TECHNICAL ARTICLE

Conservation of the insulation of wound stators - surface tracking mechanism

Fernando Roberto Spezia
Specialist in Electrical Processes and Insulation Systems

Fredemar Runcos, PhD
Consultant in R, D & I of Rotating Electrical Machines

Friedrich Weege
Consultant in Manufacturing Processes for Rotating Electrical Machines

Waldiberto de Lima Pires
Product Technology Coordinator

1. INTRODUCTION

Rotating electrical machines must ensure the supply of energy, mechanical (in the case of motors) or electrical (in the case of generators), required by the various existing activities. Basic, intermediate or consumer goods industries are somehow dependent on the operation of these machines.
The insulation system is a vital part of the rotating electrical machine! Its durability is crucial for the machine's service life and, as a consequence, directly impacts the robustness and reliability of the processes.
There are several factors that influence the durability of an insulation system. In service, under ideal operating conditions, some aging factors are inherent, causing the insulation to degrade slowly, as expected, without prejudice to its service life. However, under non-ideal operating conditions, insulation degradation can occur at an accelerated rate, reducing machine life.
Among the factors that can accelerate insulation degradation, leading to premature failure, is the mechanism known as surface tracking, which is discussed herein. It is, among other things, a consequence of the accumulation of contaminants on the surface of the machine winding.

Figure 1: From left to right, evolution of the surface tracking mechanism

2. ACCUMULATION OF CONTAMINANTS ON THE SURFACE OF THE INSULATION

Depending on the constructive characteristics of the machines, some operating environments can be hostile to the insulation system. Therefore, assigning the correct degree of protection to the machine, as well as monitoring and ensuring the cleanliness of its winding, are good practices that can avoid serious problems, which include a possible catastrophic failure of the insulation.
Figures 1 and 2 show a wound stator, subject to surface contamination in service. The dust present in the environment, even dry, once deposited on the surface of the insulation, favored the development of partial discharges. In addition, when combined with moisture, it allowed the transfer of the surface potential from one point to another on the end windings, as it created an electrically conductive layer.
In this case, the combination of solid contaminants existing in the environment with moisture led to the development of the surface tracking mechanism. It is the current flow on the surface of the insulation, which ends up eliminating humidity in the paths through which it flows, creating areas of lower electrical conductivity. These small dry spots that appear are subject to high electric fields, as a consequence of the effect of transferring the surface electric potential from one point to another, resulting in partial discharges on the surface of the insulation.
Successive surface discharges produce by-products, which tend to form a conductive path (carbonization), electrically reducing the distance of parts suitable to very different electrical potential., developing an electric arc, or flashover, which can lead to a permanent breakdown of the insulation.

Figure 2: Tracking on the contaminated insulation surface

3. PREVENTIVE DETECTION OF THE SURFACE TRACKING MECHANISM

Based on what has been discussed so far, it is clear that excessive contamination on the winding, by itself, is undesirable. However, not every so-called “dirty” winding will develop the surface tracking mechanism, as it is necessary to combine some factors and characteristics for this.
Periodic visual inspections are a good tool for detecting surface contamination in a winding. In addition, for more quantitative evaluations, it is recommended to follow the trend of the Insulation Resistance and Insulation Polarization Index (IEEE Std 43) periodically, when there is an opportunity to stop the machine.
Monitoring the activity of partial discharges in the stator (IEEE Std 1434 / IEC 60034-27-2) provides good sensitivity to this type of degradation mechanism and can be used as a decision tool for machine shutdown and further detailed analysis of the condition of the stator. Figure 3 exemplifies, for the case addressed in this document, how the partial discharge diagnosis clearly indicated the existence of discharges of relevant magnitude (~30nC) on the surface of the end windings. It is noteworthy that the patterns and magnitudes of partial discharges can be significantly different on a case-by-case basis.

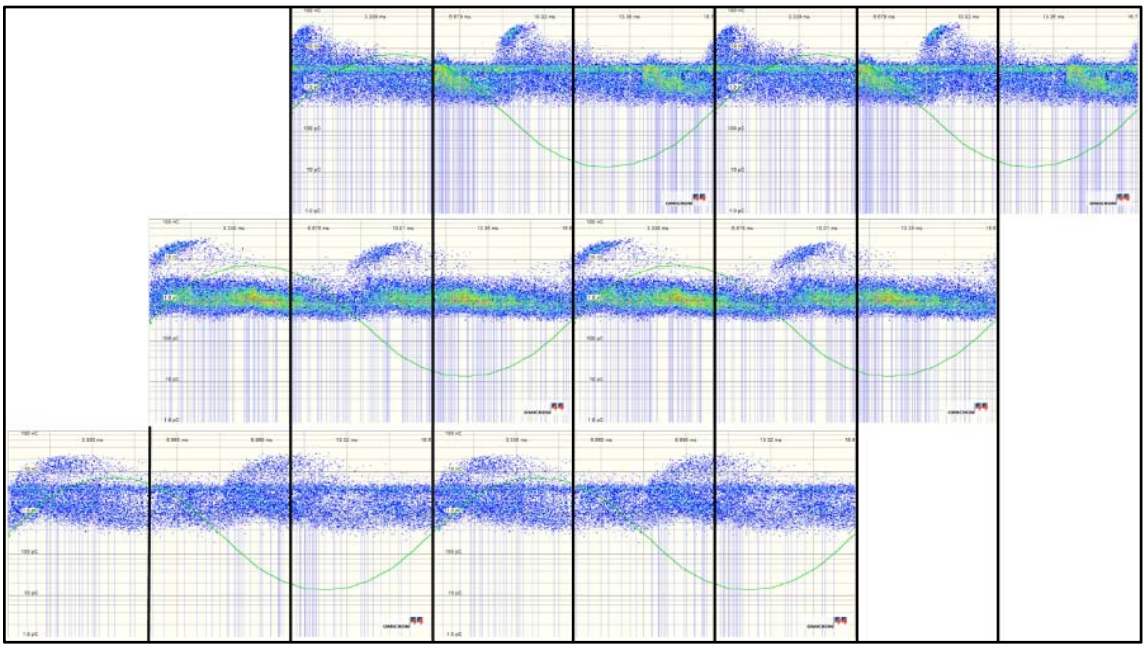

Figure 3: Example of the pattern of partial discharges in the stator discussed herein (Precondition for tracking with carbonization)

4. CORRECTIVE ACTIONS

When detected prematurely, the development of the surface tracking mechanism can be interrupted by means of adequate cleaning, followed by complete drying of the winding. On the contrary, in case of late detection, the correction method may vary in difficulty level, as it may be necessary to eliminate the conductive paths already existing on the insulation surface, requiring a complete repair work by a trained professional. Therefore, the analysis of the winding condition by a specialized professional is mandatory to define the action plan.

5. CONCLUSION

Due to the surface tracking mechanism, the presence of some types of contaminants on the surface of the insulation can, for example, bring the ground potential closer to parts with high electrical potential, subjecting regions of discontinuity of the main insulation, such as the coil terminals, to electric fields higher than is considered safe. This condition can cause accelerated degradation of the insulation and consequent premature failure (reduced service life) of the machine.
For this reason, continuous monitoring or periodic inspections of the condition of the surface of the winding are important and can avoid the need for major interventions. There are several practices that can be adopted for this purpose, from the simplest and cheapest, such as carrying out visual inspections of the windings, through the measurement of electrical quantities, to assess the Insulation Resistance and the Polarization Index of the Insulation, to the most sophisticated techniques, such as the diagnosis of the behavior of partial discharges in the winding.