Experimental study for Reduce Stray Losses of 50KVA Proto Type Three Phase Transformer using Edgewise Magnetic Shielding

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Abstract— The load losses in the transformer consist of I^2R & stray losses. In large rating transformer, the stray losses constitute about 20-25% of the total load losses. Designers adopt various cost-effective measures to minimize the losses and make the transformer more efficient. This Stray Losses we can reduce by using Edge-wise Magnetic Shielding. These losses could be controlled by means of Edge-wise Magnetic shielding judiciously placed so as to canalize the leakage flux. By Experimental study with the help of Transformer manufacturing industry we can make 50KVA, 200/16v, 144.33/1804.22 ampere Proto Type Three Phase Transformer in which 18.43% Stray Losses reduce by using Edge-wise Magnetic shielding by Trial and Error Method .We can Compare calculation for with and without Edge-wise Magnetic shielding which specify that how much stray losses reduced by using Edge-wise Magnetic Shielding. We can also compare real data sheet and tested data sheet of three phase transformer for stray losses for without Edge-wise Magnetic shielding.

I. INTRODUCTION

The load loss of a transformer consists of losses due to ohmic resistance of windings (I^2R losses) and some additional losses. These additional losses are generally known as stray losses, which occur due to leakage field of windings and field of high current carrying leads/bus-bars. The stray losses in the windings are further classified as eddy loss and circulating current loss. The other stray losses occur in structural steel parts like core edge, Frame , Flitch plates, Tank, Bushing Mounting Plates etc. The stray loss in a structural component is reduced by a number of ways but here we use Edge-wise Magnetic shielding to reduce stray losses as a reduction of flux density in the component by diverting/repelling the incident flux. There are basically two types of magnetic shunts, viz. width-wise and edgewise shunts. Here we use Edge-wise Magnetic shielding because the flux is incident on the thickness (edge) of laminations resulting in negligible eddy loss in them. There is always some amount of leakage field in all types of transformers, and in large power transformers (limited in size due to transport and space restrictions) the stray field strength increases with growing rating much faster than in smaller transformers. The stray flux impinging on conducting parts (winding conductors and structural components)
gives rise to eddy currents in them. A typical edge-wise shunt is shown in fig.1.

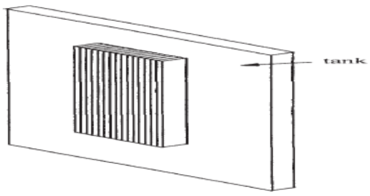

Fig.1 Edge-wise Magnetic Shielding

The effective permeability of laminations as seen by the incident flux is much higher for this shunt as compared to the width-wise shunt since the flux does not encounter any non-magnetic gaps once it enters the shunt. In the width-wise shunt, due to non magnetic gaps (however small they be), the effective permeability at the entry point reduces making it less effective as compared to the edge-wise shunt. The flux distribution at the entry point is quite complicated. The presence of inter-laminar non-magnetic gap reduces the average permeability in the direction normal to the laminations to a low value, hence the flux tends to stay within a particular lamination until it saturates. The flux finds its way through the next lamination when the earlier lamination saturates and so on. Thus, it can be seen that the effectiveness of the width-wise shunt is less as compared to the edgewise shunt.

II. MANUFACTURING PROCESS OF EDGE-WISE MAGNETIC SHIELDING

The manufacturing process of edge-wise shunts is quite elaborate. In one of the forms, a set of laminations are epoxy molded (like that of laminated flitch plates). In another design, it can be made into a wound form. The loss advantage with the edge-wise shunts has to be assessed vis-à-vis their higher cost and manufacturing time as compared to the width-wise shunts. It is preferable to experimentally check the quantum of stray loss reduction before standardizing the use of edge-wise shunts.

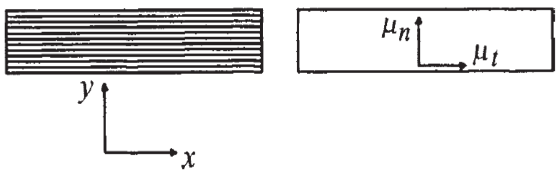

Figure. 2:.Anisotropic permeability

For a stack of laminations subjected to a magnetic field, the directional effects of material anisotropy and lamination stacking factor have to be taken into account. Because of the obvious difficulties of treating an individual lamination separately in any kind of formulation, a stack of laminations can be represented by a solid anisotropic block. For a stack of laminations (figure.2) with a stacking (space) factor of *k*, subjected to a field in the *y* direction, the effective relative permeability of the equivalent solid anisotropic block across the laminations is $\mu_{n=}\mu_y/k\ (1-\mu_y) + \mu_y=1/1-\ k$ and tangential to the laminations is $\mu_r = k\ (\mu_x-1) +1= k\ \mu_x$,where μ_x and μ_y are the relative permeability's of the lamination material in the *x* and *y* directions respectively (μ_x, μ_y >>1). The reduced effective permeability across the laminations (μ_n) gives the correct representation of much deeper penetration of the flux in the stack of laminations. This tends to make the flux density distribution more uniform as compared to the inaccurate isotropic modeling, where the flux concentrates only in the surface layers giving a highly non-uniform flux density distribution.

III. REAL DATASHEET FOR 50KVA THREE PHASE TRANSFORMER

TABLE 1

Design Input		
KVA=50		
Phase=3		
Frequency=50		
Voltage ratio=200/16volts		
Vector Group=Dyn11		
Class of Insulation=A		
Design Output		
Windings and Losses Details	LV	HV
Winding and Losses Details	LV	HV
Turns	4	87
I (L.V)/I(H.V) Amps.	1804.22	83.33
Current Density	3.573	4.35
Resistance at 20^0C	0.000056	0.04267 0.0427
Wt. Bare	30.6	24.6 0.2 24.78
Wt. Insulated	33	24.6 0.2 27
I^2R 75^0C	661.70 watts	1080.70watts
% Eddy Current	49.65%	11.93%
Eddy Current loss	328.52	128.96
Stray losses	160.1920223+328.52+128.96 =617.67watts	
Total load Loss 75^0C	2360watts	
% X	17.19	
% R	4.720	
% Z	17.83	
Core Wt	106kg	
No Load Loss	165watts	
Core Grade Thickness	C.R.G.O M_4 0.27mm	

IV. PHOTO IMAGES FOR EDGE-WISE MAGNETIC SHIELDING

Figure. 3: Edge-wise Magnetic Shielding for H.V-L.V

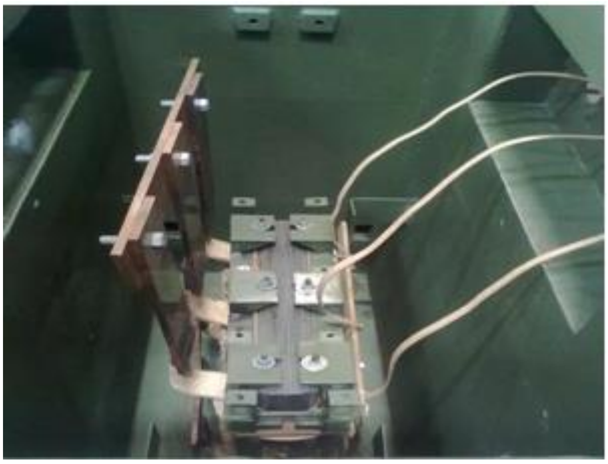

Figure.4 Tanking without Edge-wise Magnetic Shielding

Figure.5 H.V side Edge-wise Magnetic shielding

Figure.6 Tanking with Edge-wise Magnetic shielding on both H.V-L.V

V. TESTING RESULTS FOR 50KVA, THREE PHASE TRANSFORMER WITHOUT EDGE WISE MAGNETIC SHIELDING

TABLE 2

KVA=50 V(H.V)/V(L.V)=200/16volts I(L.V)/I(H.V)=144.33/1804.22Amperes
1) Ambient Temp. of a)Resistance Measurement R : 28^0C b)Load loss Measurement Rt : 28^0C
2) Lead Resistance for H.V winding: 0ohms
3) a) Avg. HV Resistance measured: 0.0271ohms b) Actual HV Resistance: 0.0271ohm

c) Actual HV Resistance at Rt: 0.0271ohms
4) a) Avg. LV Resi. measured :0.0779miliohms b) Actual LV Res. at R1 : 0.0779miliohms
5) HV I^2R Losses Rt_1 : $1.5\times144.33\times0.0271 = 846.79$watts
6) LV I^2R Losses Rt_1: $(3\times1804.22\times0.0779/1000\times1) = 760.74$watts
7) Total I^2R Losses Rt_1 : $846.79+760.74 = 1607.53$watts
8) Load loss Measurement at Rt_1 : 2350watts
9) Stray Losses at Rt_1 : 2350-1607.53 = 742.47watts
10) Total I^2R at 75^0C : $(235+75)/(235+28)\times1607.53 = 1894.81$watts
11) Stray losses at 75^0C $(235+28)/(235+75)\times742.47 = 629.9$watts
12) Load Loss at 75^0C : 1894.81+513.84 = 2525watts
13) Impedance Volt at Rt_1: 35.31volts
14) %Impedance at Rt_1 (Z) $(35.3090\times100)/(0.2\times1000) = 17.665$ %
15) %R at Rt (R): $(2350\times100)/(50\times1000) = 4.7$ %
16) %X = $\sqrt{}(Z^2-R^2)$ $(17.665^2-4.7^2)^{1/2} = 17.018$ %
17) %R at 75^0C R_1 $(2525\times100)/(50\times1000) = 5.05$ %
18) % Impedance(z) at 75^0C $\sqrt{}R1^2+X^2$ $\sqrt{}(5.05^2+17.08^2) = 17.751$ %

TABLE 3

KVA=50 V(H.V)/V(L.V)=200/16 I(L.V)/I(H.V)=144.33/1804.22
1) Ambient Temp. of a)Resistance Measurement R : 28^0C b)Load loss Measurement Rt : 28^0C
2)Lead Resistance for H.V winding: 0ohms
3) a) Avg. HV Resi. measured : 0.0271ohms b) Actual HV Resistance: 0.0271ohms c) Actual HV Resistance at Rt : 0.0271ohms
4) a) Avg. LV Resi. measured : 0.0779miliohms b)Actual LV Resistance at R1 : 0.0779miliohms
5) HV I^2R Losses Rt_1: $1.5\times144.33\times0.0271 = 846.79$watts
6) LV I^2R Losses Rt_1 : $(3\times1804.22\times0.0779/1000\times1) = 760.74$watts
7) Total I^2R Losses Rt_1 : $846.79+760.74 = 1607.53$watts
8) Load loss Measurement at Rt_1 : 2213.2watts
9) Stray Losses at Rt_1: 2213.2-1607.53 = 605.67watts
10) Total I^2R at 75^0C $(235+75)/(235+28)\times1607.53 = 1894.81$watts
11) Stray losses at 75^0C $(235+28)/(235+75)\times605.67 = 513.84$watts
12) Load Loss at 75^0C: 1894.81+513.84 = 2409watts
13) Impedance Volt at Rt_1: 34.58volts
14) %Impedance at Rt_1 (Z) $(34.5827\times100)/(0.2\times1000) = 17.291$ %
15) %R at Rt (R) $(2213.2\times100)/(50\times1000) = 4.4264$ %
16) %X= $\sqrt{}(Z^2-R^2)$
$(17.291^2-4.4264^2)^{1/2} = 16.715$ %
17) %R at 75^0C R_1 $(2409\times100)/(50\times1000) = 4.818$ %
18) % Impedance(z) at 75^0C $\sqrt{}R1^2+X^2$ $\sqrt{}(4.818^2+16.715^2) = 17.396$ %

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VI. CONCLUSION

By comparing the Testing results of without and with EDGE-WISE MAGNETIC SHIELDING (TABLE2 AND TABLE3) for 50KVA Proto type Three Phase Transformer we can conclude that

(1) According to TABLE 2 we get 629.9watt stray losses for without using Edge-wise Magnetic shielding and According to TABLE 3 we get 513.84watt stray losses for with using Edge-wise Magnetic shielding. That means we conclude that 18.43% or 116watt stray losses will reduced if we use edge wise magnetic shielding in three phase transformer.

(2) According to TABLE1 In real data sheet of Proto Type Three Phase we get 617.17watts stray losses and by trial and error method according to TABLE2 we get 629.9watts stray losses for without Edge-wise Magnetic shielding.

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