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Detection of Partial Discharge Activity in H.V Rotating Equipment

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ABSTRACT

Insulation property play important role in H.V rotating machine. Detection and monitoring of partial discharge activity gives a information about quality of insulation. It gives a indication of insulation deterioration. Partial discharge detects the points of degradation of insulation. (i) HFCT (ii) HVCC (iii) TEV (iv) Rogowski Coil(RC) sensor are used for detection and monitoring of partial discharge activity. By using this sensors PD activity detect and monitor the condition of insulation of the machine without interrupting the running of machine.

Keywords: Partial discharge, motors, on line partial discharge, high frequency current transformer, HFCT, high voltage coupling capacitor, HVCC, Partial discharge testing, PD monitoring.

I. INTRODUCTION

Indication of failure of insulation of high voltage electrical equipment is possible due to the detection, monitoring and measurement of partial discharge. It is successfully applied to equipment rated voltage 2300 voltage to 4000 voltage. By providing voltage to the neutral lead to displacement of phase to ground voltage of power cable . Depending on the magnitude of displacement the phase to ground voltage on a phase can be made equal to zero. PD detection also help to find point of degradation in insulation system. One more advantage of on line PD detection is that it can be carried out with normal operating voltage and frequency. This method is quite helpful to network operator in identifying weak spot of in the system while keeping the circuit in service.

In a high voltage induction motor partial discharge occur due to the electrical breakdown of dielectric when breakdown strength of insulation exceeded. Electromagnetic, audible and chemical change occur due to the dielectric breakdown. Assessment of the condition of the electrical insulation can be done by detection and monitoring of partial discharge activity. PD activity occur in the stator winding of induction motor can be easily measured by help HFCT,HVCC sensor at the switchgear end of supply cable. This document is a template. The main advantage of this method is monitoring the motor which is located in hazardous gas location in oil and gas industries and also asses the condition of stator winding insulation without interrupting the running of motor. Typical monitored equipment includes motor, generators, switch gear,cable,bus duct and transformer [2].

II. METHODS AND MATERIAL

It is necessary to continuous monitoring of PD from 24 hours to permanently. It is a periodic basic one to four times per year. After initial detection of PD activity in induction motor, it may be located to a position of stator winding and condition of insulation condition. The flow diagram in Figure 1 shows the different aspect of on line PD detection [1].

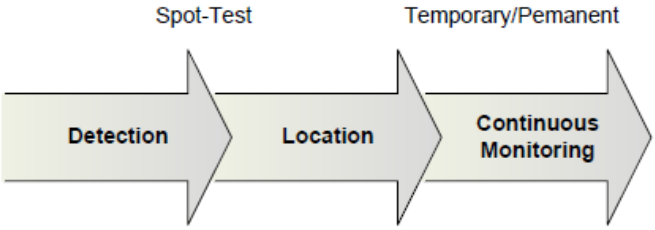


Figure 1. Aspect of On-line PD detection

Off line PD measurement is not possible due to following reason:

1) Time duration for test are six to twelve month and it is much for off-line test.
2) During the test problem is detected but does not have complete data to make proper judgment during the problem detection
3) PD activity is unstable. It is a continuous observing. PD activity depend on the following factor [2].
   - Voltage
   - Load
   - Temperature
   - Humidity
   - Vibration
   - Pressure
4) Taking a reading is a time consuming process and requires an expert for data interpretation.

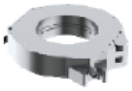
All this above deficiencies remove due to the continuous monitoring of PD activity. Advantage of continuous monitoring is given below.

1. Easy to identify the problem during initial stage and will provide a sufficient information to resolve it.
2. Identify the location of defect and types of defect such as corona, surface discharge, insulation degradation, slot damage, arcing due to loose high voltage connection.
3. No man power is used for performing the test. Finding the solution become easy due to the continuous monitoring.
4. Unnecessary maintenance will be reduced due to collecting accurate data during continuous monitoring.
5. Correlation of other dynamic such as temperature, humidity and load current to PD activity, which provide additional insight for diagnostics [2].

SENSORS FOR MONITORING OF PD IN ROTATING EQUIPMENT

Different types of PD sensor is used for monitoring of PD activity depending upon the attachment of sensor and characteristic of the PD pulses. The PD pulses depend on the construction of the machine, location of the sources, and location of sensor. Types of sensors include Stator Slot Coupler (SSC), High- Voltage Coupling Capacitors(HVCC), High Frequency Current Transformers(HFCT), Transient Earth Voltage(TEV) sensors, Rogowski Coil(RC) sensors and Resistive Temperature Devices(RTD) are shown in Table I[3].

TABLE I
PARTIAL DISCHARGE SENSOR OPTIONS

Sensor	PD Sensor Options		
	Picture	Coupling Method	Relative Sensitivity at 10 MHz
High Voltage Coupling Capacitor		Capacitive	100
Ferrite-cored High Frequency Current Transformer		Inductive	30
Transient Earth Voltage		Capacitive	5
Rogowski Coil		Inductive	1

A brief view of all sensor given below.

1. *High Frequency Current Transformer(HFCT) Sensors.*

HFCT is the most popular for monitoring of PD due to its flexibility and easy installation. Measurement of PD signal depend on the mutual inductance of coil(M) and rate of change of the PD current (*i*).

$$v = M\frac{\partial i}{\partial t}$$

Energy produced due to PD is depend on the size of discharge and severity of insulation damage. It is also detect PD signal with higher frequency(> 10 MHz) which is seen near the PD origin in the machine terminal box. This wide band frequency response of the HFCT means that the sensor can be located remotely from the rotating machine under the test [4].

2. Transient Earth Voltage (TEV) Sensors

It is attached to the outside of metal clad switchgear to monitor the PD signal within the cable. The frequency response of the TEV sensor ensures that it can be detect any PD occurring close to the sensor position, as these TEV signal consist of high- frequency component [3]. High frequency voltage pulses induced due to the PD within the HV insulation system. The TEV sensors are thus placed on the outside of the switchgear panel to capacitively couple to these induced PD signals originating from inside.

3. *High Voltage Coupling Capacitor(HVCC) Sensors.*

80 pF HVCC sensors is generally used for detection of PD signal at the machine terminations. It will install near the machine terminal or unit HVCC sensor per phase. Sometimes two sensor install per phase. Two sensor per phase method allows system noise rejection by using a time-off-flight(TOF) algorithm [3].

III. RESULTS AND DISCUSSION

Table II gives the PD level guideline comparison of both HFCT and HVCC sensors for HV rotating machine. From this table II we assess the condition of the stator insulation. Alongside, it is thus also important to measure the PD magnitude trend over time including trends in:

- Average PD Pulse Charge Content, Q(in pC or mV)
- Total PD Activity across the power cable i.e the energy density measurement [4].

TABLE II
PD LEVEL GUIDELINES FOR HV ROTATING MACHINES

Assessment	PD Level (pC) HFCT sensors	PD Level (mV) HVCC sensors
Excellent	< 2000	< 20
Good	2000 – 4000	20 – 40
Average	4000 – 10000	40 – 100
Still Acceptable	10000 – 15000	100 – 250
Inspection Recommended	15000 – 25000	250 – 600
Unreliable	> 25000	> 600

Energy density of the PD activity across the power cycle is important in the measurement of PD. PD levels and reliability of the in-service rotating HV machine depend upon the PD level, winding age and the voltage class of rotating machine. The most effective way to measure the severity of any PD activity is to use a combination of three measurement [5]

1. Peak PD level(Q) measurements.
2. Number of PD pulses(N).
3. PD activity across the cycle.

PD pulse data collected and analyse by software algorithm. The higher the frequency detected, the quicker the signal attenuates[2]. Sensitivity of sensor/analyser reduced due to the signal attenuation. In field condition, noise will be reduced due to the higher frequency measurement and so that difficulty reduced due to the many sources of noise. But zone sensitivity of the sensor decrease due to the higher frequency.

Dielectric properties of insulation change with temperature. It is shown in Figure 2[2].

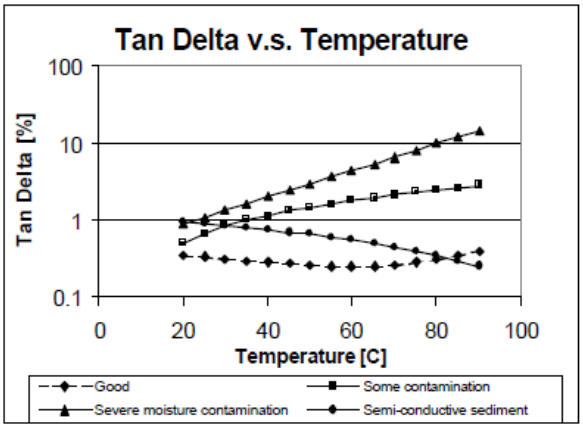


Figure 2. Tan delta v/s Temperature

In a good and dry insulation value of tanδ is none or a very slight with respect to temperature. But there is a rise of tanδ with temperature due to the presence of severe moisture. PD activity is also depend on the value of tanδ, heat dissipation factor and capacitive current under the operating voltage.

IV. CONCLUSION

The paper reviewed advantage of detection and continuous monitoring of PD activity by using different types of PD sensors. PD gives a information related to insulation degradation. It will save the time, money and provide accurate data related to the insulation condition of h.v rotating equipment. Easy to detect the PD signals from the stator winding of the h.v rotating machine. Discrimination between phase to phase PD and phase to earth PD is possible due to the wave shape based measurement.

Voltage source is the main difference between the on-line and off-line PD measurement. In on-line measurement three separate voltage sources that can be different over a time. Relationship between the site of PD activity in h.v rotating equipment and PD pulses at different location is depending on the frequency response of PD sensors like HFCT, HVCC, TEV, RC etc. All this sensors are reliable and effective for on line partial discharge monitoring of PD activity within the stator winding of h.v rotating equipment like motors located in gas and oil industries.

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