The Energy Saving through Live Line Pedestal Insulator Washing with Snow Shampoo

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Abstract: The electricity is the important energy to human activity affect to economic development. The electricity efficiency affect to the efficiency of a country's development and climate change. Various efforts have be done to reduce the loss energy. One of which is washing the pedestal insulator from pollutants sticks on the surface of the insulator. This descriptive quantitative research proves that the un-touch insulator washing treatment has succeeded to increasing the performance of the pedestal insulator. So that the insulation resistance can be meet to the standard. The media used to wash the pedestal insulator in this study was a solution of snow shampoo and clean distilled water. The implementation this method was increases the performance of the pedestal insulator. The insulation resistance increases from 73.08 Mega-Ohms to 166.49 Mega-Ohms and energy saving up to 66.60%. This washing method is safe and easy to do in live line and increase energy saving.

1 INTRODUCTION

1.1 Problems Background

The electricity have positive affect to economic development of the country (Yılmaz and Hasan.2014). The efficiency of electrical energy consumption will support the efficiency of a country's development and to decrease the climate change. There are two basic ways to significantly reduce harmful emissions: to radically increase the share of renewable energy resources and to use the electrical power more efficiently (Cepoi et al. 2017).

So many effort to increasing the efficiency of processes utilizing these resources (Rosen. 1996). Maintenance is an important action in the operation of using electrical energy. One of the maintenance actions to the pedestal insulator is to keep it clean from pollutants. The insulator with full pollution had a lower value of flashover voltage gradient compared to other contamination profiles (Salem et al. 2021). A leakage current is then established through the superficial layer causing subsequent drying of the pollution layer and electrical arcs may arise (Alphonse and Haroun.2017). The low flashover voltage gradient in the insulator will increase the flow of electric current from the conductor of overhead line to the earth which results in loss electrical energy to the earth.

Overhead lines systems are exposed to many problem including surface pollution on insulators which is a factor of energy loss on bad weather (Alphonse and Haroun.2017). Tropical climate conditions affect to the severity of the surface pollution of outdoor insulators and can reduce the level of reliability of the electric power system (Carlos.2020). To increase the efficiency of distribution of electrical energy, it can be done with regular maintenance of the insulator so as to avoid pollutant (Abouelsaad. 2013).

The higher the value of equivalent salt deposit density (SDD) to stick of the surface of the insulator affect to the conductivity of the pollution layer will be increase (Salem et al. 2021) (Carlos.2020). High humidity will also affect the low performance of polluting insulators. The high humidity of the air will worsen the performance of polluting insulators (Ahmet and Suleiman. 1990). The accumulation of equivalent salt deposit density to stick on the surface of insulators in the presence of wind, ambient

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temperature, humidity, fog and moisture, conducting layers of pollutant was performed (Majid et al. 2015).

Many studies have stated that pollutants in the form of salt deposit density (SDD) result in low insulator performance as evidenced by the low partial discharge voltage and high leakage current, but few have written about the solution to this problem. To improve the performance of the insulator in the seafront area, it can be done by giving a layer of silicone rubber (Dini et al, 2017). Room Temperature Vulcanisation (RTV) coating application increase the performance of insulator under salty or polluted conditions (Farah et al, 2017). This process is carried out by coating the surface of the insulator in an offline condition, this process will result in unsold electrical energy during the silicone rubber coating process.

In this paper, presents the performance test to the insulator under conditions polluted with NaCl, under washing process, and dry condition, insulator washed by using snow shampoo and distilled water. This polluting insulator washing process is carried out during the live line.

1.2 Problem

How is the performance of the pedestal insulator in a polluted state, the phenomena that occur in the touchless washing process and live line condition, and the performance of the pedestal insulator after the washing process is complete and completely dry?

2 RESEARCH METHOD

2.1 Research Approach and Concept

This research was designed as a quantitative approach study to find insulator performance was washing from pollutant in live line medium-voltage over head. The washing tool assembled and simulation of washing pollutant insulators were carried out at the Bali State Polytechnic workshop.

The washing tool/washing gun which is designed to be operated on online/ live line electric distribution, consists of two water guns, each connected to a water bottle, which is operated using a remote. This online insulator washing tool is an innovation by the Bali State Polytechnic Research Team in Department of Electrical Engineering.

The online condition test is done at the Executor of Adjuster Unit (UP2D) of The Indonesian State Electrical Company (PLN) Bali Distribution. The data from the test results consist of: (a) sample number, (b) voltage, (c) leakage current, (d) condition and process of polluted insulator (sample) on going washing process, the data from this test is processed mathematically and statistically, which is presented in the form of tables, figures and graphs. Analyst results will be confirmed with the standards, and the progress of improving the performance of washed insulators.

2.2 Total Sample

This research was conducted by six samples "polluted pedestal insulator on going cleaning progress by washing gun" that was taken from new insulator with dummy pollution. The dummy pollution was done by spraying salt dissolved in distilled water.

2.3 Variable Operational Definition

The focus of this study on observing the magnitude of the leakage current and voltage test on insulator washing. The test voltage is the amount of electrical potential in kilo volt applied to the sample through the medium voltage tester. Leakage current is the amount of current flowing in the volume and at the surface of the sample, due to a given test voltage and washing process.

2.4 Tested

There are three step tests in this research. The first one is the testing with the initial condition of the insulator where the insulator is in polluted conditions. The second one is the testing during washing. The third one is the testing in dry condition.

Initial testing is carried out when the insulator is exposed to artificial pollutants, the artificial pollutant is prepared from a solution of NaCl with distilled water. This solution is sprayed onto the surface of the pedestal insulator. After the pollutants are dry and evenly distributed on the surface of the insulator, this test is carried out. The test is carried out by installing an all-aluminum conductor electrode on top of the insulator, this electrode is connected to the phase terminal of the high-voltage test instrument, while the insulator holder is connected to the grounding terminal of the high-voltage test instrument. The voltage of the AC high-voltage test equipment is increased step by step from 5, 10, 15, 20, 25 kV. The leakage current value can be read in the ampere meter for each step of the test voltage.

The second test was carried out an AC voltage of 11,600 volts to the samples during the washing process through all aluminum alloy conductor electrode (IEC 60507, 1991). The washing process is carried out by washing with shampoo, rinsing with distilled water, the process is carried out three times so that it becomes 6 washing stages, the seventh step is rinsed again with distilled water. Each step is observed and recorded the leakage current flowing to the test object as displayed on ampere meter. The third step test is carried out by testing after the washing process is complete and the pedestal insulator has dried perfectly.

2.5 Data Analysis

Data obtained from the test results are processed quantitatively through mathematic and static calculation. Data is processed mathematically and statistically by finding the data variation on the step by step washing progress. The data are processed mathematically to obtain the insulation resistance of the insulator at the initial of the test, during the washing process, and finally when the insulator has dried completely. The output mathematically data is processed statistically to obtain the average data, data sequence, which is also displayed graphically.

3 RESULT AND DISCUSSION

The results of this study are exposed in the figure and characteristic of initial condition of pedestal insulator tested, figure and characteristic of pedestal insulator on going washing process, and final figure and characteristic of dry pedestal insulator. The analysis of this characteristic exposed graphically.

3.1 Result

There are seven aspects that must be considered in using a pedestal insulator (Nzenwa and Adebayo, 2013), that are : that cannot conduct electricity, economical, without compromising their ability, solid materials, have high mechanical strength, high resistivity, high mechanical strength, do not change by working area, electrical polarity, will not leave a trace.

In this study, observed the fulfilment of three of the seven aspects of a pedestal insulator. The first one is materials that cannot conduct electric current more than standards. The second one is resistivity (insulation resistance) is not lower than standards at working temperature, water spray (washing), humidity, sunlight (drying), electrical polarity (voltage), Third, if it experiences an electric jump (flash over) it will not leave a trace (disabled).

Most of the medium-voltage over head distribution construction is carried out in places where there are a lot of human activities, so that pollutants are unavoidable. Salting on the seafront is one of example for pollutant. Such as in Bali, have a high chance of salt pollution contaminated and decrease of pedestal insulator resistance will increase the leakage current at the same voltage due the insulator which can cause flashover, it can be explained by Ohm's law and can be shown as an equation below (Salman and Muhammad, 2011).

$$V = I \times R \tag{1}$$

$$R = V/I \tag{2}$$

where:

R = Insulating Resistance (Giga-ohm)
V = Voltage charge due the sample (Kilo Volt)
I = Leakage Current (micro-ampere)

Based on formula (2) it can be described that, when the pollutants increase which is characterized by an increase in the value of Equivalent Salt Deposit Density (ESDD) it can cause problems increasing the leakage current through the surface of the pedestal insulator, even with a large ESDD value it can cause flashover from wire/conductor to ground. One way to solve this problem is to reduce the ESDD value by washing the pedestal insulator from pollutants.

There are 3 aspects to be noticed in conducting all of the tests in this research such as resistivity and the insulation resistance value, the leakage current and without leave a trace (done by using the High Voltage VLF Hi-pot Instruments Type: VLF4022). The minimum resistance of pedestal insulator for medium voltage is 100 Mega-ohms (Sanjay et la, 2018). The maximum leakage current flow from line to ground and should not over than 1 milliampere (Saba, 2014). Disturbance of flashover that occurs on the surface of the pedestal insulator must not leave a trace (Nzenwa and Adebayo, 2019).

The pollutant in this experiment is an artificial pollutant with NaCl dissolved in distilled water. NaCl was chosen because NaCl is the pollutant with the biggest affect on the poor in insulation quality (Abouelsaad, 2013). The composition of the solution used was 550 grams of NaCl was dissolved in 1500ml distilled water to obtain the value of ESDD = 0.1485 mg/cm2. That is heavy pollution severity class, because the value of ESDD more than 0.1 mg/cm2 (Salman and Muhammad, 2011).

Before calculating ESDD, it is necessary to first calculate the surface area of the pedestal insulator exposed to pollution. The calculation of the surface area of the insulator is carried out in parts which are divided into 5 parts as shown in Figure 1 at below.

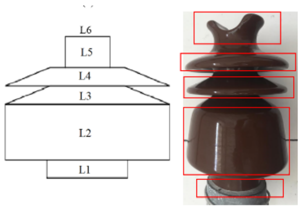

Figure 1: Pedestal Insulator surface area.

The total surface area of the pedestal insulator exposed to pollution is 881.56 cm2.

Based on the measurement results, the conductivity value of 550 grams of NaCl dissolved in 1.5 litters of distilled water, at a temperature of 27 degrees Celsius is 356 µS/m. To determine the conductivity at temperature of 20 degrees Celsius and solution salinity can be calculated as below (Salem et al, 2011).

$$\sigma(20^0\text{C}) = \sigma \text{ x } (1 - \text{b}(\text{t} - 20) \quad (3)$$

$$\text{Sa} = 5.7 \times (\sigma 20)^{1.03} \quad (4)$$

$$\text{SDD} = \text{Sa x V/A} \quad (5)$$

where:

$\sigma(20^0\text{C})$ = conductivity temperature of 20^0C (µS/m)

b = temperature coefficient=0.020166 (µS/m/^{0}C)

t = temperature measured (^{0}C)

Sa = solution salinity (mg/cm^3)

SDD = salt deposit density (mg/cm^2)

V = Volume of Solution (cm^3)

A = Surface area are pollution (cm^2)

Based on formula (3) the conductivity of the solution can be calculated as below.

$$\sigma(20^0\text{C}) = \sigma \text{ x } (1 - \text{b}(\text{t} - 20)$$

$$= 356 \text{ X } (1 - 0.020166(27 - 20) = 0.0306 \text{ S/m}$$

Based on formula (4) the solution salinity can be calculated as below.

$$\text{Sa} = 5.7 \times (\sigma 20)^{1.03}$$

$$\text{Sa} = 5.7 \times (0.0306)^{1.03} = 0.1571 \text{ mg/cm}^3$$

After 5,000 cm3 of solution is used up for 6 samples, each sample will get 833.33 cm3 of solution. The solution is sprayed from the top of the sample at an angle of 30 degrees. Spraying is carried out rotating on all sides of the sample evenly pollutants are stick to surface. After each spraying, wait for it to dry and the salts stick on the surface of the sample with white color. After the pollutant is dry, the new one of pollutant is added again with the next spray, so that each sample is sprayed five times.

Figure 2: Dummy pollution spraying process.

By using formula (5) the equivalent salt deposit density (SDD) will be calculated as shown in the calculation at below.

$$\text{SDD} = \text{Sa x V/A}$$

$$= 0.1571 \text{ x } 833.33/881.56 = 0.1485 \text{ mg}/cm^2$$

Like that calculated at the front, the equivalent salt deposit density on this paper is 0.1485 mg/cm^2. The condition of the insulator can be seen visually a lot of salt stick on the surface of the pedestal insulator which is the sample of this study, as shown in Figure 3 at below.

Figure 3: Dry dummy pollution on the surface of pedestal insulator.

To wash the pollutants sticks to the surface of the pedestal insulator as shown in Figure 3, an-touch washing was carried out, using two water guns. The water gun (A) contains distilled water, while the water gun (B) contains snow shampoo dissolved in distilled water, as shown in figure 4 below.

Figure 4: Water gun washer.

This water gun is modified from the handhold nano spray gun. Hand hold nano spray gun during this pandemic is used to sterilize a room by spraying disinfectant. This tool inspired researchers to use it to un-touch washing the polluted insulator pedestal. The work of water gun washer is not explained in this paper.

The washing to the pedestal insulator in this study was carried out using two media, namely snow shampoo and clean distilled water, the washing process is did on the insulator has a AC voltage 11.6 kV from phase to ground, the operating voltage from phase to ground only 11.6 KV. This job is done in a live line condition, as shown in figure 5 below.

Figure 5: Online pedestal insulator washing.

The first test was carried out by testing the leakage current of the sample in polluted condition. This test is carried out to determine the amount of leakage current and insulation resistance of the sample. This first test was carried out with four voltage steps of 5, 10, 15, 20 kV, at each voltage step the leakage current was recorded.

The leakage current is measured using a high voltage VLF hi-pot instruments that are shown in Figure 5 it is done at PLN UP2D Bali Laboratory. High voltage VLF hi-pot instruments are the equipment of low frequency high voltage test. This High voltage VLF hi-pot instruments converted the voltage of 220 Volts 50 Hz into a DC voltage, then converted back by decreased frequency 50 Hz into 0.2 Hz and increased voltage from 220 Volt into AC high voltage up to 40 kV. High voltage VLF hi-pot instruments is solidly grounded for safety during the observation process. Change the return switch (the red one) to guard position as shown in Figure 6 to measured the leakage current from ampere meter.

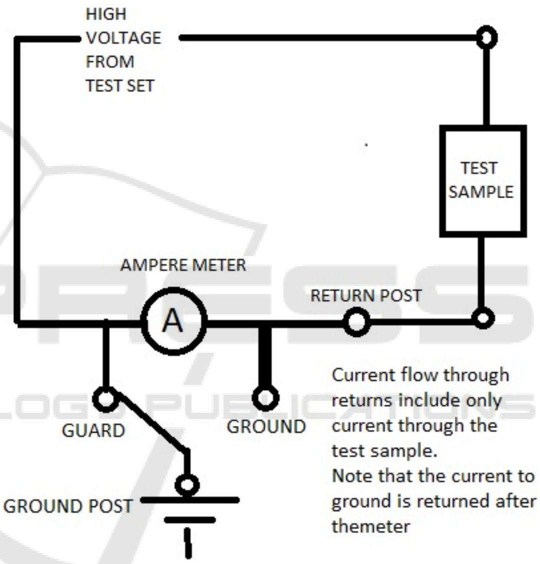

Figure 6: One line test diagram.

Leakage current test was conducted for the polluted and dry test. After four voltage steps polluted test is finished. High voltage VLF hi-pot instruments is turned off for safety, followed by washing process.

The leakage current data on polluted condition then is analyzed using the ohm formula. The Insulation resistance of pedestal insulator on polluted condition is equal to the tested given voltage divided by the leakage current flow from electrode to the earth. The calculation of insulation resistance of pedestal insulator on polluted condition to sample number one on first step tested is like describe below.

Test result:

Given voltage: 5,000 Volts AC
Leakage current: 0.053 milli amperes

The calculation of insulation resistance of pedestal insulator on polluted condition by formula (2) is like describe below.

$$\text{Riso} = \text{V/I}$$
$$= 5{,}000/(0.053 \times 10^{-3})$$
$$= 94{,}339.623 \text{ Ohm}$$
$$= 94.34 \text{ Mega} - \text{ohms}$$

Based on the results of the tests carried out on the test samples numbered 2, 3, 4, 5, and 6, the leakage currents were obtained respectively 0.056; 0.064; 0.05; 0.066; 0.061. with the same calculation method as above, the insulation resistance of each sample number 2, 3,4, 5, 6 is obtained sequentially as follows 89.29; 78.13; 100.00; 75.76; 81.97. From the test results and calculations are summed and then divided by 6, then the average leakage current and average insulation resistance are obtained through the calculations below.

$$I_{avg(5KV)} = (I_1 + I_2 \ \dots I_6)/6$$
$$= (0.053 + 0.056 + 0.064 + 0.05 + 0.066 + 0.061)/6$$
$$= 0.058 \text{ m.A.}$$

$$R_{iso(5KV)} = R_{iso1} + R_{iso2} \dots + R_{iso6})/6$$
$$= (94.34 + 89.29 + 78.13 + 100.00 + 75.76 + 81.97)/6$$
$$= 86.58 \text{ Mega} - \text{Ohms}$$

Conducting the same calculation process, the insulation resistance for all measured step is as displayed in the table 1.

Table 1: Pedestal insulator insulation resistance analysis with high voltage VLF hi-pot instrument on polluted condition.

SAMPLE	LEAKAGE CURRENT (mA)			
	5 KV	10 KV	15 KV	20 KV
1	0.053	0.112	0.188	0.269
2	0.056	0.111	0.186	0.271
3	0.064	0.124	0.195	0.282
4	0.050	0.11	0.184	0.258
5	0.066	0.125	0.198	0.285
6	0.061	0.123	0.196	0.279
AVG	0.058	0.118	0.191	0.274
SAMPLE	INSULATION RESISTANCE (M-Ohm)			
	5 KV	10 KV	15 KV	20 KV
1	94.34	89.29	79.79	74.35
2	89.29	90.09	80.65	73.80
3	78.13	80.65	76.92	70.92
4	100.00	90.91	81.52	77.52
5	75.76	80.00	75.76	70.18
6	81.97	81.30	76.53	71.68
AVG	86.58	85.37	78.53	73.08

In table 1, data has been presented, that the higher the test voltage, the leakage current also increases, but on the other hand the insulation resistance decreases. When the test voltage is the small one is 5 kV, there is the smallest leakage current in sample number 4 with a value of 0.050 milli amperes, so that the largest insulation resistance occurs with a value of 100 Mega Ohms. When the high one test voltage is 20kV there is the largest leakage current that are 0.285 milli amperes in sample number 5, so that the lowest resistance occurs with a value of 70.18 Mega Ohm. Based on the average value, it can be explained that the higher the test voltage also the higher the leakage current and this was followed by the lower insulation resistance of the test sample in a polluted condition.

The second test is a test carried out during the pollutant washing process, which consists of three stages, spraying shampoo, rinsing with clean distilled water and drying, this washing process is repeated three times, dried, then rinsed again with clean distilled water, and dried by relying on the flow of the surrounding wind and the heat of the sun. This washing process is carried out when the sample is given a test voltage of 20 kV, and in each process the leakage current is observed and recorded. Finally at completely washing and dry, the performance of insulator as shown in table 2.

Table 2: Pedestal insulator insulation resistance analysis with high voltage vlf hi-pot instrument on completely clean and dry.

SAMPLE	LEAKAGE CURRENT (mA)			
	5 KV	10 KV	15 KV	20 KV
1	0.168	0.253	0.213	0.107
2	0.288	0.271	0.239	0.143
3	0.288	0.251	0.219	0.144
4	0.282	0.251	0.221	0.112
5	0.294	0.25	0.218	0.108
6	0.299	0.25	0.21	0.118
AVG	0.270	0.254	0.220	0.122
SAMPLE	INSULATION RESISTANCE (M-Ohm)			
	5 KV	10 KV	15 KV	20 KV
1	119.05	79.05	93.90	186.92
2	69.44	73.80	83.68	139.86
3	69.44	79.68	91.32	138.89
4	70.92	79.68	90.50	178.57
5	68.03	80.00	91.74	185.19
6	66.89	80.00	95.24	169.49
AVG	74.12	78.70	91.06	166.49

The average value of each testing process, the average leakage current value is taken at the end of the measurement. Base on leakage current multiple by Voltage 11.6 kV, multiple by time operation, the loss energy can be calculated as describe at below.

$$WL = IL \text{ x } V \text{ x } t \quad (6)$$

where:

W_L = Loss Energy (KWH)

I_L = Leakage Current (Ampere)

V = Voltage (kV)

t = times (hour)

The leakage current on the polluted is 0.274 milli amperes at a operated voltage of 11.6 kV, in one year consisting of 365 days, the energy loss can be calculated as below, while after the washing and drying process is complete, the leakage current value data is 0.092 milli amperes at a voltage of 20kV. The energy loss will be reduced according to the calculation by formula (6) as describe atbelow.

$W_{L1} = I_{L1}\ x\ V\ x\ t$

$= 0.274\ x\ 11.6\ x\ 24\ x\ 365$

$= 27{,}843 \text{ WH} = 27.84 \text{ KWH/Year/Insulator}$

$W_{L2} = I_{L2} \text{ x V x t} = 0.092 \text{ x } 11.6 \text{ x } 24 \text{ x } 365$

$= 9{,}349 \text{ WH} = 9.35 \text{ KWH/Year/Insulator}$

$W_S = W_{L1} - W_{L2}$

$= 27.48 - 9.35 = 18.13 \text{ KWH/Year/Insulator}$

Based on the calculation results above, it is found that the energy loss if the insulator pedestal experiences pollutants with SDD = 0.1485 mg/cm2, it can cause losses of up to 27.84 KWH/Year/Insulator. After washing with shampoo and distilled water, the pollutants are clean, the insulator is reduced to 9.35 KWH/Year/Insulator. The full results of this calculation can be shown in table 3 below.

Table 3: Pedestal insulator insulation saving energy analysis with high voltage vlf hi-pot instrument on completely clean and dry.

Insulator Condition	Leakage current (m A)	R_{iso} (M-ohm)	Loss Energy (KWH/Year/ Insulator)	Saving Energy (KWH/Year/ Insulator)
Polluted	0.274	72.99	27.84	0
1st washing	0.157	127.25	15.97	11.87
2nd washing	0.122	163.93	12.40	15.45
3rd washing	0.107	187.21	10.86	16.99
4th washing	0.103	195.12	10.42	17.43
Dry	0.092	218.58	9.35	18.13

Based on Table 3 can be illustrated in graphical form. This graphic form is presented to make it easier to understand the phenomena that occur in the sample of this study, as shown on figure 7 below.

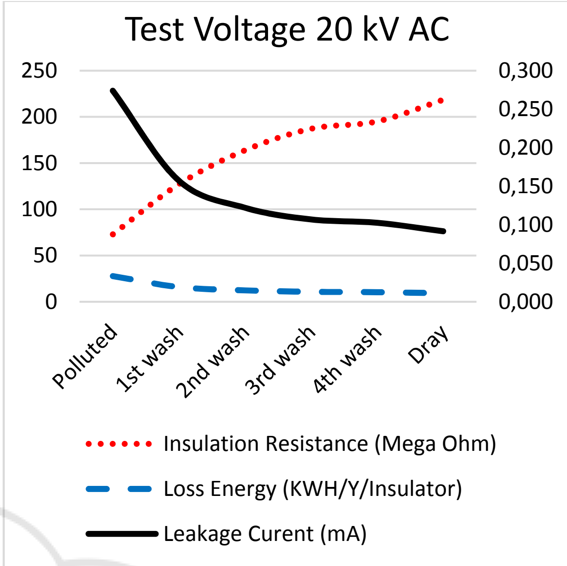

Figure 7: Graphic leakage current, insulation resistance and loss energy of pedestal insulator on clean and dry.

After the washing process is complete and the electrical test is complete, it is followed by visual observation. This visual observation was carried out to determine the traces of partial discharge left during the washing process. after the washing process the insulator pedestal looks clean as shown in the figure 8 below.

Figure 8: Pedestal insulator on clean and dry.

Figure 8 presented visual observation of the cleaned pedestal insulator, the washing result is clean, and there were no traces of partial discharge. Even though during the washing process there was a partial discharge, it didn't leave any traces. Thus, washing the pedestal insulator with the un-touch washing method can be carried out safely without damaging the surface of the insulator.

3.2 Discussion

SDD is influenced by NaCl in the solution is sprayed to the surface of the pedestal insulator and the area of the surface. The results of this study indicate that the SDD value of 0.1485 mg/cm2 is classified as heavy pollution (Salman and Muhammad 2011). Pollutants with this classification are the heaviest pollution classified, even visually it can be seen that there is evenly white layer sticks on the surface of the pedestal insulator that was sampled in this study as shown in figure3.

Based on Table 1 the insulation resistance on heavy pollution is 73.08 Mega ohms, that is lower than the minimum standard for medium voltage overhead lines, the minimum insulation resistance is 100 Mega Ohm(Sanjay et al, 2018). After washing as shown in figure5, continued to four stages and drying, the leakage current gradually decreased from 0.274 Milli Amperes to 0.122 Milli Amperes the insulation resistance gradually increased from 72.99 Mega Ohms to 166.49 Mega Ohms. The visually observation the electric jump (flash over) during washing did not leave a trace.

Based on the data as shown in table 3, insulator washing in this study is the alternative method to gets very good results to reduce the energy loss. The data shown in the heavy pollution condition of the pedestal insulator, energy loss is 27.84 KWH/Year/Insulator, after washed and dry the decreases to 16.03 KWH/Year/Insulator, go down 66.60%.

4 CONCLUSIONS AND SUGGESTIONS

4.1 Conclusions

The results and discussion have explained the process and results of this research, which can be concluded as follows. The equivalent salt deposit density SDD (SDD) value is directly proportional to the concentration of NaCl in the solution, the amount of solution sprayed onto the surface of the test sample and inversely proportional to the surface area of the insulator. Polluted pedestal insulators with heavy pollution levels have the opportunity to reduce the performance of the insulator until it does not meet to the standard because the insulation resistance drops to less than 100 Mega Ohms for medium voltage systems. The washing treatment to the live line pedestal insulator using shampoo and distilled water with the non-touch method was proven to be able to restore the performance of the pedestal insulator to meet the standard of at least 100 Mega Ohms, in this study the insulation resistance increased from 73.08 Mega Ohms to 166.49 Mega Ohms. The electric jump (flash over) during washing did not leave a trace as a complements the success of this research. Increasing the insulation resistance of the pedestal insulator after washing treatment can decrease the energy loss reaching 31.97 KWH/Year/Insulator and saving the energy about 66.60% compared to when the conditions the pedestal insulator were polluted with heavy pollution levels.

4.2 Suggestions

Based on the results of this study, the suggestions can be submitted to PLN and the researchers. It can be suggested to PLN to do the un-touch washing treatment the pedestal insulator to reduce energy loss and saving the energy up to 66.60%, because this method is safe to do and has been proven to significantly improve the performance of polluting insulators even for insulators with heavy pollution levels. The next researcher can develop this research by using other washing media such as distilled water only, or by using a bleach solution.

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REFERENCES

Abouelsaad, M.A., M.A. Abouelatta, B.Arafa, and M.E.Ibrahim. (2013). Environmental pollution effects on insulators of northern egypt hv transmission lines, environmental pollution effects on insulators of northern egypt hv transmission lines, *Annual report conference on electrical insulation and dielectric phenomena*.

Ahmet Rumeli and Suleiman M, El-Debeiky. (1990). Pollution flashover performance of high voltage insulators around jeddah region, *Medical Journal of Islamic Academy of Sciences*, 3:1. 1−5.

Alphonse Omboua1 and Haroun Abba Labane. (2017). High voltage lines: energy losses in insulators. *The international journal of engineering and science (IJES)*, Volume 6, Issue 10, Pages 58-62.

Carlos Sitompul, Zainuddin Nawawi, and Irfan Jambak. (2020). Detection of polymer insulator surface based on the effects of tropical climate using partial discharge signals measurement, *Journal of physics: conference series*.

Cepoi Radu Daniel, JAȘCĂU Flavia Florina and SZABÓ Loránd. (2017) Current trends in energy efficient electrical machines, *Journal of electrical and electronics engineering*, Volume 10, Number 2, October.

Dini Fauziah, Heldi Alfiadi, Rachmawati and Suwarno. (2017). The effect of coating on leakage current characteristic of coast field aged ceramic insulator, *Proc. EECSI 2017*, p:371-376.

Farah Adilah Jamaludin, Mohd Zainal Abidin Ab-Kadir, Mahdi Izadi, Norhafiz Azis, Jasronita Jasni and Muhammad Syahmi Abd-Rahman. (2017). Effects of RTV coating on the electrical performance of polymer insulator under lightning impulse voltage condition, *PLOS ONE*, November 14.

IEC 60507. (1991). *Artificial pollution tests on high voltage insulators to be used on AC systems*.

Majid, M., Hussain, S Farokhi, S G McMeekin and M Farzaneh. (2015). The effects of salt contamination deposition on HV insulators under environmental stresses, *IEEE 11th international conference on the properties and applications of dielectric materials (ICPADM)*.

Nzenwa, E. C. and Adebayo. A. D.(2019). Analysis of insulators for distribution and transmision networks, *American journal of engineering research (AJER)*, Volume-8, Issue-12, pp-138-145.

Rosen, M. A. (1996). Energy efficiency and sustainable development, *IEEE Technology and society magazine*, vol. 15, no. 4, pp. 21-26, Winter.

Saba, T. M.. Tsado.J., 1Raymond. E., Adamu. M. J.. (2014) The level of awareness on electrical hazards and safety measures among residential electricity user's in Minna Metropolis of Niger State, Nigeria, *OSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)* Vol. 9, Issue 5 Ver, I (Sep – Oct. 2014). PP 01-06 www.iosrjournals.org www.iosrjournals.org.

Salem, A. A. et al. (2021). Pollution flashover under different contamination profiles on high voltage insulator: numerical and experiment investigation, *IEEE Access,* vol. 9, pp. 37800-37812, 2021.

Salman Amin and Muhammad Amin. (2011). Thermoplastic elastomeric (tpe) materials and their use in outdoor electrical insulation, *Semanticscholar*, Edition 29 (2011), 15-30.

Sanjay Gothwal, Kaustubh Dwivedi and Priyanka Maheshwari. (2018). Partial discharge characteristics and insulation life with voltage waveform, *International Research Journal of Engineering and Technology (IRJET)*, Volume: 05 Issue: 07 July.

Yılmaz Bayar and Hasan Alp Özel. (2014). Electricity consumption and economic growth in emerging economies, *Scientific papers* (www.scientificpapers.org), *Journal of knowledge management. economics and information technology*, Vol. IV. Issue 2.