Chapter 6
Oil and Paper Insulation for DC Converter Transformer

ABSTRACT

Transformer oil and oil-impregnated paper, serve as the essential parts of converter transformer, suffering various electric fields. The accumulation of surface charge on the paper would lead to flashover. When the power flow of the HVDC system is reversed, the charge field will easily lead to discharge. Direct-fluorination is a method which could affect the material property without alternating the bulk property. Besides, a new type of nano-modified transformer oil is a method to improve properties. This chapter presents a study of the effect of fluorination on surface charge behavior, the effect of polarity reversal voltages on interface charge behavior and the effect of Boron nitride (BN) nanoparticles on the high thermal conductivity of transformer oil. Results show that fluorination had an influence on the chemical property of the paper and BN nanoparticles has improvements in heat transfer process. In the polarity reversal test, the dissipation rate becomes smaller as the reversal time gets longer.

INTRODUCTION

In recent year, with the development of the worldwide power industry and voltage levels, the capacity and level of power transformers are increasing. The HVDC system is becoming very popular and its safe operation of high capacity converter transformers is related to the security of entire grid.
Meanwhile, transformer oil and paper are vital essential parts of EHV and UHV transformers, and oil–paper insulation is also commonly used in large power transformers. As a bridge between AC and DC transmission systems, the valve side of the main insulation in the converter transformer under normal conditions should have considerable ability to withstand the AC and DC voltages. Due to the imbalance of permittivity and resistivity in mass dielectrics such as the transformer oil, pressboard, and others, the interface between the dielectrics will accumulate charge (Wada et al., 2006; Yang et al., 1997; Xu et al., 2016; Hanaoka et al., 2002). When the power flow of the system is reversed or a sudden outage occurs, the local electric strength of the dielectrics will have a serious distortion, most likely leading to the occurrence of discharge or insulation damage. Owing to the fact that the flashover breakdown field strength along the oil–paper interface direction is lower than the bulk field strength which is vertical to the interface, surface discharge can occur easily, and will cause power failures. So the effect of the interface charge on oil–paper insulation becomes the topic of focus (Huang et al., 2014).

Oil–paper insulation dielectrics are complex combinations of solid–liquid two–phase morphology, and the injection, transport, accumulation, attenuation characteristics and mechanism of space charge are not entirely clear yet. These characteristics are closely associated with aging and damage mechanisms and directly affect the variation in electrical performance and insulation life of oil–paper insulating dielectrics. Direct-fluorination is a method to modify the chemical constituents of the material which possess the advantage of alternating the surface property only and leaving little modification on the essential property of the matrix, and thus, has been widely applied in many areas (Yi et al., 2015; Saulnier et al., 2013; Charlet et al., 2015; Prorokova et al., 2015; Lee et al., 2009). In recent years, researches have focused on the paper applied in transformers for improved dielectric properties (Chen et al., 2014; Zhuge et al., 2015). However, most studies on direct-fluorination have concentrated on the chemical stability, wettability, mechanical strength, etc. Few researches discussed the effect on electrical property after the treatment. In recent research, efforts have been paid on the surface modification of insulation material for improvement on the dielectric property.

Moreover, the oil applied in transformers is highly refined mineral oil which performs dual functions of insulating and cooling materials. The oil fills up the pores in the fibrous insulation thus affecting the dielectric property of oil-
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