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Improvement Electrical Insulation for Partial Discharge : Using Large Capacitors Technique System

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Abstract*—Partial Discharge developments of dielectric materials and their applications, including improvement of insulating oils, development of new insulating oils, and introduction of polypropylene films. This paper presents topics in power capacitor advancement and a technical overview of capacitors used this simulation model MATLAB based Digital analysis of partial discharges (PDs) in power apparatus is addressed. This work serves as a basis for future investigations, to provide a guide for those attempting to set acceptances levels to parameters of PD measured using digital techniques, and to present methods for the graphical representation of these parameters commercially available partial discharge (PD) detectors are described, along with their important characteristics. The primary characteristics that detectors have in common and that are used as a basis for classification are the number of inputs used, the bandwidth of the detector, and the method of display processing. Ancillary test components, which complete an integrated test system, are discussed. PD measurements for quality assurance require not only a detector, but an entire system coordinated to maximize the measurement sensitivity for the specific type of apparatus under test. To illustrate how a coordinated system is applied, examples of some systems in commercial use are discharge measurements on capacitor units are reported. For large capacitance objects the inception and extinction levels are very clear and distinct in the HFCT technique. The technique can be extended to the in-site diagnostic testing of power capacitors.*

Keywords- *Power capacitor, insulator materials, dielectric materials.*

1. INTRODUCTION

In high voltage (HV) electrical power system, variety of solid, liquid and gaseous materials are used for insulation purpose to protect the incipient failure inside the HV power equipment. Among these the solid insulation is widely used for high voltage power equipment HV electrical power system. Most of insulating materials are not perfect in all respect and contains always some impurities. The presence of air bubble is one of such impurities in insulating materials and highly undesirable for such type of insulation which causes a local weak zone inside the insulator. Insulation of the HV power equipment gradually degrades inside the insulator due to cumulative effect of electrical, chemical and thermal stress. Due to the high voltage stress the weak zone inside the insulator causes the partial discharge (PD) which is known as local electrical breakdown. As a result the insulation properties of such materials are enormously degrades its quality due to the PD. In this work, the simulation of PD activity due to presence of a small cylindrical void inside the solid insulation

material of high voltage power equipment is studied with the MATLAB Simulink platform. In most of the high voltage (HV) power equipments are made of with different type of high quality insulation to protect against the high voltage tress. A variety of solid, gaseous, liquid and combination of these materials are used as insulation in high voltage power equipment [1-5]. Among those the solid insulation like epoxy resin is widely used, not only as a component of complex insulating system such as HV rotating machine insulation but also in indoor insulators, in transformers and in many different high voltage power equipments[1-2]. To access the quality of such insulation is a challenging task to the power engineers while the same power equipment is under operating with high voltage stress for a long period. The quality of such insulation plays an important role on HV power equipment in view of quality assessment.

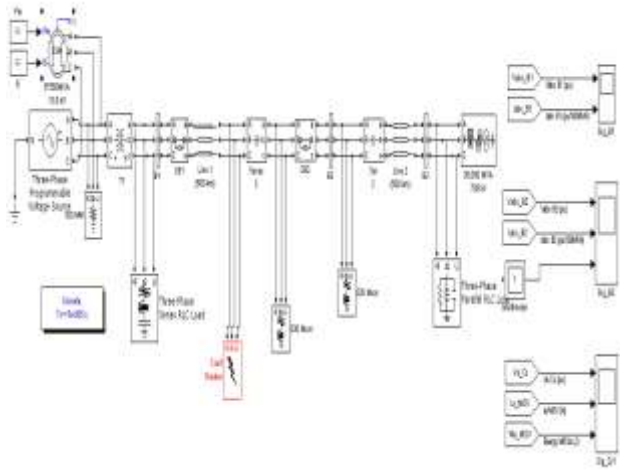

Figure-1 Simulation model of distribution system

However, the insulation of power equipments are gradually degrades due to the cumulative effects of electrical, chemical and mechanical stresses caused by the partial discharges (PDs). Partial discharge is a localized electrical discharge that only partially bridges the insulation between electrodes [1-2]. It is studied from the several articles that most of insulators are not hundred percent perfect in nature and always contains some impurity [3-5]. During the manufacturing process the presence of air/gas bubble in the insulating material is one of the causes for making the insulation imperfect. The presence of air/gas bubble during the manufacturing process may in the form of different geometrical shape such as rectangular, spherical, elliptical, cylindrical etc. The presence of air bubble in any shape inside the insulation formed an impurity inside the insulation which weakens the insulation region and responsible for occurrence of PDs in the high voltage power equipment. It is studied that the field intensity while exceeds the breakdown strength of gas in void, then partial discharge takes place. However, once the PD starts inside the high voltage power equipment it is continue for a long time if it is not taken care of and finally insulation properties of such materials degrades its quality. Because of the above reason PD detection and measurement is necessary for prediction of insulation life for HV power equipment. In this work, an electrical circuit model of void presence inside the solid insulation material is used to study the PD activity inside the insulator. A small cylindrical void is taken into consideration and placed at the middle of the insulator which is kept under the plane-plane electrode arrangement which produced the uniform electric field. The whole simulation has been done with very well known software MATLAB simulink environment shown in figure-1. The simulation is the basis for a physically meaningful interpretation of PD data. In this study an efforts have been made to investigate the maximum PD magnitude, number of PDs and number of other PD related parameters like PD distribution, frequency content of obtained PD pulse by using phase resolve partial discharge (PRPD) measurement technique Partial discharges are electrical discharges confined to a localized region of the insulating medium in high voltage (HV) power equipment.

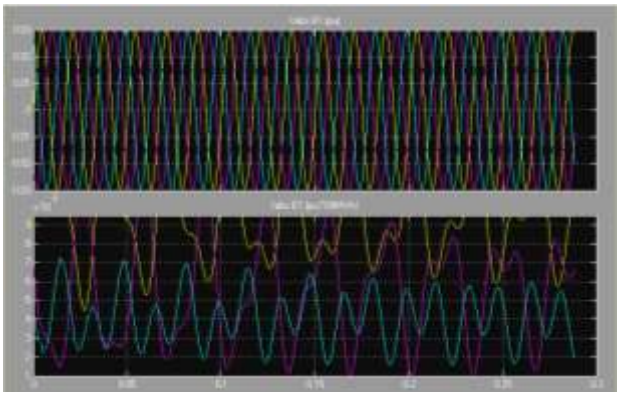

Figure-2(a) Partial discharges occur

The PD phenomenon usually commences within the void, cracks, in bubbles within liquid dielectrics or inclusion within the solid insulating medium. In addition, PDs also occur at the boundaries between the different insulating materials, Contamination, poor conductor profiles and floating metal-work in the HV equipment [2-3].

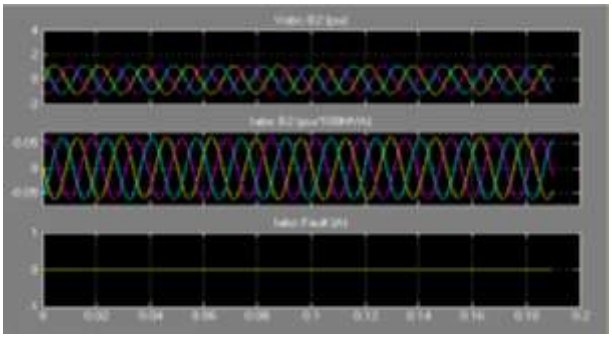

Figure-2(b) Partial discharges Remove

The electrical PD detection method are based on the appearance of the PD current or voltage pulse across the test object for fundamental investigation, which may be either a simple dielectric test object or large HV power apparatus [1-2]. To evaluate the fundamental quantities of PD pulse, a simple equivalent capacitor circuit of solid insulator having cylindrical void is taken into consideration for this work. In the equivalent circuit the capacitance corresponds to the cylindrical void present inside the solid insulation, if injected in a short time between the terminals of a test object in a specified test circuit, would give the same reading on the measuring instruments as the PD current pulse itself. It also studied that, apparent charge is an important factor for PD measurement in the high voltage power equipment. As the partial discharge is highly depends on the geometrical configuration of the void presence in the solid insulation the relation between apparent charge and height of the void, volume of the void and diameter of the void is considered in this study. The relation between the apparent charge and It is understand from the above result that the magnitude of the PD is also vary as the apparent charge is varying with changing the void height, diameter and void volume. To simulate the PD activity inside the solid insulation medium a MATLAB Simulink model figure-1 is considered in this work. An increasing voltage of 0-13.8 kV is applied between the void models to observe the PD activity inside the solid insulation. It is observed that with application of kV between the models no PD was found. The field intensity within the void not exceeds beyond the breakdown strength of gas in void below the applied voltage o f 0- 13.8 kV. In the presented model the field intensity within the cylindrical void not exceeds beyond the breakdown strength of air presence inside the void at the applied voltage of kV. However, further with increase of high voltage between the test object PDs are appearing and it is having small amplitude. The PD inception voltage due to presence of cylindrical void in the solid insulation model is observed at RLC of applied high voltage. In this work the discharge mechanism inside the void model has been studied for inception voltage, breakdown voltage and between the inception voltage and breakdown voltage. It is observed that PD signal is appeared at the applied voltage of kV with having small amplitude which consider as the inception voltage in the presented model and breakdown voltage is found beyond the applied voltage of 30 kV. However, the PD signal is observed and studied in between the different applied voltage from 13.8 kV to 735 kV. Load transformer of high voltage between the test object PDs are appearing having small amplitude. At the applied voltage of 5 kV PDs are found due to presence of void inside the solid insulation. With the applied voltage of 5 kV the field intensity within the void exceeds

the breakdown strength of gas in void and PD pulse is observed which is shown in figure-2 (a). As the detection of the partial discharge signal are done generally in two way, either the measuring impedance Z_m is placed in series with the test object or Z_m is placed in series with the coupling capacitor shown in figure-2 (b). As the high voltage source impedance is large both the detection method is electrically same as the same voltage occurs across the impedance Z_m. In this work, as the test object is very small the measuring impedance is connected in series with the test object with a parallel combination of the RLC circuit. The output of the RLC circuit is damped oscillatory in nature which therefore, in positive half cycle of the applied voltage small negative pulses appear and in negative half cycle of the applied voltage small positive pulses appear. In RLC circuit, the voltage impulse During the simulation process both the applied voltage of 5kV and the [5] PD data are collected in the time domain with a length of 20 ms. There after only PD data are collected and processes for frequency analysis to know the actual frequency contain of the PD signal throughout the time domain. To analysis the observed PD signal the recorded PD data are analysis with Fast Fourier Transform (FFT) and corresponding frequency spectrum of the PD signal is plotted which. As the supply voltage frequency is always fixed and known value (i.e., 60 Hz) therefore the unknown frequency contain of the PD signal has been plotted by considering the PD data only. The frequency plot of the recorded PD signal is observed that the number of frequency spectrums is found due to presence of PD pulses at different time instances. It is observed that the frequency is varies in the range of 1.5 kHz to 20 kHz. That the different combination of the frequency is presence as the PD pulse duration of each PD pulse appears along the time axis is different. As the PD phenomenon is the random in nature so the frequency appears for this PD pulse is also fluctuating in nature. It is also observed from the each PD pulse presence in the both the positive and negative half cycle of the applied voltage is that the pulse duration of the PD signal appeared in the range of 60 to 70 μ sec respectively. It is also observed that the maximum amplitude of the frequency of the same PD pulse is appears at 5 kHz, 8 kHz and 12.5 kHz which is The dominant frequency of PD appeared at 5 kHz, 8 kHz In this work, an increasing voltage of 0-30 kV is applied between the void models to observe the wide range of the PD activity inside the solid insulation. It is also observed from that the maximum amplitude of the PD is the function of the applied voltage. As the PD is random phenomenon the appearance of maximum amplitude of such PD signal is also changes over a cycle of applied voltage. The maximum amplitude is varies range.

2. CONCLUSION

Partial discharges are a major source of insulation failure in high voltage power system which needs to be monitor continuously to avoid the incipient failure in the power system

Network. To understand the PD activity inside the solid insulation a MATLAB based simulink model has been developed in this work. In this work it is studied that the PD activity in side the RLC circuits and capacitors used solid insulation is highly depends on the entire geometry of the void presence inside the solid insulation model. In addition, PD is increases with the increase of applied voltage inside the solid insulation. In this study an efforts have been made to investigate the maximum PD magnitude, number of PDs and number of other PD related parameters like PD distribution, frequency content of obtained PD pulse by using phase resolve partial discharge (PRPD) measurement technique. This study will ensure the power engineers to predict the quality of the insulation used for high voltage power equipment. The present work is to be extended for further study in different high voltage power equipment such as current transformer (CT), potential transformer (PT), switch gear and circuit breaker.

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