COST EFFECTIVE AND ENVIRONMENTAL FRIENDLY DESIGN OF THREE PHASE OIL IMMERSED 315 KVA DISTRIBUTION TRANSFORMERS

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Abstract: A Three Phase Distribution Transformer is widely used in urban as well as rural area for power supply. It is also used in many industrial purposes to run many appliances. A three phase 315KVA, 11/0.433kV distribution transformer. Winding design and performance practice for power and distribution transformers has focused in the differences between rectangular core and coils and layer windings common in the production of distribution transformers [3]. The inherent safety and performance properties of Envirotemp FR3 fluid have led to its application in electrical equipment other than transformers, including industrial electromagnets, superconducting motors, klystron modulators, transformer/rectifier sets, and heat transfer applications. Envirotemp FR3 fluid has excellent lubricity, an important characteristic for application in equipment with moving parts. High voltage bushing applications also appear promising due to the fluid's excellent ability to minimize insulating paper degradation and its low gassing tendency value of approximately -79 µl/min.

I. INTRODUCTION

A three phase 315kVA, 11/0.433kV Distribution transformers which has per phase voltage 250V. The high side 11000V having U-phase, V-phase, W-phase. While low voltage side 433 V there is four terminal i.e., N-phase, U-phase, V-phase, W-phase. Each terminal along with Neutral caries 250 V. The increasing demand of electricity oil immersed 3- phase Transformer in an economic way the cost optimization of the transformers design by reducing the mass of active part has become vital importance.
Transformer design technique, designer had to rely on their experience and judgment to design the required transformer [1].
Several design procedure for low frequency transformers have been developed in past research. Mathematical design calculation using MS- excel in an attempt to eliminate time consuming calculations associated with reiterative design procedure.
The power scenario in India, as on March 31, 1988, the total installed capacity in India was 88,861MW. New power projects expected are over 2700MW. By 2010 AD, the expected requirement of power would be around 200,000 MW, which means there will be almost 100% more generation over the next 10/12 years.
With the addition of 100,000MW more power, we may expect enormous requirement of power and distribution transformers in India.
The transformer emits no-load and load losses. It is necessary to keep these losses at a minimum to reduce the line losses [2]. The configuration of connection for distribution transformer in India is usually 'Delta' in primary and 'Star' in secondary with a vector group Dyn-11. The huge numbers of distribution transformers are required for electrification of any country [6]. It is estimated that number of distribution transformer installed in electrical distribution Network is growing approximately 1.5% per annum [7]. Around 15% of investment in transmission System goes towards transformer [8].

Thermal design and operation considerations

Rectangular core and coil design are frequently used for distribution transformer design and offer advantages of reduction in direct labor and material when compared to circular core and coils with disc and helical winding usually wound with sheet conductors for the LV winding. The rectangular core design reduces the core window and result in a result in reduction of core losses compared to a circular winding design.

II. MATHEMATICAL CALCULATIONFOR TRANSFORMER

Description of basic details:
V/T, volts per turn or E_t
C_d, current density in winding (A/mm2)
CD, core diameter in mm.
LL, Load loss or copper loss
NLL, No-load loss or core loss
A/L, axial Length of coil.

R_l, Radial build of coil
g, Gap between LV/HV winding in mm.
E_t or V/T, Volt per turn.
Ag, cross-sectional area of core in centimeter.
B_m, Flux density in tesla.
F, frequency=50 Hz.
Stacking factor= 0.97

B_m T	Ag CM	NLL W	LL W	%Efficiency
1.54	189.99	436	2885	99.29
1.64	178.41	464	2831	99.28
1.74	168.15	488	2778	99.27

Impedance value Z% = 4.44
Density of copper, Cu= 8.96 g/cm^3
Density of core steel (iron) in 7.65g/cm^3
Resistivity of copper is $21*10^{-9}$ ohm-/mm^2
Grade of core is MOH 0.23

Core diameter, CD= $4.44 * f * B_m * A_g * 0.97 * 10^{-4}$

Weight of complete set of core in kg

= (3* W/H * 4 * C/L) + (2 * Width of 1st step * 0.86) * gross are of core * density of core material * 0.97 * 10^{-3}

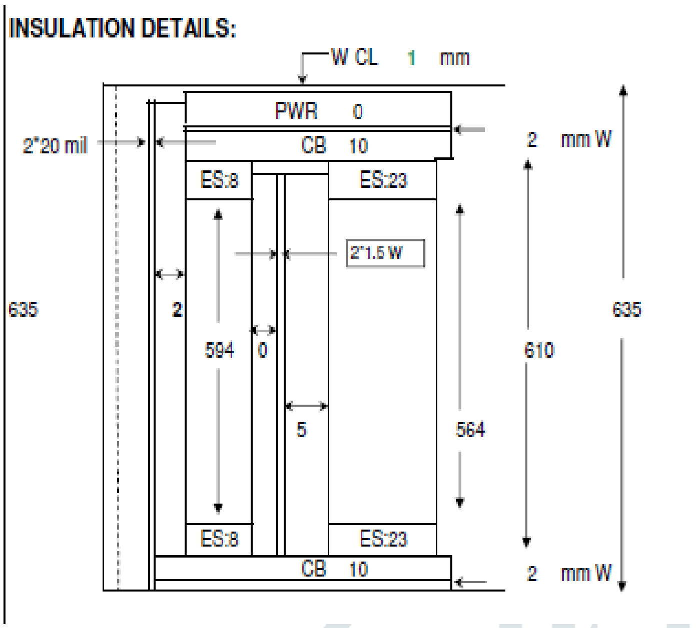
	Primary coil	Secondary coil
Voltage per phase	11000V	250 V
Current per phase	9.55 A	420.02 A
Current density	1.61 A/sq.mm	
Conductor Area	5.94 sq.mm	260.88 sq.mm

Weight of copper conductor,

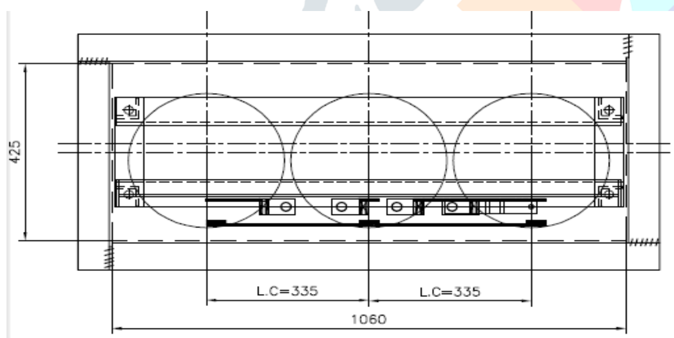
=3 * 3.142* mean diameter of coil * turns * conductor area * density of copper * 10^{-6}

Total number of LV turn is 40. And total number of HV turn is 1848. Which has 5% Tapping voltage at different tap number in the winding of coils. And has no transposition in the winding. Temperature rise of oil is 45ºC and winding temperature rise 40ºC.

POSITION	% TAPPING	RATIO	HV VOLTS
1	5.00	47.18	11550
2	2.500	46.10	11275
3	0.000	45.00	11000
4	-2.500	43.90	10725
5	-5.000	42.80	10450
6	-7.500	41.70	10175
7	-10.000	40.62	9900



Geometry of core type transformer



LV/HV connection

III. RESULT AND DISCUSSION

The 315KVA, 11/0.433KV Distribution Transformer works on guaranteed losses in Efficiency level-1

COST ESTIMATION:

Flux density,	1.54 T	1.64 T	1.74 T
Wt. of core material kg./ cost of material 161 per kg	**495 = 79695/-**	**461 = 74221/-**	**429 = 69069/-**
Wt. of copper material kg./ cost of material 501 per kg	**451 = 225951/-**	**442 = 221442/-**	**433 = 220440/-**
Vol. of oil Ltr./ cost of 82 per ltr.	**533 = 43706/-**	**515 = 42230/-**	**497 = 40754/-**

IV. CONCLUSION

This paper proposed to design a 315kVA, 11/0.433kV, Delta/Star, Distribution Transformer with the different losses. Total loss of the 315kVA, 11000/433V transformer is about **2831**W at 100% Load at given flux density. And if we use FR3 oil which is made of grown soya beans and has fire point 360ºC and Environmental Friendly. Proven to increase the life of transformers paper insulation material by decades, increasing the transformer asset's life

V. FUTURE SCOPE

In the Design of 315kVA, 11/0.433kV Distribution Transformers we can minimize the losses by using a better quality of CRGO and copper(PICC) and increase the life of transformer by using a better quality of insulating oil i.e., Edible oil instead of mineral oil. Edible oil not only increases the life of Transformers but also environmental friendly. Envirotemp FR3 fluid is especially suited for upgrading the environmental and fire safety of mineral oil-filled transformers. It is miscible with mineral oil, high molecular weight hydrocarbons and other ester fluids. FR3 fluid is not miscible with silicone and should not be applied in transformers previously containing silicone. FR3 fluid can also be used in PCB (Askarel) replacement initiatives.

Unlike most other fluid types, the residual transformer oil in a properly retrofilled transformer should not reduce the fire point of Envirotemp FR3 fluid below the NEC minimum of 300°C. This is true even after full equilibrium has been achieved between the replacement fluid and the residual mineral oil in the paper.

Additional advantages of retrofilling with Envirotemp FR3 fluid include high dielectric strength, better match of dielectric constant to Kraft paper insulation, excellent lubricity, material compatibility, and a coefficient of expansion similar to conventional transformer oil. Envirotemp FR3 fluid has superior resistance to coking and sludge formation when compared to conventional transformer oil. In addition to passing the Power Factor Valued Oxidation (PFVO) test, Doble Laboratories' Sludge-Free Life tests resulted in no measurable sludge. The fluid also acts as a drying agent for transformer insulation that has become wet from aging, extending the useful life of the transformer insulation system.

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