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Transformer Insulating Paper Diagnosis: for a Worldwide Application of Methanol as an Innovative Marker

Mariela Rodriguez, Jocelyn Jalbert and Marie-Claude Lessard
Research Scientists, Materials Science Department, Hydro-Quebec Research Institute (IREQ)
Varennes, Québec, Canada

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Abstract
Transformer insulation paper is generally recognized as the most significant limiting factor in the thermal operating life of a transformer. Under the combined effects of temperature, oxygen and moisture, there is an irreversible rupture of the cellulose molecular chains leaving over time a weak and brittle material that has lost its mechanical strength. The measurement of the cellulose degree of polymerization allows a direct assessment of the progress of paper aging, although it is an impractical step since there is need to stop the transformer operation to extract representative paper specimens. Therefore, the identification of an oil-soluble by-product has been recognized as essential since mineral oil can be easily sampled from a unit under operation.
In the last decade, many efforts have been geared toward using methanol as a chemical marker for assessing the condition of insulating paper. This marker associated with the life of the paper presents many advantages over the well-known furanic derivatives.
In order to go further in demonstrating that methanol can be used as a universal indicator in power transformers, many laboratories ageing studies were conducted in the past. The results indicate that cellulose degradation proceeds via a random opening of the glycosidic bonds in the amorphous and crystalline regions of the material. There is also indication that a pyrolysis-like mechanism exists, even at low temperatures, together with acid hydrolysis which dominates the general ageing system. Moreover, it has been observed that the methanol concentration in oil is influenced by the partition of this molecule between the oil and the paper. Since there are temperature fluctuations during transformer operation, a temperature correction equation was developed to normalize the methanol concentrations to a specific temperature.
Even though, it has been demonstrated that methanol is an indicator of cellulose degradation and that it is possible to account for variations in the transformer temperatures, until now, no interpretation model is available for a comprehensive use of methanol by the transformer community. Further progress in this subject includes post-mortem studies of dismantled transformers, which allowed the development of an interpretation model. This model allows estimation of the average degree of polymerization of a transformer's cellulose winding from the quantity of methanol available in the transformer. Moreover, threshold values on the significance on the model determination, based on the methanol concentration, are given using this approach. The next step consists on the worldwide validation of this preliminary model using more post-mortem data analysis. This presentation will also include an overview of the contributions of other IERE group members.