Partial Discharge Measurement Increases Availability of Electrical Machinery

Background
Electrical, mechanical, thermal and environment-specific stresses during operation cause aging in high-voltage insulation. Partial discharges (PD) can occur in the resulting local defects, the corrosive effect of which damages the insulation progressively (see Fig. 1).

Preventive maintenance on high-voltage insulation requires efficient diagnostic methods. In addition to the various integral current measurements (measurement of discharge and charging currents, as well as dielectric loss factor and capacitance) partial discharge measurements have also been performed increasingly over the last years. These measurements enable the more exact analysis of defects in the insulation with regard to cause and location of the damage (see Fig. 2).

Unlike to other methods, the partial discharge measurements are performed without any relevant dielectric stress of the existing insulation system.

Measurement procedure
The measurements can be performed with the generator at standstill (offline) and/or with the generator running (online).

The partial discharge pulses are detected by connecting coupling capacitors to the generator power leads. The partial discharge signal and the phase reference of the generator voltage are transmitted via a coaxial cable to the measuring instrument, which records and analyzes the partial discharge pulses.

The PD pulses are sorted by phase angle, amplitude and frequency of occurrence for analysis.

Fig. 1: Traces of partial discharge, defective outer corona protection
Fig. 2: Defective bonding of outer and end corona protection
Fig. 3: Schematic of online measurement configuration
Fig. 4: Partial discharge pattern
The resulting distribution functions are also designated as partial discharge patterns, the appearance and features of which (e.g. mean discharge current, mean pulse charge, etc.) are typical for the various partial discharge types.

**Offline partial discharge measurement**
After disconnection and isolation of the generator, a coupling capacitor is set up as close as possible to the power leads and is temporarily connected to the phase to be tested. The partial discharge signal is connected to the measuring equipment via a coaxial cable. Power is supplied through a stepless controllable high-voltage transformer.

**Online partial discharge measurement**
Unlike the with offline measurement, online measurement is performed under operating conditions, i.e. in three phases (see Fig. 3).

**Monitoring**
Monitoring enables continuous surveillance of the partial discharge activities of a high-voltage insulation system. The sum of the partial discharge activities is provided as a smoothed analog value at the 4 - 20 mA interface for further analysis, such as for the I&C and/or storage in a data recorder.

The provided LCD display shows a FIFO (first-in, first-out) trend over the last 100 days as well as the set alarm threshold which is used to switch potential-free contacts.

The measuring device has three coaxial cable inputs from the coupling capacitors and three outputs. A switch enables bridging of the inputs to the coaxial cable outputs, providing the unaltered signal from the coupler for detailed diagnoses.

**Refit scope**
The partial discharge signal couplers vary depending on the rated voltage of the generator and the existing installation possibilities.

Siemens offers two variants with different analysis options:

**PDtrend – local monitoring:**
- Comprising coupling capacitors (see Fig. 5) and analysis unit, including terminal box and power supply (see Fig. 6)
- Measurement of total partial discharge activity as a 4 - 20 mA signal; automatic display when exceeding of the set alarm threshold
- If necessary, Siemens personnel can perform detailed analyses (see Fig. 7).

**PDesexpert – remote monitoring:**
- Coupling capacitors as in variant 1, but with combined monitoring and diagnosis unit
- Remote analysis through the Internet at any location is possible.

**Summary**
The equipment offered by Siemens for partial discharge measurement, monitoring and generator diagnosis enable condition monitoring and evaluation of high-voltage stator windings.

This yields the following advantages for the operator:
- Early detection of (incipient) insulation damage
- Localization of damaged areas
- Increased availability with improved utilization of the available remaining service life of the high-voltage insulation without an unallowable increase in operating risk
- Prevention of high-cost consequential damage
- Non-location-specific analysis of data by modem (optional), expert advice from Siemens specialists, integration in existing monitoring systems possible.
- Planning of maintenance based on current insulation condition