrate exponential characteristics, which means that corona losses will rise as the voltage is raised steadily. Because the high voltage ionizes the surrounding air, ozone ionization occurs [16][17]. When the high voltage is removed, the ozone transforms into oxygen. According to this study, a loud and little sound first appeared at a voltage of 7 KV, followed by a purple light at 13.5 KV [15]. Maintenance can also be performed using corona detection as a guide [18][19] [20].
Prior studies detected this corona by putting the sensor 100 mm away from the corona occurrence point and 35 mm between the two electrodes. The author used aluminium as the electrode material in this work but followed the same procedure. This study examines the corona effect's properties on aluminium conductors with the same distance and sensor.

2. Method

Corona started to be identified using various methods; the method used was to determine the conductor's symptoms of corona. Here are some tips for using the senses of hearing, sight, and smell to identify coronavirus symptoms. Because of the sense of hearing, corona symptoms cause the conductor to make noise. By using the sense of sight, one may locate corona symptoms by observing the location of the corona, which will produce purple light. The onset of corona symptoms can then ionize the surrounding air through the sense of smell, converting oxygen into ozone. However, this process takes a lot of strength and energy. Since the energy source will revert to oxygen if lost, this oxygen shift is only transient. Power outages [21], noise from electromagnetic interference [22], a characteristic smell, and burning [13] are all possible outcomes of corona losses.

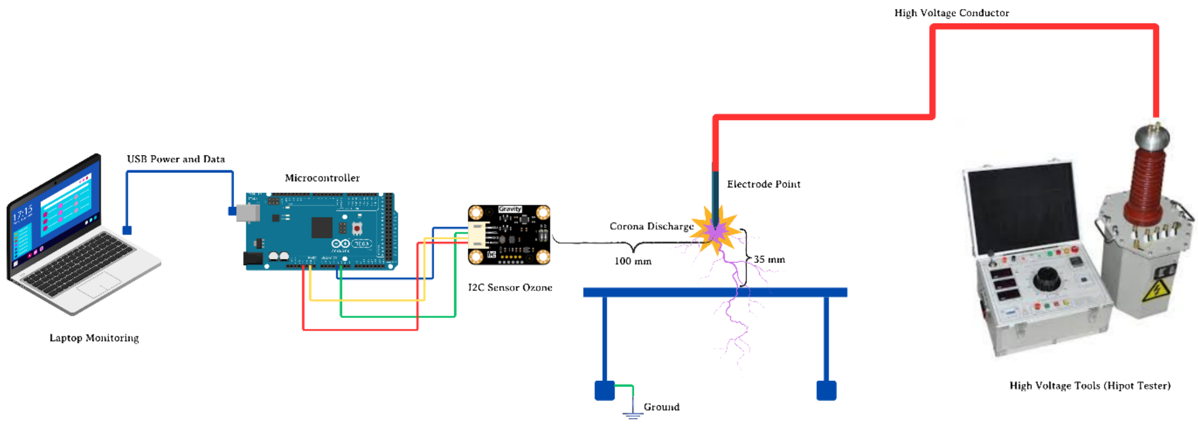

Fig 1. Scheme System Detection Corona Discharge

This method uses an Arduino Mega microcontroller as the primary tool to detect corona pleasant, followed by a sensor to detect the presence of Corona in aluminium and iron electrodes. corona is installed using the Hipot test device, which measures voltages of 6.7, 7.5, 9.5, 10.5, 11.4, 12.7 KV, 14.6, 15.6 KV, 16.4 KV, 17.7, 18.4 KV, 19.3 KV, 20.1 KV, and 21.3 KV safely. After that, an ozone sensor with a 100 mm range detects any corona for 1–2 minutes and displays the highest possible result the sensor can obtain. Every electronic device is accompanied by an iron, slowing the voltage process. This voltage is being handled using a battery of ±0.1 KV. Following the appearance of the ozone gas, the computer will record the reading findings and show the reading on the screen.

3. Result and Discussion

Following the appearance of the ozone gas, the computer will record the reading findings and show the reading on the screen.

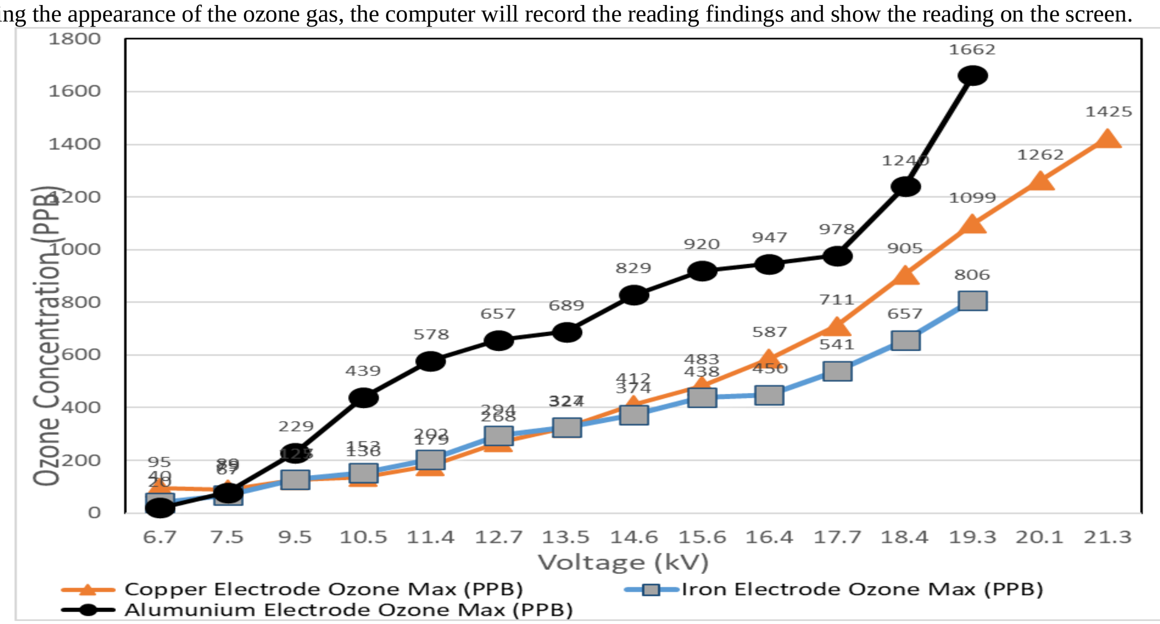

Fig 2. Result Corona Detection
(Source: Copper Electrode Ozone Max [15])

The results of the aforementioned illustration show that a corona started to emerge around 7.5 KV. The purple light is set between 11 and 12 KV with an ozone value of 202 PPB and 578 PPB for the iron and aluminium electrodes as soon as the voltage is finished on time. The sensor then steadily raises the amount of ozone gas it detects until it achieves the 19.3 KV electrical voltage of iron and aluminium. The most significant element is aluminium, and the lowest value generates ozone at the electrode's field point, as demonstrated by the ozone found in the iron electrode. At 19.3 KV, the iron and aluminium electrodes start to break down.

Metal materials have seldom been distinguished in previous corona discharge experiments. The three metals—copper, aluminium, and iron—may differ due to their varying densities and ionization energies. However, this needs more research. Does it stem from the metal's electron density or ionization energy factor?

Consequently, the incidence of corona discharge will decrease if this research is carried out further to lessen power outages, noise, and other issues. Research on corona detection has to be developed regularly to prevent the corona effect from damaging electrical equipment and to perform preventive maintenance.

4. Conclusion

Based on the findings of a study using two metals, aluminium and iron, using the plane point electrode technique. Copper and iron do not create as much ozone as aluminium does. Because iron and aluminium electrodes leap to the next electrode more readily under high voltage settings, the metal experiences extreme dielectric stress, making the air incapable of withstanding the energy jump from the plane point electrode to the ground electrode medium.

References

[1] Elinur, "Perkembangan Konsumsi dan Penyediaan Energi dalam Perekonomian Indonesia," *Indones. J. Agric. Econ.*, vol. 1, no. 1, pp. 19–38, 2010.
[2] F. Damayanti, H. Sasana, and R. Destiningsih, "Analisis Faktor-Faktor Pendorong Total Konsumsi Energi Akhir Di Indonesia Analysis of the driving factors for total final energy consumption in Indonesia," *Dir. J. Econ.*, no. 2, pp. 501–514, 2020.
[3] Hariyadi, "Agenda penggolongan pelanggan listrik rumah tangga," vol. IX, no. 23, pp. 13–16, 2017.
[4] M. M. Rahman Redoy Akanda and M. A. Hossain, "Smart-devices in Human Behavior Manipula-tion: Process diagram with exploratory assessment," *Int. J. Eng. Sci. Inf. Technol.*, vol. 1, no. 3, 2021, doi: 10.52088/ijesty.v1i3.88.
[5] S. Dwi Putra and V. Yasin, "MDA Framework Approach for Gamification-Based Elementary Mathematics Learning Design," *Int. J. Eng. Sci. Inf. Technol.*, vol. 1, no. 3, 2021, doi: 10.52088/ijesty.v1i3.83.
[6] R. Aryanto, M. A. Rosid, and S. Busono, "Penerapan Deep Learning untuk Pengenalan Tulisan Tangan Bahasa Akasara Lota," *J. Inf. dan Teknol.*, vol. 5, no. 1, pp. 258–264, 2023, doi: 10.37034/jidt.v5i1.313.
[7] Waluyo, S. Saodah, and E. Hidayatullah, "Internal online partial discharge analysis of 68.75 MVA generator stator winding insulation," *Int. J. Electr. Comput. Eng.*, vol. 6, no. 5, pp. 2088–2095, 2016, doi: 10.11591/ijece.v6i5.10066.
[8] N. PASRA, M. FIKRI, K. T. MAURIRAYA, T. RIJANTO, and I. G. P. A. BUDITJAHJANTO, "Deteksi Suara Corona Discharge berdasarkan Noise menggunakan Metode LPC dan Euclidean Distance," *ELKOMIKA J. Tek. Energi Elektr. Tek. Telekomun. Tek. Elektron.*, vol. 11, no. 1, p. 72, 2023, doi: 10.26760/elkomika.v11i1.72.
[9] S. Rahmat, R. Prima Dewi, A. Abdi Musyafiq, and H. Purnata, "Implementation of Multi-sensors to Detect Corona Effects in Medium Voltage Distribution Cubicles," *JTERA (Jurnal Teknol. Rekayasa)*, vol. 7, no. 2, p. 289, 2022, doi: 10.31544/jtera.v7.i2.2022.289-294.
[10] R. Masarrang, Lily Stiowaty Patras, and Hans Tumaliang, "Efek Korona pada Saluran Transmisi Gardu Induk Tello Sulawesi Selatan," *J. Tek. Elektro dan Komput.*, vol. 8, no. 2, pp. 67–74, 2019.
[11] A. Putra, "Analisis Rugi Daya Akibat Korona Dengan Metode Peterson Dan Peek Pada SUTET 275 kV GI Payakumbuh – Kiliranjao Prosiding Seminar Nasional Teknik Elektro Volume 8 Tahun 2023," *Semin. Nas. Tek. Elektro*, vol. 8, pp. 37–44, 2023.
[12] N. Pasra, A. Makkulau, and M. O. Abriyanto, "Analisa Efek Korona Pada Sistem Distribusi Tenaga Listrik 20 kV Pada Gardu Beton," *J. Ilm. SUTET*, vol. 8, no. 2, pp. 103–113, 2018.
[13] R. Syahbana, "Analisa Terbentuknya Korona pada Saluran Kubicle Tegangan 20Kv Serta Pengaruhnya Terhadap Rugi-Rugi Daya," *Lensa*, vol. 2, no. 48, pp. 14–21, 2019.
[14] V. N. Ogar, S. A. Bendor, and A. E. James, "Analysis of Corona Effect on Transmission Line," *Am. J. Eng. Res.*, no. 6, pp. 75–87, 2017.
[15] S. D. Nugroho and R. Setiabudy, "The Corona Losses Detection Analysis at High Voltage," *J. Pendidik. Teknol. Kejuru.*, vol. 5, no. 3, pp. 83–89, 2022, doi: 10.24036/jptk.v5i3.28423.
[16] M. N. Faizi, "Prototype Penetralisir Asap Rokok Pada Ruangan," vol. 08, no. 1, pp. 91–97, 2018.
[17] N. M. Aljaidi, "Analisa Pengaruh Korona Terhadap Distorsi Harmonik Gelombang Tegangan Pada Kubikel," *Skripsi Dep. Tek. Elektro Univ. Indones.*, 2010.
[18] A. Kautsar, "20kV Cubicle Maintenance at PT PLN (Persero) APJ Banten Utara Rayon Prima Krakatau," *Fidel. J. Tek. Elektro*, vol. 6, no. 2, pp. 41–48, 2024, doi: 10.52005/fidelity.v6i2.226.
[19] M. R. Setyanto and Y. Saragih, "Gangguan Penyulang Akibat Kegagalan Proteksi di Circuit Breaker Output Pelanggan Pada Gardu Distribusi MP 244," *Maj. Ilm. Teknol. Elektro*, vol. 22, no. 1, p. 111, 2023, doi: 10.24843/mite.2023.v22i01.p14.
[20] J. S. Pasaribu, "Development of a Web Based Inventory Information System," *Int. J. Eng. Sci. InformationTechnology*, vol. 1, no. 2, pp. 24–31, 2021, doi: 10.52088/ijesty.v1i2.51.
[21] D. Chairani, "Analisis Pengaruh Korona Terhadap Rugi-Rugi Daya pada Saluran Transmisi," *J. Pendidik. Sains dan Komput.*, vol. 2, no. 02, pp. 212–217, 2022, doi: 10.47709/jpsk.v2i02.1525.
[22] L. Zhao *et al.*, "Corona current and audible noise characteristics of HVDC transmission lines and their relationship at high-altitude," *IET Gener. Transm. Distrib.*, vol. 17, no. 15, pp. 3399–3409, 2023, doi: 10.1049/gtd2.12832.