



PARTIAL DISCHARGE TESTING AND ANALYSIS

Partial Discharge monitoring has been found to be a powerful tool in assessing the insulation condition in form wound stators with rated voltages above 4.1 kV.

PROCESS

Partial discharge is seen as a symptom of a failure mode or modes in HV machines. Some of the failure mechanisms that may be identified by PD testing and trending are –

- Thermal Deterioration / Cycling
- Inadequate Impregnation or Dipping
- Loose Stator Coils
- Semi-conductive Coating Failure
- Scarf Joint Failure
- Electrical Tracking
- Inadequate Endwinding Spacing



DETECTION

There are numerous methods for detecting and trending PD in HV form wound stators. The various methods all have their own advantages and disadvantages therefore an assessment of the individual installation is necessary to determine the best method applicable for each installation. The 3 most common methods utilized for PD trending and analysis are –

- Antennae such as RTD or thermocouples
- HV capacitors
- HFCT (high frequency current transformer)



DATA ACQUISITION

Once a suitable method of detection is determined portable instruments are utilized to record data periodically.

The test typically takes 1 hour after site establishment.

Monitoring is conducted every 6 months, with this monitoring interval PD signals can typically be detected up to 2 years prior to serious insulation deterioration that could lead to a failure or irreversible mechanical damage.



EXTERNAL FACTORS

PD activity in a motor is strongly dependant on several factors and is somewhat dependant on other factors. The individual motor installation and operating parameters can influence these factors. These factors can be –

- Stator Voltage (increase in voltage results in increased PD)
- Enclosure Pressure (increasing pressure inside a motor enclosure decreases PD)
- Humidity (an increase in humidity results in higher electrical tracking thus resulting in a lower PD level)
- Winding Temperature (delaminated insulation systems may experience a decrease in PD activity as the endwinding temperature increases due to the voids becoming smaller)
- Machine Loading (loose coils are influenced by magnetic forces with higher loads thus PD increases)



DATA TRENDING

Data trending is the most powerful means of interpreting PD data no matter which detection method is utilized. The ideal situation would be to gather data from when the motor is relatively new and trend the data over time. As a winding deteriorates the volume of the worst defects increases resulting in a higher PD level. Thus an increasing PD level indicates that the deterioration is increasing and there is a greater risk of failure.



COMPARISON TO SIMILAR MOTORS

The initial reading taken on a motor is best interpreted and gives the best indication of the relative condition of the insulation system if it can be compared to a identical motor. This is of particular assistance if a monitoring program is instigated after the motor has been in service for some time and no previous data is available. It must be noted that for the comparison to be effective the external factors effecting PD mentioned above must be relevant.





IDENTIFICATION OF FAILURE MECHANISMS

Some basic analysis of failure mechanisms may be made based on the following. If a motor's trend or an individual reading is high the data can be further analyzed to determine the probable cause for the high readings of PD activity. The relationship of the discharge activity to the phase or polarity is important in determining the possible failure mechanism. PD will normally produce both positive and negative pulses thus a positive to negative ratio can be calculated. The following ratios are a guideline for initial analysis –

- > 1.5 then there is a positive pulse predominance and the PD may be mainly occurring on the surface of the coils in the stator lamination slot. This indicates that the coils may be loose in the slot or the semi-conductive or grading tapes are deteriorating.
- < 0.5 then there is a negative pulse predominance. This can be an indication that the PD is occurring close to the copper conductors. This may indicate that some deterioration has occurred due to poor impregnation or load cycling.
- If the ratio changes from phase to phase or the ratio is approximately 1.0 then either endwinding PD is occurring or some form of thermal deterioration has occurred.

Further information can be gained by measuring the effect of various motor operating factors on the PD levels. Simultaneous readings of vibration and temperature are taken to help determine if a particular influence is causing a change in the PD levels, some influences when compared to the level of PD can help determine the likely deterioration mechanism. For example –

- If the PD level increases with an increasing load (for a constant temperature) the possibility of loose coils should be examined.
- If the PD level decreases with increasing temperature then the possibility of thermal deterioration or load cycling damage may have occurred.
- If the PD level increases with increasing temperature (load constant) then a deterioration of the Silicon carbide coating may have occurred.
- If the PD level decreases with an increase in humidity the PD may be predominately on the endwinding due to increased electrical tracking

If multiple failure mechanisms are present particularly in older machines it may be extremely difficult to differentiate between the different failure mechanisms from the recorded data alone and a visual inspection or other testing may be prudent if required.