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Sea Salts Contamination Pattern on High Voltage Insulators In Littoral Region of Peninsular Malaysia

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Abstract

This paper describes series results of experiments conducted at Paka Thermal Power Station, which is located near the East Coast of Peninsular Malaysia. More than 12 samples of typical cap-and-pin glass insulators that are commonly installed on electrical power transmission lines are used in the experimentation. Three types of insulator topology are employed, single units, suspension-type and tension-type. These un-energized insulators are allowed to be exposed to 3-4 months duration of sea salts contamination. Equivalent salt deposit density (ESDD) measurement is conducted to measure insulator's contamination level. It was found that salt accumulation on suspension type insulator is much heavier than the tension type. Also the direction of inward coming winds has some influence on the salt deposition to the insulator surfaces. Experiments showed that ESDD increases linearly with an increase in time of exposure. This work will help in the establishment of maintenance policies especially in the months of monsoon when generally many utilities thought that during these months maintenance of insulators is not necessary.

Introduction

Power transmission lines sometimes pass through the areas near the sea. Salts blown from the sea to the land causing them to deposit on power system insulators. It is generally believed that the failure rates due to polluted insulator flashover are higher in coastal areas than rural areas. Salt deposition eventually contaminating the insulator surfaces, hence triggering to insulation flashover. Thus the performance of insulators under polluted conditions is the critical aspect in electrical power supply reliability, serviceability and efficiency. Thickness of these contaminants depends upon the distance of the insulators from the seashore and the speed of the wind coming from the sea. In Malaysia, terms of (ESDD) equivalent salt deposit density is widely used to determine salt contamination level and it suggests the need of washing the insulators when the ESDD value is equal or greater than 0.03 mg/cm^2 [1].

In marine area, build-up of salt contamination can be very rapid some times because of heavy wind coming from the sea. The knowledge about the level of contaminants on the insulator surfaces is important to determine the outdoor insulation level and insulators design, and also to predict the interval time for washing period of the insulators. The properties and behavior of the insulator surface mainly determine the electrical performance of insulators. The study of the surface conditions, as well as the related electrical performance is therefore an essential requirement [2].

In spite of heavy rain such salt will remain some times sticking to the insulator for long time as compare to the other soluble salts, small rate of precipitation will make it wet and sticking and its cessation will make it more attraction to further contamination [3].

Salt contamination makes a drastic reduction in the breakdown insulation level of the affected insulators, which will lead to breakdown. The voltage across the insulator causes the flow of leakage currents of varying magnitudes, depending on concentration of salt [4].

Detecting of Pollution

The monitoring of the contamination is of such importance requirement for the choice of suitable design and to determine the insulation level. To avoid any possibility of flashover it is important to determine the critical contamination level. A pollution detector machine (PODEM) was developed in the H.V. laboratory in Faculty of Engineering, Universiti Teknologi Malaysia. Figure 1 shows the machine parts. Washing of insulators is performs in two ways, either manually or automatically. This machine has a test

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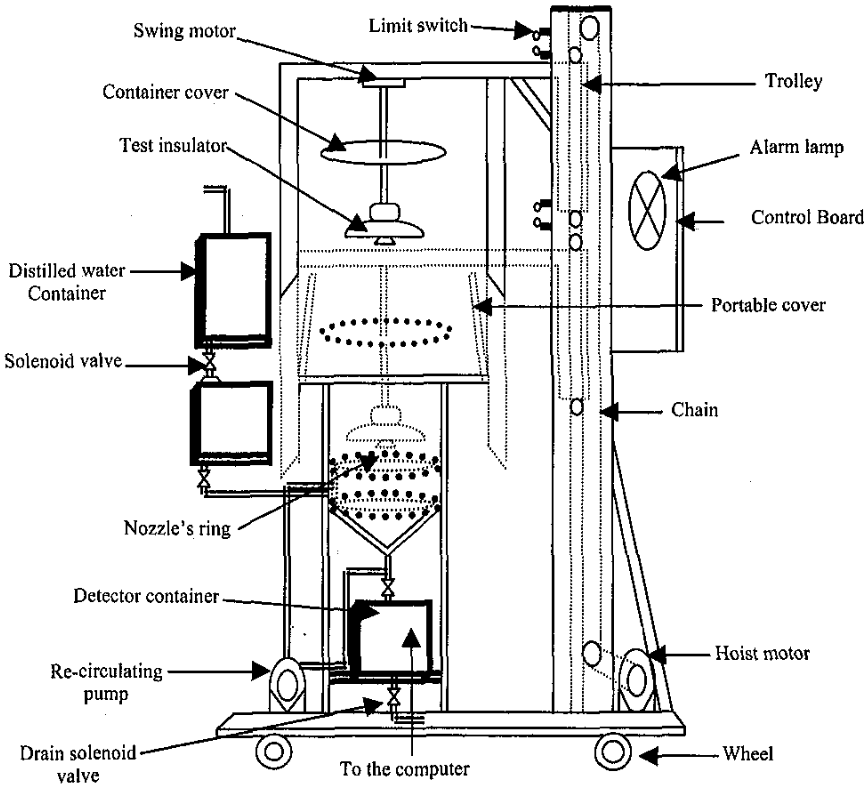

Figure 1: Pollution Detector machine

insulator, which is positioned in a gallows of suitable high, lowered by means of chain into a water tank. The tank has a portable lid, which is normally closed, but it will open by trolley hands when the insulator is lower into the tank and the tank will cover again by the material lid fixed over the test insulator. In the base of the tank there is an impeller driven by electric motor. When the insulator enter the tank it will be between two spray rings, every ring has 8 nozzles, the upper nozzles is oriented to the top surface of the insulator and the lower nozzles is oriented to the bottom surface of the insulator. There is a re-circulating pump, which pressured the water and targeted the insulator to remove the pollution thoroughly. The insulator rotating slowly by mean of swing motor which is fixed in the shaft. This will give a good removal of contaminants. After a thoroughly cleaning the insulator is raised out of the tank. Polluted solution is drained into the detector container. The detector container is connected by fiber optic wire to the computer and by a simple program we can calculate the (ESDD) for any kinds of pollutants in the presence of conductivity of polluted solution and insulator area.

Test Location and Metrology

West peninsular of Malaysia is surrounded with Seas. Power plants in the littoral territories very often suffer from salts due to salt contamination resulting from seasonal hydro-meteorological conditions.

An attempt has been made to derive relevant parameters for contamination severity based on the measured ESDD data during three months at Sultan Ismail Power Station in Paka-Terengannu. The station is located approximately 500 meters from the coast of South China Sea. More than 12 samples of typical cap-and-pin glass insulators are used in the experimentation. Three types of insulator topology are employed, single units, suspension-type and tension-type. The contamination collection process was carried out daily (three units) and weekly (two units). All the samples were installed before the rainy seasons and removed from the site when this season is over. The samples were taken down from the site and the pollutants were removed by washing the insulators with brush and distilled water.

Laboratory Measurements

In the chemical laboratory the following measurements were made:

1- Measuring of conductivity for the contaminated solution obtains after washing of samples in 100 ml-distilled water.
2- Measuring of pH for the contaminated solution after washing of samples.
3- ESDD of the contamination in mg/cm^2 is determined by measuring the current flow through the polluted solution using simple electrical circuit as well as the conductivity. These values are converted to resistivity value. From the resistivity value, the concentration of the salt is found. Determining of ESDD is achieved by dividing the concentration of the salt on the specific surface area of the insulators.

Figure 2 shows the relationships between the ESDD and conductivity for the natural contamination.

pH Measurement

Measuring of pH for the contaminated solution was achieved by using a pH meter immersed in the solution for 15 minutes to give accurate reading. Observations indicated that the pH increases with increase of ESDD. Distilled water (pH 5.7) is used to wash polluted samples. The pH increases to 8.20. The pH value for the solution taken by washing the lower portion contaminants is substantially high. The salt here that seemingly contributes to the pH reading is due to airborne particles that are produced by ethylene plant, petroleum refineries, YTL power plant nearby as well as the TNB Paka Power Station itself where the tests are conducted. Figure 3 shows the relationship between ESDD and pH for the one of the samples under natural contamination in the site.

Distribution of Contaminants along the Strings

The data showed that the amount of soluble contaminants expressed in ESDD collected from the bottom surface of insulators is much more than that collected from the top surface. Figure 4 shows the ESDD accumulation on the top and bottom surfaces for the suspension string of insulator. The suspension position was chosen as it permits a greater contamination accumulation on the under surface of the string units, when compared to the tension position. Pollution severity characteristics are also compared for the suspension and tension string, tension string collects less pollution relative to suspension string. Figure 5 shows the distribution of contaminants along the tension string for the top and bottom surfaces.

Discussion

Through this work the results showed in figure 6 explains that the maximum annual contamination on the insulators appeared in the rainy seasons from November to January. The results also reflect that the contamination level increase with an increase in time of exposure. The bottom surface of an insulator, on the average, accumulated about 2-3 times more than the amount of pollutant for the top surface.

The effects of hydro-meteorological parameters such as pressure, wind speed, wind direction and rainfall are studied. Through this work both critical months of the year and critical exposure periods can be found.

Because of the limited effect of the rain factor for washing the bottom surfaces of the insulators, and the heavy contamination airborne coming from the sea to land through rainy season, It is recommended that all the outdoor H.V. insulators for the Paka Power Station should be washed at least once a year. Similarly this recommendation can be applied to the neighboring power plants insulators such as YTL Power Station, Petronas Ethylene Plant, Petronas Oil Refinery and others. Due to its sensitivities to transient overvoltage especially due to the lightning bolts, the automatic washing system suffered frequent interruption and replacing or repairing it is practically difficult. So manual measuring of salt ESDD is useful when such automatic system fail to deliver its functionality. The preferred time for insulator washing in Paka Power Station and other associated insulators is in the month of January or February. This is to avoid any possibility of flashover to occur which may result in power supply interruption because the power lines protection system record it as a AC power through failure. Such interruption will incur lost of revenue in millions and customer confidence is tarnished.

Conclusion

The actual intention from this work is to develop a mathematical model using the hydro-meteorological variables to be correlated with Equivalent Salt Deposit Density (ESDD). Along the insulator string, the unit nearest to the H.V. conductor experienced less contamination compared to the top-most insulator, which is hung to the (steel frame holder). The contamination on insulator bottom surfaces shows no unique trend and it can be considered to be almost uniform. The relative magnitude of ESDD between top and bottom surfaces of the insulator is in the range of 0.4 to 0.75. The suspension type string insulator collects more contaminants than the tension type. The wind speed and wind direction are the most influential factors in effecting the ESDD variation.

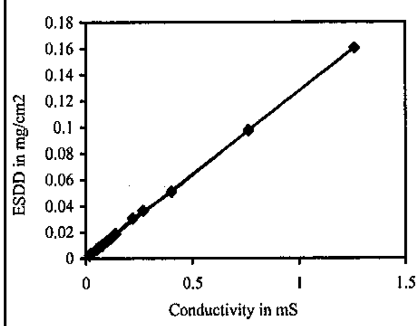

Figure2: ESDD vs. conductivity for natural contamination

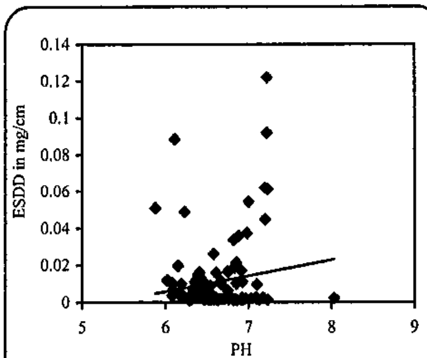

Figure 3: ESDD vs. pH for one of the samples/natural contamination

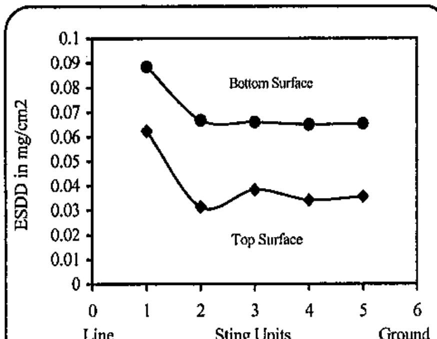

Figure 4: Distribution of contaminants along the suspension string

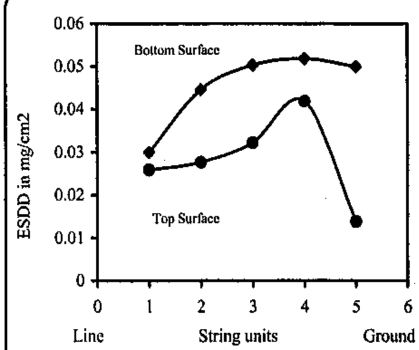

Figure 5: Distribution of ESDD along the tension string

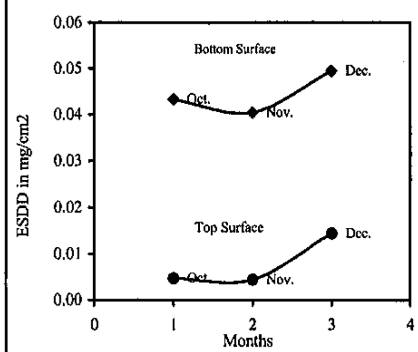

Figure 6: ESDD level per month

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