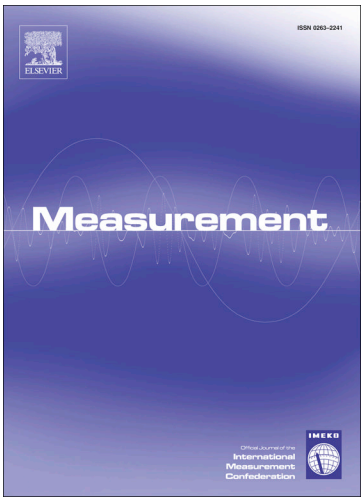

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Monitoring Power Transformers Oils Deterioration Using Structured Laser Illumination Planar Imaging

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Abstract

Reliable quality assessments of oils in power transformers are important as they provide valuable information regarding the proper functioning of transformers. Thus, an early and accurate diagnostic of power transformers oils can prevent potential failures of transformers. In this paper, an imaging technique known as Structured Laser Illumination Planar Imaging (SLIPI) was used to monitor the extinction coefficient μ_e in various oil samples. The proposed technique offers the advantage of extracting the light intensity contribution from singly scattered photons and rejecting most of the light intensity from photons that have been scattered many times. This leads to more accurate and reliable measurement of the extinction coefficient μ_e, in optically dense oil samples. The variation of the extinction coefficient was therefore determined as a function of oil aging. The results demonstrate that SLIPI is reliable as a practical measurement method for the diagnosis of power transformer oils and present an attractive solution, alternative to the conventional methods such as Dissolved Decay Products, Interfacial Tension and Turbidity.

Keywords: extinction coefficient; structured illumination; transformers oil diagnosis; dense turbid media.

1. Introduction

Power transformers are key components for electrical energy generation and delivery [1]. Degraded oil in transformers affects the power delivery and can lead to functioning failures. It is therefore critical to control and anticipate the proper functioning of power transformers by monitoring their insulation. The diagnosis of transformers is thus vital for their proper maintenance and to improve their operating conditions, which ensure a reliable and efficient supply of electricity [2]. The oil content and condition tell us about the degradation and the ageing of power transformers; therefore, it serves as diagnostic target as it contains approximately 70% of these diagnostic information [3-5]. Thus, the diagnosis of oils has long been the focus of several research projects, ultimately leading to the development of various diagnostic tools. Among these diagnostic tools, electrical-based methods allow to determining certain properties non-destructively such as the relative permittivity and dissipation factor, the capacitance, polarization index, resistivity, dielectric strength, partial discharges, electrostatic charging tendency, etc [6]. The results of these measurements provide an average value of the whole insulator volume, electrically and geometrically heterogeneous, and they do not characterize the status in a specific point of the material. The role of these methods is nevertheless very important to monitor the condition of the transformer by comparison with previous or suggested limit values. Physicochemical methods, such as the water content in oil [7-9], and the analysis of dissolved gas in the insulation oil are also widely used. Various standards/methods have been developed for the interpretation of these dissolved gas analysis. The most commonly used interpretation methods are [10]: the IEEE C57.104-1991, Doernenberg, Rogers, IEC 60599 and the Duval's triangle. The main problem concerning this technique lies in the determination of the limit values for simple gases. However, gas chromatographs are very expensive. Other techniques such as the total acid number in oil [11], the interfacial tension (IFT) [12] are also widely used. IFT test require experienced user and also, some precautions have to be taken as indicated in the American Society for Testing and Materials (ASTM), ASTM D971 in order to do measurements. Methods based on spectral analysis also exist, including spectrophotometric absorption measurements of the oil samples. In this case, light that passes through the contaminated oil is attenuated by the absorbing elements [13]. The results obtained allow assessing the relative amount of dissolved decay products (DDP) in oil. Furthermore, it should be noted that these different diagnostic methods mentioned above are for the most part time consuming and very expensive. Moreover, regarding the