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Comparison of Losses and Flux Distribution in 3 Phase 100 kVA Distribution Transformers Assembled from Various Type of T-Joint Geometry

I. Daut, Dina M.M. Ahmad, S. Zakaria , S. Uthman and S. Taib
School of Electrical System Engineering, Kolej Universiti Kejuruteraan Utara Malaysia (KUKUM), 02600 Jejawi, Perlis, Malaysia

Abstract: This paper describes results of an investigation of the variation of power loss, building factor, flux leakage and flux distribution in 3-phase model transformer cores assembled from various type of T-joint geometry. The loss of the core with T-joint 60° was 10%, 12% and 15% better than the core with T-joint 45°, T-joint 23° and T-joint 90° respectively and 1.7 T, 50 Hz. The flux lines showed that flux penetration into the central limb was an important factor in causing the differences in performance

Key words: Transformer core, flux distribution, rotational flux, 3rd harmonic flux, power loss, building factor (BF)

INTRODUCTION

Transformer represents the largest capital investment in the distribution section of a power system and provides the best opportunity to make the system more efficient whenever possible. The efficiency of transformer can be as high as 99% but because transformer is employed to a large extent throughout an electrical system distribution, the accumulative losses are significant. Reducing the waste of electrical energy is still the highest priority especially since losses in transforming electrical power can amount 4.5% of all energy generated and about one third of this is dissipated in distribution transformer. The iron loss of a transformer core is usually greater than the nominal Epstein loss of the core material and the increased loss can be expressed in terms of the core Building Factor (B.F), the ratio of core loss to nominal loss [1, 2]. The object of this investigation has been to make direct comparison between the performances of the cores of different geometry of T-joint built from identical grades of electrical steel (M5).

Experimental apparatus and measuring techniques: Four, 3-phase,3 limb stacked cores were assembled with T- joint 90°, 23°, 45° and 60°, mitred overlap corner joints.

Each core was 550 mm x 580 mm with the limbs and yokes 100 mm wide. The four cores were assembled form 0.3 mm thick laminations of M5 grain-oriented silicon iron (CGO). Each core comprised of 60 layers and laminations complete with search coils to measure the localised flux distribution [3]. Each core could be energized to 1.7 T with less than 1.5% third harmonic distortion and power loss was measured with

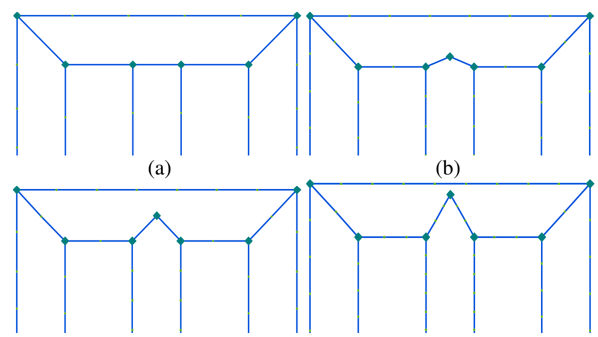

Fig. 1: Transformer core type (a) T-joint 90°, (b) T-joint 23°, (c) T-joint 45° and (d) T-joint 60°

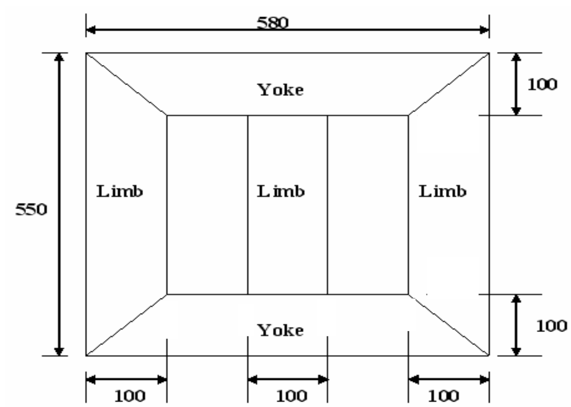

Fig. 2: Dimension (mm) of 100kVA transformer model

repeatability better than ± 1% using a three phase power analyzer. The search coils used for localised flux measurement were constructed from 0.105 mm diameter wire treaded through 0.3 mm diameter holes

Corresponding Author: I. Daut, School of Electrical System Engineering, Kolej Universiti Kejuruteraan Utara Malaysia (KUKUM), 02600 Jejawi, Perlis, Malaysia, Tel: +604-9798146, Fax: +604-9798304

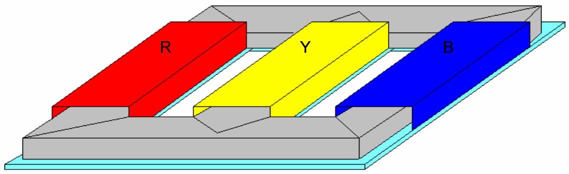

Fig. 3: 100kVA Transformer Model with 45° T-Joint

10 mm a part. The search coil induced voltages were analysed to find the magnitude and plane coil induced voltage of list, 3rd and 5th harmonic component of flux density.

RESULT AND DISCUSSION

Figure 4 shows the variation of overall power loss with flux density in the three phase cores. The core with T-joint 60° has lowest loss over the complete range.

The B.F of each core reached a peak at around 1.5 T as shown in Fig. 5. The distortion of losses is lowest in the core the core assembled with T-Joint 60° and at 1.5 T it B.F was 8%, 16% and 25% lower than that of the 45°, 23° and 90° respectively. The B.F of the core assembled with T-joint 60° is lowest over the whole flux density range. There were several differences in the localised flux density variation in the four cores. The T-joint 90° had the largest rotational flux in the T-joint. The localised rotational flux was more elliptical (with the major axis along the rolling direction) in the other three cores [4, 5].

Figure 6 shows the average flux distribution on both cores calculated using computational method. Fig. 6 (a) shows at T-joints 60° more flux entering centre limb at core assembled with $\omega t = 0$. The flux distribution more uniform in the core assembled with T-joint 60°, 23° and 45° respectively compared with the core assembled with T-joint 90°.

Figure 7 shown that the flux leakages measured at the T-joint in the core assembled with T-joint 60° was lowest than that of the core assembled with T-joint 45°, 23° and 90° respectively, over the whole flux density range.

Figure 8 shown that the 3rd harmonic flux was largest in the core assembled with T-joint 90° and the smallest in the T-joint 60°.

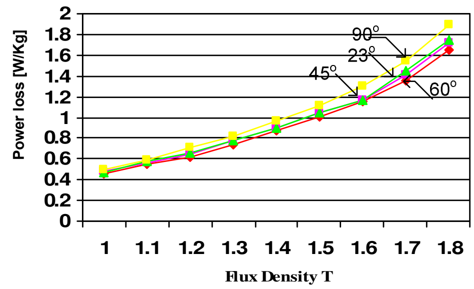

Fig. 4: Graph of power loss from measurement

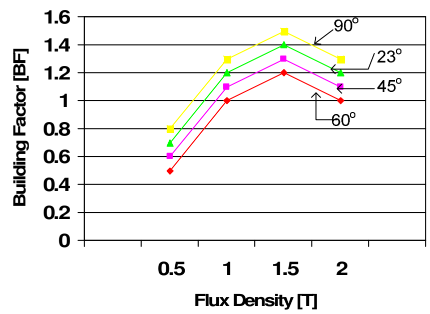

Fig. 5: Building factor for each T-joint

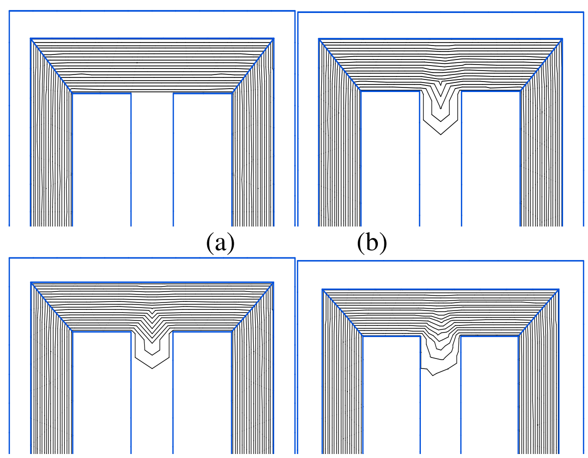

Fig. 6: Variation of magnetic flux lines in transformer core built M5 material use Software with ωt=0 (a) T- joint 90°, (b) T-joint 23°, (c) T- joint 45° and (d) T-joint 60°

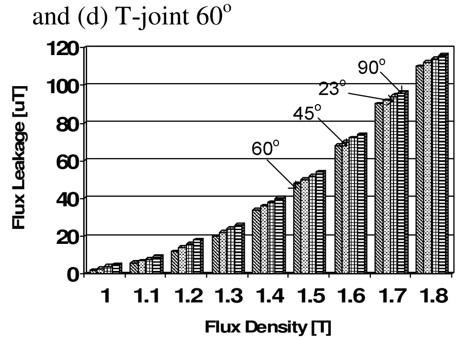

Fig. 7: Flux leakages at T-joint

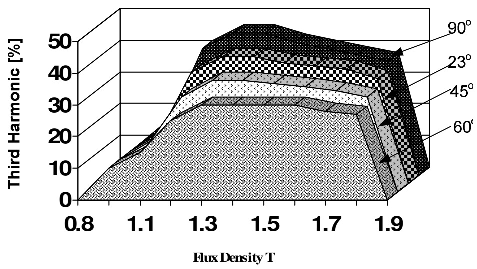

Fig. 8: Harmonic analysis of third component distortion

CONCLUSION

At 60° T-joint corner of transformer core shows there is more the line flux entering the centre limb of core. But the results find the smallest magnetic field energy, power loss and Building Factor (B.F). And the other words, the core assembled with 60° T-Joint is more efficient than other T-Joint.

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