A study on the chemical & structural changes of thermally aged XLPE cable insulation by FTIR and thermal analysis techniques

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Electric Power Systems comprises a large number of power cables which are quite expensive. These cables and their accessories, which are subjected to various kinds of stresses during their service life undergo ageing and deterioration of insulation and hence lead to forced outages. Forced outages are of serious concern and are not economical. Ageing processes are complex in general and take place under different stresses simultaneously or sequentially. Thermal ageing is a chemical process like molecular decomposition and oxidation of organic materials.

Over the past a few decades, the progressive deterioration of extruded cable insulation is assessed through non destructive techniques like measurement of Insulation Resistance, Dissipation factor, Loss angle & capacitance, partial discharge (PD) measurements mainly for trend analysis. However, determination of remaining life becomes the most difficult part due to lack of well-defined deterioration models, lack of adequate data, and multiplicity of failure mechanisms. The study of structural and chemical changes that insulation undergoes during ageing is scanty and not fully explored which is absolute necessity to understand the deterioration mechanisms. As suggested by CIGRE Working group 33/15.08 there is a need to apply physical / chemical tools like structural, morphological and spectroscopic procedures which do not appear to be in use for dielectric diagnosis. Such an approach seems to be desirable for understanding the ageing mechanisms in a more comprehensive way and to increase the reliability of measurements.

In this paper an attempt has been made to understand the structural and chemical changes that XLPE insulation undergoes during thermal ageing. Techniques like Fourier Transform Infrared (FTIR), Differential Scanning Calorimeter (DSC), Thermo Gravimetric Analysis (TGA), Thermo Mechanical Analyser (TMA) and Scanning Electron Microscope (SEM) were used to understand the chemical and structural changes. XLPE cable samples taken from long length distribution and transmission cables were used in the present study. The samples were subjected to accelerated thermal ageing at three different temperatures as per the international guidelines.

Experiments were conducted on fresh and aged samples in order to study the effect of thermal ageing on the chemical changes which take place in the XLPE material. The structural changes observed are the formation of carbonyl groups. The effect of ageing on the melting peak temperature Tm, melting enthalpy were examined using thermo analytical technique. The results showed that thermal ageing at temperatures above the melting temperature of XLPE has a great effect on the material structure. The decomposition temperatures of the specimens though are not that distinct from the normal curves; the derivatives precisely show the peaks at which decomposition is occurring. SEM Pictures showed a significant difference in surface morphology between sound and aged cable XLPE samples.

Key words

Dielectric diagnosis, XLPE insulation, FTIR, chemical changes, structural changes