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Analysis and Design of Toroidal Transformer

Harshit Sawant[1], Keyur Patel[2], Rahi Tapare[3], Prof. Darshit Patel[4]

[1, 2, 3] *Students, Department of Electrical Engineering, Vadodara institute of engineering, Kotambi, Vadodara-390018, Gujarat, India*
[4] *Assistant professor, Department of Electrical Engineering, Vadodara institute of engineering, Kotambi, Vadodara-390018, Gujarat, India*

Abstract – *A Toroidal transformer provides increased design flexibility, efficiency & compact design when compare to traditional shell & core type transformers. The design of most efficient toroidal transformer that can be built gives the frequency, volt ampere ratings, magnetic flux density, window fill factor and material which can use. With the above all constant and only the dimension of the magnetic core is varied. The most efficient design occurs when the copper losses equal 60% of iron losses. When this criterion is followed efficiency is higher. The model parameter calculated from the design information. Therefore it is suitable to be included in design loop of transformer design software. The results are compared with the finite element simulations.*

Key Words: Toroidal core, Toroidal Transformer

1. INTRODUCTION

This the purpose of this project is currently used in low voltage low power applications, is to use a core made up of continuous steel strip that is wound into a construction allows for smaller more efficient, lighter and cooler with reduced electromagnetic interferences lower acoustic noise. The main technical advantage is that the no load losses substantially reduced. It is possible to replace oil immersed transformer with dry toroidal units, reduce the potential for violent fault in addition to environmental benefits of avoiding the use of oil.

1.1 Design Principle symbols:

V_1 = Primary voltage

V_2 = Secondary voltage

I_1 = Primary current

I_2 = Secondary current

P = Power

D_o = Outer diameter

D_i = Inner diameter

A = Cross sectional area of core

H = Height of core

T_p = Number of Primary turns

T_s = Number of secondary Turns

1.1.2 Consideration input assumptions for design of toroidal transformer:

V_1= 220, V_2=120, P=1200, D_o=18cm, D_i=8cm, A=10cm, H=8cm

1.1.3 Calculation of primary side:-

$\frac{42}{A} = T_p \times \text{volt}$

Assumptions for design calculation:

Assumption based on our input based and a fixed power value based we can directly finding on internet source and use that values according to some reference.

18cm = D_o
8cm = D_i
10cm= A
8cm = H
Cross sectional area of core
10×8=80cm

Equivalent core area = $\frac{80}{2}$

= $40m^2$

Numbers of turns:

Turns×volt $= \frac{42}{A}$

$T_p = \frac{42}{40}$ = 1.05 v [no. of turns/volt]

So now,
Primary turns = Primary voltage/ Number of turns/volt
T_p = 235/1.05
= 224 T_p
Assume 40cm cross sectional area of winding
Total wire = Cross sectional area × Numbers of turns in primary side
40cm × 224 T_p = 8960cm
= 89.60M
Wire use for primary winding

$I = \frac{P}{V1} = \frac{1200}{235} = 5.10A$

$I = \frac{P}{V2} = \frac{1200}{115} = 10.43A$

Table select for gauge of winding wire:-

Table 1.1: Gauge of winding wire

Windings	Gauge	Circular mill	Diameter in mm	Ampere
Secondary	13	5178	1.83	10.5
Secondary	14	4170	1.63	8.3
Primary	16	2583	1.29	5.2
Primary	17	2048	1.15	4.1

Wire calculation in gram:-

= Diameter × gauge
= 1.26 × 16
= 20.64 gram

1 m weight of wire is 20.64 gram.
89.60 m weight of wire is 1849.344gram.

1.1.4 Calculation for secondary winding:

T_s = Secondary voltage/ no. of turns per volt
V2=120
= 115/1.05
= 110T_s

Assume 42cm cross sectional area of winding

Total wire = Cross sectional area × Numbers of turns in Secondary side
= 42 × 115cm= 4830
= 48.30m

For,

1m weight of wire is 23.69 gram.

48.30 m weight of wire is 1144.22gram.

1.1.5 Design data sheet:

Table 3.2: Design data sheet

Sr. No	Design parameter	Value
1.	Primary voltage	$V_1 = 235$
2.	Secondary voltage	$V_2 = 115$
3.	Primary current	$I_1 = 5.10$
4.	Secondary current	$I_2 = 10.43$
5.	Power	P = 1200watt
6.	Number of primary turns	$T_p = 224$
7.	Numbers of secondary turns	$T_s = 110$
8.	Outer diameter	D_o = 18cm
9.	Inner diameter	D_i = 8cm
10.	Cross sectional area	A = 10cm
11.	Height	H = 8cm

1.2 SIMULATIONS: Analysis of toroidal transformer

1.2.1 Design of toroidal transformer:

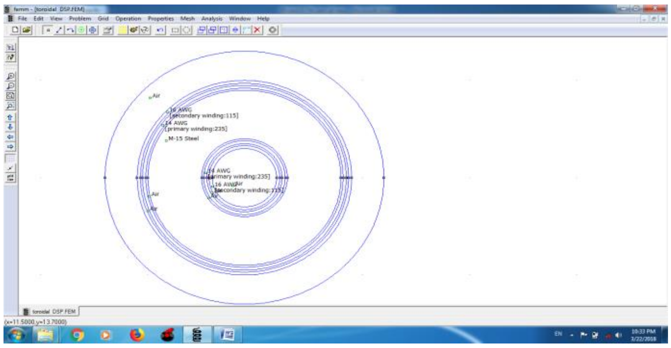

Fig. 1.2.1: Design of toroidal transformer

We are using such a parameter in FEMM above figure:

Material use for Core is M-15 Steel.

Gauge of primary windings is 14AWG.

Winding turns are 235 for primary side.

Gauge of secondary windings is 16AWG.

Winding turns are 110 for secondary.

Insulating medium is Air.

1.2.2 Primary winding parameter :

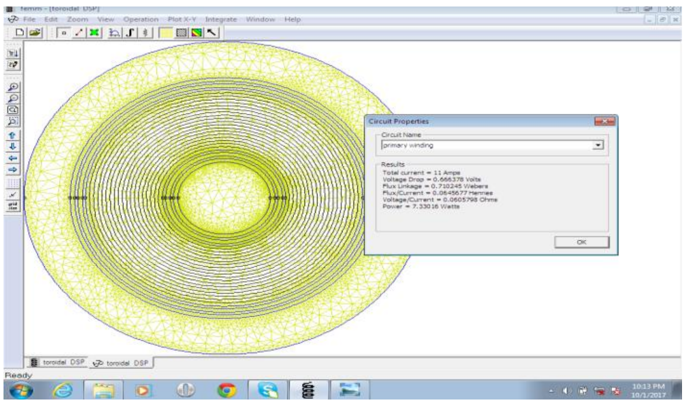

Fig. 1.2.3: Primary winding parameter

We are going towards the analysis of primary winding parameter for getting results:

Total current is 11amp.

Voltage drop is 0.666378 volts.

Flux linkage is 0.710245 Webbers.

Flux/current is 0.645677 henries.

Voltage/current is 0.0605798 ohms.

Power is 7.33016 watt.

1.2.4 Secondary winding parameter:

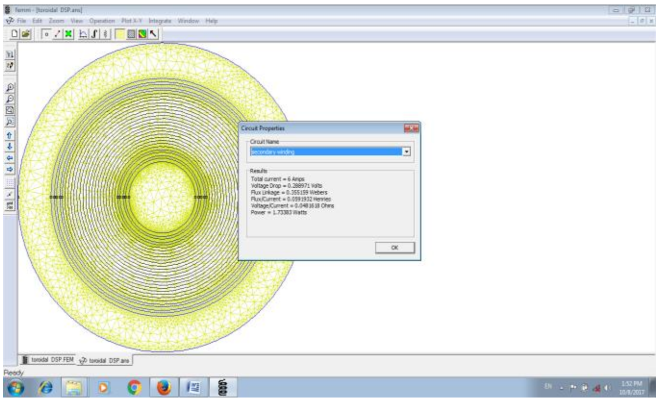

Fig. 1.2.4: Secondary winding parameter

We are going towards the analysis of secondary winding parameter for getting results:

Total current is 6 amps.

Voltage drop is 0.288971volts.

Flux linkage is 0.355159 Webbers.

Flux/current is 0.0591932 henries.

Voltage/current is 0.0481618 ohms.

Power is 1.73383 watt.

1.2.5 Magnitude of field intensity for primary:

This graph represents the magnitude of field intensity for primary winding. This graph will be L → H. L represents length in terms of inches and H represent flux density in terms of amp/m graph shape will be longitudinal.

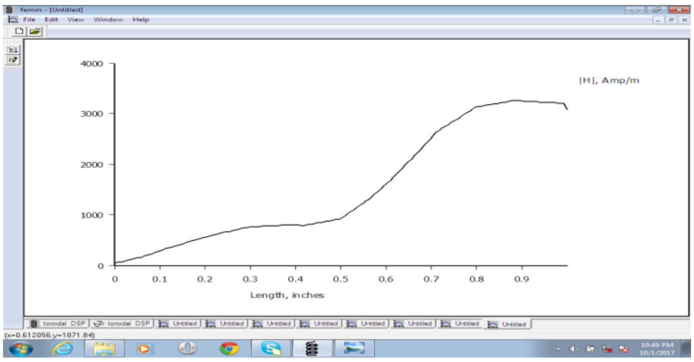

Fig. 1.2.5: magnitude of field intensity for primary

1.2.6 Magnitude of flux density for secondary:

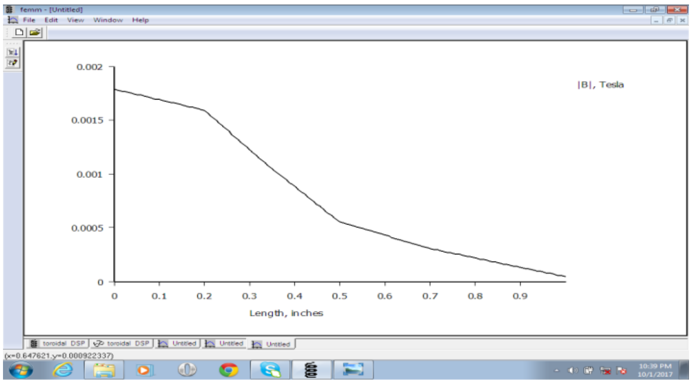

Fig. 1.2.6: Magnitude of flux density for secondary

This graph represents the magnitude of flux density for secondary winding. This graph will be L→B. Here, L is representing length in terms of inches and B represent magnetic field in terms of tesla.

2. Hardware Implementations:

2.1 Toroidal Transformer Core:

Fig. 2.1: Toroidal Transformer core

In this above figure we can see that the core diameter, width & height. That was be like a design data sheet height is 8cm, inside diameter is 8cm, outer diameter is 18cm and the cross sectional area is 10cm. That was be clearly mention & seeing in above figure.

2.2 Toroidal Transformer:

Fig. 2.2: Toroidal Transformer

Above figure in which we see that toroidal transformer hardware Completed with winding of the core. In which one side input terminal that side we given input as a 230volt and output we get 110volt. In the figure the black wire is a input terminal and the red wire is output terminal. The insulation is provided between core and windings and between two windings. The insulation type is the paper insulation & outer body covered by the plastic tap. The total weight of transformer is 12.24kg and the weight of core is 9.81kg. the copper wire which are use for transformer is 2.43kg.

2.3 Toroidal Transformer Input & output:

Fig. 2.3: Toroidal Transformer input & output

In this figure we can see that in input terminal we can apply 230volts. And as per our requirement it steps down the voltage to 110volts.

That can we achieve by very efficient without losing a copper loss.

3. CONCLUSIONS

The research perform for this project has demonstrate that it is possible to design build a utility grade distribution transformer in toroidal core. The gapless construction of toroidal transformer brings important advantages over the traditional design. It has been show that the higher efficiency compares the traditional shall type and core type transformer.

REFERENCES

[1] Energy Conservation Program for Commercial Equipment: Distribution Transformers Energy Conservation Standards, Department of Energy Final Rule, 10 CFR Part 431.

[2] IEEE Standard General Requirements for Dry-Type Distribution and Power Transformers, Including Those with Solid-Cast and/or Resin Encapsulated Windings, IEEE Std. C57.12.01, May 2006

[3] S. Purushothaman and F. de León, "Heat Transfer Model for Toroidal Transformers", Transactions on Power Delivery, vol. 27, no. 2, April 2012, pp. 813-820.

[4] P. Gómez, F. de León, and I. Hernández, "Impulse Response Analysis of Toroidal Core Distribution Transformers for Dielectric Design", IEEE Transactions on Power Delivery, vol. 26, no. 2, April 2011, pp. 1231-1238.

[5] F. de León, S. Purushothaman, and L. Qaseer, "Leakage Inductance Design of Toroidal Transformers by Sector Winding", IEEE Transactions on Power Electronics, vol. 29, no. 1, January 2014, pp. 473-480.

[6] Hernández, F. de León, and P. Gómez, "Design Formulas for the Leakage Inductance of Toroidal Distribution Transformers", IEEE Transactions on Power Delivery, vol. 26, no. 4, October 2011, pp. 2197-2204.

[7] UltraSIL polymer-housed Evolution (10 kA) IEEE surge arresters for MV systems to 36 kV, Technical Data 235-99, Cooper Power Systems.

BIOGRAPHIES

Name: Harshit R. Sawant
Diploma in Elect. Engg. [Butler Polytechnic Institute, Vadodara]
Pursuing Bachelors in Elect. Engg. [Vadodara Institute of Engineering, Kotambi]

Name: Keyur D. Patel
Pursuing Bachelors in Elect. Engg. [Vadodara Institute of Engineering, Kotambi]

Name: Rahi N. Tapare
Diploma in Elect. Engg. [Parul Polytechnic Institute, Vadodara]
Pursuing Bachelors in Elect. Engg. [Vadodara Institute of Engineering, Kotambi]

Name: Prof. Darshit S. Patel
B.E. Degree in Electrical Engineering From Charutar Institute of Technology , Changa, Gujarat, India in 2007 and M.S. In Electrical Engineering from University Of Bridgeport, CT, USA in Dec.2010.He is currently an Assistant Professor in the Department of Electrical Engineering, Vadodara Institute Of Engineering, Vadodara, Gujarat. His research interests include Design of Rotating Machines , Transformers and Testing of electrical machines