Scientific Journal of Impact Factor(SJIF): 3.134

e-ISSN(O): 2348-4470

p-ISSN(P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 2,Issue 5, May -2015

Effect of Surface Discharge on Solid Insulating Materials under the Application of HVAC

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ABSTRACT: Surface Discharge is a typical electrical release that regularly happens on the surface of outside of insulator furthermore causes the failure in the electrical insulation system. One of the reasons for surface discharge is the vicinity of high voltage stress. Experimental work has been carried to inspect the surface discharge qualities on insulating materials. The IEC (b) electrode configuration had been utilized to examine the surface discharge phenomena of diverse sorts of protecting materials. In this paper insulation materials like Flexitherm (class F), Trivoltherm (class F), Lamiflex (class B), are choose for investigation. Surface discharge intensity and surface morphology of every insulating material were additionally studied. It is shown that the surface degradation that happen on the specimen, may be brought on by the surface conductivity & when the surface conductivity of solid insulating material increase the discharges magnitude intensity also increase this lead to severe surface degradation on the specimens.

Keywords: Surface Discharge, IEC (b) Electrode, Surface Morphology, Surface Discharge Intensity, Surface Degradation

I. INTRODUCTION

Surface releases will happen in an exceedingly a gas, fluid, or a vacuum in near to a dielectric surface. Despite the very fact that the greatness of such discharge is mostly very little, even though they can result in deterioration and cause to crumple. Consequently, it is important to analysis these surface discharge qualities to get the answers for the problem happening in dielectrics like solid insulating materials. Solid dielectric materials are used as a part of a wide range of electrical contraption and gadgets to protect one current conveying part from another when they work at diverse voltages. A decent dielectric must to have low dielectric misfortune, high mechanical quality, free from vaporous incorporations and dampness, and impervious to warm and synthetic decay. Solid dielectrics have higher breakdown quality contrasted with fluids and gasses.

Partial Discharge is an electrical discharge that extensions a little divide of protection between two directing terminals when voltage is connected to the surface of an encasing. It can be partitioned into three sorts, which are inward discharge, surface discharge and corona discharge [1]. They are the essential element of ageing in the insulation surface which prompts failure of insulation framework.

Surface discharge is one amongst the electrical discharges and it's reliably developed into a starting part of ageing procedure of the insulating materials. It can be expressed that the meaning of the surface discharge is discharge happening at the surface of the dielectric. It occurs when the surface conductivity is expanded because of a consolidated activity of humidity and the dissociation of air.

The impact of surface discharge exercises will be seen by electrical trademark, for example, discharge intensity and the physical surface morphology of the material's surface. Surface exposed to the discharge may bring about weakening to the surface of the materials and after prompt failure of the insulating materials.

II. EXPERIMENTAL PROCEDURE

2.1 Sample

In this experimental study, three types of polymeric materials used were Flexitherm (class F), Trivoltherm (class F) & Lamiflex (class B).Each material has its own characteristics. Surface discharge tests were carried out on the specimens using IEC (b) electrode system.

2.2 IEC (b) Electrode Configuration Chamber

IEC (b) electrode configuration (IEC 60343:1991) is a recommended standard test method for determining the relative resistance of insulating materials to breakdown by surface discharges. According to this method, we can also observe the

discharge intensity as an electrical parameter for this experiment. In this experiment, the IEC (b) electrode chamber was placed in closed condition to control the relative humidity of the air inside the chamber during the experiment as shown in below Figure 1.

The IEC (b) electrode configuration used in this experiment consists of three important parts i.e. rod electrode, plane

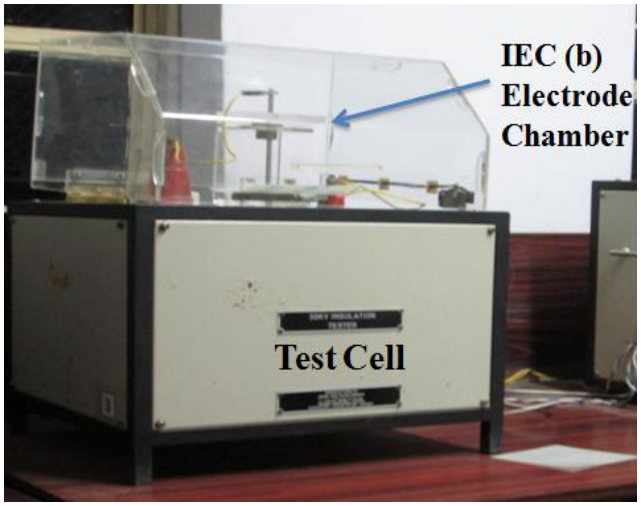


Figure 1: : Complete closed chamber electrode configuration setup for surface discharge test

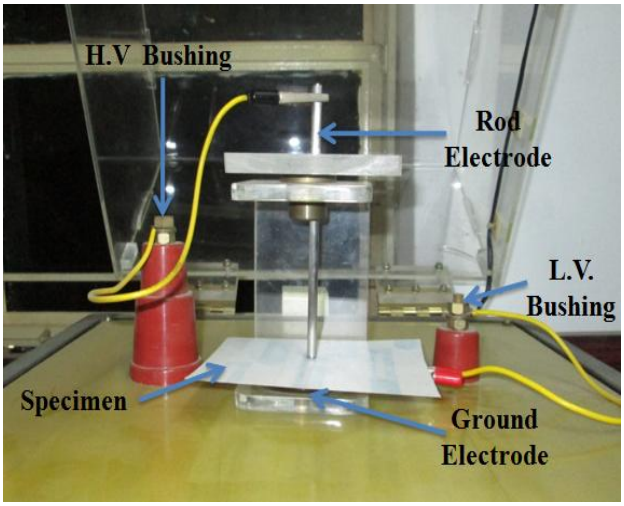


Figure 2: IEC (b) rod-plane electrode assembly.

electrode, and closed chamber. The diameter of the rod electrode is 6 mm with radius of curvature 1 mm. The sample was placed in between the rod and plane electrode. Figure 2 shows the IEC (b) rod-plane electrode assembly setup used in the current research.

2.3 Experimental Procedure

Figure 3 shows whole experimental setup. The experiment was done using HVAC supply to test the insulating material specimens. The relative humidity in the closed electrode chamber was fixed at medium range. HVAC voltage was applied on the sample at frequency of 50Hz with time application of 1hr, 2hr & 3hr.

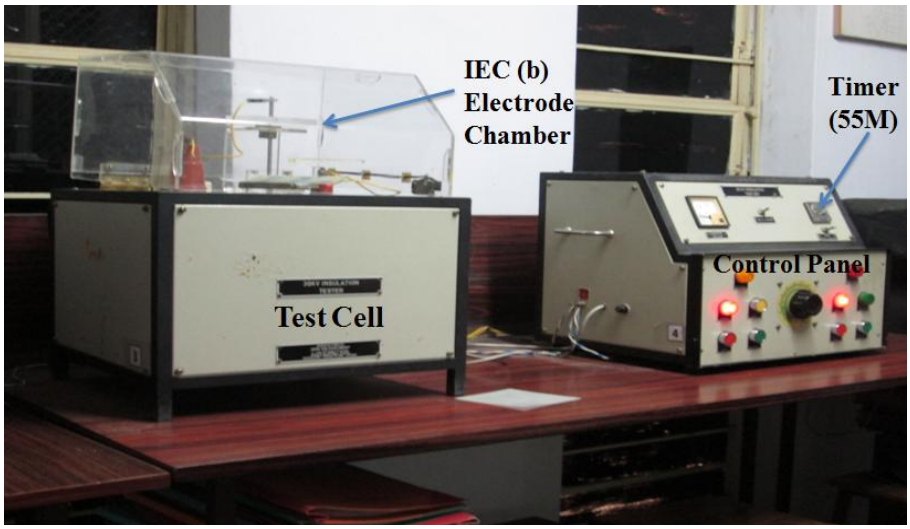
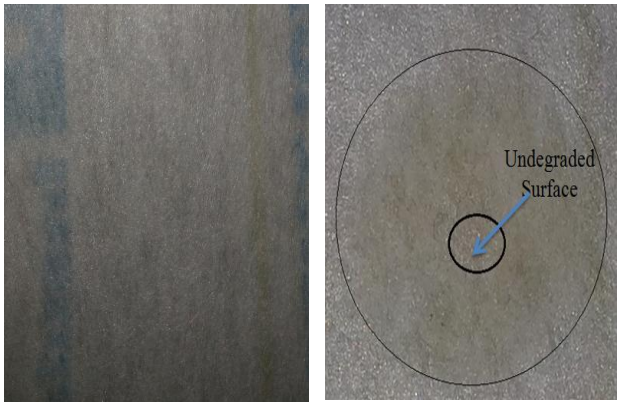


Figure 3: Experimental setup for surface discharge test

III. RESULTS AND DISCUSSION

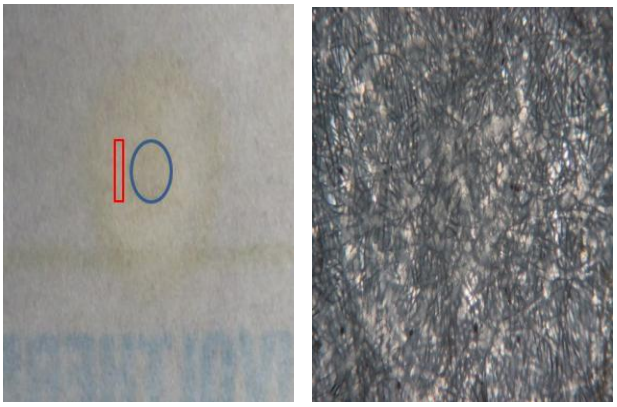
The degraded area on the samples surfaces that were affected from the high voltage application are observed by using digital microscope. (Arcifab Company) By using the microscope, the surface morphology of each sample was analyzed based on qualitative method. The physical surface of insulating material is observed before and after experiment using digital microscope at various magnifying levels at 8X, 10X & 40X etc.

Generally, the surface discharge characteristic observed from this experimental study depended on the types of insulating materials and the relative humidity. Each insulating material has its own characteristics and properties. The arrangement of the electron and molecule bonding greatly influences chemical and physical properties of the insulating materials. The stronger the chemical bonding, the harder the surface degradation to occurs. So, when a high voltage stress is applied on the surface of the insulating materials it affects the arrangement of its electrons and thus, some chemical reactions occur. It is observed that there is a trend of discharge voltages which rise and fall during experiment.



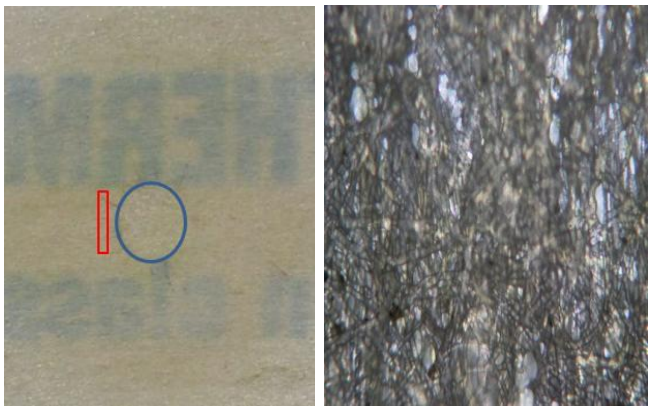
(a) **(b)**

Figure 4: (a) Virgin Sample (b) Surface degradation of class F (Flexitherm) insulation under 5 KV after 1 hr ageing time at visual view



(a) **(b)**

Figure 5: Surface degradation of class F (Flexitherm) insulation under 5 KV after 2hr ageing time (a) Visual View (b) Microscopic View using 40X zoom level



(a) **(b)**

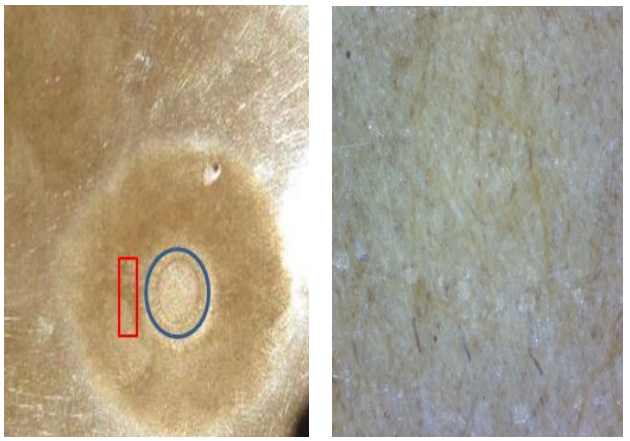
Figure 6: Surface degradation of class F (Flexitherm) insulation under 7 KV after 2hr ageing time (a) Visual View (b) Microscopic View using 40X zoom level

Figure 4 to 8 show the picture of each sample for virgin and aged images of the degraded area on the samples. In this figure circle parts shows the undegraded parts of insulating materials & rectangular area shows the location observed under the microscopic view. The parts (b) of the all figures are images taken using microscope.

This is due to the discharge voltages that have become a source of energy that used in breaking the covalent bond within the material molecular structure causing electrochemical degradation of material structure. Later, energy is released in the form of heat and this heat roughens the surface and cause erosion to form surface cavities.

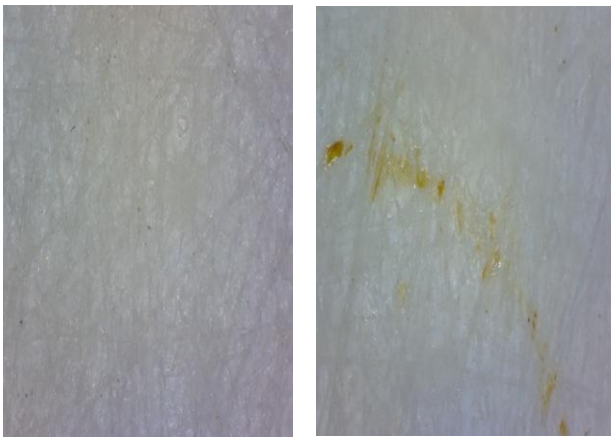
Degradation occurs when the electrons in a materials bond are very strongly attracted to another atom or molecule (called a "foreign" atom or molecule) outside the bond that the polymer bond breaks. The foreign molecules are often part of the environment surrounding the polymeric material. In this experimental study, it is affected through source of high voltage.

The surface discharges of Flexitherm, Lamiflex and Trivoltherm might cause chemical reaction which alters the inner molecular bonding of insulating sample. Energy from partial discharges is used to break the covalent bond to form free radical to react with moisture in the air when operations are prolonged. Heat dissipated in form of spark erodes the surface of the flexitherm and causes rough surface with many small cavities. This is observed on the surface of the sample under



(a) (b)

Figure 7: Surface degradation of class B (lamiflex) insulation under 7 KV after 2hr ageing time (a) Visual View (b) Microscopic View using 10X zoom level



(a) (b)

Figure 8: Virgin Sample Of class F (Trivoltherm) insulation (b) Surface degradation of class F insulation under 11 KV after 1hr ageing time using 8X zoom level.

microscopic view.

As application time increases, these cavities eventually lead to treeing and possible of insulation failure. High humidity and contamination such as dirt will speed up the process of breakdown. Dirt contamination and moisture film foamed on the insulation surface due to high humidity in an open-air arrangement cause increased electrical conductivity which might increase the frequency of the partial discharges. Hence, dry and clean surface may assist to minimize or eliminate the ageing time effect of partial discharge on insulating materials.

IV. CONCLUSION

By using closed condition IEC (b) electrode configuration (IEC 60343:1991), surface discharges characteristics of insulating materials could be observed and studied under AC voltage to explore surface discharge and its effect on insulating materials.

In summary, surface discharges of insulating material under high voltage AC cause severe insulating sample's surface deterioration. The prolonged operation under high voltage stress causes tracking and treeing; this mechanism affects and gradually leads to permanent insulation failure or breakdown.

The results revealed that Flexitherm samples have the most severe degradation on its surface compared to that on lamiflex and Trivoltherm

ACKNOWLEDGEMENT

The authors would like to thank Mr. Pratik Mistry (Employer of Acrifab Pvt Ltd., Ahmadabad) & Agricultures University, Anand for providing digital microscope facility.

REFERENCES

[1] E. Kuffel, W. S. Zaengl, J.Kuffel, *High voltage engineering: fundamentals*, Published by Elsevier, ISBN 0-7506-3634-3, second edition, 2005

[2] M. A. Elborki, P. A. Crossley, Z. D. Wang, A. Darwin, G. Edwards. 2002. *Detection and Characterisation of Partial Discharges in Transformer Defect Models*

[3] British Standard (BS EN 60343:1993/IEC 343:1991) *Recommended Test Methods for Determining the Relative Resistance of Insulating Materials to Breakdown by Surface Discharges*.

[4] Kim Morales, John Krile, Andreas Neuber, Krompholz, "Dielectric Surface Flashover at Atmospheric Conditions with Unipolar Pulsed Voltage Excitation" IEEE Trans. Dielectr. Electr. Insul., Vol. 14, pp.774-782,2007

[5] Parimal Maity, Sumit Basu, Venkitanarayanan Parameswaranand and Nandini Gupta, " Degradation of Polymer Dielectrics with Nanometric Metal-oxide Fillers due to Surface Discharges" IEEE Trans. Dielectr. Electr. Insul., Vol. 15, pp.52-62,2008

