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Thermal and Lifetime Behavior of Innovative Insulation Systems for Rotating Machines

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ABSTRACT

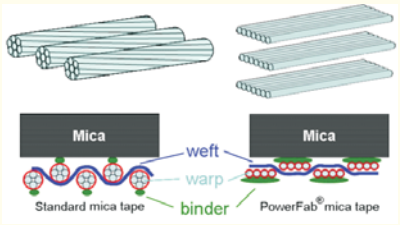
The innovative insulating tape for rotating machines shows advantages concerning the electrical and mechanical strength as well as its thickness and thermal conductivity. In this paper the new developed mica tapes should be tested with respect to the thermal behavior of the end corona protection and voltage endurance of various types of used mica paper. For this reason a test series of different defined insulation systems was carried out to test the temperature rise and a long time test with increased voltage stress was applied. The results were evaluated within a statistical analysis and lifetime charts.

Introduction

The base of the new mica insulating tape is the glass carrier, which is different from standard products in following point: normally the individual glass yarns are twisted. With the new production method, the glass yarns are not twisted and the individual filaments are simply laid in parallel. In addition, every single filament of the yarn strand is coated with a finish.

	Standard (STD)	New (FAB)
Thickness	0.04 mm	0.029 mm
Base weight	24 g/m²	25 g/m²

Figure 1: Scematic design of glass yarn



Applied Tests

Measurement of dielectric properties and material consistency: The dielectric constant was determined by measurement and the resin content by burning out in a furnace.

Thermal observation of the warming of the voltage grading end corona protection tape. This test was done by means of a wireless temperature measurement (Infra-red camera) at different rated voltages.

Lifetime of generator bars. The generator bars were tested with high voltage stress: 2.2 and 3.0 times rated voltage. The

Glass Cloth Type	Production Technology	Mica Type
FAB	VPI	Muscovite
FAB	VPI	Phlogopite
FAB	RR	Muscovite
STD	RR	Calcined Muscovite
STD	RR	Uncalcined Muscovite
STD	VPI	Muscovite with small grain size
STD	VPI	Muscovite with big grain size

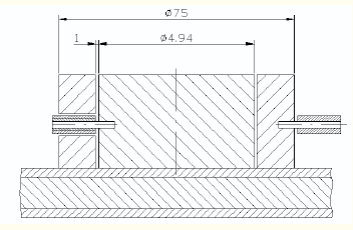


Figure 2: Test-setup Capacitance and ε_r Measurement

Measurement Equipment

For the determination of the dielectric behaviour an unbalanced dissipation factor bridge was used. The capacitance of the model bars was measured at several points on both sides and an average value of the dielectric constant ε_r was calculated.

Thermal Behavior

For the observation of the thermal behavior of the different model bars and the performance of the end corona protection a infra red camera was used.

The generator bars were loaded with following electrical stress ratings: nominal voltage UN, 2xUN+1kV, 3xUN. A test cycle took a duration of 10 minutes and the starting temperature for each cycle had to be the same (room temperature). The special interest of these tests was the temperature rise, the location of hotspots and the determination of absolute temperatures.

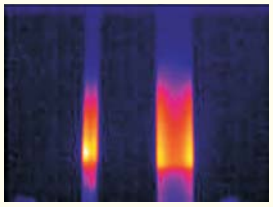


Figure 3: Test setup for observation of thermal behaviour

Figure 4: Thermal performance of voltage grading tape

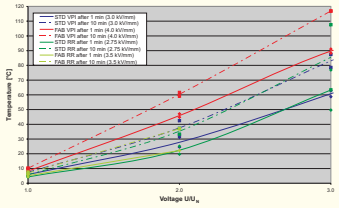


Figure 5: Warming-up of voltage grading tape

Figure 6: Preparation of bars for optical investigation

Voltage Endurance Tests

The test results of the voltage endurance tests were evaluated by application of a life time diagram with doubled logarithmic scale according to the inverse power law for electrical ageing processes. The statistical parameters for this diagram were determined by the median of the breakdown times. Normally a Weibull distribution is applied for life time investigations of electric equipment, but due to a statistically low number of test specimen its use was not appropriate.

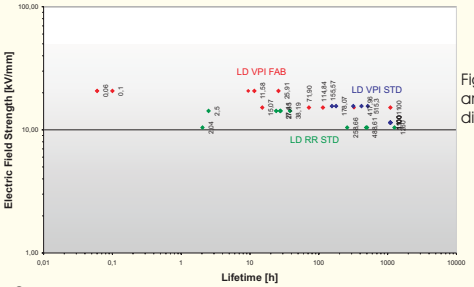


Figure 7: Life time points of VPI and RR bars produced with different mica types

Summary

The measurement of the dielectric constant showed a deviation of 5 % due to production variances. The influence due to the variation of the material was in the same range. For this reason the resin content was determined by using a high-temperature furnace to glow out the resin.

The observation of the thermal behaviour was done with warm-up test. The evaluation of the results showed that the highest temperatures were recorded at the VPI FAB material having the highest electrical load.

The best results concerning voltage endurance was also recorded at the VPI bars, the FAB bars showed better lifetime behaviour with respect to the applied field strength.