Djoumé SALVETTI
Université Paris-Sud Orsay
DEA Génie Électrique

ALSTOM
DGX260-WK22-0001FR-A

Transformer
Research Center

Bibliographic Report

To study the usage of EMTP for low frequency model.

Application of a Power Transformer.

April 9, 2003

Contents

Abstract

Uncontrolled energization of power transformers may results in large inrush current which reduce the power quality of the system and can even damage the transformer. Therefore these currents have to be predicted with the highest possible accuracy by transformers manufacturer.

In this paper, the usage of EMTP for Inrush current calculation was investigated. After a general presentation of the software, the capabilities of EMTP in transformer modelling was studied and several inrush current calculations were performed. While results from EMTP are very close than results from SABER, the usage of EMTP for inrush currents calculations is thus validated.

However, to increase the accuracy of simulations, an Hopkinson based model would be required.

Key Words : Power transformer, inrush current, simulation, ATP-EMTP, SABER.

Résumé

La mise sous tension des transformateurs de puissance peut être à l'origine d'importants courants d'enclenchements qui réduisent la qualité de la puissance délivrée et peuvent même endommager les transformateurs. C'est pourquoi ces courants doivent être prédéterminés avec la plus grande précision possible par les fabriquants de transformateurs.

Ce rapport de stage étudie l'utilisation d'EMTP pour le calcul des courants d'enclenchement. Après une présentation générale du logiciel, les possibilités qu'offre EMTP pour la modélisation des transformateurs sont étudiées. Plusieurs simulations de courants d'enclenchement ont été faites. Les résultats d'EMTP étant très proches de ceux obtenus avec SABER, l'utilisation d'EMTP pour la simulation de courants d'enclenchements est donc validé.

Cependant, pour améliorer la précision des simulations, un modèle basé sur la représentation d'Hopkinson serait nécessaire.

Mots clés : Transformateur de puissance, courants d'enclenchement, simulation, ATP-EMTP, SABER.

Acknowledgements

I would like to acknowledge all the people of the Transformer Research Center of ALSTOM at Saint Ouen to have welcomed me in their team and for their friendly assistance.

This was a very nice experience for me to work in an industrial and international environment and I am sure it will be useful for my future career of teacher.

I would like to express special thanks to François Devaux, responsible of the TRC, for offering me the opportunity to make this intership and to Jan Prins, for not only supervising this internship, but spending all the time I need to discuss about any kind of issues I had to faced up and always give me some valuable suggestions.

Introduction

Power transformers in electric systems are one of the most cost effective apparatuses. Breakdown causes high costs for repair or replacement and may often lead to very high costs due to temporary loss of the power delivery capability.

Uncontrolled energization of large power transformers may results in large dynamic flux and saturation in one or more winding cores of the transformer. This saturation results in inrush current which have an amplitude in the range of the short circuit current and may produce severe dynamical stress in the windings [1] [2].

The amplitude of these inrush currents usually does not exceed the fault current withstand capability of the transformer, however the duration of these stresses are significantly longer and occurence is more frequent than of the short circuit which is normally cleared by the protection relays within some tenth of milliseconds.

It is assumed that due to the unbalanced magnetomotives forces and high saturation of the transformer core, local (axial) forces under severe inrush conditions could exceed the dimensioning criteria for support structures of the coils (bandages, wedges and heavy bolts). So it seems likely possible that conductor and winding insulation are damaged due to mechanical overstress at inrush.

In fact damages are mostly in the form of reduction of insulation capability, dues to an attrition of winding and conductor insulation material, which may cause insulation failures a certain time span after the occurence of high inrush currents.

Besides these deteriorations of the insulation and mechanical structure of winding, inrush current reduce the power quality on the system and may cause false relay protection operations. A dangerous overvoltage may also occur if the inrush current is interrupted due to a false differential protection [3].

Due to evolutions in transformer technology the inrush currents reached during energising have increased [4]. ALSTOM, as a Power Transformer manufacturer, has to pay much attention on value and shape of these inrush currents to give quality assurance on the performance of the transformer to his customers.

SABER has been used in the Transformers Research Center (TRC) of ALSTOM for inrush currents calculation for a long time. But due to the increasing cost of his license fee and a limited usage of the capability of the program, another alternative is necessary.

The purpose of this internship is to study the capabilities of EMTP, a widely use electromagnetic transient program, for inrush current and voltage drop calculation as a replacement of SABER.

To be able to give some conclusions on the feasibility of the replacement of SABER, a good knowledge of EMTP operation is required. That is the object of the first two chapters.

The third chapter deals with builtins capabilities of ATP-EMTP in transformers modelling. An inventory of the built-in models and subroutines of EMTP in concern with transformer modelling was made.

In the fourth chapter, all simulations principles are presented in a step by step inrush current calculation. Then a test program is performed and results are compared with results from SABER to validated the usage of EMTP for inrush current calculation.

The last chapter talks about some others transformer modelling approaches that would be possible to adopt to increase the accuracy of our inrush current calculation. These modelling approaches could also be useful for some other low frequency studies such as flux distribution calculation or faults studies.