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Characteristics of partial discharges and electrical insulation of inverter-fed random wound motor coils

インバータサージによる低圧乱巻モータコイルの絶縁劣化と部分放電特性

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Repetitive partial discharge inception voltage (RPDIV) of twisted enameled magnet wires was investigated in order to clarify insulation capabilities of inverter-fed random wound electrical motors. A power supply which produces bipolar repetitive impulse voltage pulses was used in this study. The measured data of RPDIV has a relatively large dispersion in the early stage of the voltage sequence. After that, it reached to the steady-state value.

1. Introduction

It is recently known that a transient surge voltage induced by the switching of insulated gate bipolar transistors (IGBTs) is a critical issue for electrical insulation of inverter-fed random wound motor coils [1]. Partial discharge (PD) activities in motor windings due to the surge voltage have been identified as one of the main factors of insulation failures of inverter-fed motors. Then, the IEC60034-18-41TS requires no PD during the lifetime of motor.

A PD inception voltage (PDIV) is defined by a voltage at which PDs start to occur. A lot of studies of PDIV measurements under ac voltage applications have been performed. In particular, dependences of PDIV on environmental humidity and temperature have been investigated [2, 3]. On the other hand, a voltage waveform of inverter-surge is repetitive transient voltage oscillations, so that PDIV measurements under repetitive impulse voltages have to be studied.

In this study, results of PDIV measurements under repetitive impulse voltage applications are presented.

2. Experimental setup

The twisted pair consists of two enameled magnet wires to simulate random wound motor coils, as shown in Fig. 1. The enameled wire with a diameter of 1 mm is used in this study. Polyamide-imide is used as insulation organic material for the enameled wire.

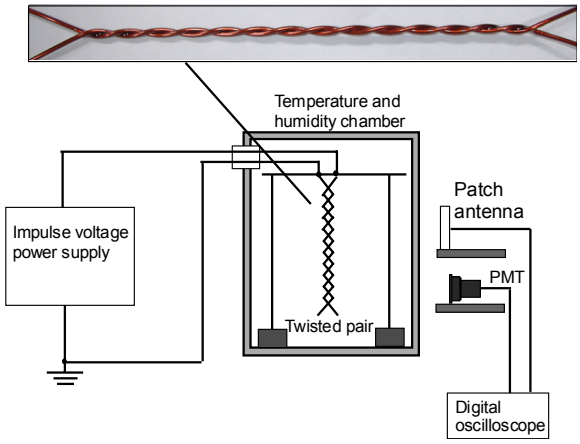

Fig. 1 Experimental setup.

Ten twisted pairs are simultaneously installed in a temperature and humidity chamber (ESPEC Co., type: LHU-113), as shown in Fig. 1. The temperature and relative humidity fluctuation levels at the control sensor are 0.5 °C and 3 %, respectively. Here, the experiment was carried out in atmospheric air. Bipolar repetitive impulse voltage pulses were generated by an impulse winding wire testing machine (ECG-KOKUSAI Co., type: DWX-05). The unipolar (negative) power supply has been used as a common impulse generator with a fixed impulse sequence pattern specific to round-robin test (RRT) for repetitive PD inception voltage (RPDIV) measurement in Japan [4]. The waveform of single pulse voltage is triangular with 140 ns in rise time. The waveform of repetitive impulse voltage pulses are shown in

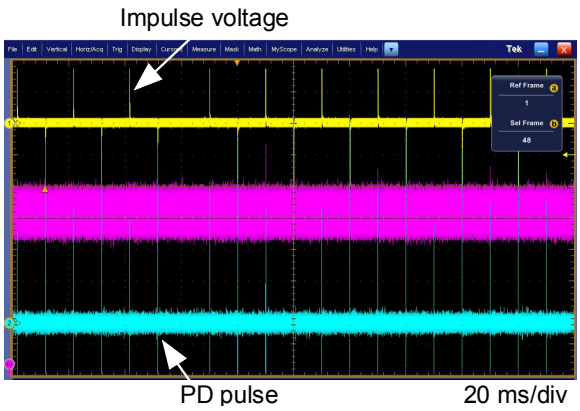

Fig. 2 Time evolutions of the applied impuse voltage pulses and the PD pulses.

Fig. 2.

The PD was detected by a photomultiplier tube (PMT, Hamamatsu Co., type: R960, 185-650 nm) and narrowband antenna (patch antenna, center frequency 1.8 GHz) [5]. The repetitive impulse voltage pulses were measured by a high voltage probe (Tektronix Co., type: P6015A, 75 MHz). The measured data was recorded by a digital oscilloscope (Tektronix Co., type: DPO7104).

3. Experimental results

The ten twisted pair samples are tested thirty times in sequence. The sequence is as follows: Ten voltage impulses with the same voltage peak amplitude were applied with a period of 20 ms. After 50 ms pause, the next ten voltage pulses with an increase of 10 V follow. If PD pulses exceed five against ten impulse voltages, the averaged voltage of the impulse was defined as RPDIV. Thus, the definition of PPDIV is one of statistical data analysis methods, because the PDIV under impulse voltage pulses has a relatively large degree of dispersion in comparison with the traditional measurements under ac voltages.

Figure 3 shows the result of measurements of RPDIV, where the horizontal axis is number of the voltage sequence. Here, the temperature and humidity were set 30 deg. and 40%. It is found that there is relatively large dispersion of the measured RPDIV. After the 20 sequences, the RPDIV reaches to the steady state. It is considered that surface charges on the enameled wire due to the PDs affect the next PD. On the other hand, the behavior of the RPDIV was not observed in the experiment with the unipolar power supply [4]. The surface charge distribution on the enameled coated copper plate due to PDs will be performed in future.

4. Summary

The RPDIV of the twisted pair samples under the bipolar repetitive impulse voltage were measured in order to clarify electrical insulation capabilities of inverter-fed random wound motors. The RPDIV has fluctuates with large dispersion in the early stage of the voltage sequence, and it reaches to the certain steady-state value. It could be considered that surface charge accumulation on the enameled wire causes the fluctuation of the RPDIV data.

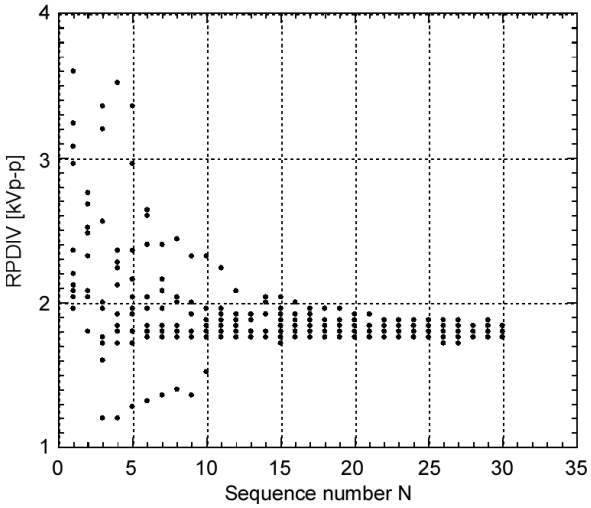

Fig. 3 The history of the RPDIV with respect to the pulse number.

Acknowledgments

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