UNIVERSITI PUTRA MALAYSIA

USING A DYNAMIC THERMAL MODEL APPROACH TO ESTIMATE LOSS OF LIFE OF MINERAL OIL-IMMERSED TRANSFORMERS

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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Chairman : Mohd. Zainal Abidin Ab Kadir, PhD

Faculty : Engineering

Transformers are among the most important equipment in electrical power systems, where their operations play the main roles in providing the reliable power systems. Because of the high cost of transformers and their permanent connections to the transmission and distribution systems, reliable measures are needed to extend the life span. Insulation life of the transformer and loading capabilities depend on several parameters, among which cooling mode, ambient temperature, oil viscosity are critical. Hot spot temperature is a major factor on the insulation life of the transformer. To predict the hot spot temperature and top oil temperature, many principal models have been proposed such as the classic thermal model, and thermal-electrical models.

This research attempts to determine an accurate hot spot temperature, hence evaluate the loss of life of the transformer according to the numerical analysis method. Top oil temperature and hot spot temperature were determined by an accurate thermal model which takes into account the dynamic parameters such as ambient temperature, oil

viscosity, winding losses, and loading profile. IEEE standards and thermal-electrical model, which are regarded as the two acceptable and reliable thermal models, have been used as underlying principles of this research.

Both linear and non-linear regressions have been used for solving these thermal models. The Runge-Kutta numerical method is proposed in this study for solving the thermal model and for carrying out the work on different types of the transformer based on the data that have been collected from heat run tests, loading profile and electrical and physical characteristics of each transformer. An alternative solution for solving the thermal model is proposed in this study. Results are compared with the actual temperature and hot spot temperature in the IEEE standards. Since data has been collected from different types of electrical transformers, this thesis proposes a model which is based on the previous researches that are carried out on 187 MVA, 2.5 MVA, 30 MVA and 250 MVA transformers.

The prediction of top oil temperature and hot spot temperature is very important for estimating the loss of life of the transformer in the system. Therefore, such an accurate technique is needed for solving the thermal models. The findings reveal that the uses of numerical methods are in good agreement with the measured values when comparing with the traditional methods. In addition, based on the theoretical definition and results obtained, the proposed fourth order Runge-Kutta has given reasonably good accuracy among other numerical methods such as the second order Runge-Kutta and Euler methods. This has led to an improvement in calculating the

top oil temperature and hot spot temperature, as well as in predicting the loss of life of the transformer.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENDEKATAN MODEL TERMA UNTUK PENGANGGARAN MUATAN BAGI PENGUBAH-PENGUBAH TERENDAM MINYAK GALIAN

Oleh

MOHAMMAD TOLOU ASKARI SEDEHI ESFAHANI

Mei 2010

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Pengubah adalah salah satu peralatan yang penting dalam sistem elektrik kuasa di mana operasinya merupakan peranan utama dalam menyediakan kebolehharapan dan kualiti bekalan kuasa. Disebabkan oleh kos pengubah dan sambungan kekal untuk penghantaran dan sistem agihan, sebarang peningkatan diperlukan untuk melanjutkan jangka hayat alat pengubah tersebut. Hayat penebatan bagi pengubah dan keupayaan pemuatan bergantung kepada beberapa parameter seperti suasana pendinginan, suhu ambien, kelikatan minyak dan sebagainya. Suhu bintik panas telah memainkan faktor paling berkesan pada penebatan hidup alat pengubah. Untuk meramalkan suhu bintik panas dan suhu minyak atas, banyak prinsip model telah dicadangkan seperti terma klasik model, dan terma-elektrik.

Penyelidikan ini cuba menentukan suhu bintik panas yang tepat dan menilai kehilangan hayat pengubah itu mengikut cara penganalisis berangka. Suhu minyak atas dan suhu bintik panas telah ditentukan oleh satu model terma yang tepat di mana dinamis parameter seperti suhu ambien, kelikatan minyak, kehilangan gegelung dan profil pemuatan diambilkira. Piawaian IEEE dan terma elektrik model, dianggap sebagai dua terma yang boleh diterima dan boleh dipercayai yang telah digunakan sebagai prinsip kerja ini.

Model-model terma ini telah diselesaikan menggunakan kaedah regresi secara linear dan tidak linear. Kaedah berangka Runge-Kutta telah disarankan sebagai kaedah penyelesaian kepada model-model terma tersebut dan juga sebagai pelaksana tugasan yang dijalankan ke atas pelbagai jenis alat pengubah berdasarkan kepada data yang telah dikumpulkan daripada ujian larian haba, profil muatan dan ciri-ciri elektrikal dan fizikal setiap alat pengubah tersebut. Semua keputusan dibandingkan dengan suhu sebenar dan suhu bintik panas dalam piawaian IEEE. Disebabkan data-data dari pelbagai jenis alat pengubah ini berbentuk diskret, tesis ini mencadangkan suatu model yang berasaskan kerja-kerja yang dilaksanakan pada pengubah-pengubah 187 MVA, 2.5 MVA, 30 MVA dan 250 MVA.

Ramalan bahagian suhu minyak atas dan suhu bintik panas adalah amat penting untuk menganggarkan jangka hayat alat pengubah di dalam sesuatu sistem. Oleh yang sedemikian, satu teknik tepat diperlukan untuk menyelesaikan model-model terma. Penemuan-penemuan mendedahkan bahawa penggunaan kaedah-kaedah

berangka berada dalam landasan yang baik dengan nilai-nilai yang diukur apabila dibandingkan dengan cara-cara tradisional. Sebagai tambahan, berdasarkan definisi teori dan keputusan yang diperolehi, Runge-Kutta peringkat keempat yang dicadangkan telah memberi ketepatan agak baik berbanding kaedah-kaedah berangka lain seperti Runge-Kutta peringkat kedua dan Euler. Ini telah menyebabkan satu peningkatan di dalam pengiraan suhu minyak atas dan suhu bintik panas, dan juga dalam penganggaran jangka hayat alat pengubah.

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I certify that an examination committee met on month/date/year to conduct the final examination of Mohammad Tolou Askari Sedehi Esfahani on his Master of Science thesis entitled "Dynamic Thermal Model Approach to Estimate Loading of Mineral Oil Immersed Transformer" in accordance with University Putra Malaysia (higher degree) act 1980 and University Pertanian Malaysia (higher degree) regulations 1981. The committee recommends that the candidate be awarded the relevant degree.

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently submitted for any other degree at Universiti Putra Malaysia or at any other institutions.

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