Analysis of Partial Discharge Model Under Various Stress Conditions

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Abstract

The existence of cavity in solid insulation, repetition of PD activities is one of the key sources of insulation degradation, which could lead to breakdown. Therefore, continuously monitoring of insulation is very important through PD data. Therefore, in this work PD model within a cavity in solid insulation is done and parameters related to electron generation is analyzed using an optimization technique.

Keywords: *Condition Monitoring, Power Cable, Insulation Degradation*

I. INTRODUCTION

In the electrical power system generation and utilization of power is mostly done at lower voltages while transmission of power is done at higher voltages. For lowering transmission power losses, reducing conductor size and for economical purpose high voltages are being used. Some factors are being considered while transmitting power through high voltages; insulation, stress, corona losses and communication interference.

The major concern for high voltage is insulation, therefore different types of insulants i.e. solids, liquid and their alloy materials are employed to provide protection of high voltage equipments from faults. During faults the amplitude of voltage increases that can affect the insulation of equipment. From these insulation materials, solid is widely used for high voltage equipments. These insulating materials are not ideally perfect, because they contain some impurities. The existence of air bubbles inside the insulation material is one of such impurities that is highly undesirable which can cause a local weak zone inside the material. The insulation of high voltage equipments progressively reduces due to electrical, mechanical, chemical and thermal stresses. These stresses create weak zone inside the material, and are one of the reasons of Partial Discharge activities in the insulation [1].

Partial discharge is caused by the presence of cavties in the insulation material. Even a local electrical stress in a cavity exceeds its threshold value hence discharge can occur. It can only be limited within cavities by providing strong surrounding insulation to cavity breakdown. The Partial Discharge induced current in the circuit depends on nature of discharge as well as the geometry of system [2]. However, once the PD occurs inside the equipment. It will remain for a long time until initial measures are not to be taken. The PD usually initiates inside the cavities, cracks inside the solid insulation whereas bubbles within liquids insulation. Impurities inside the insulation material lower insulation properties and its quality. Therefore detection and measurement of PD is very important for estimation of insulation life of high voltage equipment [3]. The presence of cavity in solid insulation, recurrence of PD activities is found one of the main sources of insulation degradation, which could lead to sudden breakdown. Continuously monitoring of insulation is very important through PD data analysis.

II. LITERATURE REVIEW

In past literature, Asima Sabat deduced through MATLAB simulink that the Partial Discharge is also due to the presence of a small cylindrical void and its geometry inside the insulation material. Partial Dicharge also depends on the duration of applied voltage [1]. Gopinath [8], has performed Partial Discharge simulation to describe the behaviour of PDs in the stable insulation. The PD version includes a number of parameters to assess the magnitude of discharges. The paper describes the shape of cylindrical void and its behaviour with the deviation in the applied voltage. It is understood that the PD value is excessive for the higher charges of the applied voltage for the void axis perpendicular to the utilized electric place. The simulated study additionally depicts the position of void axis with its relationship on PD magnitudes. Higher expertise of PD mechanism will limit the failure and defects of the robust insulation. For this reason the lifestyles expectancy, reliability and integrity of the excessive voltage equipments will possibly be ensured.

Jasmin James [9], has presented the cause of discharge based on energy exchanges which take place during the discharges. To recognize this one, firstly determine the presence of discharge, magnitude of voltage that exhibit up the region of discharge. The magnitude of this discharge and deterioration restrict with the help of evaluation of the PD distribution. Even though the maximum and minimum charge remains practically same the charge of partial discharge raises with increase in utilized voltage of the cable. It is usually decided that this swell in price would lead to large current and short circuit when the cable is under maximum potential for a prolonged interval of time.

Oleg Emelyanov [11], investigated a PD under ramp voltage in submillimeter air-gaps within non uniform fields. He concluded that the breakdown voltage for the positive needle depends on the permitivity and thickness of the barrier and it is also 25-35% larger voltage than for negative one. It is also concluded that the positive charge has arborescent shape and negative charge has homogeneous (or diffusive) shape. He assumed in case of positive needle polarity the PD is governed by streamer mechanism and the discharge current amplitude is about 1A for 100 - µm air-gap and relatively having thin barrier.

The superiority of insulation equipments used in high voltage is very important for successful and reliable operation. Slight defects and irregularities such as cavities, surface imperfection in the insulation material are unavoidable and may lead to partial discharge which can cause electrical breakdown in the electrical insulation materials [4]. A various materials like solids, liquids, gaseous and alloys can provide insulation to the high voltages equipments. Among these insulation materials the epoxy risin solid insulating material is widely used as an insulator in rotating machines, transformers and in many equipments.

The selection of cables at higher voltages for transmission is challenging task for engineers because insulation is a function of voltage and quality of these contribute vital role in quality assessment [1]. However their quality degrades by electrical, chemical and mechanical stresses caused by partial discharge (PD). PD is a confined discharge that builds a partial discharge between electrical insulating electrodes [5]. The insulation is not ideal in nature due to existence of some impurities like air bubbles; these may be in the form of different geometrical shapes like rectangular, spherical, elliptical and cylindrical etc. The air bubbles inside cable weaken the insulation and would be the cause of partial discharge in HV equipments. During operation the change in temperature and other external stresses due to load current may add these defects, and PD may be incipated, erosin by ion bombardment and chemical effects gradually change small defects to electrical stress and can lead to final breakdown [6].

The Partial Discharge occurs due to cavities, cracks and mechanical cuts at a time of installation in solid insulation materials or in the form of bubbles within liquid dielectrics and can occur along the boundary of insulation materials. Once PD has begun, can lead to electrical breakdown, it can be prevented by proper selection of material and design high power equipments. In the HV equipment, the reliability of insulation could be confirmed by using PD detectors during the manufacturing and periodically through whole equipment life. The detection and preventation of PD is important for reliable and efficient long term operation of high power equipments [7].

III. RESEARCH METHODOLOGY

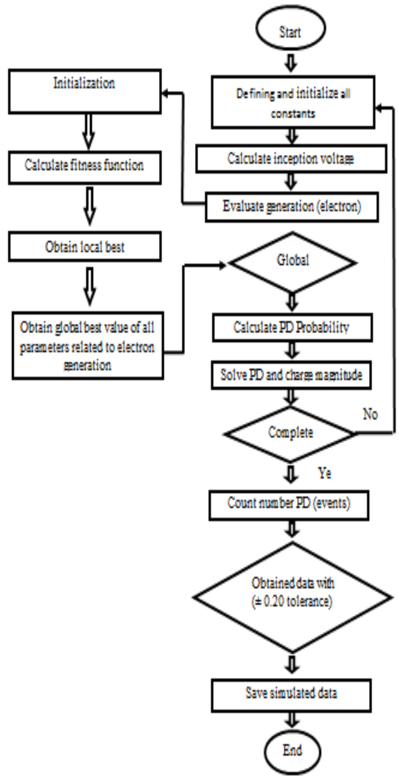
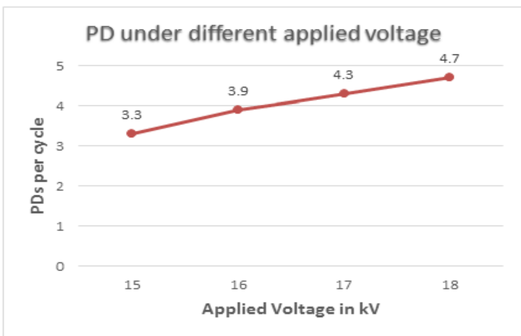


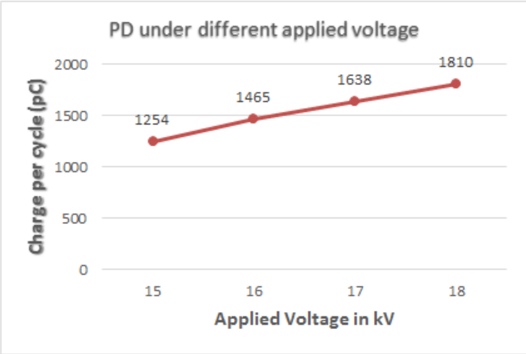
Fig 1: Flow chart representing the flow of methodology

IV. RESULTS

Figure 2(a-d) shows the simulated data at variable voltages. The simulated data shows that discharge events increases with applied stress.



(a)



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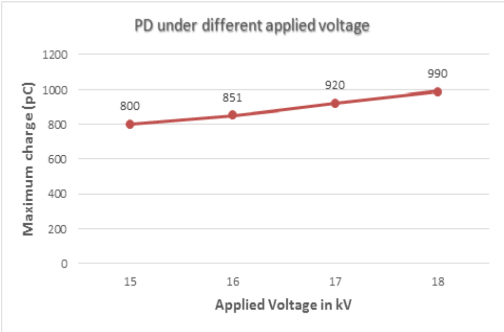

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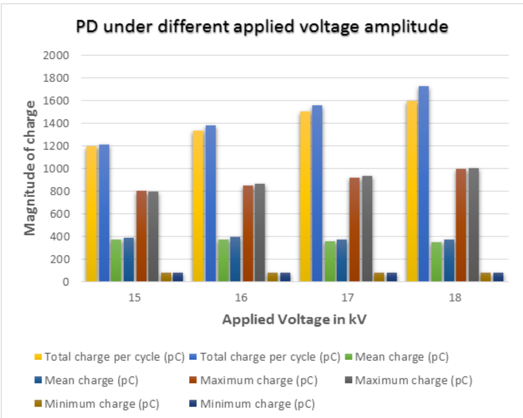
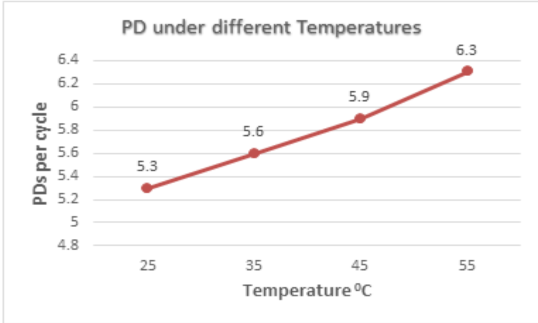


(d)

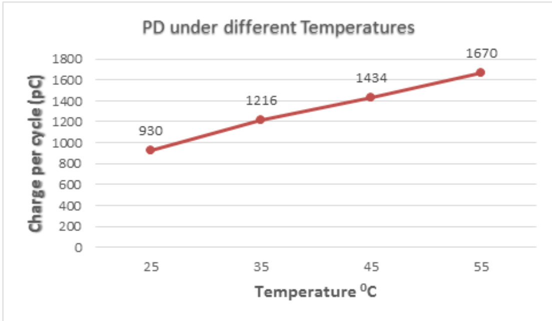
Fig 2 (a-d): Simulated Results under variable applied voltage stress.

As the voltage stress is increased, the maximum PD magnitude (that is the max: apparent charge without sign) increases. In contrast the min: PD magnitude is nearly remain constant. The number of PDs (per cycle) of the applied voltage is between 2.5 and 3.5 and does not change significantly with applied stress. The overall simulated results are shown in Figure 2(d).

The simulated results at different temperatures are shown in Figure 3 (a-d). As per obtained results, it has been seen that discharge events increases with higher temperature of insulating material. Moreover, the simulated data as shown in Figure 3(d) is found increasing at higher temperature of insulating material.



(a)



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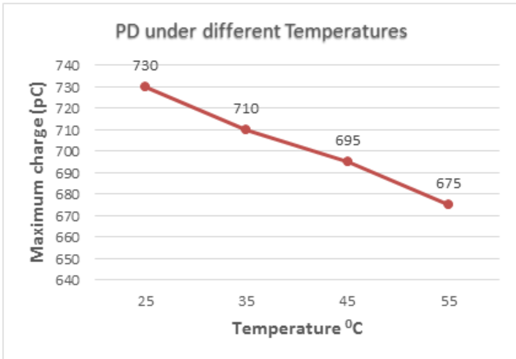

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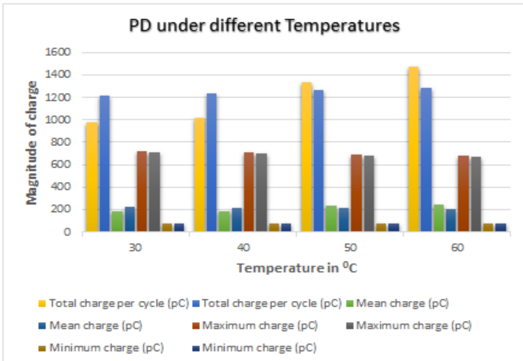

(d)

Fig 3: Simulated data at different temperature of insulating material.

V. CONCLUSION

In this research work, partial discharge model of cable insulation shaped is developed in Matlab. The developed model was analysed under variable voltage and temperature of insulating material. It has been observed from results that the discharge events increase with stress. Moreover, the impact of temperature of insulating material was also been analyzed and according to the obtained results, discharge events are found dependent on the temperature of insulating material.

VI. REFERENCES

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