CIGRE WG A2.38 - Transformer Thermal Modelling
Progress Report, August 2010

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Summary

The Working Group was initiated as a result of a proposal at the CIGRE SC meeting in Bruges, October 2007, and became operational in mid 2008.

Members

The membership comprises a good balance between manufacturers and utilities and includes several young engineers. The membership is restricted to active participants who can contribute to the development of the subject. We do not intend to distinguish between full and corresponding members: any members who cannot attend meetings in person are expected to contribute via webcam. Some inactive members have been removed from the circulation list.

	Members	Company	Country
1	John Lapworth	Doble Powertest	UK
2	Dejan Susa	SINTEF	Norway
3	Guenter Fleck	Siemens	Austria
4	Patrick Picher	Hydro-Québec (IREQ)	Canada
5	Hasse Nordman	ABB	Finland
6	Frank Trautmann	Siemens	Germany
7	Shinji Yamamura	Toshiba	Japan
8	Cees Spoorenberg	Smit	Netherlands
9	Jurjen Kranenborg	ABB	Sweden
10	Mohamed Ryadi	Areva	France
11	Nico Gunter	Powertech	South Africa
12	Stefano Zunino	Terna	Italy
13	Valery Davidov	Monash University	Australia
14	Edward Simonson	Southampton Dielectric Consultant	UK
15	Oleg Roizman	IntellPower	Australia
16	Wei Wu	University of Manchester	UK
17	Gordon Wilson	National Grid	UK
18	Wim Van der Veken	Pauwels	Belgium
19	Jacques Aubin	GE	Canada
20	Damien Laval	EDF	France
21	Hugo Gago	Iberdola	Spain
22	Joaquin Gortazar	Union Fenosa	Spain
23	Mohinder Pannu	Wilson Transformers	Australia
24	Zhong JUNTAO	Shenbian	China
25	Zoran Radakovic	University of Belgrade	Serbia
26	Tim Gradnik	EIMV	Slovenia
27	Alberto Prieto	ABB	Spain
28	Frederique Berthereau	Jeaumont Schneider Transformers	France

Meetings

Our meeting schedule has been as follows:

Meeting	Venue	Date
1	Godalming, UK	June 16-17, 2008
2	Paris	August 28, 2008
3	Stuttgart	December 9-11, 2008
4	Montreal	June 9-11, 2009
5	Cordoba, Spain	January 2010
6	Paris	August 27th, 2010

The next meeting will probably be held in Sydney or Melborne, Australia, in May 2011, to co-incide with the Asia Pacific Techcon Conference and an Australia A2 Panel Conference.

Progress

During the early meetings, members gave presentations outlining the state of the art in their companies/countries and identified areas where the Working Group could usefully contribute to the development of the topic.

We then proposed to share the characteristics of a transformer from a utility in Canada and we asked the members to perform thermal modelling calculations on this example. The results of the members were presented at subsequent meetings. Some additional simulations were required to complete this exercise, including calculations of stray losses, and the preliminary findings are interesting, showing some unexpected variation in results. The results of the modelling using various tools on the common geometry will be reported in the brochure and it will hopefully form a valuable contribution to the transformer industry, with new knowledge, particularly relating to the differences between ON and OF cooling, and the relative benefits of CFD and network models.

We are looking forward to receiving additional information on modelling and the use of fibre optic temperature sensors from Paris 2010 Session papers.

We are ready to prepare an interim summary of progress in the form of an Electra article.

The annex presents a proposed outline (first draft) of the brochure.

Annex: Proposed outline of the brochure (draft #1)

Introduction

Definitions

Steady state & dynamic thermal modelling

Purpose of thermal modelling

Applications for new and existing transformers
Example of failures caused by poor thermal performance

Steady state modelling

Losses calculation (Q factor)
- List of parameters required (geometry, material characteristics, etc.)
- RI2 losses
- Eddy & stray losses calculation
  - Eddy losses in windings
  - Stray losses in other metallic parts
- Critical parameters affecting the accuracy

Temperature calculation (S factor)
- List of parameters required (geometry, material characteristics, etc.)
- Analytical model
- Thermal Network Modelling (TNM)
- Computational Fluid Dynamic (CFD)
- Typical S factors vs. winding/cooling design? S vs. flow rate?
- Critical parameters affecting the accuracy

<u>Example: 66 MVA transformer LV winding</u>

Losses calculation by WG members
- Summary of results
- Derivation of Q factor
- Discussion / conclusion

Temperature calculation by WG members
- Summary of results
- Derivation of S factor
- Discussion / conclusion

Dynamic thermal modelling

State of the art (IEEE 'Annex G', IEC 60076-7, 'improved' models from D. Susa)
List of parameters required to perform dynamic thermal modelling

Heat Run Test
- Normal
- Extended

Parameters determination from factory testing
Exponents x, y, z
Time constants
'Hot spot' factor
Examples

Direct measurements

Applications
FO for windings
Thermocouples for other metallic parts
Good practices for FO measurement
Examples

Annex : Thermal modelling of shell-type transformers

Review of the design
List of parameters required for thermal modelling
3D calculation of leakage flux and eddy losses
Temperature calculation
Critical parameters affecting the accuracy
Application of direct measurement