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Effect of Rubber Material Clamp on Core Loss of 3-phase 100 kVA Transformer Core

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ABSTRACT

This study describes the result of an investigation on the effect of rubber material clamp of core lamination with stagger yoke on three 100 kVA three-phase distribution transformer. The investigation involves the variation of power loss, building factor and the total harmonic distortion of flux. The method that used in the measurement is a no load test. Loss at the core of the clamps of wood is lower than the core without clamps and using rubber materials clamp. The Total Harmonic Distortion (THD) of flux is larger in the core using wood clamp material and smaller in the core assembled without clamp, over the whole flux density range. Using wood material clamp of core lamination in transformer core is more efficient than using the other two types of transformer core lamination. In which the use of rubber in addition as clamp material will increase the losses in transformer core due to the surface area of core clamp is inhibit and not easily released to air in a short period.

Key words: Transformer core, power loss, clamp material, rubber, building factor

INTRODUCTION

It is important to measure the overall power loss of the material when assembled in transformers and to evaluate and understand the variation of Building Factor (B.F.) which is the ratio of core loss to nominal loss (Haidar *et al.*, 2006; Qader and Basak, 1982; Daut, 1992). From the calculation result of building factor will be obtained later on the appropriate design.

In making the core of the transformer is required once a clamp with a view to holding a core when it was founded and use clamp have a lot of research done by researchers. As the use of compression stress will increase the loss at the core (Sasaki *et al.*, 1987) but as a result of the clamping pressure is not expected to arrive at the core of transformer losses increase to 20% (Daut, 1992). For the best configuration of the core can be achieved by estimates obtained from the local loss of flux changes among lamination (Yao *et al.*, 2007). Hence, shows that the using of materials clamp on the core is more important than the configuration of the core connection. (Basak *et al.*, 1990). The various factors which contribute to the total no load loss and magnetising power of transformers it is difficult to quantify directly the effect of stress.

According to Norman P. Goss, that the grain orientation process material will have easy directions of magnetisation in the strip rolling direction (Beckley, 2002) with the purposes to facilitate the flow flux in the in-plane and normal direction.

The objective of this investigation is to know the rubber material clamp effect on power loss of the transformer core of identical geometry built and the grain oriented of electrical steel (M5) with 3% silicon iron assembled without clamp, with wood material clamp and combination of wood and rubber material clamp.

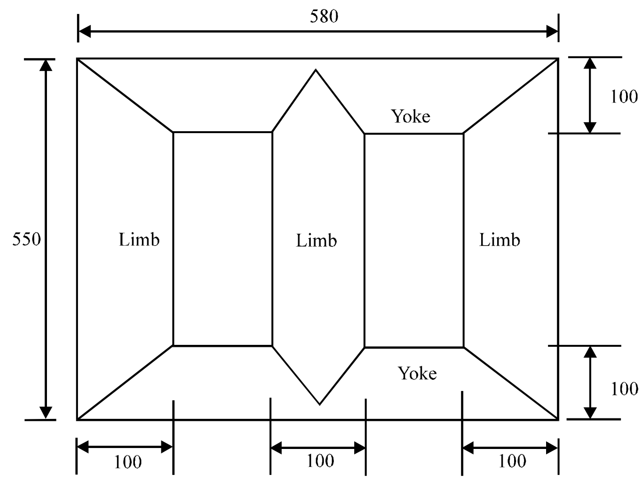

Fig. 1: Dimension (mm) of 100 kVA transformer core model

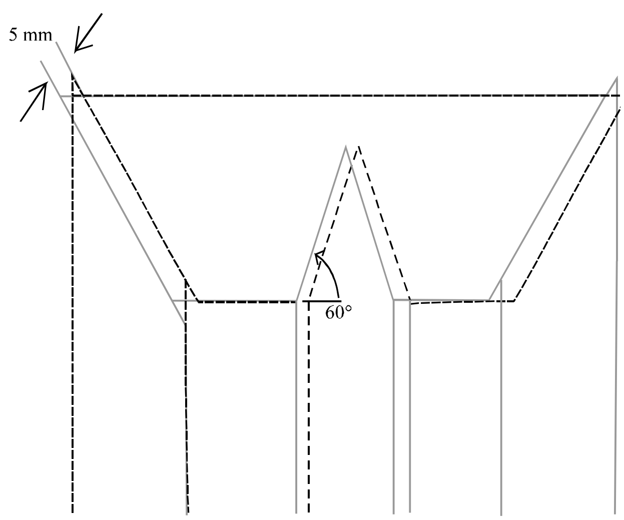

Fig. 2: Transformer core type of 60° T-joint core

Experimental apparatus and measuring techniques: The three-phase of three limbs stacked core are assembled with T-joint 60° mitred overlap corner joints are shown in Fig. 1. The outer core dimensions are 580×550 mm with the limb of 100 mm wide. The three cores are assembled using 0.3 mm thick of laminations of M5 grain-oriented silicon iron (CGO) with a nominal loss of 1.12 W kg^{-1} at 1.5 T and have stagger yoke of core with overlap length of 5 mm from other adjacent lamination when setting the transformer core lamination as shown in Fig. 2.

Each transformer core comprises of 15 layers. One transformer has without clamp. Other transformers have clamp material like first will be clamped use wood and the second will be clamped use combination of wood and rubber. Sample clamp model as shown in Fig. 3. The pressure will be taken at 12, 16 and 20 Nm.

Each core could be energized 1-1.8 T with less than 1.5% third harmonic distortion and the power loss is measured with repeatability better than±1% using a three phase power analyzer.

Experimental result: Figure 4 shows the variation of overall power loss with flux density in the three phase cores for without clamp, with wood material clamp and combination of wood and rubber

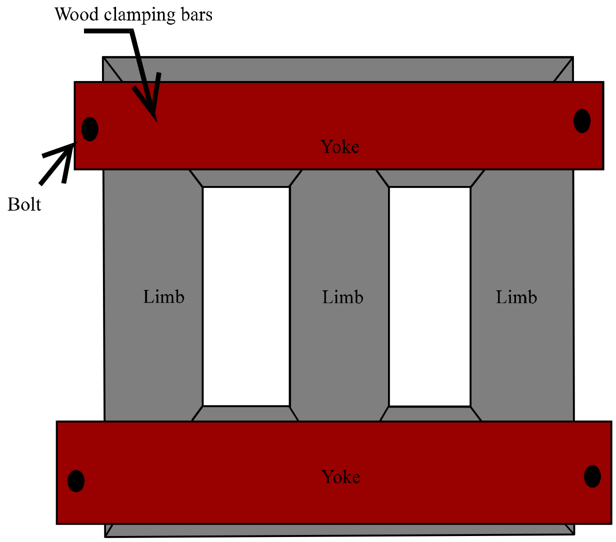

Fig. 3: Transformer core assemble with clamping stress

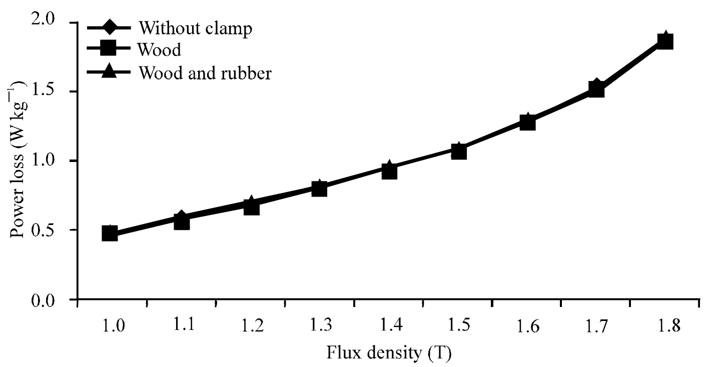

Fig. 4: Power loss from measurement for without, wood and combination wood and rubber clamp material of core lamination of transformer core

material clamp of core lamination of transformer core. The power loss of the transformer core assembled with wood material clamp increases up 1.29 and 0.83% when the transformer core without clamp and with combination of wood and rubber material clamp at flux density of 1.5 T, 50 Hz, respectively.

The BF of each core reaches a peak at around 1.4 T as shown in Fig. 5. The BF of the core assembled with wood clamping material is lower than without clamp and with combination wood and rubber clamp material over the whole flux density range. The use of wood material clamp is suitable material for construct which is the calculation result of building factor shows 1 that is the actual result is similar with nominal loss of transformer core.

Figure 6 shows that the loss of core assembled 20 Nm clamping stress of core using wood clamp material is lowest than the core assembled with 12 and 16 Nm clamping stress of core using wood clamp material, over the whole flux density range. In transformer design application of the 20 Nm clamp stresses will be used. The result shown is in accordance with opinion of Daut (1992).

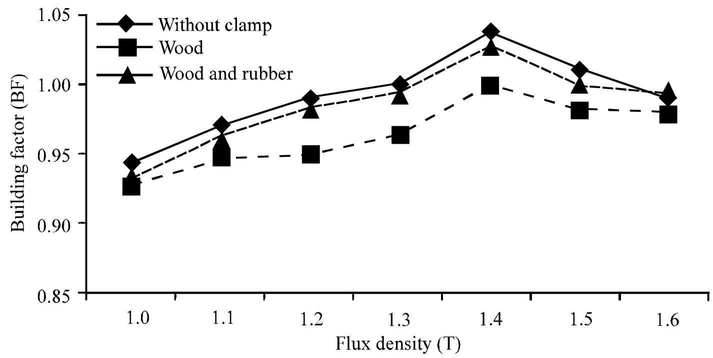

Fig. 5: Building factor for without, wood and combination wood and rubber clamp material of core lamination of transformer core

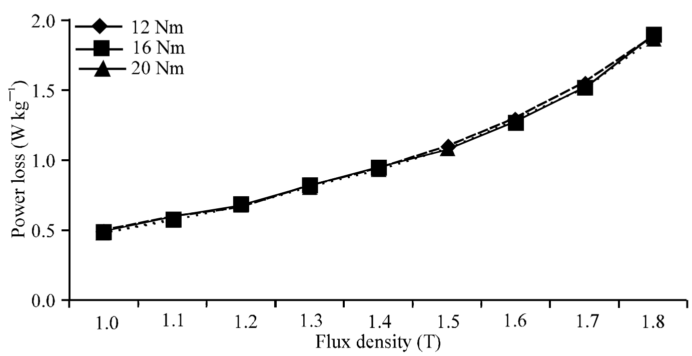

Fig. 6: Power loss from measurement for transformer core using wood clamp material

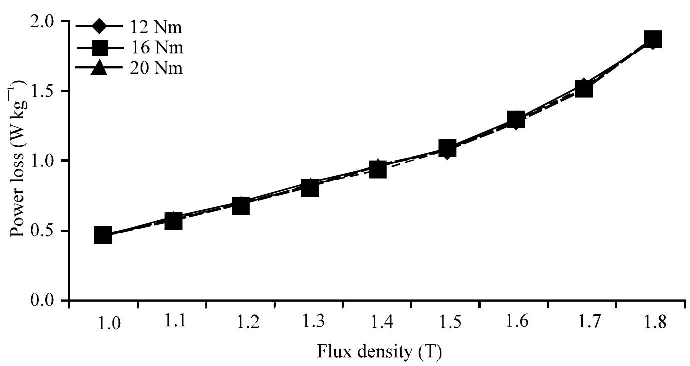

Fig. 7: Power loss from measurement for transformer core using combination of wood and rubber clamp material

Figure 7 shows that the loss of core assembled 20 Nm clamping stress of core using combination wood and rubber clamp material is lowest than the core assembled with 12 and 16 Nm clamping stress of core using combination wood and rubber clamp material, over the whole flux density range. Application of 20 Nm clamping stress could still be used than other clamping stress that investigate.

Figure 8 shows that the Total Harmonic Distortion (THD) of flux is larger in the core using wood clamp material and smaller in the core assembled without clamp, over the whole flux density range. Which is application of rubber material clamp also can reduce the total harmonic distortion but the data record for the without clamp of core shows the lowest data of total harmonic distortion because in the without clamp of core lamination position is not stable.

DISCUSSION

The transformer core without material clamp will cause the air gap among layers of lamination. Hence, the flux will be existing from laminate through air gap in normal direction as shown in Fig. 9. It will cause the leakage flux. The flux which is stay in the laminate is the useful flux. The loss that produces by transformer core is highest than the core using clamp as shown in Fig. 4. So, it will reduce the efficiency of transformer core. This view is also explained by the Yao *et al.* (2007) and Basak *et al.* (1990).

With using the material clamp as shown in Fig. 10 and 11 will reduce the air gap among laminate and flux full flows in plane direction and also the noise and joint air gaps at corners and T-Joint according to Basak *et al.* (1990). With increases clamping stress so the power loss of transformer core will decreases as shown in Fig. 6 and 7.

Adding rubber material as the clamp material in Fig. 11 will increase heat on the surface of core so the loss is higher than using wood clamp material only as shown in Fig. 4. Which is the rubber makes heat on the surface of core inhibited and not easily released to air in a short period because

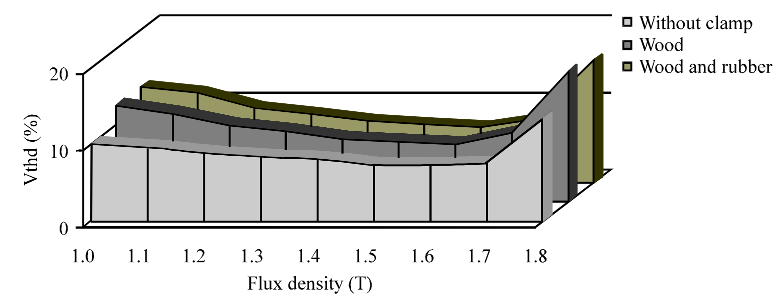

Fig. 8: Total harmonic distortion of flux for without, wood and combination wood and rubber clamp material of core lamination of transformer core

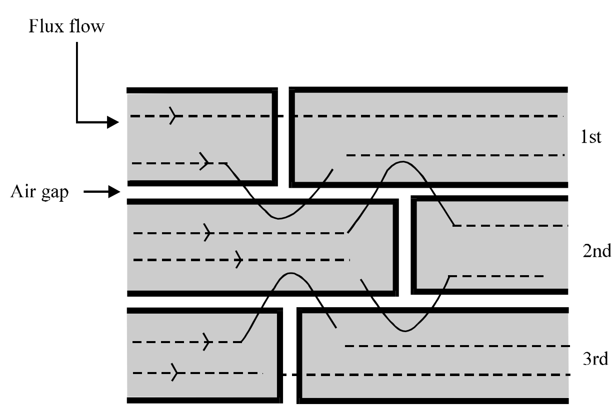

Fig. 9: Core lamination model without clamp

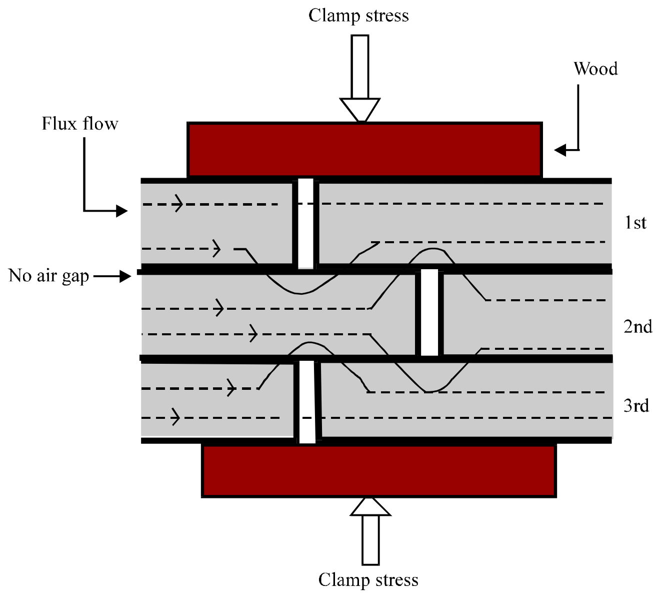

Fig. 10: Core lamination model with wood clamp material

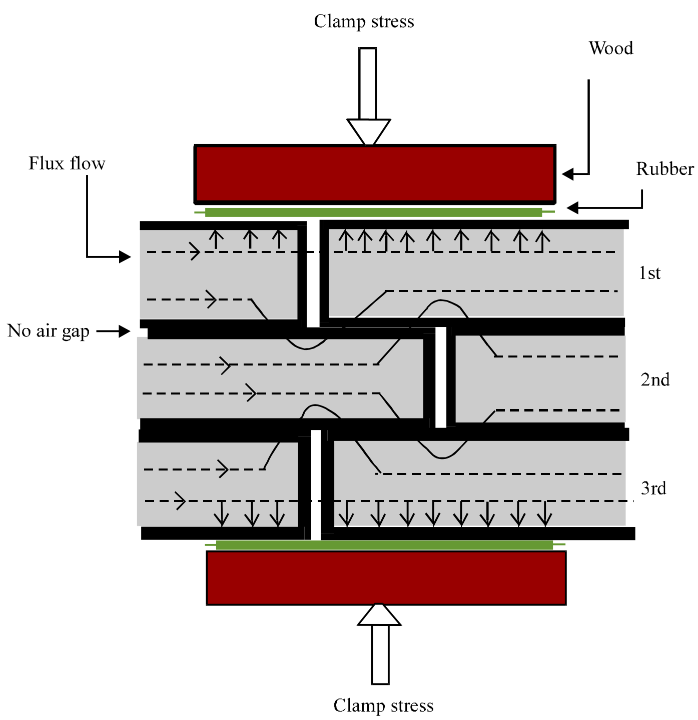

Fig. 11: Core lamination model with combination wood and rubber clamp material

rubber is isolator function. The rubber cannot stop harmonic vibration as shown in Fig. 8 because rubber has the elasticity whiles the wood only static.

It is suitable to developed transformer core using wood clamp material based on Fig. 5 because to reduce losses on the core is best to use the wood clamp material only.

CONCLUSION

From the result of this investigation it is obvious that if the core is assembled with the wood clamp material of core lamination we can find smaller power loss, smaller Building factor but higher total harmonic distortion of flux. In other words, the core assembled with the wood clamp material of core lamination is still more efficient than the core assembled without clamp and the combination of wood and rubber clamp material of core lamination.

Using the rubber makes heat on the surface of core inhibited and not easily released to air in a short period and also cannot stop harmonic vibration that occurs on transformer core.

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