THE NOVEL DESIGN OF THREE PHASE AUTOTRANSFORMER

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Abstract: The development of three phase auto transformer meet with some issues as by changing the conventional design we can reduce the costing as well as performance can be improved. This paper proposes a novel design of linear three phase auto transformer in which the design details and its performance is compared with conventional three phase toroidal core autotransformer. During study it is found that, there is a huge scope for modifications in autotransformers. At the end of paper its hardware design and performance analysis is conducted.
Keywords: Linear Transformer; Autotransformer; Linear Autotransformer.

I. INTRODUCTION

Conventionally in autotransformer manufacturing widely toroidal core is used and due to the lack of residual gap in magnetic path it is having higher inrush current. Also it requires expensive machinery for winding purpose and skilled labor to manufacture it ultimately increasing the cost of manufacturing as it is required to pass the entire length of coil winding through the aperture every time a single turn is integrated to the coil. As a consequence, toroidal transformers rated more than a few kVA are unconventional. Diminutive distribution transformers may achieve some of the benefits of a toroidal core by splitting it and coercing it open, then inserting a bobbin containing primary and secondary windings. In this project by utilizing U-I lamination we are going to design linear autotransformer to amend the cooling, to reduce labor cost and withal to reduce inrush current. So that cost of transformer will additionally get reduced and in case of damage it can facilely rehabilitated.

II. LITERATURE REVIEW

Karnath, Girish R: has presented the design and analysis of a novel autotransformer. The autotransformer is utilized for the application of AC-DC converter for induction motor drives. The aim of this research work was to achieve the improved power quality. In the design of an autotransformer, authors have used two single phase transformers.

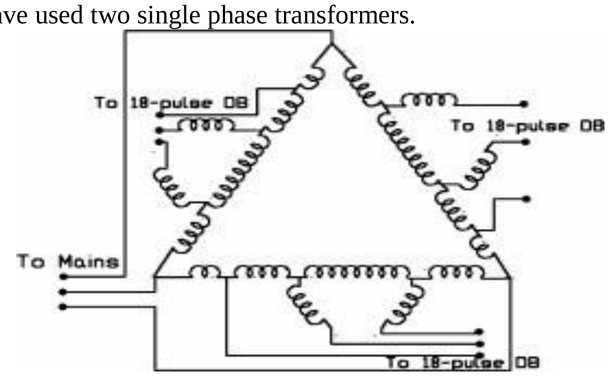

Figure 1: Proposed autotransformer model

This transformer is used to feed the 18 pulse rectifier. Authors have carried out the analysis of the rectifier over all the parameters in mathematical design. This provides more flexibility over diode rectifiers. The implemented model has given more efficiency and lower harmonic distortion over convention rectifier [1]. Singh, Bhim: has developed a novel autotransformer. Authors have claimed it as first T-shaped autotransformer. This transformer was used by the authors to feed the 12- pulse rectifier circuit.

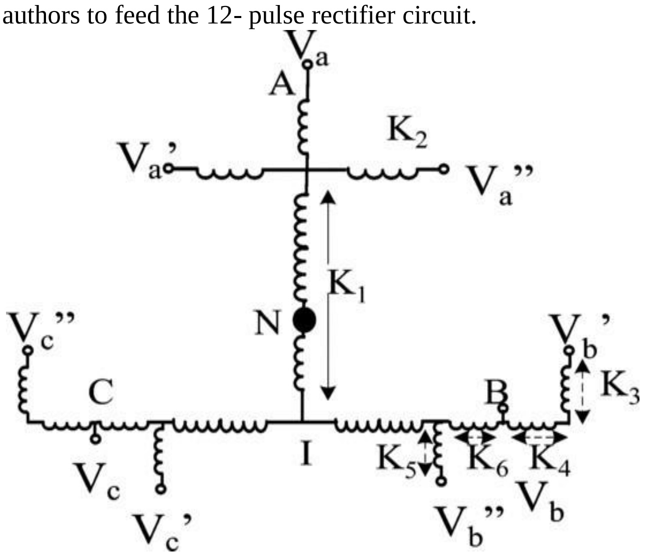

Figure 2: Proposed T-Connected autotransformer model

Fig.2 above shows the T- Connected autotransformer model, using two single phase transformers. This proposed design gives requires less space, volume and weight [2]. Høidalen, Hans K: have proposed the novel transformer model, where two or three phase autotransformer windings can be used. Authors have used ATP Draw environment to implement the model. Gusev, A. S.: has proposed and implemented the universal mathematical model. In this model power and autotransformers are combined and a new model is developed. The model is tested and found more reliable than the other hybrid models [4]. Arturi, C. M: has proposed the highly saturated autotransformer model. This model is more effective in power system during the transient state. Authors have proposed a five limb core autotransformer. Authors have used the ATP environment for development of the said model [5].

III. DESIGN STEP FOR LINEAR AUTOTRANSFORMER

The design steps of Three Phase Linear Auto Transformer are as follows:
Design of Core

Core is heart of any transformer as it play important role to

provide low reluctive path to linkage of flux
The kVA rating can be calculated as,
kVA= (Vs*Is)*10^-3 (1)
From kVA rating cross sectional area of core in square inch is given by,
Ai = {(kVA*10^-3)^1/2}/5.6 (2)
The core area then converted in to square mater to get turns/volts, (Here value of maximum flux density Bm is considered as 1Wb/square meter)
Te = 1/ 4.44*f* Φm (3)
Width of central limb
Wd= (Ai)1/2 (4)
Design of winding
Calculate current in winding
I= VA/Vp*η (5)
Where,
VA =Volt ampere (6)
η = Efficiency and its value is to be considered in between 80 to 96%
Calculate area of conductor
A= I/δp mm2 (7)
Where,
δp – Current density of copper winding conductor in A/mm2 value is generally taken as 2.3 A/mm2
Number of primary turns
T = Primary voltage* Turns/volts (8)
T = Vp*Te (9)
Window space required
= (Tp*A) mm2 (10)
Calculation of core dimension
Height of Winding
H= (turns/layer) * Diameter of conductor(11) Width of winding
W= number of layer * diameter of conductor (2)

TABLE 1: LIST OF PARAMETER FOR INITIAL MODEL

Sr. No	Specifications	Value
1	Output-kVA	1
2	Voltage-V1/V2	V1=440
		V2=470
3	Frequency-f in Hz	50 Hz
4	Number of phases	3 Phase
5	Cooling	Natural
6	Type – Core or shell	Core
7	Winding Material	Copper
8	Insulation Level	F Class
9	Efficiency	0.9

IV. OVERALL DIMENSION OF CORE

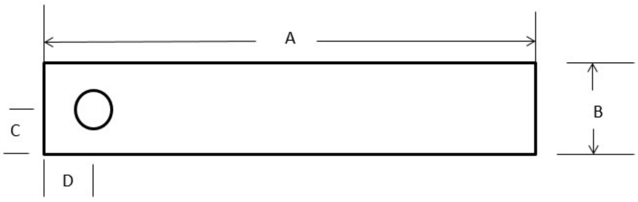

Figure: 3 Core lamination overall dimension

TABLE II: CORE LAMINATION DIMENSION

A	B	C	D
150	50	25	25
130	50	25	65
90	50	25	25

TABLE III: DESIGN SPECIFICATION

Specification	
kVA rating	1
Secondary Voltage	470
Secondary Current	1.3
Gauge of conductor	20
Number of turns	420
Core area	2750*10^-6
Window height	260
Window width	20

V. NOVEL CONCEPT OF LINEAR AUTOTRANSFORMER

There is the opportunity for developing as design of the autotransformer with the arrangement of linear motion. Generally, the autotransformer has circular core. Here we are developing the autotransformer with the novel approach. The aim of this development is to reduce the losses present in the autotransformer by means of reduction in magnetizing current. The fig. 4, and fig. 5; below shows the side and top views of proposed three phase autotransformer. A slider with brushes is provided with the arrangement of linear motion which can vary the supply as per requirement. Generally autotransformers are suitable for step down applications, the proposed system found suitable for the same.

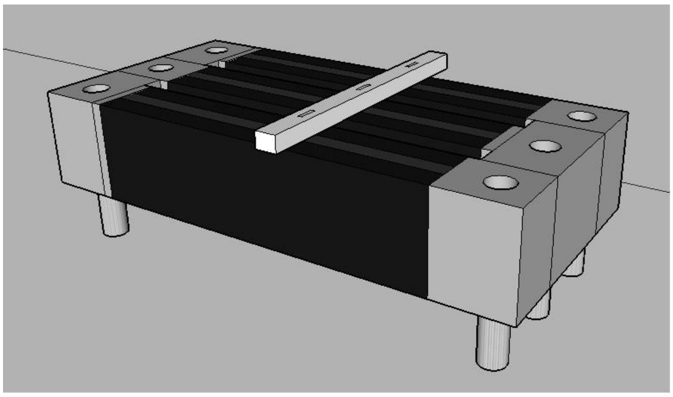

Figure 4: 3 phase, Linear Autotransformer (Side View)

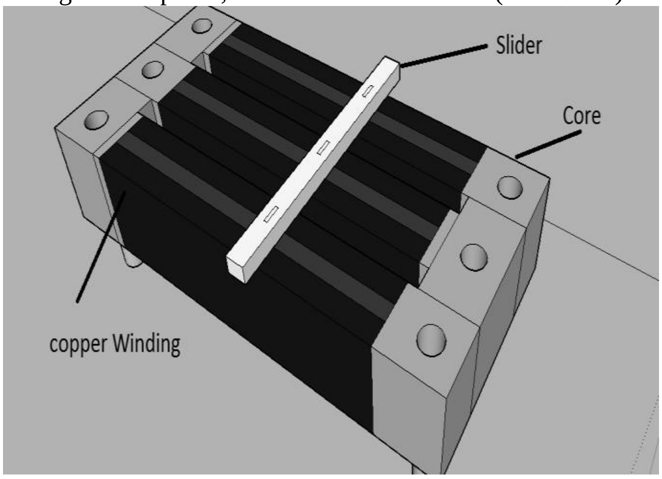

Figure 5: 3 phase, Linear Autotransformer (Top View)

VI. INITIAL MODEL

Core assembly

For better performance of autotransformer core material is used having grade of 50C530 with coating C6A. The CRNO material used has the watt losses of 4.09 watt/kg. The assembly of core is as shown in fig. 6

Figure 6: Core assembly of linear Autotransformer

Winding

For winding Bakelite former is covered with 5 mil craft paper to provide proper insulation. The copper used is of double coated super enameled having F class to give better temperature withstands capacity. The assembly is as shown in fig. 7 below. The Bakelite bobbin provides better mechanical strength as well as guide to brushes.

Figure 7: Copper winding on Bakelite bobbin

Brush and sliding mechanism

To collect the current rectangular carbon brushes are used having very less contact area to provide precise variation in output voltage. With the help of sliding mechanism shown in fig. 8 required output is provided

Figure 8: Brush holder and sliding mechanism

VII. TESTING OF LINEAR AUTOTRANSFORMER

The experimental set up of linear auto transformer is as shown fig. 9 and fig.10 below. Two wattmeter method is used to measure the power in linear autotransformer.

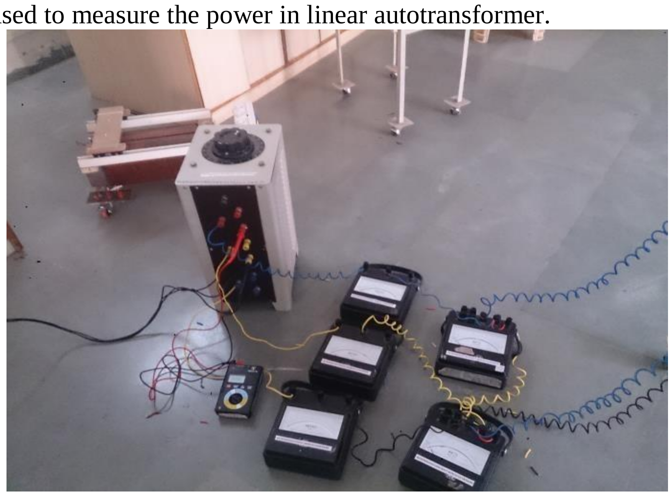

Figure 9: Testing of three phase autotransformer

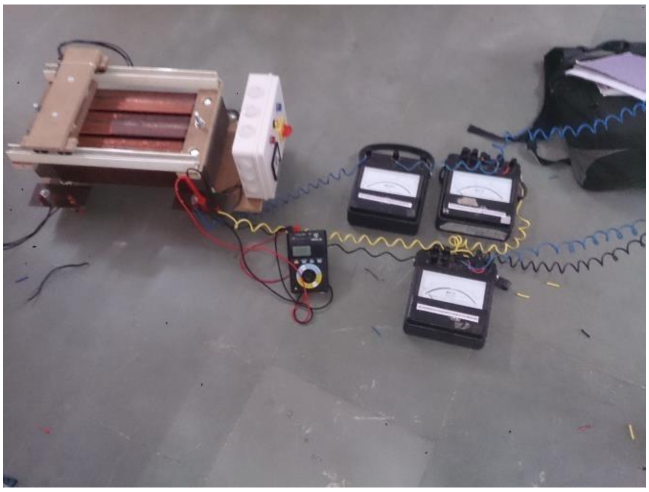

Figure 10: Testing of three phase linear autotransformer

VIII. RESULTS

TABLE IV: RESULTS

Parameter	Autotransformer	Linear Autotransformer
kVA rating	1	1
Input voltage	440	440
Output voltage	470	470
Insulation class	F	F
Number of turns	340	280
Volts per turn	1.451	1.3157
Regulation	1.14	0.22
Efficiency	91	95

IX. CONCLUSION

In this paper, by using linear autotransformer less expensive and efficient model can be achieved which will leads to improve the efficiency and overall cost of manufacturing and process of manufacturing. In short it is less expensive and more feasible solution against the autotransformer. In future scope current collection method can be improved by using splitting method to reduce heating at brush.

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