A Review on Partial Discharge Behavior in High voltage Equipment

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Abstract: **Insulators are very important part of high voltage power equipment. There are so many types of insulators are used in high voltage power system to protect the power equipment like gases, vacuum, solid & liquid or a combination of these. It is very important to keep the insulators in a normal or healthy condition during its operation. Since insulators are always available in impure form and weak points, voids, cracks are present inside the insulators and this will create Partial discharge (PD), which in cause of time reduce the strength of insulation leading to a total or partial failure or breakdown of insulation. Therefore detection of partial discharge is very important task for electrical engineers to keep the high voltage power equipment in healthy or normal condition. Modeling of the partial discharge process allows a better understanding of the phenomena. In this paper a brief description of PD, PD mechanism, classification of PD, effect of partial discharge in insulating system.**

INTRODUCTION

Partial discharge commonly begins within cracks, voids at conductor dielectric interfaces within a solid insulation system or in bubbles within liquid dielectric. For various applications, liquid dielectrics are superior to solid or gaseous electrical insulation materials. When liquid dielectrics compared with solid dielectrics, their ability to circulate leads to better suited to applications involving complex geometries. Since discharges are limited to only a portion of the insulation, the discharges only partially bridge the distance between electrodes. PD can also occur along the boundary between different insulating materials. Partial discharges within an insulating material are usually initiated within gas filled voids within the dielectric. Because the dielectric constant of the void is considerably less than the surrounding dielectric, the electric field across the void is significantly higher than that across an equivalent distance of dielectric. If the voltage stress across the void is increased above the corona inception voltage (CIV) for the gas within the void, PD activity will start within the void.

Once begun, PD causes progressive deterioration of insulating materials, ultimately leading to electrical breakdown. PD can be prevented through careful design and material selection. In critical high voltage equipment, the integrity of the insulation is confirmed using PD detection equipment during the manufacturing stage as well as periodically through the equipment's useful life. PD prevention and detection are essential to ensure reliable, long-term operation of high voltage equipment.

PARTIAL DISCHARGE MECHANISM

According to IEC (international Electro Technical Commision) standard 60270, Partial discharge is a localized electrical discharge that only partially bridges the insulation between conductors and which may or may not occur adjacent to a conductor .In general PDs are a consequence of local electrical stress concentration in insulation or on the surface of insulation. Such electrical discharges are appeared as impulse i.e; various forms of voltage impulse and current impulse having duration of much less than 1sec.

PD activity usually observed in high voltage power equipment like transformer, cable, bushing etc. PD usually begins within voids, cracks, or inclusions within a solid dielectric, at conductor- dielectric interfaces within solid or liquid dielectric, or in bubbles within liquid dielectrics. Since discharges are limited to only portion of the insulation, the discharge only partially bridge the distance between electrodes. PD can also occur along the boundary between different insulating materials.

CLASSIFICATION OF PARTIAL DISCHARGE

Partial disc phenomenon is divided into two types.

(a) External partial discharge

External partial discharge takes place outside of the power equipment .such type of discharge occurs in overhead lines, on armature etc.

(b) Internal partial discharge

The partial discharge which is occurs inside of system. The discharge in void is belonging to such type of partial discharge and necessary for PD measurement system. PD phenomena include several types of discharge which is surface discharge, cavity discharge, corona discharge, Treeing discharge.

Corona discharge- corona discharge takes place due to non-uniformity of electric field on sharp edges of conductor subjected to high voltage. The insulation supplied for such type of discharge is gas or air or liquid.

Surface Discharge- Surface discharge takes place on interfaces of dielectric material such as gas/solid interface as gets over stressed times the stress on the solid material. This may occur in bushing, end of cable, any point on insulator surface between electrodes (High voltage terminal & ground)

Cavity discharge- The cavities are generally formed in solid or liquid insulating materials. The cavity is generally filled with gas or air. When the gas in the cavity is over stressed such discharge are taking place.

Treeing channel- High intensity fields are produced in an insulating material at its sharp edges and it demerits the insulating material. That is responsible for production of continuous partial discharge, called as Treeing channel.

EFFECT OF PARTIAL DISCHARGE IN INSULATING SYSTEM

Appearance of PD is the main reason for degradation of insulating material and responsible for happening of electrical breakdown. The generation of discharge again and again is the reason for mechanical and chemical degradation of the insulating material. The effect of discharge on high voltage power equipment is dangerous to the insulation system. Insulation damage due to appearance of partial discharge (PD).The conductivity property of the insulating material rises due to chemical changes in the dielectric.

Generally, Pd generates energy in the form of heat. Heat energy is the main reason for degradation of the insulation. This effect is known as thermal effect on insulating material used .For high voltage power equipment; the deterioration of the insulation can be known by monitoring the PD activities .PD activity should be monitored time to time by the power engineers.

NECESSITY OF DETECTION OF PARTIAL DISCHARGE

Most of the insulators are not pure or we can say they are in impure form. Due to presence of air impurity bubbles (void) are created within the insulating materials. It weakens the insulation regions and responsible for generation of partial discharge. The reason behind it is, the dielectric constant of the void is less than of its surroundings .so it causes the insulation failure in high voltage equipment's. Partial discharge are always generates at void, cracks bubbles .since such discharge has less magnitude but it is responsible for detrition and degradation of insulators. Due to generation of discharge ultimately failure occurs in the insulation system. Because of all severe reasons PD detection and measurement is necessary for prediction of insulation life for HV power equipment.

Development of PDs in liquid dielectrics

Development of PDs in liquid dielectrics is a complex phenomenon, which is not yet fully agreed upon in literature. However, it is widely regarded that electrons are the main driving charge carrier in all PDs. If free electrons in the bulk are exposed to a sufficiently strong electrical field, an electron avalanche may be initiated. In order for this to occur free electrons has to be released into the bulk of the liquid by some sort physical mechanism. Five mechanisms for electron injection is mentioned here.

Field emission

In liquids is a form of electron injection at the cathode, and is considered one the main mechanisms for charge injection into liquids. If the electrical field is sufficiently strong, electrons may be freed from the lattice at the electrode, and pushed into the bulk. The field strength required is dependent on the material of the electrode, but is often in order of 107 -108 V/cm [5]. Such field strength may occur near small bumps, points and other irregularities at the electrode, and create a highly divergent electrical field, even at relative low applied voltage levels (2-5 kV). The energy required to remove an electron from the metal lattice is known as the Fermi level, given by the work function (Wa). The freeing of these electrons are also known as "tunnel effect" and is explained by Fowler-Nordheim.

Suspended Solid Particles

Suspended Solid Particles may be present in the liquid, such as fibres from paper insulation or loose pieces of other solid dielectrics. Such particles can become polarized due to the electrical field, and thereby experience an applied force.

If the field is uniform, the particles may align and cause breakdown due to the particles essentially acting as a conductor. If the field is non-uniform the particles may align in the area with the strongest field, and thereby initiate PD due to extreme field

stress. This electron injection is conducted by field emission; basically, the same phenomenon as discussed above, but the suspended particles in the bulk amplifies the field strength. It should be noted that the movement of particles in the electrical liquid field is also dependent on the viscous drag.

Cavity Breakdown

Cavity breakdown in liquids shares a similarity to void breakdown in solids. Bubbles are filled with gas that generally have lower permittivity then the liquid in which it is submerged. The bubbles are formed by: 6 - Gas pockets on the electrode surface - Changes in temperature and pressure - Electron collision causing gaseous products - Liquid vaporization by corona-type effects. As the electric field is applied across the cavity, electric breakdown may occur due to high field stress inside the bubble.

Photoionization

Electrons may be released into the bulk by ionization of the molecules in liquid. Some photons can acquire enough energy in order to create a caution when colliding with some molecules. As a caution is created, an electron is freed from the molecule. Such high-energy photons can be found from relaxation of other excited molecules as well as from inserted photons into the liquid by cosmic radiation or other installments.

Field ionization

Field ionization at anode is another form of ionization in the bulk, freeing electrodes. If the electrical field is strong enough, the molecules in the bulk may experience an applied force sufficiently large to release electrons from the molecules.

Conclusion

A brief description of PD has been presented in this paper. It has been seen by power engineers that one of the major problems in high voltage (HV) power system is breakdown of insulators or degradation of insulators. Modeling of the partial discharge (PD) process allows a better understanding of the phenomena. Partial discharge (PD) inception, propagation and breakdown (BD) characteristics under ac voltage application were obtained and discussed at atmospheric and pressurized conditions.

The survey shows that, most of the work on PD has been carried out with consideration of voids. Research has to be extended to obtain a figure of merit for PD of single and multiple discharges and for complex PD patterns observed in practical insulation systems

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