*National Conference On Recent Research In Engineering And Technology (Ncrret-2015)*
*International Journal Of Advance Engineering And Research Development (IJAERD)*
*E-Issn: 2348 - 4470 , Print-Issn:2348-6406*

# Condition monitoring of insulation system of an isolation transformer with partial discharge test

Jasmin James, Archana Nanoty

**Abstract**— Electrical machines have become a vital asset in any industry or power station or house hold.Periodic or continuous condition monitoring has also become a crucial requirement in anticipating any fault for preventive maintenance which may earn the goal of efficient functioning of the same.In this paper a case study based on condition monitoring of insulation system of an isolation transformer using partial discharge test which is one of the important techniques employed in assessing the electrical discharge activity and ultimately the health of the insulation system of the same.

**Index Terms**— Condition monitoring, electrical discharge, insulation system, partial discharge, isolation transformer.

## 1 INTRODUCTION

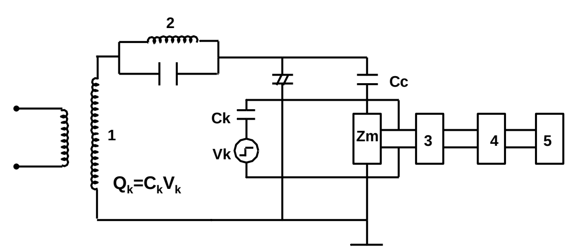
ELectrical machines have become a vital asset in any industry or power plant or household. Periodic or continuous condition monitoring has also become a crucial requirement in anticipating any fault and for preventive maintenance which may earn the goal of efficient functioning of the same. One of the research areas pertaining to electrical machines were currently a lot of research work is taking place is Condition monitoring and diagnostics of electric machines [1].

Monitoring techniques can be very broadly classified as electrical and non electrical [2]. Temperature, wear and vibration monitoring techniques are grouped under non electrical techniques [3]. In electrical monitoring methods for machines, stator or supply system current monitoring[5], shaft[6] or magnetic flux monitoring[4] and electric discharge monitoring techniques are used. Electrical discharge monitoring [11] techniques give an idea about the state of insulation system of an electrical machine by analyzing the influence of discharges [13] on supply voltage waveform. Depending on their damage capability they are divided as corona discharge [12], partial discharge, spark discharge, arc discharge etc.These discharges are also dependent on the quality of the insulation and mechanical and electrical conditions to which the insulation is exposed. For monitoring the electromagnetic, acoustic and thermal energy radiated from these discharges, various monitoring techniques have been developed and research is also going on over it. Various RF monitoring techniques are used to detect these arcs. The main limitation of RF methods is need for large directional RF antennas for large hydrogenerators.Also no way was found to relate the received signals to the discharge magnitudes in pico coulombs.

An isolation transformer is a transformer used to transfer electrical power from one alternating current circuit to another.It can also be a source of alternating current (AC) power to some equipment or device at the same time can isolating the powered device from the power source, usually for safety reasons. Isolation transformers provide galvanic isolation and are used to protect against electric shock, to suppress electrical noise in sensitive devices, or to transfer power between two circuits which must not be connected. A transformer sold for isolation is often built with special insulation between primary and secondary, and is specified to withstand a high voltage between windings.

This paper is outlined in such a way that section II contains experimental set up[14], section III contains the calibration of discharge detector, section IV contains high voltage production and measurement technique, section V contains procedure for analysis of partial discharge distributions, section VI contains partial discharge distributions of the sample at different voltage levels, section VII contains graphical analysis and observations, section VIII contains conclusion and future scope.

## 2 EXPERIMENTAL SET UP




The circuit arrangement shown above gives a simplified circuit for detecting 'partial discharges'. The high voltage transformer (1) shown is free from internal discharges. A resonant filter (2)is used to prevent any pulses starting from the capacitance of the windings and bushings of the transformer. 'Cx' is the test object, 'Cc' is the coupling capacitor and 'Zm' is the detection impedance. The signal developed across the impedance 'Zm' is passed through a band pass filter(3) and amplifier(4) and displayed on a CRO(5) or counted by a pulse counter multi-channel analyzer unit.

## 3 CALIBRATION OF DISCHARGE DETECTOR

Partial discharge detectors are connected across measuring impedance 'Zm' as shown in figure1 and the signal measured across impedance is read by the detector. The signal voltage developed across 'Zm' depends on the circuit parameters 'Cx' and 'Cc' and also on the internal circuitry of the instrument (Blocks 3, 4, 5) shown in figure 1.

Hence, the measuring instrument or detector is calibrated by injecting a pulse having a charge of known magnitude into the detecting system. For this purpose, square wave generator and a calibrating capacitor 'Ck' are usually used. The magnitude of the charge injected is qx =Ck Vk, where 'Vk' is the magnitude of the voltage pulse. The rise time of the pulse is about 0.1µs, and the pulse width varies from 10 to 20 µs. With suitable attenuation, the output voltage of the pulse generator can be varied from a minimum output of about 10µV to a maximum value of 100V steps. The value of Ck, usually used, lies between 1000 to 2500pF. If the calibrating pulse is directly injected at the HV terminal of the test object, the measuring of the calibration pulse will be CkVk. If the pulse is injected across the measuring impedance, then the calibrating pulse magnitude should be multiplied by (Cx + Cc)/Cc.

Another method of calibration is to use a secondary standard, consisting of a point – hemisphere electrode system of specified dimensions. This method is more accurate and is easily reproducible. With an over voltage of 10% - 20% applied above the discharge inception voltage, the arrangement gives discharges which are used for calibration purposes.

## 4 HIGH VOLTAGE PRODUCTION AND MEAUREMENT TECHNIQUE

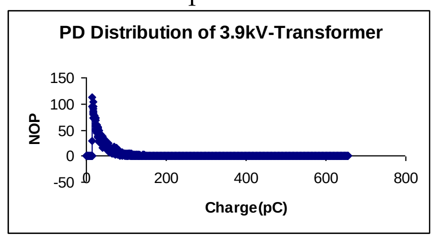
Use tested earth connect at two places of the unit. Use independent earth for high voltage tester. Use extra high voltage grade oil. Check oil level in case of oil cooled units. Connect 230/415V AC supply. Keep audio fault ON/OFF switch at OFF in case of high voltage tester. Switch ON MCB for LT ON. Bring regulator to zero position with push button incase of motorized or with knob in case of manual models. Adjust time select tripping current in case of high voltage tester. Press push button marked HT ON. Switch on fault ON /OFF switch in case of high voltage tester. Finally increase the voltage.

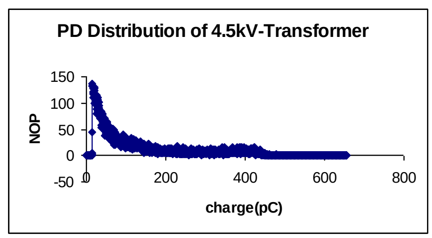
## 5 PROCEDURE FOR ANALYSIS OF PD DISTRIBUTIONS

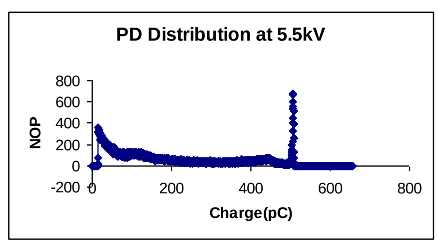
The Partial discharge distributions are recorded using multi channel analyzer software. Using the calibration value obtained, convert the channels on the X axis of distribution to charge. Enlist the number of pulses (NOP) corresponding to each charge in an excel worksheet from the distribution having NOP on Y axis and charge on X axis. Using multi channel analyzer software read minimum charge (Qmin), maximum charge (Qmax), and peak charge (Qpeak) from the distributions. Find total charge and total NOP from excel worksheet and calculate average charge (Qav) = Qtotal / Total NOP. Find average current using the formula Iav= Qtotal / t.Find number of electrons using the formula 'Qmax / e'.Find the frequency of Partial Discharge pulses using the formula NOP/50×60, where 60seconds is the time for which distribution is recorded consisting of 50 cycles each. This procedure is repeated in the analysis of the distributions of the sample.

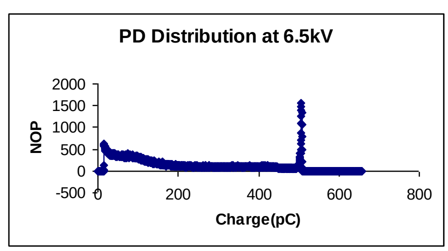
## 6 PARTIAL DIACHARGE DISTRIBUTIONS.

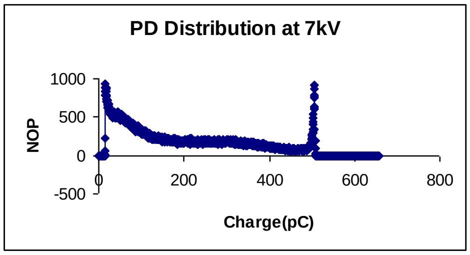
CALIBRATION VALUE 500pC-CHANNEL 1560



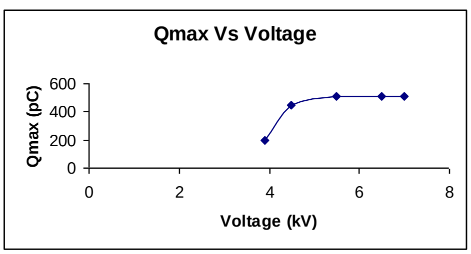



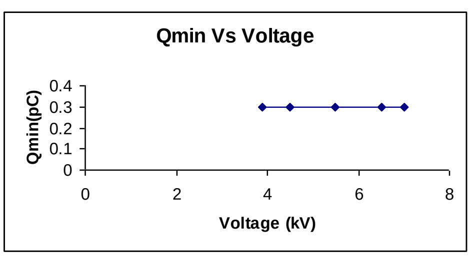


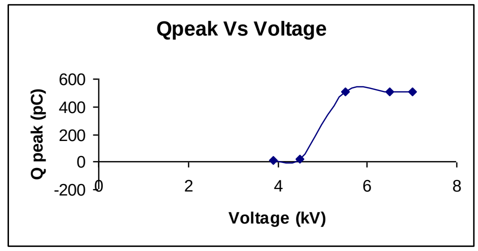

## 6.1 Electrical quantities obtained from the distributions.

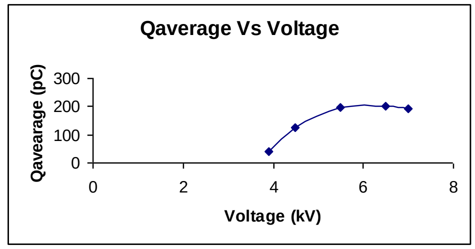
| Voltage kV | Qmax(pC) | Qmin(pC) | Qpeak (pC) | Qav(pC) | NOP | Frequency NOP/cycle |
|---|---|---|---|---|---|---|
| 3.9 | 194.9 | 0.3 | 15.4 | 38.65 | 121.81 | 2.165 |
| 4.5 | 449.4 | 0.3 | 17.7 | 124.92 | 280.8 | 8.271 |
| 5.5 | 509.3 | 0.3 | 506.4 | 195.34 | 318.31 | 36.613 |
| 6.5 | 509.3 | 0.3 | 506.7 | 200.76 | 318.31 | 86.96 |
| 7 | 508 | 0.3 | 505.8 | 193.37 | 317.5 | 113.568 |

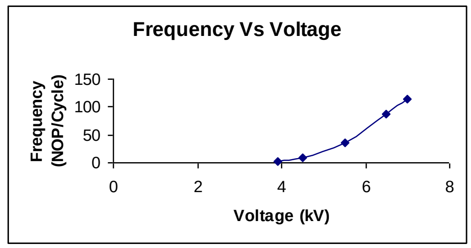
## 6.2 Graphical Analysis of the Quantities Obtained and Observations.




## 6.3 Observations.

1) The striking point in the analysis of distribution of isolation transformer is the shifting of peaks as the voltage applied is increased.
2) There is a tremendous increase in number of pulses as the voltage applied is increased.
3)Even though the maximum charge and peak charge started increasing so much initially as the applied voltage is increased, in the later stages it came to almost constant though the applied voltage is increased.
Here all the parameters analyzed have increasing graph with respect to applied voltage.

## 7 Conclusions and Future Scope.

### 7.1 Conclusions

1) The main feature in the distribution of isolation transformer is that all parameters analyzed are having increasing graph with respect to applied voltage.
2) Shifting of peak charges are increased in number of pulses was also observed with increase in applied voltage . It is concluded that the sudden change in charge and NOP is due to change in breakdown channel or tree structure created within the non transparent insulation, which is not going to invoke a breakdown immediately, but may lead to further tree growth and hence a breakdown.

————————————————


- *Author Jasmin James is currently working as assistant professor inelectrical engineering department at G H Patel College Of Engineering And Technology, VVNagar, Gujarat. E-mail: jasminjames@gcet.ac.in*
- *Co-Author Archana Nanoty is currently working as professorelectrical engineeringdepartment and principal at Dr Jivraj Mehta Institute of Technology, Mogar. E-mail: archanananoty@yahoo.com*

### 7.2 Future Scope

Partial discharge measurements and degradation state of the insulation material can be correlated and a detectible residual life extension can be made further. Attempts are going on to predict the breakdown time at the insulating material by analyzing the partial discharge distribution at various stages of tree growth. Even though a number of quantities like qmax, qpeak, qaverage, NOP, maximum number of electrons, frequency e.t.c could be calculated, an accurate prediction is still difficult. One of the main limitations is that there are a number of mechanisms that influence partial discharge at the same time. So monitoring of all these mechanisms should be done at the same time for an accurate result regarding partial discharge and breakdown of insulating material.

.

## References


[1] Negoita, A. Scutaru, Ionescu, R.M. (2010). A brief review of monitoring techniques for rotating electrical machines. Bulletin of the Transilvania University of Brasov, 3, 52, 276-284.

[2] Mortazavizadeh, S.A. and Mousavi, S.M.G. (2014). A review on condition monitoring and diagnostic techniques of rotating electrical machines. Physical Science International Journal. 4, 3, 310-338.

[3] Ozdemir, G.and. Andrew, N. (2007).Condition monitoring of large electrical machines. Zeszyty Problemowe-Maszyny Elektrcyzne, 77, 197-202.

[4] Menzhi, E.I., Lamiaa, Saad, A. (2007).Induction motor fault diagnosis using voltage spectrum of an auxiliary winding. IEEE International Conference on Electrical Machines and systems. 8-11 Oct. Seoul.

[5] Pineda, S.M. (2011).Diagnostics of induction motor faults in time varying conditions using the polynomial-phase transform of current. Industrial Electronics, IEEE Transactions 58, 4, 1428-1439.

[6] Dorrell, David, G., William, T., Thomson, and Roach, S. (1997). Analysis of air gap flux, current, and vibration signals as a function of the combination of static and dynamic air gap eccentricity in 3-phase induction motors. Industry Applications, IEEE Transactions.33, 1, 24-34.

[7] Thomson, W. and Gilmore, R.J.(2003).Motor current signature analysis to detect faults in induction motor drives. Fundamentals, Data Interpretation and Industrial case Histories, Proceedings of Thirty second turbo machinery symposium.

[8] Stefan, G., Aller, J., Lu, B. and Thomas, G.H. (2008).A survey on testing and monitoring methods for stator insulation systems of LV induction machines focusing on turn insulation problems. IEEE transactions on Industrial Electronics, 55, 12, 4127-4136.

[9] Stone, G.C. (2013). Condition monitoring and diagnostics of motor and stator windings –A review. IEEE Transactions on Dielectrics and Electrical Insulation, 20, 6, 2073-2080.

[10] Ward, B, H. (2001). A survey of new techniques in insulation monitoring of power transformers. IEEE Electrical Insulation Magazine, 16-24.

[11] Kouadria.D, Watt.G, 'Partial discharge patterns and the identification of defects in High voltage stator windings insulation', Dielectric materials, Measurements and applications .Conf Publications .No.473, IEEE 2000

[12] Dissado.LA, Dodd, SJ, Champion, J.V .Williams, AlisonJ.M 'Propagation of electrical tree structures in solid polymeric insulation' IEEE Trans On Dielectrics and electrical Insulation, Vol4 ,No3,June1997,pp259-79.

[13] F.W Peek, 'Dielectric phenomena in high voltage engineering', McGraw Hill, New York , 1929 : Arch. Elekt.26, 219-232 ,1932

[14] IEEE Standard Technique for H.V Testing, ANSI/IEEE Std 4-1978.


,