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THE INFLUENCE OF PULSE STRESS ON MAIN-WALL INSULATION OF ELECTRIC ROTATING MACHINES

WPŁYW IMPULSÓW NAPIĘCIOWYCH NA IZOLACJĘ GŁÓWNA WIRUJĄCYCH MASZYN ELEKTRYCNYCH

Abstract: The diagnostics of insulating system of electric machines under pulse stress is at the present one of the most focused fields. The converters produce repetitive pulses with the high level of voltage rise fronts (slew rates). Rise fronts attain values of up to the tens of kilovolts per microsecond and voltage pulse repetition frequency up to some tens of kilohertz. However, this technology is an advantage for a drive control; the voltage waveforms generated by power frequency converters may significantly affect the reliability of the electric motor insulation systems. To improve understanding of the processes in the electrical insulation materials during the pulse voltage aging, it is necessary to monitor values of the electric parameters within a pulse stress aging process. For the studying of the main-wall insulation material pulse voltage aging processes there were chosen these electrical parameters: the dissipation factor, capacity, absorption and resorption currents, corona inception voltage (CIV) and partial discharges (PD) activity level. These parameters are easily detectable and their development characteristics are very well known in the terms of sinusoidal voltage aging process. This paper presents experimentally measured data of the observed electric parameters during the pulse and sinus voltage aging. The difference between the sinusoidal voltage aging and pulse voltage aging time dependencies is shown as well observable in this paper as well.

Streszczenie: Diagnostyka układu izolacji maszyn elektrycznych metodą impulsową nabiera coraz większego znaczenia. Przemienniki wytwarzają powtarzające się impulsy o wielkiej stromości narastania napięcia osiągające wartość kilkudziesięciu kilowoltów na mikrosekundę i częstotliwość dziesiątków kiloherców. I choć technologia ta ma wyraźne zalety dla regulacji prędkości obrotowej napędów, fale napięciowe generowane przez przemienniki mogą znacząco wpływać na trwałość układu izolacyjnego maszyny. Dla poprawy zrozumienia procesów starzeniowych układu izolacyjnego zachodzących w trakcie impulsów napięciowych koniecznym jest monitorowanie wartości elektrycznych występujących w czasie trwania impulsu. Dla analizowania starzenia izolacji głównej wybrano takie parametry jak: współczynnik rozproszenia, pojemność, prąd absorpcji i resorbcji, napięcie początkowe korony, i poziom wyładowań niezupełnych. Te parametry są łatwe do pomiaru a ich przebiegi są dobrze znane dla procesów starzeniowych od napięcia sinusoidalnego. W artykule przedstawiono zależności czasu starzenia układu izolacji skutkiem działania napięcia sinusoidalnego i starzenia izolacji od impulsów napięciowych.

1. Introduction

The electrical pulse stress (of rotating machines stator insulation) with very sharp rise times (du/dt) causes a quick degradation of insulation and this leads to the premature failures or destruction of the insulation system of an electric machine. Most of the papers published so far focused on the pulse stress and its influence on an electrical machine insulation system have dealt mostly with the influence of the pulse stress on inter-turn insulation of electric machines [1-3]. The effects of influence of pulse stress on main wall insulation were to a certain extent neglected. This submitted study presents first of all the monitoring of the influence of pulse stress on three-component insulation system Resin-rich, composed of glass fibre, mica paper and c. 40% of modified binder resin. Besides the classic layout of the material, in the field of these (Resin-rich) insulating systems there exist new procedures for the glass fibre processing, especially in the glass fibre profile modification and for their placing into the matrix. This placing ensures the superior contact of the glass fibre with the binder resin (Fig.1) [4]. According to the producer, this modification ensures better mechanical, electrical ant thermal properties of the composite due to higher homogeneity of the material and thus lower probability of air voids occurrence in the space between the glass fibre and binder resin.

It is therefore interesting to pay attention to the aspects of material behaviour during both the pulse and sinus electrical stress.

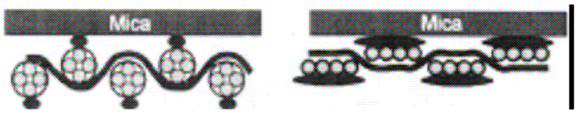

Fig. 1. Different conceptions of glass fibre processing and different contacts of glass fibre with binder resin (new conception on the right) [4]

2. Experiment

In order to gain data on possibilities of the above mentioned monitoring the behaviour development of various Resin-rich insulating system types, it was first necessary to determine an adequate diagnostic system. The diagnostic system consists of the methods effectively monitoring the changes of key parameters of both focused materials. The main indicator is naturally monitoring the time dependence of the loss factor tg δ, sample capacity C_x, insulation resistance R_{iz} and polarization index p_i. The investigated materials were exposed to both the sinusoidal electrical stress of 11 $kVmm^{-1}$ and the pulse stress (pulse power supply DEI PVX-4110) with the following parameters of pulses:

- bipolar polarity of pulses
- voltage : ±2 kV
- rise time c. 250 ns
- slew rate 16kV/μs
- frequency 1 kHz
- pulse width 1 μs

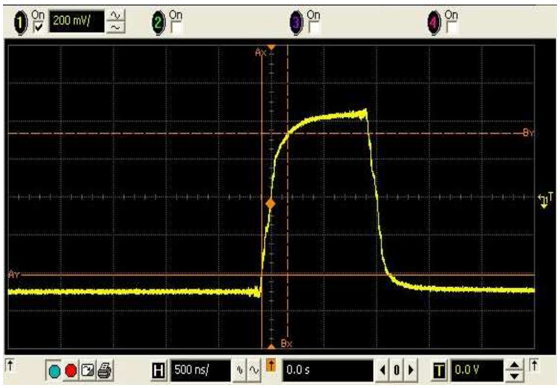

Fig. 2. The shape of the pulse simulating the pulse stress

The electrical stress is carried out on flat shape specimens of tested materials (100×100 mm, 0,5 mm of thickness) at defined times of stress. The electrical properties characterizing the insulating conditions of tested specimens are measured at strictly defined times.

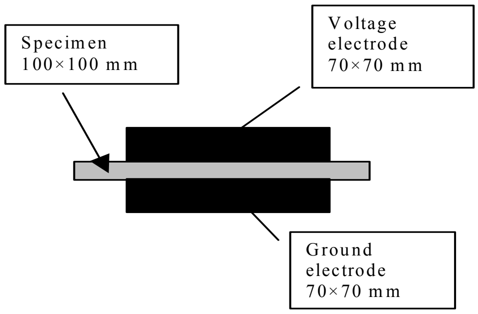

Fig. 3. The electrode system for aging at both types of electrical stress

Tab.1. Investigated materials

Material	***Code***
Mica glass composite with the conventional placing of glass	A
Mica glass composite with the new placing of glass	B

3. Results and discussion

3.1 Loss factor and capacity

The loss factor tg δ and capacity C_X measured at voltage level 1,5 kV (automatic Schering bridge LDV-5) shows the increasing tendency of tg δ level at both types of electrical stress (pulse, sinus). Figure 4 indicates that with the sinus stress the level of tg δ of material A is lower than at material B. The slope of material A rising is bigger than B. The tendency of the tg δ curve at pulse stress is similar to the variant B at sinus stress. The capacity of specimen has the similar increasing tendency at all cases.

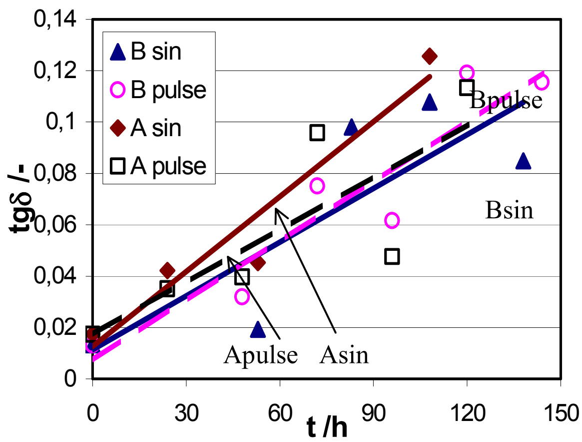

Fig. 4. Comparison of tg δ

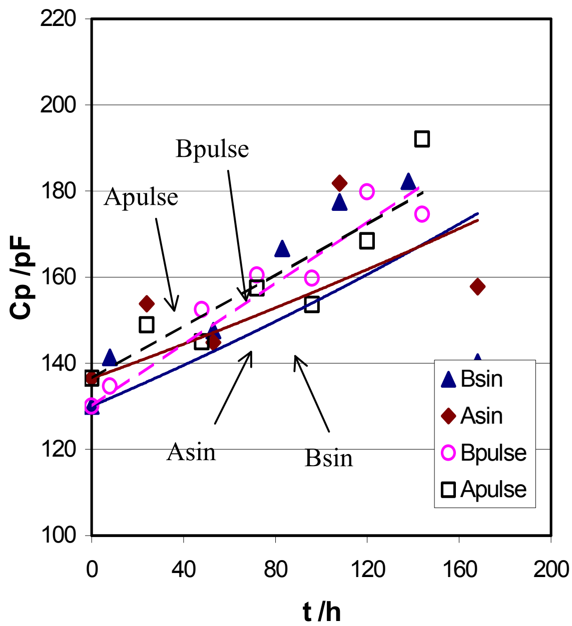

Fig. 5. Comparison of capacity C_x

3.2 Insulation resistance

The results of DC tests of insulation resistance are shown in picture 6. The insulation resistance has a decreasing tendency during aging for both types of the electrical stress. The material B shows higher values of insulation resistance thanks to its design.

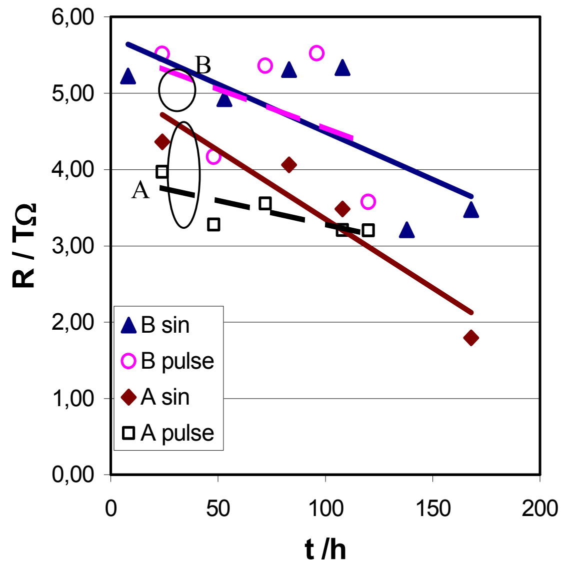

Fig. 6. The comparison of insulation resistance (pulse stress is plotted with a dash line)

3.3 Polarization index

The one minute polarization index and its time dependence on aging is shown in figure 7. The material A has a decreasing tendency at sinus stress while the material B at sinus stress and as well as at pulse stress has the decreasing tendency of the polarization index.

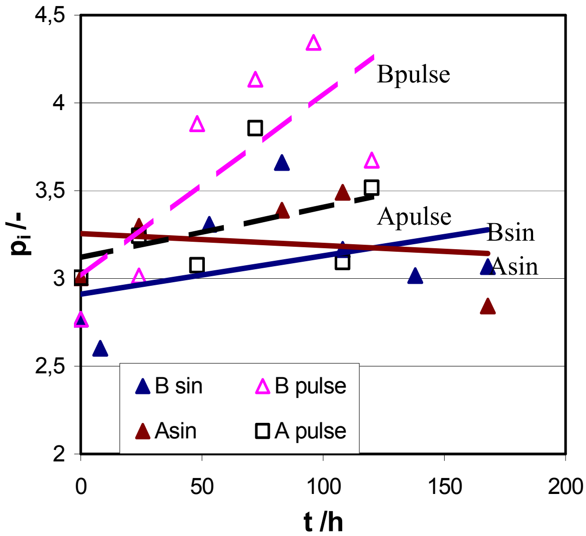

Fig. 7. Comparison of polarisation index

4. Conclusion

The presented study shows the difference in the behaviour of two variants of Resin-rich insulation systems, which differ in the manufacturing and placing of the glass fibres in the binder resin, under the pulse and sinus electrical stress. The comparison of various materials and the monitoring of time dependent changes of their electrical properties implies the diversity of material properties and the different endurance to pulse and sinus electrical stress. In the future this new complex view on the above-mentioned issue will allow to determine the optimal material variant of an insulating system resistant to pulse stress.

5. Acknowledgement

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