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Influencing Factors of Noise Generation in Transformers

Hitesh Paghadar*[1], Dr. R. A. Kantaria[2]

*[1]Reserach Scholar, Rai University, Ahmedabad, Gujarat, India

[2]Electrical Engineering Department, V.V.P. Engineering College, Rajkot, Gujarat, India

ABSTRACT

Noise pollution is an important issue in modern societies. Power transformers are a significant contributor to this unwanted ambient noise. It is therefore desirable to optimize the acoustic behavior of power transformers, i.e. either to minimize the level of noise radiation or to optimize its characteristics in order to lower the level of disturbance for humans. The performance of a transformer core may be considered in terms of power loss and by the noise generated. It is important to ensure that the core loss is low by using an optimum core material and an optimum core fabrication technique. This paper discussed about influencing factors for noise generation like Flux density, core construction, core construction, Building Factor, Core clamping & Pressure, winding diameter, cooling fans and etc. Core vibration is the main factor in the no-load sound level. Flux density, core material, core geometry and waveform of the excitation voltage are the factors that influence the magnitude and frequency components of the transformer core sound levels. Sound level also depends on magnetic property of transformer core material. Factors such as sheet thickness, stress, coatings, induction level and frequency of magnetization affect the magnetic properties of the core material.

Keywords: Transformer Noise, Transformer core, Flux density, Core material, core construction, core joints, Building Factor, core clamping

I. INTRODUCTION

It is important to reduce the power loss associated with transformer cores by use of electrical steel of the optimum magnetic grade, it is equally important to minimize the noise generated by the core.

In many countries, the local ordinances specify maximum allowable sound levels. As per Indian government rules, the 'Ministry of Environment and Forest Notification' in February-2000 specifies the acceptable limits of sound level in dB(A) as shown in Table-I below.

Environmental revolutions demand that the transformer core with low noise generation. For that in-depth understanding of factors, are affecting to the transformer core for noise generation, is imperative.

TABLE I
ACCEPTABLE SOUND LEVELS

Category of Area/Zone	Limits in dB(A)	
	Day Time	Night Time
Industrial Area	75	70
Commercial Area	65	55
Residential Area	55	45
Silence Area	50	40

II. INFLUENCING FACTORS OF NOISE GENERATION

A. Flux Density

It is given that a variation of 10 percent in the flux density relative to the rated value produces on average a difference of about 2 to 3 dB(A). The sound level is closely related to the operating peak flux density and core weight. The change in sound level as a function of these two factors can be expressed as below.

$$\Delta p = 10 \log\left[\left[\frac{B2}{B1}\right]^{8} \times \left[\frac{W2}{W1}\right]^{1.6}\right]$$

Where, B = Flux density (T), W = Core weight (kg)

In the above formula, core weight is assumed to change with flux density approximately in inverse proportion. It is observed that for a flux density reduction of 0.1 T, the sound level reduction of about 2dB is obtained. However, this results in increase of material content (copper and core) and hence it is advantageous only if the no-load loss capitalization rate is high. An alternative way of reducing flux density in transformer core without affecting winding weight is to increase top and bottom yoke diameter, keeping limb diameter fixed.

B. Magnetostriction

No-load sound level of core mainly depends on magnetostriction & magnetic forces. The magnitude of magnetostriction could be reduced by lowering flux density. Magnetostriction is directly proportional to flux density and it could be reduced by increasing cross sectional area of core with constant volt/turn or reducing volt/turn with constant core area. Thickness of lamination sheet could be increased to reduce the magnetostriction effect. Most of the sound transmitted from a core comes principally from the yoke region because the sound from the limb is effectively damped by the surrounding windings (copper and insulation material) around the limb. Winding diameter will increase with the increase in core diameter and if winding diameter exceeds 6m, then radial vibration will come in picture. Based on the above, analytical studies were carried out by increasing top and bottom yoke cross-sectional area. Thus there are three methods studied for controlling sound level at design stage by reducing flux density: (1) Increase in core area with constant volt/turn (Method-I) (2) Reduction in volt/turn with constant core area (Method-II) (3) Increase in yoke cross-sectional area with constant volt/turn (Method-III).

C. Choice of CRGO Material

Desirable magnetic properties of electrical steels are (i) Low loss, to minimize energy loss due to magnetization of the core; (ii) High permeability to minimize the applied current (magnetizing current) required to achieve a particular induction level; (iii) Low noise generation from the core. The popular grades of CRGO (Cold Rolled Grain Orientation) are M4, MOH and HI-B (ZDKH). The HI-B grade core material offers 2-3dB reduction of sound level as compared to normal grade CRGO because of comparatively less magnetostriction amplitude (Refer Fig. 1). The increase in lamination sheet thickness could result in lower sound level due to damping of core vibration. This however increases the overall no-load loss.

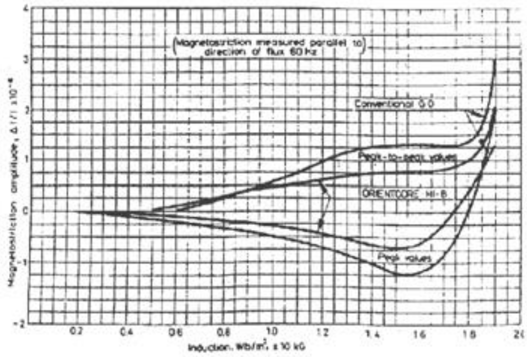

Figure 1: Amplitude of Magnetostriction as a Function of Flux Density

D. Core Construction

There are many types of core configurations. However, there are some common features in terms of core corner joints. The three most commonly used types of corner joints are (a)Interleaved joints; (b)Mitred joints; and (c)Step-lap joints.

Normally, we tend to relate type of core joints with the core losses. However, magnetostriction changes in length and magnetic forces arising at the joint regions of the core excite vibrations in the core, giving rise to noise. Therefore it is relevant to discuss here the types of core joints and their influence on noise.

The interleaved joints, as shown in fig.-2, are the simplest ones and are usually preferred only for small rating transformers, where the total core loss itself is very small.

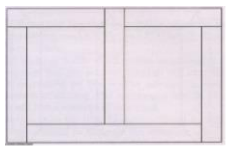

Figure 2: Interleaved Joints

Mitred joints or single steplap core joints consists of 45degree overlap arrangements at the corners as shown in fig-3. In such arrangement, the magnetic flux leaving/entering the joints finds a smooth path for its permeance. This is most commonly used type of joint.

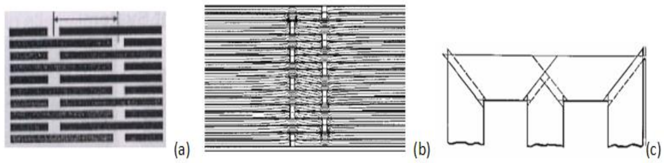

Figure 3: Mitred Joints: (a) Cross-sectional view (b) Flux distribution (c) Front view

Steplap cores comprise several laminations cut to different lengths. Steplap core configurations comprises, say in case of a 5 step lap core, 5 laminations of different lengths, each successive lamination being slightly longer than the previous one by a specific step overlap of, for example 2, 4 or 6 mm. Such arrangement, as shown in fig-4 generally leads to much better magnetic and noise performance than the mitred overlap joints, considered to arise due to fewer inter-laminar forces arising in the multi steplap cores. This type of core with 5 or 7 steplap is finding increasing acceptability due to reduction in core loss and noise. It is reported to effect noise reduction on an average to the tune of 4dB.

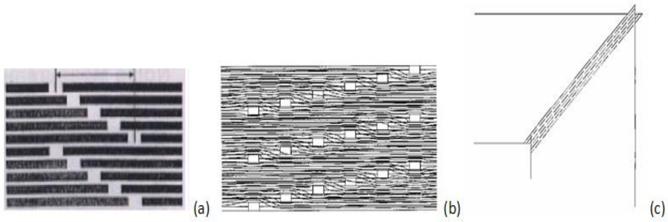

Figure 4: Step-lap Joints: (a) Cross-sectional view (b) Flux distribution (c) Front view

E. Building Factors

The relationship between the core loss of a fully assembled core and the product of core mass multiplied by specific loss is known as the building factor of the core. The building factor and sound level are function of operating flux density & gap sizes at core joints. The building factor is poor for better grade of CRGO material (i.e. it increases as the grade of material improves from say M4 to HI-B) with the increase in operating flux density. The higher gaps of core joints result in higher building factor. The building factor could be effectively controlled to achieve reduced sound level and no-load losses by appropriate selection of flux density and type of core joint.

F. Core Clamping

For reducing the transformer sound, the laminations are clamped together. For effective clamping of the core leg laminations, Flitch plates made up of steel are used on either side of each leg. These plates are mechanically strong enough to prevent buckling, bending of laminations and are able to withstand the lifting load of core and windings. Over the clamp plates, 50 mm wide fiberglass tapes are tightly would around the legs. For effective clamping of the yoke laminations, bolted yoke or boltless yoke clamping arrangement is used. In bolted yoke clamping arrangement, yoke clamping frames made of steel are used on either side of top and bottom yokes and entire core and frame structure is properly secured through yoke bolts at a number of positions. While in boltless yoke clamping arrangement, top and bottom yokes are bound through end frames with the help of 40 mm wide resiglass tapes at a number of positions.

G. Core Pressure

During the manufacturing of a transformer, the core is generally clamped to prevent slippage of the laminations during handling, and to produce a stable final structure. The clamping pressure on the core should be adequately distributed so that no appreciable length of the core is left unclamped. If limbs/yokes are clamped with resin-glass or fiber-glass tapes, the pitch (distance between two tapes) should be small so that adequate uniform pressure is applied. The effect of clamping pressure on transformer sound has been evaluated for a three phase, 5step lap core with 6mm step overlap comprising 27M3 grade CGO material. It is observed that excessive pressure result in an increase in sound level, as shown in fig-5.

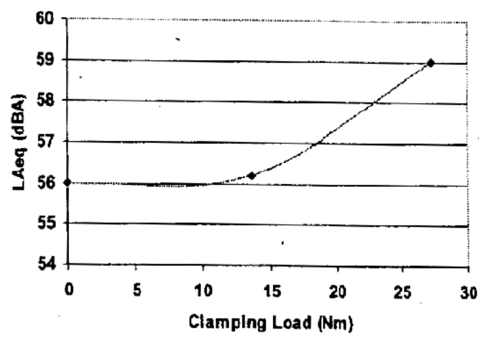

Figure 5: Effect of Clamping Pressure on Sound level

H. Vibration in Winding

Sound level under full load condition is significantly lower as compared to the core sound level at rated excitation. However, the trend could reverse in case of operating flux density below 1.4T and coil diameter in excess of 6m.

Till now no effective measures have been specified for reducing winding sound. A theoretical possibility consists in lowering the elasticity of a winding through insulating materials with a high dynamic elastic modulus and through appropriate design of winding assembly. Winding type, winding arrangement, current density, tank shielding/shunts, and tank design parameters have a significant effect on the magnitude of load sound level. Extensive development work has resulted in the following measures for load-sound reduction:

- Using winding designs that generically provide for lower magnitudes of leakage flux density
- Avoiding winding resonance
- Improved tank design having lower sound radiation properties
- Sound enclosures covering the entire tank

I. Cooling fans and Oil Pumps

As a part of cooling equipment, standard size of 18 & 24 inch fans with speed of 900-950 rpm are used & their sound level is in the range of 64-65dB(A). The fan noise is a function of its speed and circumferential velocity, a low speed fan (say 750 rpm) has smaller noise level. As the speed is lowered, air delivery also reduces necessitating an increase in number of fans. Many a times, the specified noise level specified is so low that it may not be possible to get matching low noise fans. In such cases, ONAN cooling should be preferred to mixed ONAN/ONAF cooling for small and medium rating power transformers, even if it results in increase of number of radiators. When cooling pumps are required, pumps with low noise emission should be adopted.

III. CONCLUSION

The main factor is core vibration, which gives major contribution in the generation of transformer noise. Low flux density and low magneto striction with CRGO material and step lap core joints are required for the design of low noise transformer. Design factors like, flux density, core material, core construction and some manufacturing practices like tightening of limb and yoke laminations, araldite application on lamination edges, yoke bolts, bend tie rods, cross clamping beam [c-bracket] at top and bottom yoke with slot and bolted scheme on horizontal/vertical faces of frames and pitch of the fibre glass tap on the limbs gives the significant effect on noise generation.

IV.REFERENCES

[1] Neha Shrivasatava, Dr. Samina Elyas Mubeen, Evaluation of Different Grades of Steel CGRO Distribution Transformer, International Journal of Scientific Progress and Research, ISSN:2349-4689, Vol.-8, No.-2, 2015.

[2] Lee, Chang yao, cheng, Effect of magnetostriction and magnetic reluctances on magnetic properties of distribution transformers, Journal of Applied science, Vol.115, IEEE, May-2014.

[3] Abhinavkumar, Causes of noise generation & its mitigation in Transformer, Journal of Environmental science and Engineering & Technology, vol.2, 75-79, 2013.

[4] S.V.Kulkarni, S.A.Khaparde, “Tansformer Engineering Design, Technology & Diagnostics”, Second Edition, CRC press, 2013.

[5] J. G. Charles The effect of the level of magnetostriction upon noise and vibration of model single-phase transformer cores. Electrical Research Association (ERA), January- 1967.

[6] Messrs Keith Jenkins, David Snell, “Noise in Electrical Machines-aspects of noise associated with GO electrical steels in transformer applications”, Cogent power limited, UK magnetic society, 4th February-2009.