Flashover Phenomenon On Contaminated Glass Insulator

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ABSTRACT

The performance of outdoor insulators will be always influenced by their surrounding environment condition. The pollutant particles such as smoke, cement dust, coal dust, salt deposition and many others could deteriorate the performance of outdoor insulators. Further, this could initiate flashover on the surface of insulators which is could disturb the process of transmission and distribution of electrical energy to the consumer. To observe the influence of contamination deposition and flashover process on the surface of insulator a research has been conducted by simulating the phenomenon use an artificial contamination chamber.

Keywords: flashover, insulator, contamination, transmission and distribution energy

1. Introduction

The rapidly growing industrial has increased the demand of electrical energy. The transmissions of the electrical energy from remote power station to the load centres are accomplished by overhead lines. Due to the need to transmit greater amount of power for longer distance, transmission lines with higher and higher operating voltage have been built.

In upgrading and construction of transmission lines, tower design and insulator selection are crucial. An insulator would ideally be solid dielectric which is functionally nonconductive to the flow of electricity. However, no material is a perfect insulator. For practical purposes, an insulator is a material that for a particular application limits the flow of current through it to a value small enough to be ignored [1]. The insulator can be of indoor or outdoor type. The outdoor type is easily affected by the atmospheric contamination and pollution. Therefore, it is imperative that power system network components are affected by environmental conditions.

In Indonesia, power system networks spread all over the island. Some of them traversed the coastal regions, industrial areas, valleys, plains and thick forests. The build-up of contamination can sometimes be very rapid on HV insulator installed near marine environment. Sudden storms cause excessive built-up of conducting contaminant on the insulator surface in just a few hours. Other hydrometeorology parameters are also responsible in the case of service insulators near coastal areas. Outdoor insulators are contaminated by salt depositing on the surface of the insulators. This obviously can adversely affect the performance of the insulators when energized with Alternating Current (AC) or Direct Current (DC) voltages. The Basic Lightning Impulse Insulation Level (BIL) and Basic Switching Impulse Insulation Level (BSL) of the insulator are greatly reduced in a contaminated environment.

A contaminated environment can cause the insulation level of outdoor insulators to be deteriorated. The degree of contamination on the insulator surface can be correlated with the magnitude of the surface leakage current flowing in these surfaces. In the case of the insulators near littoral region, salt deposition on insulator surface deteriorates its performance.

Dry salt deposit on the insulator surface is not usually conductive enough by itself to affect electrical flow. But with the presence of dew or light rain, the dissolved salt that moisten the insulator surface produces an electrolytic layer on the surface itself and eventually trigger the flashover which start from the high voltage point to the grounded part of the insulator.

The flashover of a contaminated insulator can cause failure of the power system for a long period of time [2]. During the flashover period, the total resistance of the insulator decreases abruptly. This flashover is seen by the system protection as an AC power failure and can trip the complete line. It becomes worst when no automatic mean of re-closure to restore the supply installed to avoid possibility of flashover reaching a dangerous level. The performance of the HV equipment in the contaminated condition is the most important and decisive factor for determining the external insulator design of the overhead electric power lines and also substations in the coastal area. The environmental impact on the performance of the insulator entails the use of right and suitable insulator materials.

This paper present a research was conducted in order to simulate the flashover phenomenon on glass insulator in the developed mobile artificial contamination chamber.

2. Research methodology

This research was conducted in Institut Voltan dan Arus Tinggi (IVAT), Universiti Teknologi Malaysia. The artificial contamination chamber used was developed by M. Abu Bakar Sidik et al [3]. The pictorial view of artificial contamination chamber is shown in Figure 1.

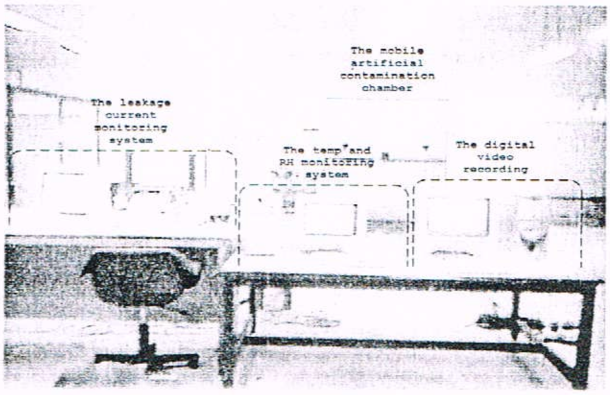

Figure 1. Artificial contamination chamber with the observing and collecting system unit.

All flashover events on the insulator under test were continuously videoed by means of a four-camera system and stored in a PC. The leakage current signatures were visually displayed in the form of graphic showing leakage current magnitude and time variation. A resistor with value 468 W was used and connected to measure leakage current magnitude. Figure 2 shows the block diagram of leakage current measurement system.

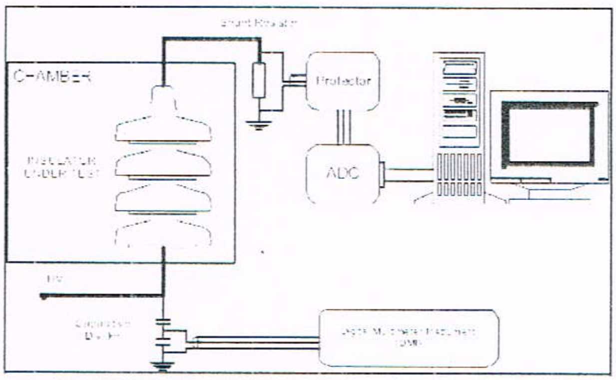

Figure 2. Leakage current measurement system.

Before testing the insulator was thoroughly rinsed with tap water (IEC 507, 1991) in order to remove any dirt on the surface of the insulator. After that the insulator was covered by appropriate plastic bag to ensure its cleanliness and stored for about 24 hours.

To start the test, a suspension consisted of 120 grams kaolin and 150 grams of NaCl were dissolved in a 3 liter tap water to develop contaminant of ESDD level of about 0.12468 mg/cm^{-2}. Once this process was done the insulator was dipped in the suspension. For uniform contamination of the entire surface on the insulator, complete immersion of insulator in the solution must be maintained and at the same time the insulator was regularly rotated and moved horizontally and vertically while it was still in the solution.

The insulator were then removed from the container and placed to dry under the direct sunlight for duration of not less than 6 hours. This ensured that no traces of moisture still remained on the insulator surfaces. After this activity has been completed, the artificially contaminated insulators were stored in an environmentally cleaned room for testing.

To proceed with the testing the contaminated insulator was placed in the chamber. An AC supply of 17 kV, 50 Hz was continuously applied on to the tested sample. Concurrently, artificial fog was introduced in the chamber, by activating the fog generator, with constant spraying capacity of 25.0 ml/second with 80.0 psi air pressure. The fog generated filled up the chamber, not allowing it to be sprayed directly to the test insulator.

3. Result and Discussion

With increased fog density in the chamber the leakage current magnitude tends to increase with the time. Once the fog accumulation has reached the threshold after energizing, the flashover occurred. What really happened was that partial discharges appeared at the bottom surface of the insulator in the form of surface tracking and finally a complete flashover took place. At about 6 (six) minutes after the test commenced the leakage current magnitude started to decrease. This so called sudden change over of leakage current magnitude was due to insulator surface condition that was completely moisten with layer of water. Figure 3 illustrates the leakage current oscillogram. In addition, a moving average per three point and five order polynomial fitting function were presented graphically providing more information about the wave-shape of leakage current oscillogram and flashover activities. The flashover events captured from DVR were presented in Figure 4.

The sharp spikes running over the leakage current oscillogram shows a drastic change in the insulator surface resistance value. This changeover involved resistance value from high to low resistance. This could be justified by the occurrence of so-called "Dry Bands" on the wetted insulator surfaces. Under cleaned surface condition, the potential was totally across the glass surfaces i.e. between the cap and pin part of the insulator. However as the wetting process started to creep all over the surfaces, the surface resistance R_{srf} started to decrease because of the leakage current thermal effect begun to dry-up the moisture and formed so-called "dry bands", and if the voltage gradient across these bands exceeded the surface dielectric strength partial flashover took place and this could be translated into a sharp jumped in leakage current values.

In the case when contaminated layer on the insulator surfaces was too 'heavy', "Dry Bands" formation could not occur but this did mean that no flashover could occur. On the other hand, if the voltage applied exceeded the insulator critical flashover voltage, a complete flashover occurs and this resulted in a sharp and higher leakage current magnitude formation.

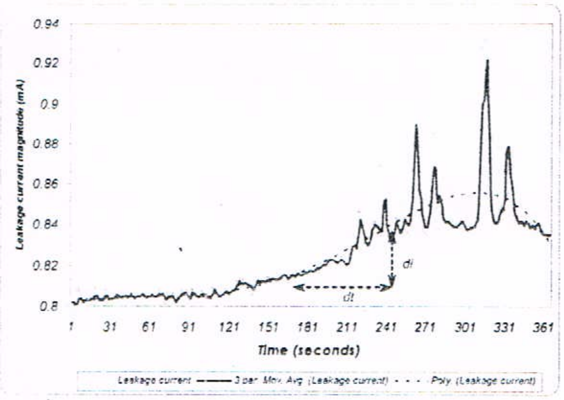

Figure 3. RMS leakage current magnitude with time

Figure 4. A particular event of the flashover scenario.

4. Conclusion

The flashover phenomenon on the surface of contaminated glass insulator has been simulated in this current work. It is shown that the flashover occurs when the dry contamination deposit on the surface of insulator become gradually moisten.

References

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