THERMAL MODELING OF HV SURGE ARRESTER

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Dedication to my beloved father, Che Ani bin Mad, my wife, Zawani binti Mohd Yusof and my sonswhom support me, physically, mentally and emotionally, throughout my Master's study.

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ABSTRACT

The gapless metal oxide surge arresters have been available in the market for many years since they were first introduced in the 1970's. Its primary function is to protect the equipment in the system against various electrical overstresses. They are widely used for lightning protection of power system equipment. A reliable condition monitoring of zinc oxide surge arrester is vital to its performance to ensure the continuity and reliability of power supply. It is known that voltage-current characteristics of zinc oxide varistors become degraded due to a series of stresses. Leakage current of the surge arrester can be increased by some environmental factors. This fact has a significant effect on the arrester performance resulting in the eventual failure of the surge arrester. The aim of this study is to investigate the effects of the ageing mechanism of the gapless surge arrester using COMSOL software. A 10kA, 132kV rated gapless zinc oxide surge arrester was modeled in the software using actual dimensions. The different temperature is modeled and simulated in the software. The results show that the ageing of the gapless zinc oxide surge arrester is dependent on its internal temperature, surface temperature. This is to say that there is a relationship between the arrester's surface temperatures. The surface temperature increases as the ageing increases. Ageing can be simulated by either the increase in leakage current artificially or changing the material properties.

ABSTRAK

Gapless arresters logam oksida lonjakan (MOSA) telah terdapat di pasaran selama bertahun-tahun kerana mereka telah mula diperkenalkan pada tahun 1970-an. Fungsi utamanya adalah untuk melindungi peralatan dalam sistem daripada pelbagai tekanan berlebihan elektrik. Mereka digunakan secara meluas untuk perlindungan kilat peralatan sistem kuasa. Keadaan pemantauan dipercayai zink oksida lonjakan penyekat adalah penting untuk prestasi bagi memastikan kesinambungan dan kebolehpercayaan bekalan kuasa. Adalah diketahui bahawa ciri-ciri voltan semasa zink varistors oksida menjadi rendah sejajar dengan siri tekanan. Arus bocor penangkap lonjakan boleh ditingkatkan dengan beberapa faktor persekitaran. Fakta ini mempunyai kesan yang besar ke atas prestasi penangkap mengakibatkan kegagalan akhirnya penyekat lonjakan. Tujuan kajian ini adalah untuk mengkaji kesan faktor-faktor persekitaran yang berbeza seperti kelembapan suhu penuaan penangkap lonjakan gapless menggunakan perisian COMSOL. A gapless zink oksida lonjakan Penyekat, voltan 132KV tertinggi dan kelas 10KA, dimodelkan dalam perisian. Semua dimensi adalah sama seperti arresters yang telah pun digunakan dalam eksperimen dan mengikut standard. Faktor-faktor suhu dimodelkan dalam perisian dengan menukar suhu persekitaran. Akhirnya keputusan simulasi dibandingkan dengan data eksperimen yang ada. Keputusan menunjukkan bahawa penuaan gapless zink oksida lonjakan penyekat adalah bergantung kepada suhu dalaman dan suhu permukaan.

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HV	High Voltage
ZnO	Zinc Oxide
^{o}C	Degree Centigrade
kV	Kilo Volt

CHAPTER 1

INTRODUCTION

1.1 Project Background

Surge arresters are important equipment for the protection of expensive electrical in the systems. The monitoring of this equipments plays major rule for this system integrity, an arrester failure may results in and its explosion of system turn off.

Thermal modeling is one of the most techniques for monitoring high voltage devices. It registers the temperature gradient along the equipments surface, indicating thermal profile of the surge arrester. For zinc oxide (ZnO) arresters, this technique presents a limitation. Because of the low thermal conductivity of the polymeric housing there is no direct relation between the temperatures on the housing surface and the temperatures on varistors.

A solution for this limitation is the development of computational simulation to make this correlation. This paper presents a simulation based on COMSOL software that makes the heat transfer over all the arrester indicating the temperature of any desired point. It considers polymeric housing arresters used to simulate the thermal model of surge arrester using the difference voltage applied to the surge

arrester in order to observe the thermal behavior with difference voltage source. A comparison between two difference voltage sources to the arresters is also present.

1.2 Problem Statement

Generally the main reason the surge arresters should be periodically monitored is to avoid the damage on electrical equipment. Years of experience revealed that the degradation of the surge arresters results in increase in resistive component of a leakage current.

Gapless ZnO surge arrester is widely used for lightning protection of power system distribution and transmission equipment. When surge arrester functioning normally in power station, it should be able to withstand the effects of operating voltage, lightning and switching overvoltage. A reliable condition monitoring of ZnO surge arrester is vital to its performance to ensure the continuity and reliability of power supply.

It is important to know the thermal characteristic in order to determine the arrester is working properly. When the surge arrester absorbs the impulse current from lightning or switching overvoltage, degradation may occur.

Previously some researchers carried out different tests such as multi stressed situations, salt fog tests, etc under humid and polluted conditions to estimate the ageing of the surge arrester [9, 10, 18]. Most of the ageing detection techniques done before are based on leakage current measurement and thermal profile of the surge arrester since it is found that the total leakage current measurement and thermal imaging are two reliable indicators of surge arrester ageing level [11, 13]. It is also believed that there is a relationship between the ageing, leakage current and temperature of the surge arrester. However, there are still unanswered questions

regarding the effects of environmental factors on the ageing prediction. Increased leakage current has a significant effect on the arrester performance resulting in the eventual failure of the surge arrester.

When voltage is applied to surge arresters, the temperature also give a significant influence on the arrester leakage current. If the temperature is higher, it will cause the increase of resistive component of the arresters leakage current. This phenomenon is strongly dependent on the arrester material.

This research aims to study the thermal profile using a simulation work based on COMSOL software.

1.3 Objective of Project

The objectives of this project are:

i. Study a representative model of the thermal properties at the arrester valve element and housing.
ii. To observe the principle of heat transfer using zinc oxide and polymeric housing.
iii. To simulate the physical principle of the heat transfer of HV surge arresters using COMSOL software.

1.4 Scope of Project

In order to achieve the objectives of the project, several scopes had been outlined. The scopes for this project are:

i. Literature review on the temperature effect.
ii. Utilization of COMSOL software in order to simulate the thermal model of 132kV zinc oxide surge arrester.

1.5 Significance of Project

Studies of the thermal are very attractive in search of proper tools that could help in the evaluation of the surge arrester life time (aging) under simulated “real” operative conditions for any arrester in particular. COMSOL multipysics is a proper choice for designing the simulation for the thermal effect of 132kV surge arrester with polymeric housing. Finally by collecting different results, discussion and comparison are done for reaching to a final conclusion.

1.6 Report Outline

In general, this report mainly consists of five main chapters; introduction, literature study, methodology, results and analysis and conclusion and future work. Chapter one discussed the research project in collectively. This chapter explained the background, problem statement, objective, scope and significance of the project.

Chapter two completely dedicated to literature study about zinc oxide surge arrester. In this chapter, the discussion is more to the combination of the structure and the thermal effect due to thermal. Chapter three explains on the methodologies that have been done in order to simulate the thermal effect of surge arrester. Chapter four discussed in depth on the obtain simulation results. The result will be analyzed in terms of thermal. Chapter five describe on the conclusion and future work suggestion in improvising this research.

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