PARTIAL DISCHARGE TEST WITH SURGE VOLTAGE IN ELECTRIC MOTORS WINDINGS

Abstract: A typical damages of insulation in electrical machines and methods for their detection are shown in the article in a simple way. As one of many diagnostic methods surge test and partial discharge detection are selected. The author describes in the simple way the mechanism of the partial discharge formation.

1. Introduction

Within the last few years the partial discharge test has become more and more important to evaluate insulations in electric motors. This is especially true due to the large increase of frequency inverters for the motor speed regulation. Our experience shows that many operators namely refer to the partial discharge test but only a few really understand what partial discharge means. This article is intended to “shed light” on this type of testing. This is a general description of the test method and its applications.

2. What is a partial discharge test?

From the classic AC high-voltage test with we already know the typically complete breakdown. With the high voltage test a breakdown occurs between the damaged conductor and the motor housing.

But what happens, if the conductor is not damaged? In the first instance, nothing will happen. Nowadays the copper wires are of such high quality, that the wire insulation is able to resist high stresses for a time.

Fig. 1. A breakdown between the damaged conductor and the motor housing

3. How and where do partial discharges occur?

Partial discharges arise, where high voltage between turns or between coil and motor housing exist.

Such weakness often occur in the new motors due to a qualitatively poor production. A typical example of this case, would be a missing or partly shifted phase separator. In aged motors the weakness often occurs due to aged insulations as e.g. brittle resin insulation.

In Figure 2, a pictorial diagram of the insulation between two wires is shown.
Partial discharge is a voltage-dependent physical effect. With increasing voltage partial discharge will occur eventually. The question to be asked is at which voltage level they should be measured? The answer is in the application of the electric motor. Depending on this application the test voltage for the partial discharge should be selected.

High frequency voltage is greatly attenuated in the first coils of the winding. The result is a non-linear voltage distribution at the beginning of the winding, depending from the surge pulses’ rise time. Towards the end of the winding the voltage is distributed linearly again. This means that at the highest proportion of additional VFD related stresses are dissipated at the leading turns of the winding (with respect to the leads for motor incoming power). This effect must be considered for VFD operated motors. This is why the partial discharge test reproduces conditions as they occur in reality with VFD operation.
The surge voltage test is especially useful, if wires are already damaged and if they already show blank spots. But if wires in a winding or between phases only have contact with each other, the limits become obvious. Although partial discharge occurs in such cases it is not detected by the surge voltage test. To detect such kinds of faults the partial discharge test should be performed in addition to the surge voltage test. The partial discharge test supplements the surge voltage test. Without stimulation by the surge voltage test partial discharge will not occur. Partial discharge always occurs when the voltage reaches the highest level (Fig. 6). This is at the respective maximum of the sinusoidal surge voltage test. Concentrate on the first amplitude of the surge voltage test since it is the highest (the maximum voltage level).

**Fig. 6. Partial discharges occurring during the surge test.**

4. Conclusion

The partial discharge test should also be performed in combination with a AC High Potential test. Both test methods serve as basic test in order to activate the partial discharge (Fig. 8). The surge test primarily looks directly into the winding (from winding to winding) to detect weak insulation spots. This is its specialty. In addition it also measures the partial discharge. However, under certain conditions the partial discharge in combination with the surge test does not react to sensitive weak spots between the winding and the body or between the phases. Thus both test methods are recommended to reliably measure partial discharge on a machine.

**Fig. 7. Partial discharges occurring during the surge test - enlargement of the first fragment of wave.**

**Fig. 8. The view of the series MTC2 tester during partial discharge measurement and test Surge voltage detection with automatic initiation and partial discharge extinction.**