



Remarkable Tanδ Suppressin of Oil Filled Cable Insulation with Extremely Degraded Tanδ Oil

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ABSTRACT

The following two effects ((1)&(2)) cause the peculiar phenomena of the remarkable tanδ suppression in oil impregnated paper with extremely degraded tanδ oil. (1)Tanδ decrease in high electrical stress (including operating stress of oil filled (OF) cable) region by so-called Garton effect.

(2) Tanδ decrease due to the absorption of ionic substance in oil to the insulating paper.

These effects were also confirmed in OF cable splice box insulation flowed by extremely degraded tanδ oil, together with the locally degraded tanδ portions such as the boundary layer between cable paper and joint paper.

KEYWORDS: oil filled cable, degraded tanδ oil, Garton effect, absorption effect

1. Introduction

Many of oil filled (OF) cable (self contained fluid filled cable) has been applied for 66~500kV extra high voltage cable system for a long time. Extremely high dielectric loss (tanδ) of oil (several tens % of tanδ, for example) is occasionally observed in splice box etc.

The relation between oil tanδ and oil impregnated paper tanδ according to simple combination model of oil/paper expressed as equation (1) is shown in Fig.1.

$$\tan\delta = (\theta_f \varepsilon_f^K \tan\delta_f + \theta_o \varepsilon_o^K \tan\delta_o) / \varepsilon^K \dots (1)$$

(subscript : f paper fiber, o oil, & tan : value for oil impregnated paper
θ volume fraction, ε relative permittivity
k=-0.5 for insulating paper structure)

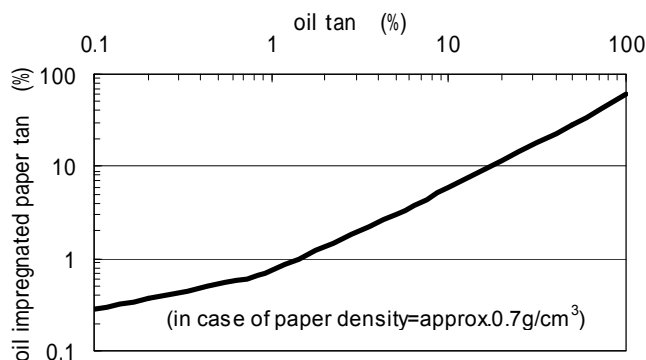


Fig.1 Relation between oil tanδ and oil impregnated paper tanδ according to simple combination model (equation(1))

Naturally when oil tanδ is extremely high, oil impregnated paper tanδ is also extremely high. (for example, oil tanδ =10% oil impregnated paper tanδ =5.5%, oil tanδ =50% oil impregnated paper tanδ =30%) In that case, thermal breakdown by the dielectric loss must occur. However, such an event has never taken place so far. This fact suggests that some tanδ suppression mechanism has acted in the oil impregnated insulation.

In this paper, tanδ characteristics of extremely degraded tanδ oil impregnated paper was investigated in detail and the feature of tanδ in OF cable splice box insulation flowed by degraded tanδ oil was also examined.

2. Tanδ characteristics of extremely degraded tanδ oil impregnated paper

The degraded alkyl-benzene oil (AB-oil) and mineral oil (M-oil) used for OF cable with the tanδ level of approx. 10% and 50% (at 80 °C) were prepared by the thermal oxidation of oil combined with the organic material coated copper tape. As shown in Fig.2, after the insulating paper was set into the plate electrode and was dried by the vacuum heating, degassed and dehydrated degraded tanδ oil was introduced. Oil impregnated paper tanδ (50Hz, temperature: RT ~ 120 °C, electrical stress:0.1 ~ 20kV/mm) was measured under the oil pressure of approx. 0.5kg/cm².



insulating paper: : thicknes=200 μm, density=approx.0.7g/cm³
kind of oil : alkyl-benzene oil(AB-oil), mineral oil(M-oil)
oil tanδ : tanδ =0.01% (new oil), tanδ =10%, tanδ =50%

Fig.2 Plate electrode for oil impregnated paper tanδ measurement (just after setting insulating paper& before intoduction of oil)