Paper ageing analysis in power transformers

Abstract

For decades until now, manufacturers and end users alike have been absorbed by the challenge of extending the life span of power transformers. The life span of power transformers averages between 50 to 70 years, as the high capital cost of its replacement is astronomical. It is therefore essential that the utilization of the transformer can be optimized to the fullest extent of its maximum lifespan. It is generally accepted that the reliability of power and distribution transformers decreases with the ageing of their insulation system. This ageing is mainly due to the degradation of the characteristics of the insulating materials. In determining the life consumption of the transformer, measuring the degree of polymerization of the insulating paper is the more reliable way. However, this intrusive test requires a sample of the paper which means that the transformer has to be taken out from service and that portion of the unit be destroyed in the process. Therefore this method is not suitable for the transformers in service. The operating conditions of power and distribution transformers and other oil filled electrical equipment are usually monitored by measuring dissolved gasses in the insulating oil using gas chromatography. The analysis of oil samples does not represent a significant difficulty. Most electrical equipment is provided with sampling valve and a number of physical and chemical analyses can be performed both in the field and in the laboratory to determine the oil condition. Moreover, the insulating oil is widely used in predictive maintenance because its degradation under faulty operating conditions such as thermal defects, arcing or partial discharges, will produce gases that partially dissolved by the oil and their analysis may indicate the type or severity of the fault.

The deterioration of transformer insulation is primarily a function of temperature and time, but it is also influenced by other factors such as moisture and oxygen content. Therefore, most predictive maintenance techniques of the transformer are focused on the monitoring of these factors. This is quite satisfactory for the assessment of the insulation conditions of the liquid. However, the techniques adopted such as the gas-in-oil analysis cannot give an account on the condition of the paper insulation. Similar sampling technique cannot be easily implemented with cellulosic paper due to the bad accessibility from the outside of the transformer tank. Therefore, a method of assessing the condition of the paper without involving the paper sample itself is required. An in-depth oil analysis had shown the presence of 2-fulfuraldehyde and related

compounds, where these compounds are known to be specific to the degradation of cellulose and other paper constituents [1-3]. One such in-depth oil analysis is known as the High Performance Liquid Chromatography (HPLC). When the cellulosic insulation materials within a transformer undergo degradation, either by normal aging or by being involved with an incipient fault, among the by-products formed are carbon monoxide and carbon dioxide gases and derivatives of the aromatic compound called furan. Thus the amount of furans present in the oil might be a good indication of the cellulosic insulation condition. In this work, the degradation of Kraft transformer insulation paper is examined by means of monitoring the increase in the concentration of furan compounds as well as the increase of moisture content.