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Identification of electrical discharge on electric insulation material using acoustic emission method

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Abstract. Insulation system is essential to be equipped on high voltage equipment. One of the tests on insulation system is the electrical discharge test. In this work, the electrical discharge detected using an acoustic emission method to find out the characteristic of the discharge. Epoxy resin was taken as the insulation material, whereas one to two artificial holes were made inside the insulation. An AE sensor placed at a distance of 24 mm and 36 mm away from holes or discharge source. The main frequency component of the detected AE signal on single hole test was approximately 975 kHz. Meanwhile, test on double holes caused two main frequency component; i.e. 63 kHz and 930 Khz. For single hole test and sensor distance of 36 m, the AE signal intensity tends to be worth 40% from the AE signal at a distance of 24 mm.

1. Introduction

Electrical energy consumptions increase along with the growth of population and the development of industry and fabrication. It makes the state electric company must provide the electrical energy supply better. Therefore we need the continuity and reliability of power system in order to meet the supply of energy required by the community. A reliable electricity system requires also a good insulation system. The good insulation system in particular is very much needed in medium and high voltage system.

An insulation material used to separate two or more electrical conductor so that at the conductor, electrical spark or spark over does not happen. In insulation material, in process of time, electrical discharge or corona will occur, especially when the applied voltage exceeds dielectric strength of material [1]. Corona that take place on electrical equipment can cause damage to the appliance so that the continuity of the system will be disrupted. Therefore, the condition of insulation system must be very noted. A good insulation material must be chosen also to minimize the corona.

In general, damage in an insulation system occurs due to the high pressure of electric field. High electric field on insulation system can trigger a local discharge which is known as electrical discharge or partial discharge. Discharge is events of electrical sparks jump that occurs on one part of insulation as a result of the existence of high potential different on isolation. In addition, events of electrical discharge can also be caused due to the bad equipment construction,_continuous high pressure, and contraction of insulation material, environmental and chemical factors, and heat effects that arise because of the increase of voltage [2].

One way to know the condition and characteristics of insulation material is by performing a diagnosis using acoustic emission method. In insulation that being subjected to an aging process, an electrical discharge will occur because of high pressure of electric filed The process of electrical discharge also referred to partial ionization process. The ionization process will produce an energy that propagates in the form of elastic waves. Elastic waves will propagate from inside to the outside or at the surface of isolation. The wave then will be detected by the acoustic emission sensor [3].

2. Test Setup
The test setup is divided into two work stages.

2.1. The series of test
A series of tests were arranged as figure 1. The testing framework was created in the form of square using acrylic materials.. The top frame is made in the size of 18 cm x 20 cm as the place for placement of insulation material that will be tested. AE Sensor was installed at a certain distance from the center point of the ground electrode. The high voltage was connected to the needle electrode, while the grounding electrode connected to the ground. Sample of epoxy resin made with a thickness of 8 mm. At the middle point of the epoxy resin, one and two holes made with a diameter of 3 mm.

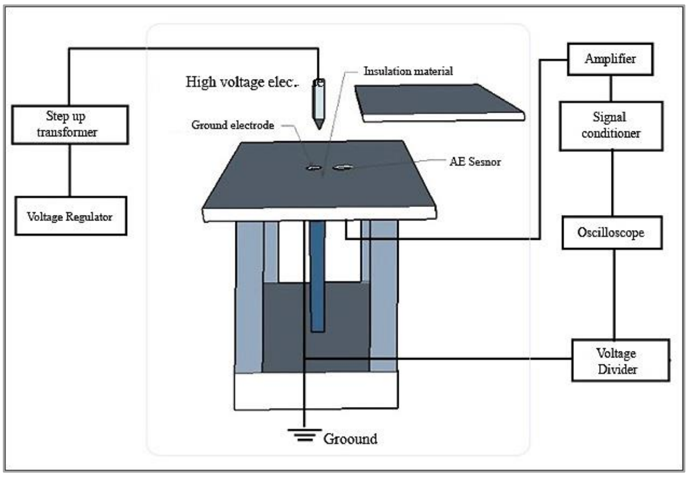


Figure 1. Test setup for identifying discharge characteristics of epoxy resin

2.2. Test and data processing
High voltage source was raised step by step until significant electrical discharge detected by AE sensor. The AE signal was detected by the AE sensor with an operating frequency 50 kHz – 900 kHz. Then, the signal was amplified by a preamplifier of 40 dB with a frequency band of 10 kHz - 2 MHz and mixed by a signal conditioner. The output of the signal conditioner was measured by a digital oscilloscope with sampling frequency of 125 MHz and recorded in a personal computer. These data will be analysed by using a Wavelet and Fast Fourier transform (FFT) to get the characteristics [4]. The discharge current was detected by a current detection circuit.

3. Result and Discussion
The identification of activities of electrical discharge on the epoxy resin conduted in two research variables, namely (1) number of holes (consist of a single hole and double holes), and (2) sensor distance from artifical holes (24 mm and 36 mm).

3.1. Tests on single hole

3.1.1. The sensor distance of 24 mm
In the test, signal of electrical discharge detected by AE sensor is shown in figure 2.

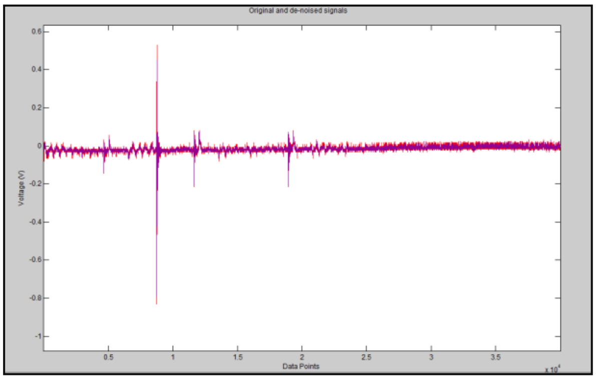


Figure 2. AE signal intensity on sensor distance of 24 mm (2,4 kV)

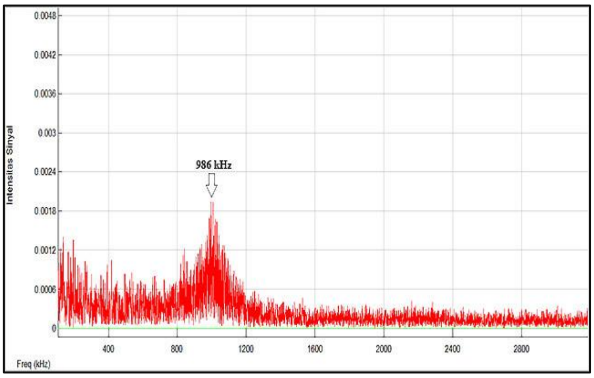


Figure 3. Frequency spectra on sensor distance of 24 mm (2,4 kV)

The signal in figure 2 was processed by using the Wavelet to reduce the noise. Spectral analysis of frequency was performed using Fast Fourier Transform (FFT), and shown in figure 3. From figure 3, it was obtained that the test had one main frequency component. Data from the test result (sensor distance of 24 mm) is shown in table 1.

Table 1. Test results on single hole with sensor distance of 24 mm

Test Voltage (kV)	AE signal intensity (V)	Discharge current (mA)	Main frequency (kHz)	Time of significant discharge current (min)
2.3	0.58	42.21	970	35
2.4	0.72	43.88	986	33
2.5	0,80	46.12	990	31

Table 1 showed the test was conducted at the voltage test of 2.2 kv, 2.3 kv, and 2.4 kv. There is an increase of AE signal instensity with a rise in voltage test. The significant discharge current is tend to increase too. Those are also illustrated better in figure 4. Figure 5 shows discharge current and AE signal intensity are directly proportional to test voltage.

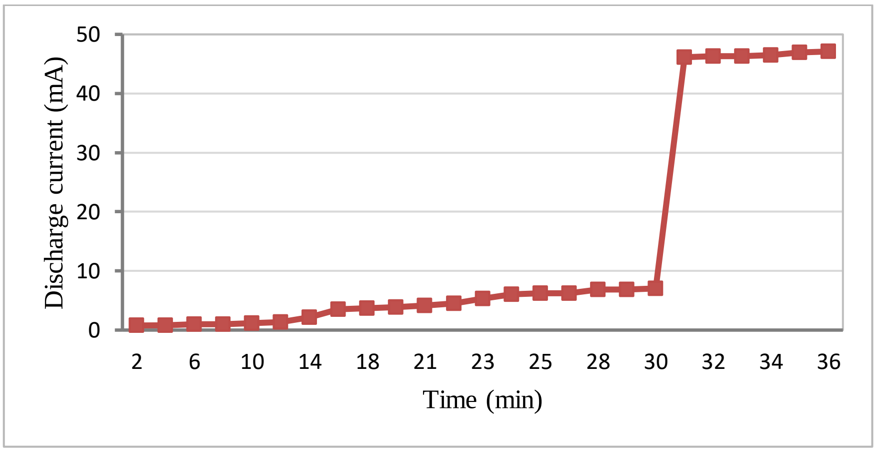


Figure 4. The increase of discharge current

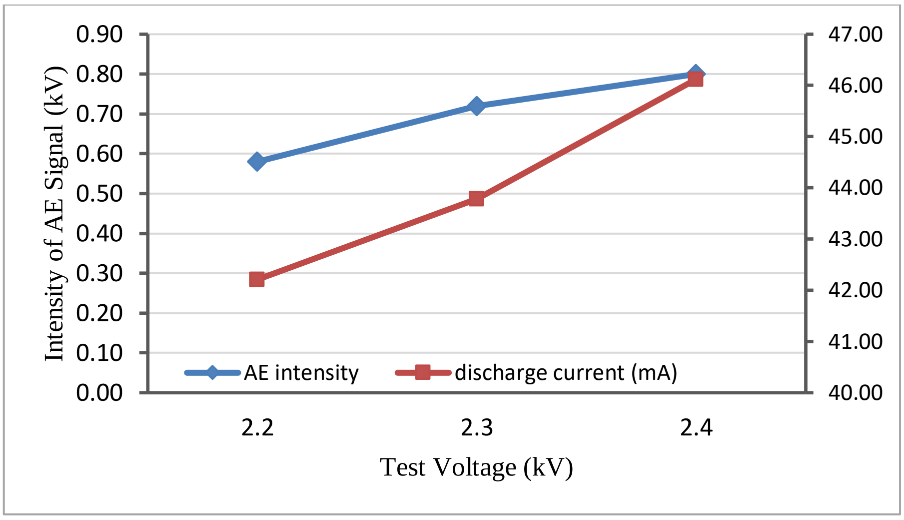


Figure 5. AE signal intensity and discharge current to voltage test at a distance of 24 mm

3.1.2. The sensor distance of 36 mm

In this test, the shape of discharge signals detected by AE sensor were almost the same with sensor distance of 24 mm that shown in figure 2. The table 2 shows the results of test. It also can be seen that with the increase of test voltage, some increase of AE signal intensity and discharge current are occur (ilustated in figure 6). Figure 3.5 is also shows the discharge current and the test voltage is directly proportional.

Table 2. Test results on single holes with sensor distance of 36 mm

Test Voltage (kV)	AE signal intensity (V)	Discharge current (mA)	Main Frequency (kHz)	Time of significant discharge current (min)
2.3	0.28	44.10	962	36
2.4	0.32	45.80	967	35
2.5	0,52	46.95	970	34

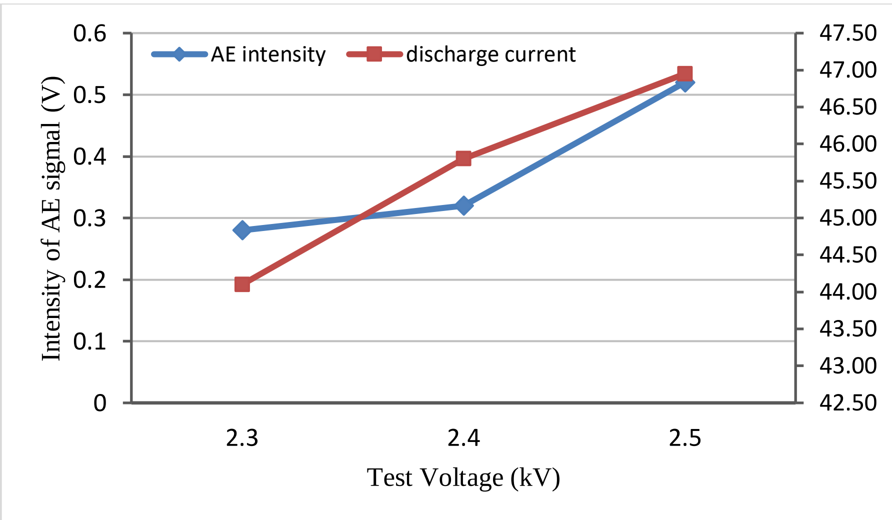


Figure 6. AE signal intensity and discharge current to voltage test at 36 mm

3.1.3. The comparison of test results between the sensor distance of 24 mm and 36 mm

(1). AE signal intensity at a sensor distance of 36 mm was smaller than the distance of 24 mm on the same test voltage. Signal intensity of AE at sensor distance of 36 mm was 40% from the distance of 24 mm. It happens because with the sensor position farther away from the hole, AE signals detected will be much smaller. The comparison is shown in figure 7.

(2). The magnitude of the discharge current at both distance of sensor was almost the same because of the same test voltage.

(3). The magnitude of main frequency component at both distance of sensor was almost the same. It happened because of the same type of material (insulation) and the same kind of test voltage. The magnitude of average of main frequency component was 975 kHz.

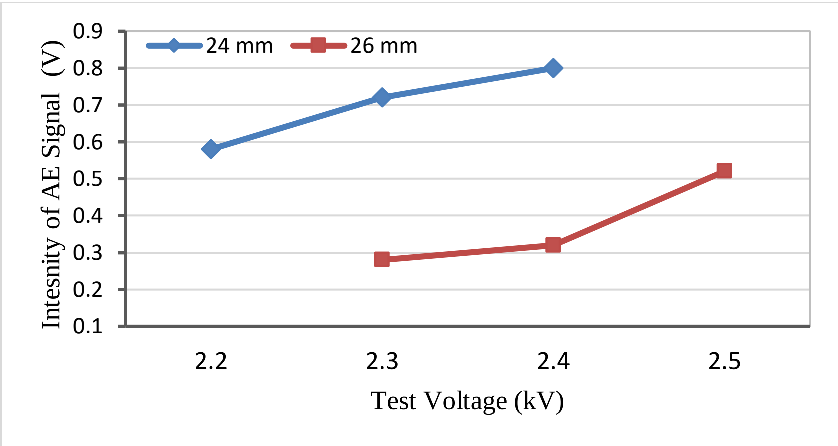


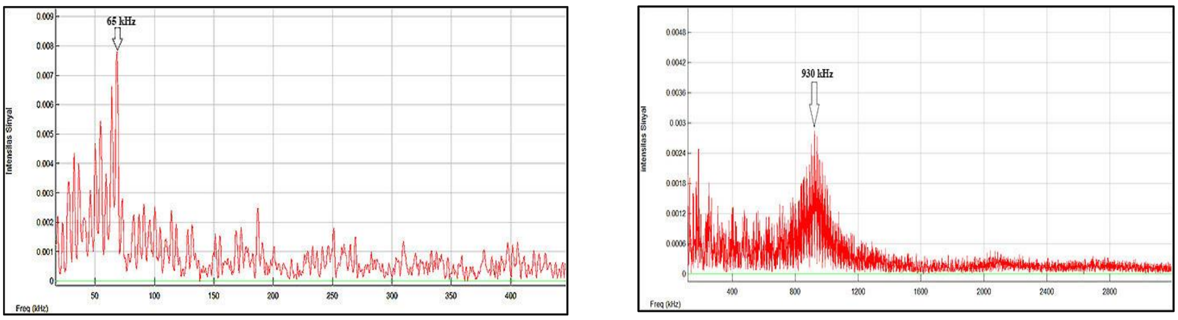
Figure 7. AE signal intensity for sensor distance of 24 mm and 36 mm

3.2. Tests on double holes

Test on epoxy resin with double holes was conducted at sensor distance of 24 mm only. Results data of the test is shown in Table 3.

Table 3. Test results on double holes

Test Voltage (kV)	AE signal intensity (V)	Discharge current (mA)	Frequency-1 (kHz)	Frequency-2 (kHz)	Time of significant discharge current (min)
2.2	0.57	45.93	62	940	33
2.3	0.60	46.71	63	930	32
2.4	0,64	47.20	63	940	30



(a). Frequency 1; 63 Khz (b). Frequency 2, 930 kHz

Figure 8. Frequency spectra of test on double holes

Table 3 also shows the relationship between the discharge current and time of significant electrostatic discharge. From the table, it is apparent that the discharge current jumped up significantly to the value of 45 mA or more, started in minutes 30. From the test, two ranges of frequency component were obtained, namely 60-66 kHz and 910-950 kHz. Therefore we got two averages of main frequency; they were approximately 63 kHz and 930 kHz as they are illustrated in Figure 8).

3.3. The comparison of test results between the single hole and double holes

(1). The main frequency components acquired on single hole test at sensor distance of 24 mm and 36 mm was 975 kHz (the frequency range was 960-990 kHz). Meanwhile, test on the double holes resulted in two main frequency components; they were approximately 63 kHz and 930 kHz (frequency ranges were 60-66 kHz and 910-950 kHz). It may happen because with the existence of two cavities, electrical (electrostatic) discharge occurs twice in the duration of very short time.

(2). There was no significant difference of AE signal intensity at sensor distance of 24 mm on single hole and double holes.

(3). There was no difference significant of discharge current on both tests. There was a trend that the time of the significant discharge current on double holes test also larger than single hole test (around 30 minutes in minimum). But, further and more carefully research is required to verify the trend.

4. Conclusions

A research has been done on the epoxy resin with single and double holes by giving high voltage to find the characteristics of insulation when electrical (electrostatic) discharge happened. A single hole experiment had a main frequency component; it was approximately 975 KHz. The double holes experiment had two main frequency components; they were approximately 63 kHz and 930 KHz. On the sensor distance of 36 mm, the AE signal intensity tends to be worth 40% from the AE signal at a distance of 24 mm.

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