Project title	Characterizing and modelling of bearing current activity
Project number	TG5-2
Organisation	Chalmers University of Technology, High Voltage Engineering
Project leader	Jörgen Blennow
Other participants	Abhishek Joshi (PhD student)
Report for	2014-10-01 – 2016-12-31
Participating companies	

Project description

The mechanical bearing constitutes a key component for the reliability of a wind turbine. Understanding of how bearing damages arise and how they can be prevented is therefore of great importance. Failures of bearings in electrical machines caused by current damages started to increase during the 1990's after the introduction of high frequency switched converters based on IGBT (Insulated Gate Bipolar Transistor) technology. The high frequent voltage source in combination with capacitive parasitic elements charges the shaft and its corresponding capacitance. The energy is then discharged through the lubricating film in the bearing with mechanical wear as a result. The objective with this project is to increase the knowledge of the mechanisms behind current induced damages in wind power applications based on modelling and experimental work. The focus will be on understanding of the discharge mechanism present and of how the damages occur.

Results

The main achievements in the project during the period are shortly summarised below.

Investigations in memory effects in recovery of insulating properties of bearing

Electrical breakdown of the lubricant film in a running bearing at dimensionless speeds of 30000 (2000 rpm) and an axial load of 4 N is found to occur at DC electric field strength of 29.6 V/µm, upon step-wise increment of electric field strength across the bearing in steps of 3.7 V/µm. After the bearing is exposed to high electric field stress, the bearing current activity causes the bearing to lose its insulating ability. This is referred to as 'memory effect' and is corresponds to inability of electrical insulation of bearing to withstand electrical stress after being exposed to high electric field stress, as shown in Figure 17. The memory effect is seen to affect the insulating ability of the bearing, and could last for as long as 2 hours after exposure to bearing current activity, and given that no grounding is provided to the bearing. Minor current conduction in the bearing is found to initiate at electric field stress of 14 and 20 V/µm, while the extinction electric field level for current conduction is found to be between 8.4 and 5.6 V/µm.

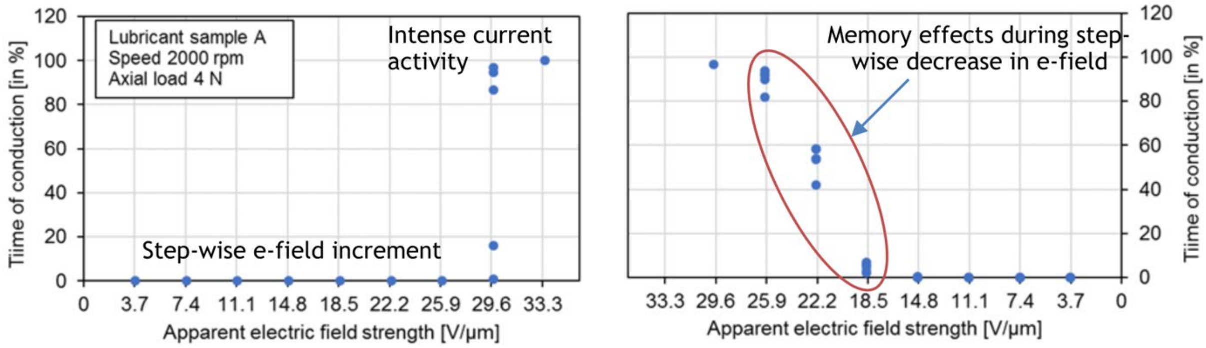

Figure 1 Breakdown of electrical insulation of bearing occurs at e-field of 29.6 V/µm, seen when e- field is step-wise increased. Upon decreasing the e-field after intense current activity, the bearing shows memory effects, where it fails to recover electrical insulating ability at lower values of e-fields.

Frequency domain spectroscopy of lubricants

Relative permittivity (ε_r) and dielectric loss factor (tanδ) of different lubricant samples was measured at 50 °C using frequency domain spectroscopy as a function of swept frequency. The particle concentration was kept fixed at 150 mg/L. The relative permittivity of the samples with particles (i.e., A1 – Arizona test dust, A3 – Aluminium powder, A4 – Fine iron powder) and electrically aged sampled (A5) is slightly lower (ε_r = 2.13) than the virgin Sample A of (ε_r = 2.16), as shown in Figure 18. Dielectric loss factor (tanδ) only slightly increase after running-in process (A+), but by addition of particle and electrically aging the lubricant by arcing results in slight decrease in tanδ. A very minor change in these properties suggest that inclusion of foreign particles and processes such as running-in and electrically aging of the samples do not result in significant change in dielectric properties of the lubricant.

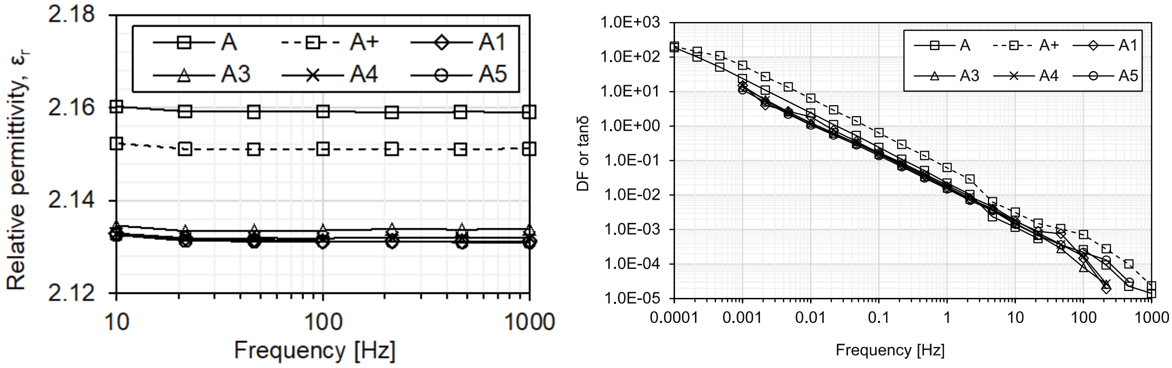

Figure 2 Relative permittivity (left) and dielectric loss factor, tanδ (right) of lubricant samples shown at 50 °C. Adding particles to the samples and electrically aging samples does not alter the relative permittivity and DC conductivity of the samples. The dielectric loss factor in Samples A1, A3, A4 and A5 is only slightly lower than that of Sample A.

Fulfilment of SWPTC's goals

This project contributes to fulfilment of several of the Centre's goal. A better understanding of bearing currents, their detrimental effect and how they can be mitigated will reduce maintenance cost for exchange of damaged bearings and thus contribute to a longer lifetime of the turbine. When increasing power electronic components in the system to reduce weight it is important to consider effects on bearing currents. The project also contributes to research of the highest class through state-of-the-art study of fundamental aspects of a mechanical bearing considered as an electrical component as a part of an electrical circuit. The project also contribute to the engineering education since these phenomena is relevant to use as application examples in the subject of high voltage engineering.

Deviations from project plan

Finalising the doctoral thesis and submission of two journal publications which are in process of being completed have been delayed. A technical report has been submitted to the project partners, and is recorded in CPL. Tests have been made to quantify asperity contacts, and the submission of the journal paper is delayed. The journal paper will be submitted during spring 2019. The doctoral defence is aimed to be held in March 2019.

Publications

A. Joshi, *Electrical Characterisations of Bearings*, Doctoral Thesis, Dept. of Electrical Engineering, Chalmers University of Technology, Gothenburg, Sweden, 2019, submitted to opponent and committee

External activities

The project was presented at a wind conference, *Vindkraftsforskning i fokus*, 6-7 October, 2015 in Uppsala, Sweden