MANCHESTER 1824
The University of Manchester

Effectiveness of Using Simplified Methods to Estimate Transformer Loss of Life

Introduction

The actual loss of life (LOL) of a transformer is a useful figure for an asset owner / operator to know for replacement planning. The LOL is estimated by calculating the hottest spot temperature (HST), ϑ_h, and then applying a known relationship to a 'rated temperature' (usually 98 °C) using the equation $V = 2^{(\vartheta h-98)/6}$.

HST can be intensive to calculate and the input data required for calculation of a dynamic factor can be costly. It is therefore desirable to have a method of estimating the HST and hence LOL of a transformer which reduces calculation effort.

Three methods of doing so are proposed:
1. root-mean-squared (RMS) method
2. two-step method as described in [1]
3. half-hourly averaging

These three methods are assessed for their ability to match the baseline calculation in estimation of LOL. Examples of the load profiles are shown in Figures 1 and 2.

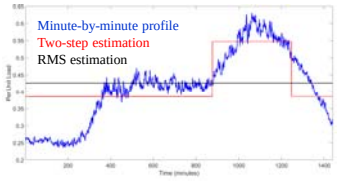

Figure 1 – Well-matching two-step, poorly matching RMS load profile

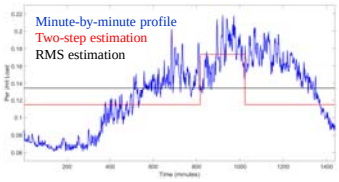

Figure 2 – Well-matching RMS, poorly-matching two-step load profile

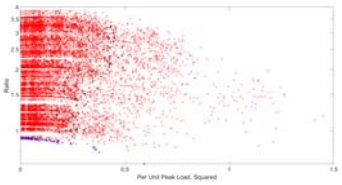

Figure 3 – RMS results as ratioed against full calculation

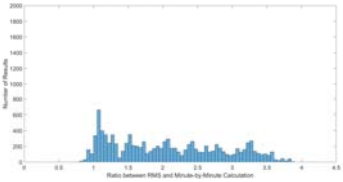

Figure 4 – Histogram of RMS results

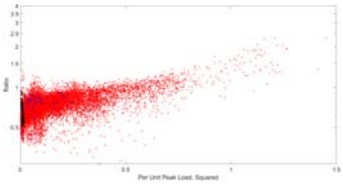

Figure 5 – Two-step results as ratioed against full calculation

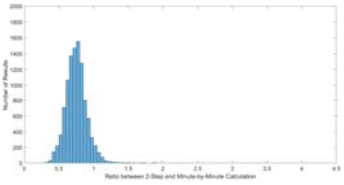

Figure 6 – Histogram of two-step results

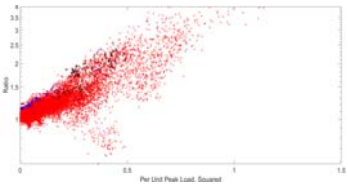

Figure 7 – 30 Minute averaged results as ratioed against full calculation

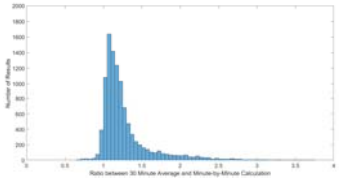

Figure 8– Histogram of 30 minute averaged results

Results

- Figures 3, 5 and 7 show the relationship between the squared value of the peak load and the ratio to the minute-by-minute calculations (shown on a log scale) for 81 transformers, over 137 days.
- Blue points show the data for one day, and black points for one transformer.
- Figures 4, 5 and 8 show the variation of the ratio to the minute-by-minute calculation.
- Table 1 shows:
  - model accuracy
  - computational savings

Table 1 – Results summary table

	RMS	Two-step	30 Minute Average
Results within ±10%	11.9 %	12.2 %	30.2 %
Time Saved	86.80 %	82.32 %	83.74 %

Conclusions

The results of this study show:
- that it is hard to simplify the calculation of transformer LOL.
- LOL is dominated by ambient temperature (not load) for transformers that are low-loaded (especially in the RMS case).
- computational time saving is made using simplified methods

As absolute LOL is low (minutes per day), this level of (in)accuracy may be deemed acceptable when considering the time saved in calculation.

References

"IEEE Guide for Loading Mineral-Oil-Immersed Transformers and Step-Voltage Regulators," *IEEE Std C57.91-2011 (Revision of IEEE Std C57.91-1995)*, pp. 1-123, 2011.

Transformer Research Group
School of Electrical and Electronic Engineering
The University of Manchester

Authors: ***James Hill*, Xiang Zhang, Zhongdong Wang, Qiang Liu***

E-Mail: ***james.hill-4@postgrad.manchester.ac.uk***

Acknowledgements: The authors acknowledge financial support from EPSRC (EP/L016141/1) through the Power Networks Centre for Doctoral Training.