Simulation and Experimental Validation of the Core Temperature Distribution of a Three-Phase Transformer

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Introduction: The operating temperature of a transformer core heavily influence the service life of the device. With this information, a designer can consider the long-term economic trade-offs and the maintenance engineer can predict the location of hotspots.

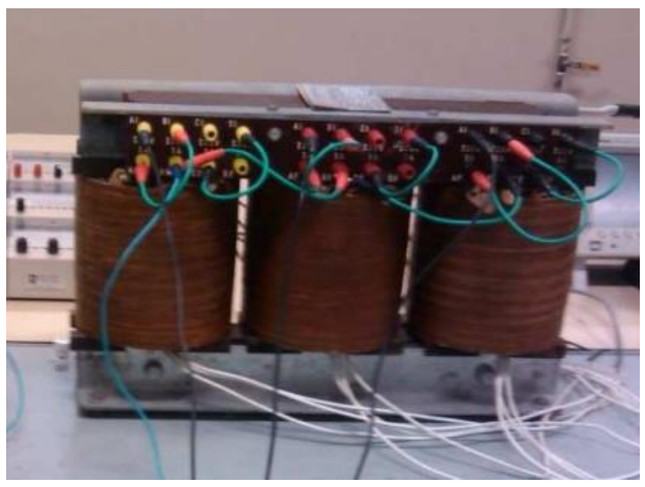

Figure 1. 5kVA Transformer.

Computational Methods: The core of the transformer was considered a constant density heat source whose magnitude is determined by the equivalent circuit parameters. The heat diffusion equation governs the flux inside the core:

$$\dot{q} = -k\nabla^2 T$$

The boundaries of the device with the surrounding air were modelled with the Newton's Law of Cooling:

$$\vec{q} = h(T_s - T_{oo})$$

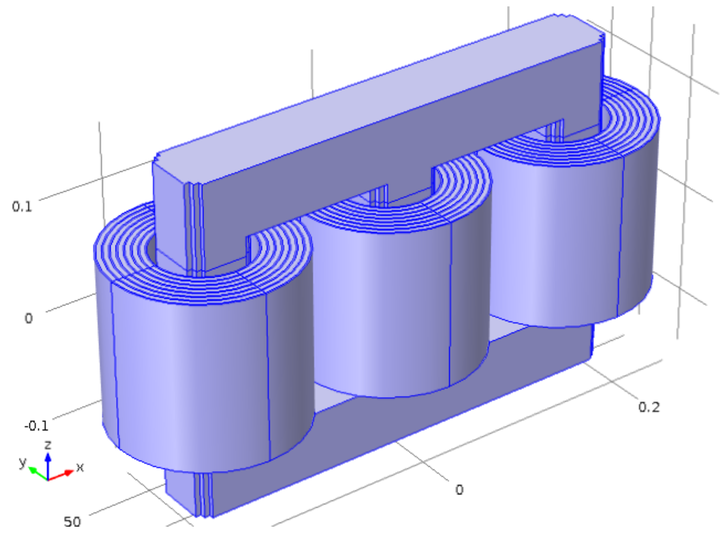

Figure 2. 3D Model.

Results:

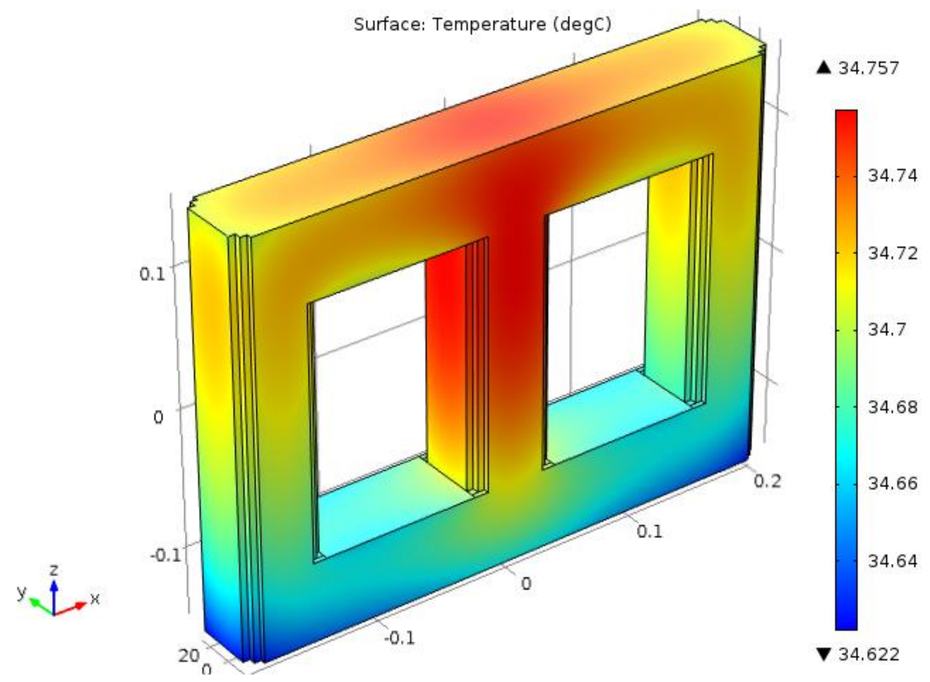

Figure 3. Temperature distribution.

Probe	Measurement [^{o}C]	Simulation [^{o}C]	Difference [^{o}C]
T1	37,0	34,7	2,3 (6,22%)
T2	37,0	34,8	2,2 (5,95%)
T3	37,0	34,7	2,3 (6,22%)
T4	37,0	34,7	2,3 (6,22%)
T5	34,0	34,7	-0,7 (-2,06%)
T6	37,0	34,7	2,3 (6,22%)

Table 1. Comparison with experimental data.

Conclusions: Despite the number of simplifying assumptions regarding the construction of the model, a low margin of error was found between the experimental measurements and the predicted values of temperature.

References:

1. Saraiva N.V., *Desenvolvimento de um Sistema de Monitoramento Térmico Aplicado a Transformadores a Seco*, Undergraduate thesis. (in portuguese), Fortaleza, Ceará (2013)
2. F.P. Incropera, D.P. DeWitt, T.L. Bergman, and A.S. Lavine, *Fundamentals of Heat and Mass Transfer*, 6th edition, John Wiley & Sons, 2006.