Partial Discharge Testing of Rotating Apparatus

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This column focuses on electrical inspection methods and technologies that are performed while the electrical system remains energized. Although no-outage inspections can be very valuable tools, always remember to comply with proper safely guidelines when conducting energized, on-line inspections.

Statistics indicate that up to 37 percent of rotating equipment failures occur due to stator insulation breakdown. For several decades, partial discharge (PD) testing has been a very beneficial tool for assessing the stator insulation condition of medium-voltage rotating apparatus. This article examines how PD activity occurs and why PD testing is unique as applied to generators and motors.

What is Partial Discharge?

Partial discharge is a localized partial breakdown within or on the surface of insulation that causes a spark to occur. This partial failure of the insulation is generally caused by poor design, flaws, voids, or contamination that create a localized stress that exceeds the dielectric breakdown strength of the insulation material. The sparking activity then leads to further insulation decomposition through a combination of thermal, chemical, and electrical phenomena and persists until complete failure occurs. The detection and monitoring of PD activity has been found to be very useful in assessing the condition of electrical equipment. Although PD can occur at lower voltages, equipment operating below 2,000 volts to ground usually does not discharge frequently and usually fails by other mechanisms.

Rotating Apparatus Insulation

Switchgear, cable, and transformer insulation cannot tolerate PD activity very well. Generally, PD activity will lead to further destruction of the insulation and eventual failure. Therefore, these types of equipment should always operate PD free.

The design of rotating apparatus creates inherent difficulties that make producing PD-free equipment impossible. The complex configuration of stator coil insulation (see Figure 1), difficulties with the manufacturing impregnation process, and the problems fitting the coils within the stator slots can all create voids which lead to PD activity. Since PD in rotating apparatus is inevitable, the coil insulation employs mica tape which is very resistant to partial discharge damage. So, when assessing the condition of rotating apparatus, it becomes very important to monitor and trend PD activity over the course of many years as opposed to assessing the condition of other types of equipment insulation where periodic PD testing may suffice.

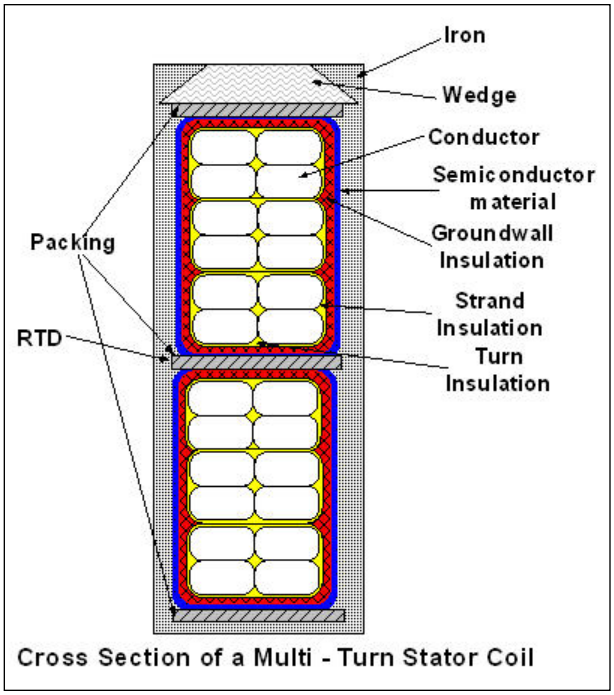

Figure 1

PD Sensors

Effective on-line PD testing of switchgear, cable, and transformer insulation generally involves taking regular (annual) spot checks using temporary sensors that are safely attached to grounded components of the apparatus. The main goal of this procedure is to ensure a PD-free apparatus.

In order to best monitor rotating apparatus, permanent coupling capacitors (see Figure 2) are connected to the machine output bus during an outage. These sensors provide a standardized method to decouple the PD signals. Additional data can be obtained by using the RTD's that are embedded in the insulation as auxiliary PD measurement points. The RTD's act as antennas that can pick up the high frequency pulses associated with PD.

Figure 2

Since the rotating equipment PD activity is trended over many years, it is more economical to install permanent monitors than conducting regular spot surveys. These monitors (see Figure 3) accept other sensors for trending load, temperature, and humidity data along with the PD data so that correlations can be made that provide additional information for more precise diagnostics of the cause, location, and type of the PD activity occurring.

Figure 3

Valuable Data

As previously stated, the mica insulation is quite impervious to most PD activity. However, large amplitude discharges occurring from voids in the insulation or end winding contamination can lead to direct insulation failure. This is just one category of problems that can be detected.

Insulation can also fail from the thermal or mechanical wear over the course of many years from overheating, thermal cycling and loose wedging. In these cases, increases in PD activity will show as a slow rise over time. This type of PD activity relates directly to the machine's overall thermal or mechanical condition, as the PD activity is not the primary problem but is actually an indicator of the presence of other age-related problems.

Conclusion

Monitoring PD activity in rotating apparatus is very important for increasing reliability and prolonging equipment life. All generators and critical motors should be monitored continuously and consideration should be given to performing annual PD spot testing to the balance of plant medium voltage rotating apparatus.

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