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REVIEW ARTICLE

ENVIRONMENTAL EFFECTS ON THE FLASHOVER VOLTAGE OF EPOXY COMPOSITES

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ABSTRACT

Addition of inorganic fillers for resin Epoxy helps to improve the electrical properties of polymer insulation materials, according to the percentage of filler concentrations and filler types. Experiments and measurements have been performed to study and analyze the flashover voltage of Epoxy with Magnesium hydroxide, Silica and Mica fillers with variety of samples lengths at different weather conditions. These measurements also aimed to improve the electrical properties in addition to maximize the flash overvoltage. Flashover voltage value at dry condition for resin Epoxy was 41.97kV at 25mm sample length. Epoxy with Silica filler at 50wt% concentration reached 49.84kV and this value is the greatest flashover voltage at the same sample length. The flashover voltage for resin Epoxy samples takes the same trend for than that of Epoxy with mica filler samples. The results of flashover voltage for samples of Epoxy with Magnesium hydroxide resulted in lowest values than other samples.

INTRODUCTION

In recent years, alternative materials had used (instead of porcelain and glass) for insulation. These materials are polymers. Using polymers currently is very widely in outdoor insulation applications. Polymer insulator provides about ten times the weight reduction when compared with porcelain and glass for the same effort, and furthermore they don't damage as easily as porcelain (The Comparison Of Ceramic AND NON-Ceramic Insulators, 2017). It was noted that the insulation material made from polymer deteriorate electrically and mechanically under environmental stresses such as heat and sunlight, humidity and pollution. This leads to the need to take precautions when used near contaminated areas and along the sea coast (Aging of polymeric insulators, 2006). Chains, specification and high-performance selected insulators play an important role in ensuring security, reliability and availability for customers. There are different forms of polymer insulators such as silicon rubber, Epoxy, polyvinyl chloride…etc. Polymers are chosen to give high insulation strength to work in both normal operation and emergency (Liu *et al*., 2012). Epoxy resins are used in electrical distribution system. The composite insulator contains a mixture of Epoxy resin and inorganic fillers such as magnesium hydroxide, silica and Mica in different sizes and concentrations.

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The fillers are selected to change the physical structure of Epoxy and increase the flashover voltage of Epoxy at dry and contaminated weather conditions (Tian *et al*., 2013).

Experimental details

Material Specimen: Epoxy is a thermosetting chemical compound. It consists of oxygen and carbon atomic bond which is generated by chemical reaction between epichlorohydrin and bisphenol A (Wu, 2012). A complex structure of Epoxy resin has molecule bond as shown in Figure (1). A blend of the two segments of Kemapoxy 150 JMA and B in the proportion of (3:1 wt/wt %) were blended completely utilizing a magnetic stirrer for three minutes. The blend was degassed under vacuum to remove air bubbles, and afterward filled a plastic bold (Tsekmes *et al*., 2015). The test is steady to machine after 7 days. specimens were fabricated as cylindrical rods having 1cm diameter and different lengths varied 5mm to 25mm.Then finally the filler with the required amount has been added to the blend. The hardener, catalyst and fillers will be mixed with the Epoxy resin. It is widely applied in insulator, house hold equipment, machinery component, automotive, tank, pipe, aero plane body part, bridge construction, etc. The fillers utilized were magnesium hydroxide Mg $(OH)_2$, Silica SiO_2 and mica in smaller scale.

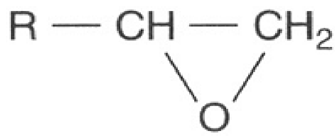

Fig.1. Epoxy Ring structure

The composite samples of Epoxy are summarized in Table1. The dimensions of the samples were limited due to the limitations of the capabilities of ac supplies available in the high voltage laboratory. Test samples were performed by using hand tools, the resulting samples rearranged as represented in Figure (2).

Fig. 2.Testing samples of Epoxy with inorganic fillers

Test Apparatus: The arrangement of the flashover test is shown in Figure (3). The alternating high voltage (50Hz) was obtained from a single phase high voltage auto transformer (100kV-15kVA). The output voltage of the transformer is controlled smoothly by a range from (0-220 V) variac regulating panel for the voltage applied to its primary winding as in Figure (4) .

Fig. 3. Flashover voltage test arrangement

Fig. 4.Variac regulating panel

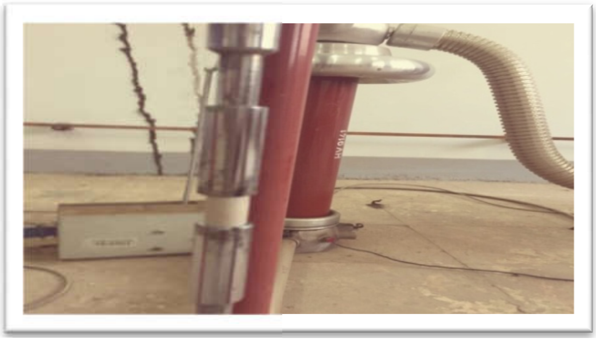

Fig. 5. The two electrode and the specimen.

The high voltage set-up has been enclosed in an earthen cage. The power supply was connected in series with two electrodes. The electrodes were made of copper with 1cm diameter as in Figure (5). The electrodes were fixed to the specimens, one at the top and the other at the bottom carefully to ensure a good contact. The test characteristics of flashover are according to ASTM D-2303-64T. The flashover voltage was measured under dry, wet, salt wet, Naphtha and Hydrochloric acid conditions of composites with different fillers and lengths. After pollution is achieved ,the test took place. The high voltage between two electrodes increased gradually from zero by constant rate 2kV /sec until reaching the flashover voltage (kV). Each test has been done five times on each sample under the same conditions to check the accuracy of the results.

RESULTS AND DISCUSSION

Experimental Results of Flashover Voltage of Epoxy with inorganic fillers

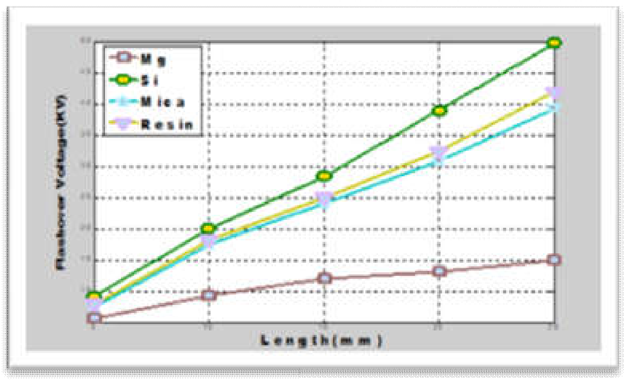

Fig. 6. Flashover voltage against length for Epoxy insulators with $Mg(OH)_2$,Silica and Mica, under dry condition

Flashover Voltage of Specimens under Dry condition

- Under normal testing conditions, the Ac (50 Hz) flashover voltage measurements have been measured for Epoxy samples with different filler percentage.
- Figure (6) represents the flashover voltage using different type of fillers under dry condition. .
- The flashover voltage increases with increasing Silica (SiO_2) as inorganic filler, $E_{Si/25}$ reaches 49.84 KV .The maximum flashover voltage of resin Epoxy($E_{R/25}$) is 41.97KV, so the rate of increase in flashover voltage due to presence of Silica is about 15.8 %.
- The flashover voltage of Mica samples is similar in value to the flashover voltage of Resin samples.

- Magnesium hydroxide Mg $(OH)_2$ filler illustrates the lower values than the other samples.

Flashover Voltage of Specimens under Wet condition:-

The flashover voltage against the length for Epoxy samples including various types of fillers under wet condition is displayed in Figure (7).

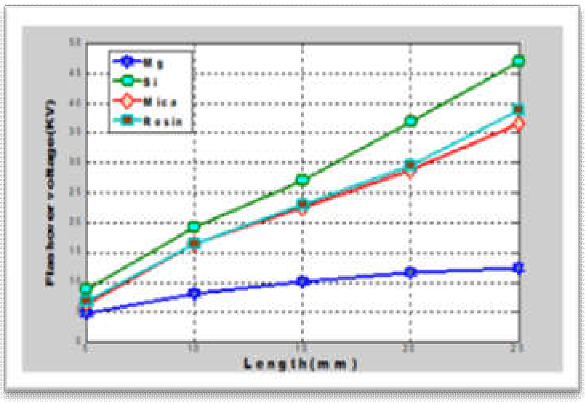

Fig. 7. Flashover voltage against length for Epoxy insulators with Mg $(OH)_2$, Silica and Mica, under wet condition

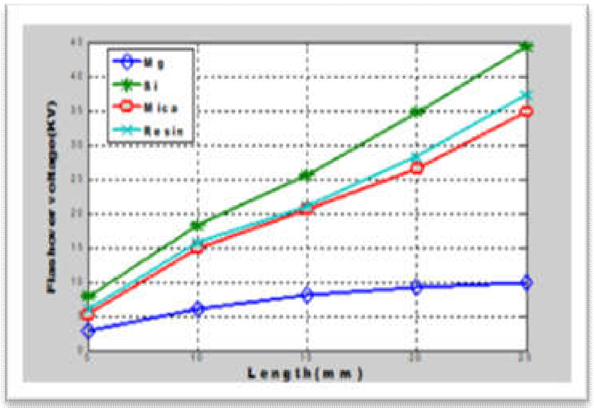

Fig. 8. Flashover voltage against length for Epoxy insulators with Mg $(OH)_2$, Silica and Mica, under salt wet (NaCl) condition

- The aim of this test is to simulates the composite materials when it is subjected to rainy weather .
- It can be seen from this Figure that, the wet condition reduces the flashover voltage.
- As Insulator contaminations become a troublesome in electrical power system operation. Wet atmospheric condition will form thin water layer on the insulator surface. Then, the present of the contaminant inside the layer will create leakage current on the insulator surface. The contaminant layer accumulation at the surface of the insulator will increase the leakage current in which causes flashover voltage and give damage to insulator.
- $E_{Si/25}$ reaches about 46.94KV. The maximum flashover voltage of $(E_{R/25})$ is 38.77KV, so the rate of increase is about 21.1%.
- There is no significant effect on the flashover voltage when adding Mica.
- Magnesium hydroxide Mg $(OH)_2$ filler reflected the lowest flashover in comparison to other fillers.

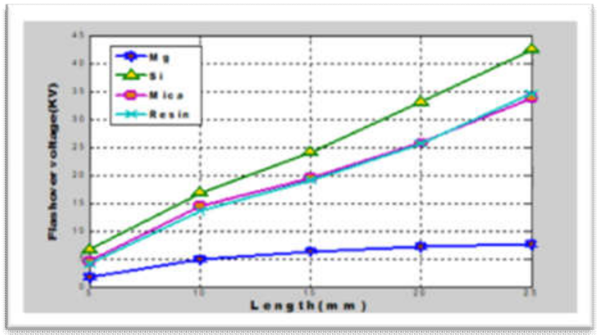

Fig. 9. Flashover voltage against length for Epoxy insulators with $Mg(OH)_2$,Silica and Mica, under Naphtha condition

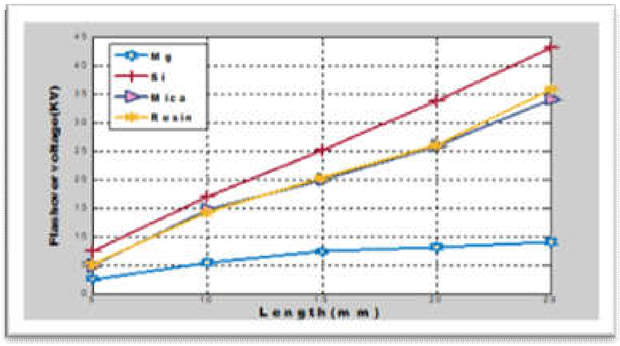

Fig. 10. Flashover voltage against length for Epoxy insulators with $Mg(OH)_2$,Silica and Mica, under HCL condition

Flashover Voltage of Specimens under Salt Wet condition

- Flashover voltage test on 54000µS/Cm salinity condition is done to simulate the composite insulators when they are subjected to coastal weather, where salts accumulate on insulator surface.
- Addition of sodium- chloride to Epoxy including SiO_2, Mg $(OH)_2$ and mica fillers is shown in Figure (8) which lower flashover voltage obtained in comparison to all values of dry and wet environment. This is occurs when dirt or salt settles on the surface and their ions combined with moisture from dew or rain to form a conducting film (7).
- The current through this film causes the water to evaporate and as drop spots or bands are formed the current is interrupted locally, which causes arcing. This effect leads to decreased flashover voltage.
- The flashover voltage increases with increasing Silica SiO_2 as inorganic filler. $E_{Si/25}$ reaches 44.43KV and $E_{R/25}$reaches 37.38KV, the rate of increase is 18.86%.

Flashover Voltage of Specimens under Naphtha condition

- Polymer materials used for outdoor insulators in urban areas encounter hydrocarbon solvents from exhaust fumes of vehicles organic insulators near railway lines are more likely to encounter hydrocarbon solvents due to their close proximity to the lines.
- Epoxy composite materials are tested in the presence of a reagent of naphtha solvent. The effect of naphtha on flashover voltage of surface samples was studied.

- It can be seen from Figure (9) that the flashover voltage increases with increasing Silica SiO_2 as inorganic filler, $E_{Si/25}$ reaches 42.58KV.The maximum flashover voltage of resin Epoxy($E_{R/25}$) is 34.65KV, so the rate of increase is about (22. 89 %).
- Magnesium hydroxide Mg $(OH)_2$ fillers result in the worst flashover voltage when mixed with the Epoxy resin . Adding Mica to the resin Epoxy has no improvement on the flashover voltage.
- It is clear that the effect of surface flashover voltage by the type of reagent affects erosion.
- Degradation of the insulation results from the heat of the sparks. This heat either carbonizes or volatilizes the insulation.
- A carbonization result in a permanent extension of the electrodes thus flashover voltage occurs. Consequently it can only occur with organic insulation which has carbon atoms in their molecular structure.
- As seen from figure(10), the sample $E_{Si/25}$ reaches 43.16KV. The maximum flashover voltage of resin epoxy($E_{R/25}$) is 35.84KV so the rate of increasing is about 20.42 %. Adding Mica to the resin Epoxy hadn't led to improvement on the flashover voltage. Magnesium hydroxide $Mg(OH)_2$ fillers had made the lowest flashover voltage when mixed with the Epoxy resin.
- If moisture finds its way to acid crystals or residual hardener on or near the surface of the insulator, it will act as a carrier for the acid allowing it to seep into cracks and reach the surface of the fibers, thereby starting the brittle fracture process.

Conclusion

The following conclusions may be drawn from the present investigation:

- Type of filler such as :magnesium hydroxide Mg $(OH)_2$, Silica(SiO_2),mica….etc and reagents such as: Naphtha, HCl, NaCl …etc in Epoxy samples effect to the flashover voltage.
- The type and percentage of filler has pronounced effects on the electrical performance of Epoxy composite insulators.
- The flashover voltage increases with increasing Silica (SiO_2) as inorganic filler almost varying between (18.75% to 22.89%) in all conditions.
- Magnesium hydroxide belongs to a group of unique inorganic compounds, which exhibit numerous advantageous properties and practical applications. It is distinguished primarily by its antibacterial activity, nontoxic nature and high thermal stability. All of the above features make $Mg(OH)_2$ an agent commonly used to reduce the combustibility of polymer materials.
- The addition of Mica to the resin Epoxy did not improve the electrical properties.
- There is a critical quantity of filler, which can be added regarding the quantity of Epoxy and the appropriate percentage of SiO_2 reach to (50wt. %) in Epoxy specimen gives the highest flashover voltage (49.84kV) at dry condition.

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REFERENCES

Circuit Interuption theory and technique", Thomas E-Brown, Jr,1984.

Liu, Z. An, J. Cang, Y. Zhang and F. Zheng, 2012. Ifluence of fluorination time on surface charge accumulation on Epoxy resin isulation", *YActa Phys. Sin*., 1 158201.

Muhammed Amin & Muhammed Salman, 2006. Aging of polymeric insulators

The Comparison of Ceramic AND NON- Ceramic Insulators", e-Journal of New World Sciences academy, Turkey, 2007, Volume: 2, Number: 4.

Tian, F., Ohki, Y. 2013. Charge transport electrode polarization in Epoxy resin at high temperatures", *J. Phys. D: Appl. Phys*., 47 045311.

Tsekmes, I.A., Morshuis, P.H.F., Smit J.J. and Kochetov, R. 2015. "Enhancing the thermal and elec*t*rical performance of Epoxy microcomposites with the addition of nanofillers", IEEE Electr. *Insul.Magn*.31 32–42.

Wu, Y. Wang, L. Xie, J. Yu, F. Liu and P. Jiang, 2012. Thermal and electrical properties of Epoxy composites at high alumina loadings and various temperatures", Iranian polymer Journal, January.

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