

Thermal Analysis of Different Design of Transformer Fins

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Abstract– Electrical power transformer is a static device which transforms electrical energy from one circuit to another without any direct electrical connection and with the help of mutual induction between two windings. It transforms power from one circuit to another without changing its frequency but may be in different voltage level. A power transformer is the electrical device which is used to change the voltage of AC in power transmission system. The first transformer in the world was invented in 1840s. Modern large and medium power transformers consist of oil tank with oil filling in it, the cooling equipment on the tank wall and the active part inside the tank.

The working principle of transformer is very simple. It depends upon Faraday's law of electromagnetic induction. Actually, mutual induction between two or more winding is responsible for transformation action in an electrical transformer. According to these Faraday's laws, "Rate of change of flux linkage with respect to time is directly proportional to the induced EMF in a conductor or coil."

As one kind of electrical components, an ideal transformer has no energy losses. However, in reality, a transformer cannot reach a 100% efficient. The main losses come from the winding resistance thermal loss, the eddy current loss and the hysteresis loss For liquid immersed transformer, the active part including cores and windings is immersed in some insulating liquid, usually the transformer oil, filling in the transformer. The heat generated by windings and cores will be transferred to the transformer wall by convection. Then, the heat will dissipate into the environment by radiation and convection. Usually, for some large transformers, fins and radiators are applied for improving the cooling capability. A typical example of the liquid immersed transformers is the large oil immersed transformer in which a blower is installed forcing the circulating air to enhance the cooling effects.

Keywords - Electrical Transformer; Cooling Performance; Distribution Transformer; Transformer Cooling;

I. INTRODUCTION

Electrical power transformer is a static device which transforms electrical energy from one circuit to another

without any direct electrical connection and with the help of mutual induction between two windings. It transforms power from one circuit to another without changing its frequency but may be in different voltage level. A power transformer is the electrical device which is used to change the voltage of AC in power transmission system. The first transformer in the world was invented in 1840s. Modern large and medium power transformers consist of oil tank with oil filling in it, the cooling equipment on the tank wall and the active part inside the tank. The working principle of transformer is very simple. It depends upon Faraday's law of electromagnetic induction. Actually, mutual induction between two or more winding is responsible for transformation action in an electrical transformer. According to these Faraday's laws, "Rate of change of flux linkage with respect to time is directly proportional to the induced EMF in a conductor or coil".



Fig. 1. Structures of disc winding transformer

As the key part of a transformer, the active part consists of 2 main components: the set of coils or windings (at least comprising a low voltage, high voltage and a regulating winding) and the iron core, as Fig. 1. shows. For a step-up transformer, the primary coil is low voltage (LV) input and the secondary coil is high voltage (LV) output. The situation is opposite for a step-down transformer. The iron core is the part inducing the varying magnitude flux. Nowadays, transformers play key roles in long distance high-voltage power transmission.

A. Operating principle of transformer

A general operating process of a transformer is that a varying magnetic flux is created in the core due to the changing of the current of the primary coil. Then, a voltage at the secondary coil is induced by this varying magnetic flux. As Figure 2 shows, wires are wrapped around each side of the core frame which is made of materials with high magnetic permeability. The left winding is the primary winding and the right winding is the secondary winding. When an AC is connected the left, the magnetic flux will be induced in the core. The magnetic flux will pass through the secondary winding in the right side and induces voltage. This principle is basing on the Faraday's law of induction or the induction law shown in Eq. (i).

$$V_{\text{secondary}} = N_{\text{secondary}} d\Phi/dt \quad (i)$$

Where Φ is the magnetic flux through one turn of the coil, $N_{\text{secondary}}$ is the number of the secondary coils and $V_{\text{secondary}}$ is the voltage generated in the secondary winding.

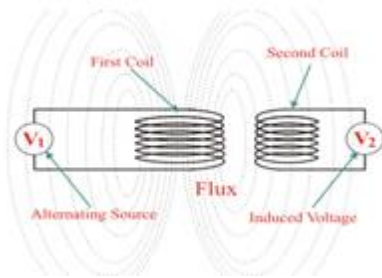


Fig. 2: Operating principle of transformer

In an ideal transformer, there is a relation between the voltages and the number of coils on both sides as shown in Eq. (ii). This equation indicates that the ratio of output voltage to the input voltage is defined by the ratio of the primary coils number to the secondary coils number. By this law, within a certain power capacity, transformer can be selected according to the output voltage.

$$\frac{V_{\text{primary}}}{V_{\text{secondary}}} = \frac{N_{\text{primary}}}{N_{\text{secondary}}} \quad (ii)$$

B. Theory of transformer

In an ideal transformer; there are no core losses in transformer i.e. loss free core of transformer. But in practical transformer, there are hysteresis and eddy current losses in transformer core.

C. Theory of transformer on no-load

Theory of Transformer on No-load, and Having No Winding Resistance and No Leakage Reactance of Transformer, Consider one electrical transformer with only core losses, which means, it has only core losses but no copper loss and no leakage reactance of transformer. When an alternating source is applied in the primary, the source will supply the current for magnetizing the core of transformer.

But this current is not the actual magnetizing current, it is little bit greater than actual magnetizing current. Actually, total current supplied from the source has two components, one is magnetizing current which is merely utilized for magnetizing the core and other component of the source current is consumed for compensating the core losses in transformer. Because of this core loss component, the source current in transformer on no-load condition supplied from the source as source current is not exactly at 90° lags of supply voltage, but it lags behind an angle θ is less than 90° . If total current supplied from source is I_0 , it will have one component in phase with supply voltage V_1 and this component of the current I_w is core loss component.

This component is taken in phase with source voltage, because it is associated with active or working losses in transformer. Other component of the source current is denoted as I_μ . This component produces the alternating magnetic flux in the core, so it is watt-less; means it is reactive part of the transformer source current. Hence I_μ will be in quadrature with V_1 and in phase with alternating flux Φ . Hence, total primary current in transformer on no-load condition can be represented as

$$I_0 = I_\mu + I_w$$

$$|I_\mu| = |I_0| \cos \theta$$

$$|I_w| = |I_0| \sin \theta$$

$$|I_w| = \sqrt{|I_\mu|^2 + |I_0|^2}$$

Now you have seen how simple is to explain the theory of transformer in no-load.

D. Theory of transformer on load

Theory of Transformer on Load but Having No Winding Resistance and Leakage Reactance, Now the behavior of above said transformer on load would be examined, that means load is connected to the secondary terminals.

Consider, transformer having core loss but no copper loss and leakage reactance. Whenever load is connected to the secondary winding, load current will start to flow through the load as well as secondary winding.

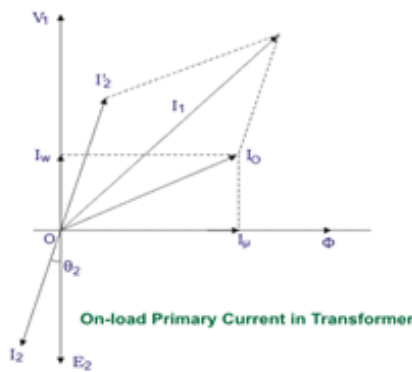


Fig. 3: On-load Primary Current in Transformer

This load current solely depends upon the characteristics of the load and also upon secondary voltage of the transformer. This current is called secondary current or load current, here it is denoted as I_2 . As I_2 is flowing through the secondary, a self mmf in secondary winding will be produced. Here it is $N_2 I_2$, where, N_2 is the number of turns of the secondary winding of transformer.

This mmf or magneto motive force in the secondary winding produces flux ϕ_2 . This ϕ_2 will oppose the main magnetizing flux and momentarily weakens the main flux and tries to reduce primary self-induced emf E_1 . If E_1 falls down below the primary source voltage V_1 , there will be an extra current flowing from source to primary winding. This extra primary current I_2' produces extra flux ϕ' in the core which will neutralize the secondary counter flux ϕ_2 . Hence the main magnetizing flux of core, Φ remains unchanged irrespective of load. So total current, this transformer draws from source can be divided into two components, first one is utilized for magnetizing the core and compensating the core loss i.e. I_0 . It is no-load component of the primary current. Second one is utilized for compensating the counter flux of the secondary winding. It is known as load component of the primary current. Hence total no load primary current I_1 of a electrical power transformer having no winding resistance and leakage reactance can be represented as follows Where, θ_2 is the angle between Secondary Voltage and Secondary Current of transformer.

II. LITERATURE REVIEW

Mushtaq Ismael Hasan (2017)[1] Studied the thermal behavior of electrical distribution transformer numerically with the effect of surrounding air temperature. 250 KVA distribution transformer was chosen as a study model and studied in temperature range cover the weather conditions of hot places. Transformer oil-based nanofluids were used as a cooling medium instead of pure transformer oil. Four types of solid particles (Cu, Al₂O₃, TiO₂ and SiC) were used to compose nanofluids with volume fractions (1%, 3%, 5%, 7%, and 9%). In addition to its good thermal characteristics the nanoparticles lead also to increase the dielectric of oil

and increase the breakdown voltage. Results obtained show that, using of transformer oil-based nanofluids as a cooling medium instead of pure transformer oil lead to improve the cooling performance of transformer by reducing the temperature of transformer and as a consequence increasing the protection of the transformer against the breakdown. Also increasing the nanoparticles volume fraction in nanofluid cause extra decrease in transformer temperature. Among all of the selected nanofluids the SiC-Oil nanofluid give lower transformer temperature.

Jackwin Vincent K(2017)[2] investigated methods of onan transformer cooling system by means of increasing heat transfer rate by implanting the axial groves along with fins and porous region within in the cooling tubes and further optimization of the cooling process by adjusting the gravity by orienting the tube. This study is carried out by means of numerical analysis by simulating Transformer geometry in Ansys Fluent. Real case geometry of distribution transformer is used in this simulation

Sachin. B. Paramane(2016)[3] studied the effect of fan air flow direction and mounting arrangement on the thermal performance of the radiators of power transformers using Computational Fluid Dynamics analysis. The study is carried out for four radiators of 3 m height and 30 fins with 0.52 m width and two fans of 1 m diameter in vertical and horizontal air flow directions. The horizontal flows from the two fans are considered in the same and the opposite direction, with the fans located in the same and the opposite side, respectively running at the same speed of 860 rpm for all configurations. Thermal radiation is modeled using the discrete transfer radiation model. A Comparison of different flow and heat transfer patterns as well as heat dissipation—for the four different configurations—is presented. Velocity and temperature contours are used to visualize the heat and fluid flow distribution over the radiators. Fans placed on one side of the radiators result in larger heat dissipation than the as compared to other studied arrangements studied results in larger heat dissipation. The Reasons for the improvement in the heat dissipation are presented.

S Anishek(2016)[4] numerical simulation of an oil natural air natural power transformer radiator was performed to determine its cooling capacity. In addition, optimum spacing between sections and optimum length of sections of radiator were also determined. An optimized radiator design was proposed and was simulated to determine its cooling capacity. The proposed radiator design was found to 14% more efficient than existing design in terms of cooling capacity for same material cost. The control volume method has been used to resolve the continuity, the momentum and the energy equations in steady state. The cooling capacity of existing ONAN radiator is found to be 10.91 kW while that of proposed radiator is found to be 12.46 k W. The proposed

design is 14% efficient than existing. The optimum spacing between sections of radiator was found to be 25 mm rather than 45 mm as in existing design. The optimum length of section was found to be 750 mm whereas the length of sections in existing design is 1500 mm.

Robert Sitar (2015)[5] studied the impact of aluminum shields on losses and temperature rise. Using a 3D finite element method (FEM) software, calculations for five different leads arrangement are done on a model of a 220 MVA transformer with phase current of 4.4 kA. Influence on results of non-linear magnetic property and non-linear thermal parameters are studied as well. Finally, calculation results are verified by measurements. Experiment has confirmed that aluminum shield is a correct measure for reducing tank local overheating. They had shown that usage of aluminum shields can be an efficient measure for reduction of temperature rise and overheating in transformer tanks with high current carrying conductors. Experimental verification has proven that the conclusion from numerical models can be applied in practice. Still it is computationally expensive to model 3D transformer structural parts in every detail. Nevertheless, sufficient accuracy was achieved since the tank temperature reduction by applying aluminum shields was confirmed. On the other side, calculation results showed that aluminum shields are not a good measure for reducing loss level, as it showed increase of loss on all analyzed lead arrangements. Introducing nonlinear calculation makes it possible to understand the impact of nonlinear parameters such as magnetic permeability and heat transfer coefficients on temperature rise in a carbon steel tank. Because of nonlinearities, the magnitude of losses and temperatures increase. Effect of aluminum shields on final results is similar in both linear and nonlinear model. It is important to note that, based on the results, in order to get exact temperature distribution a non-linear calculation is needed as the errors could be large with linear calculations. Altogether, further research should be continued with nonlinear calculation

III. STEPS OF WORKING METHOD

Specification of transformer geometry for various loads is shown in Figure 4.

Below table I gives the technical specifications of Transformer and Fin geometry created for this research.

Table I. Transformer and Fin Geometry

Specification	Dimension
Transformer Load	250 KVA
Transformer Dimension (l X b X h)	1345mm X 800mm X 1315mm
Fin Dimension	190 mm X 1192 mm
Fin Thickness	10 mm

Rated Capacity (KVA)	Voltage Schedule			Vector Group	Consumption(W)			Short/circuit impedance(%)	Weight			Out line dimension (mm±10%)		
	HV	Tapping	LV		No-load (kw)	load (kw)	No-load current (%)		Body	o.l	Total	Length	Width	Height
10				65	330	3.5	4	90	35	150	760	400	950	
20				105	480	3.0		135	60	225	885	400	955	
30				130	600	2.1		180	70	285	985	380	1015	
50				170	870	2.0		230	75	350	985	510	1035	
63				200	1040	1.9		285	90	430	1060	485	1135	
80				250	1250	1.8		295	95	475	1010	775	1070	
100				290	1500	1.6		330	100	520	1010	740	1095	
125				340	1800	1.5		380	110	600	1040	770	1135	
160	6			400	2200	1.4		440	120	685	1235	735	1165	
200	6.3	±5%	0.4	480	2600	1.6		515	135	800	1280	765	1210	
250	10	(±2 x 2.5%)		560	3050	1.2		610	180	940	1345	800	1315	
315	10.5		670	3650	1.1		715	180	1105	1395	850	1375		
400	11		800	4300	1.0		880	205	1310	1435	820	1460		
500			960	5150	1.0		1005	230	1515	1525	965	1450		
630			1200	6200	0.9		1155	265	1770	1615	1080	1615		
800			1400	7500	0.8		1420	315	2160	1700	1120	1705		
1000			1700	10300	0.7		1580	425	2520	1750	1140	1880		
1250			1950	12000	0.6		1940	495	3040	1850	1245	1835		
1600			2400	14500	0.6		2355	560	3800	1865	1285	2020		

Fig. 4: Specification of Transformer Geometry for Various Loads

Properties of Material of the Transformer and fin geometry are shown in Table II.

Table II. Properties of the Material

Materials/ Properties	Iron	Copper
Geometry	Transformer Tank, Fin, Core	Coil
Density	8030 kg/m ³	8978 kg/m ³
Thermal Conductivity	502.48 j/kg. k	381 j/kg. k
Specific Heat	16.27 w/m.k	387.6 w/m.k

Properties of Transformer Oil is shown in Table III.

Table III. Properties of transformer oil

Materials/ Properties	Transformer Oil
Geometry	Fluid Domain
Density	870 kg/m ³
Thermal Conductivity	2000 j/kg. k
Specific Heat	0.109 w/m.k
Viscosity	0.124 m.s

IV. STEPS OF WORKING

Step 1: Collecting information and data related to Transformers.

Step 2: A fully parametric model of the Transformer with fin is created in CATIA V5R20

Step 3: Model obtained in Step 2 is analyzed using ANSYS 15. (FLUENT), to obtain the heat rate , thermal gradient.

Step 4: Manual calculations are done.

Step 5: Finally, we compare the results obtained from ANSYS and manual calculations for different material, shapes and thickness.

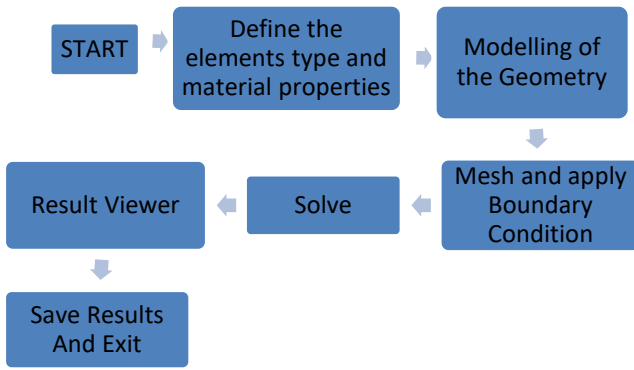


Fig.4. Setup of working

V. STEPS OF ANSYS ANALYSIS

The different analysis steps involved in ANSYS are mentioned below.

A. Building the model

To re-create mathematically the behavior of an actual engineering system is the ultimate purpose of a Computational fluid dynamics. The analysis must be an exact mathematical The ANSYS program provides the following approaches for model generation:

- Creating a solid model within ANSYS.
- Using direct generation
- Importing model created in a computer-aided design (CAD) system.

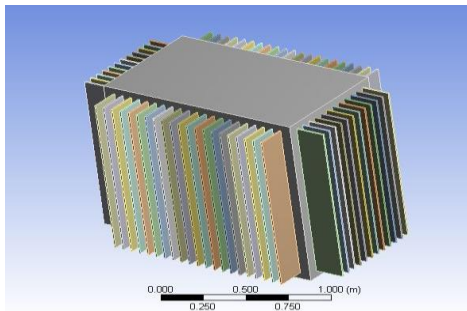


Fig. 5: CAD geometry of original 250 KVA Transformer

B. Defining material properties

For any kind of analysis material property are the main things which must be defined before moving further analysis. There are thousands of materials available in the ANSYS environment and if required library is not available in ANSYS directory the new material directory can be created as per requirement. For the present work iron used as a material of Transformer tank, Fin and core. The material properties of the present case are as: Density: 8030kg m⁻³, Isotropic thermal conductivity: 16.27 w/m k, Specific Heat: 502.48 J/kg k.

C. Boundary condition

1. The maximum temperature generated on the coil of the Transformer is taken as 390k while that on the core is taken as 370 k.
2. All the outer walls of transformer including the fins surfaces are subjected to combined natural convection and radiation, the value of convection heat transfer coefficient is assumed (1000 W/m².K) and the external emissivity is 1.
3. Transformer Oil is used as convective fluid medium between coil, core and inner walls of transformer.
4. The FLUENT solver is used for present analysis.

D. Computational fluid dynamics

The CFD analysis at 30°C atmospheric temperature and result indicates the temperature distribution of actual Transformer Geometry the maximum temperature is 390k at coil and minimum temperature is 312k at tip of fins. Result reveal that there is minute variation of temperature distribution over the Fluid domain(Figure 5).

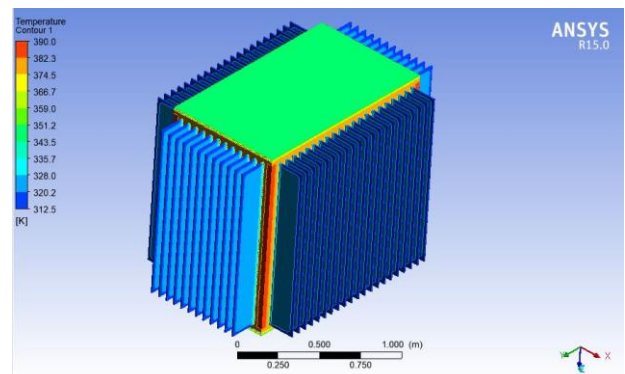


Fig. 6. Temperature Contour of Original Transformer Geometry

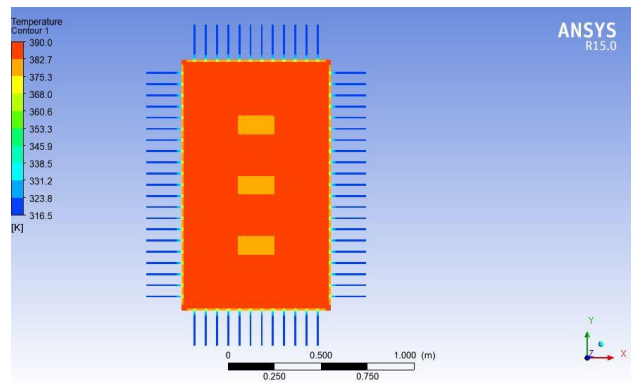


Fig 7. Temperature Contour for Transformer at XY plane at midpoint

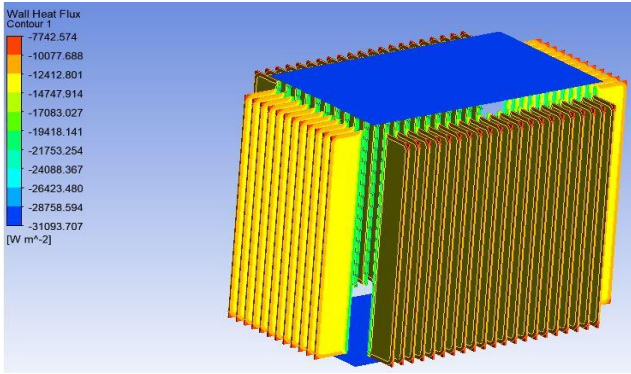


Fig. 8 : Wall Heat flux Obtained for Fins

The obtained heat flux for the fins and exposed walls of the transformer is shown in the fig 8; as it can be seen the wall heat flux of the fin varies from -7742.5 W/m^2 to -31093.7 W/m^2 .

E. Proposed design-1

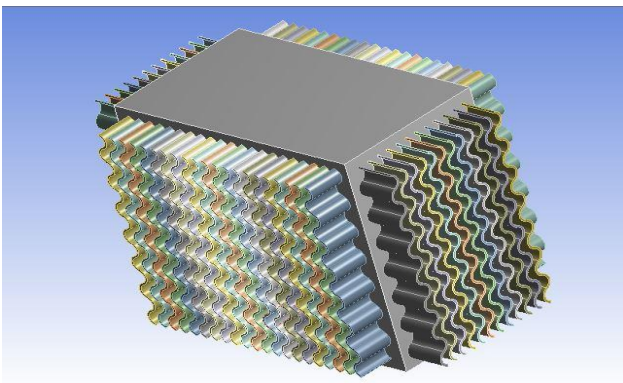


Fig.9. CAD geometry of proposed design-1

The CAD geometry of Transformer for proposed design-1 is created with the help of CATIA software then its STP format file is imported in ANSYS workbench for further analysis. A three-dimensional view of Transformer tank for proposed design-1 is shown in figure 9.

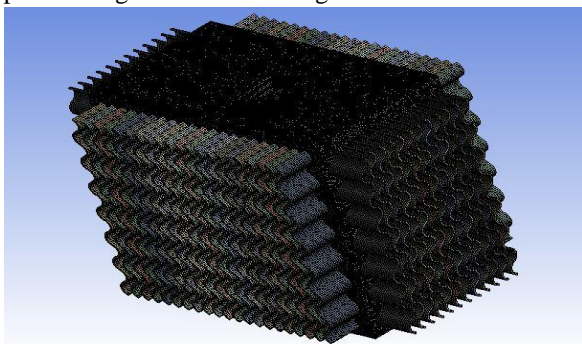


Fig.10. Meshing, Total No. of Nodes: 1426901& Total no. of elements: 4424225

After completing the CAD geometry of Transformer Tank for proposed design-1 is imported in ANSYS workbench for further thermal analysis and the next step is meshing. The mesh created in this work is shown in figure No. 10. The total Node is generated is 1426901& Total No. of Elements is 4424225.

F. CFD analysis for proposed design-1 with maximum temperature 390k&ambient temperature 30°C

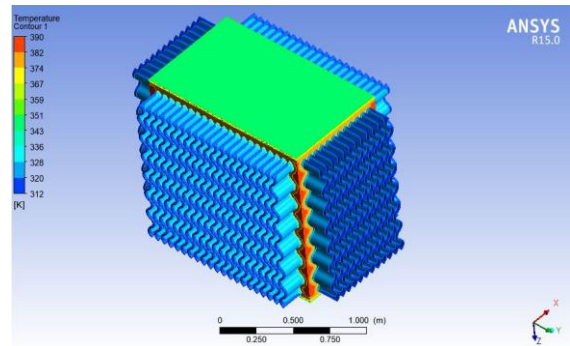


Fig.11. Temperature distribution over the Transformer of proposed design-1

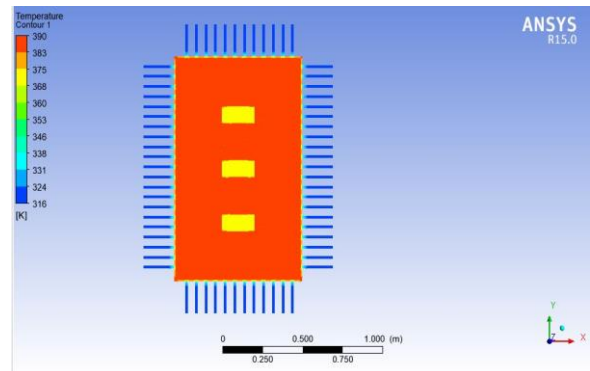


Fig.12. Temperature Contour for Transformer at XY plane at midpoint

The result of transient thermal analysis of Transformer for proposed design-1 at 30°C ambient temperatures indicates the temperature distribution of Wavy Fin Transformer tank the maximum temperature is 390K at coil and minimum temperature is 312K at tip of fin. Figure 11 Show the temperature distribution over the Transformer Tank for proposed design-1 with different color contours.

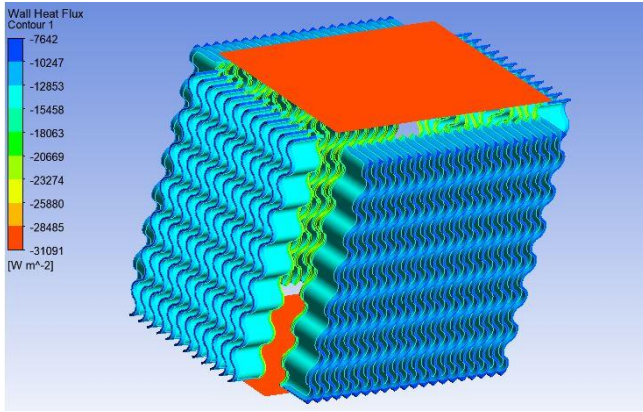


Fig.13: Wall Heat Flux Obtained for Proposed Design-1

The obtained heat flux for the fins and exposed walls of the transformer is shown in the fig above; as it can be seen the wall heat flux of the fin varies from -7642 W/m^2 to -31091 W/m^2 .

G. Proposed design-2

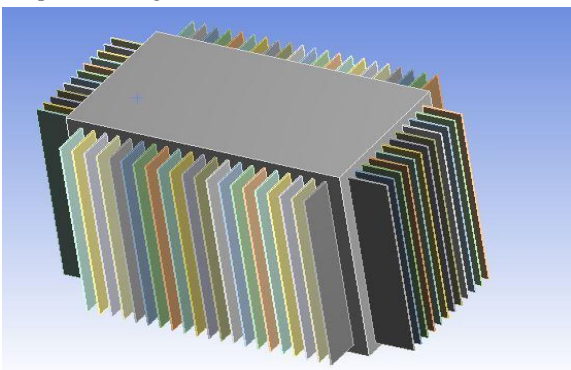


Fig.14. CAD geometry of proposed design-2

The CAD geometry of Transformer for proposed design-2 is created with the help of CATIA software then its STP format file is imported in ANSYS workbench for further analysis. A three dimensional view of Transformer tank for proposed design-2 is shown in figure No 12.

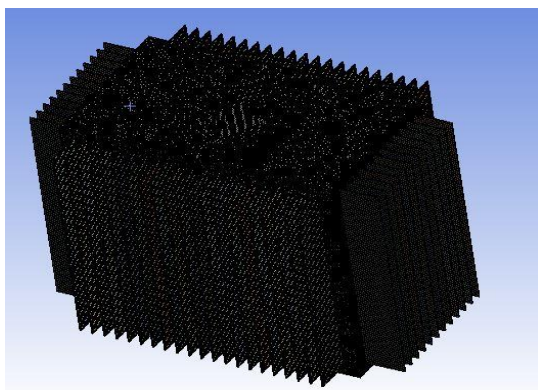


Fig.15: Meshing, Total No. of Nodes: 1495781 & Total no. of elements: 4531385

After completing the CAD geometry of Transformer Tank for proposed design-2 is imported in ANSYS workbench for further thermal analysis and the next step is meshing. The mesh created in this work is shown in figure No. 4.14. The

total Node is generated is 1495781 & Total No. of Elements is 4531385.

H. CFD analysis for proposed design-2 with maximum temperature 390k & ambient temperature 30°C

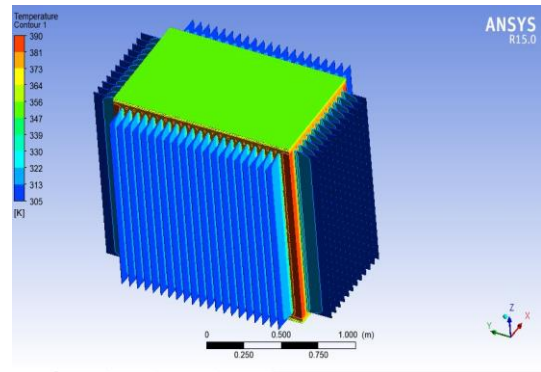


Fig.16: Temperature distribution over the Transformer of proposed design-2

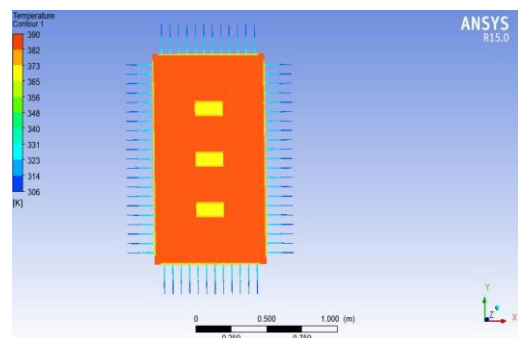


Fig.17: Temperature Contour for Transformer at XY plane at midpoint

The result of transient thermal analysis of Transformer for proposed design-2 at 30°C ambient temperatures indicates the temperature distribution of Trapezoidal fins Transformer tank the maximum temperature is 390K at coil and minimum temperature is 306K at tip of fin. Figure No.4.16 Show the temperature distribution over the Transformer Tank for proposed design-2 with different color contours.

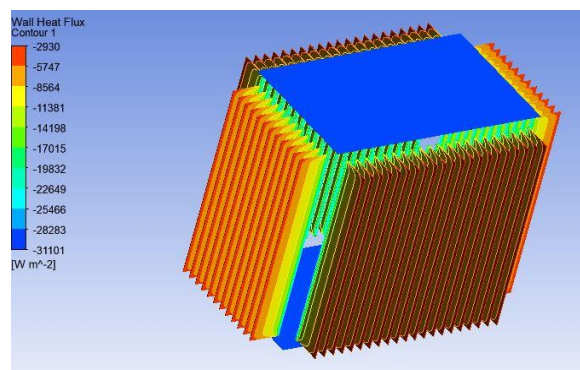


Fig.18: Wall Heat Flux Obtained for Proposed Design-2

The obtained heat flux for the fins and exposed walls of the transformer is shown in the fig above, as it can be seen the

wall heat flux of the fin varies from -2930 W/m^2 to -31101 W/m^2 .

I. Proposed design-3

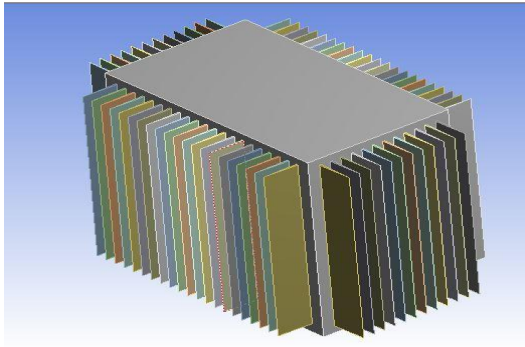


Fig.19: CAD geometry of proposed design-3

The CAD geometry of Transformer for proposed design-3 is created with the help of CATIA software then its STP format file is imported in ANSYS workbench for further analysis. A three dimensional view of Transformer tank for proposed design-3 is shown in figure No4.18.

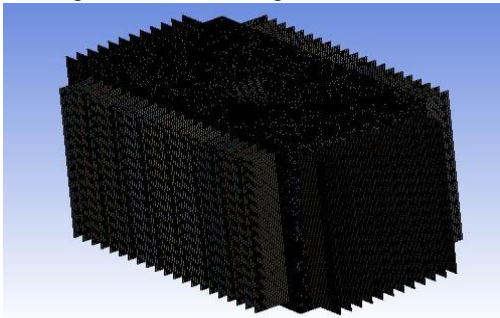


Fig.20: Meshing, Total No. of Nodes: 1336421 & Total no. of elements: 4389268

After completing the CAD geometry of Transformer Tank for proposed design-3 is imported in ANSYS workbench for further thermal analysis and the next step is meshing. The mesh created in this work is shown in figure No. 19. The total Node is generated is 1336421 & Total No. of Elements is 4389268.

J. CFD analysis for proposed design-3 with maximum temperature 390k & ambient temperature 30°C

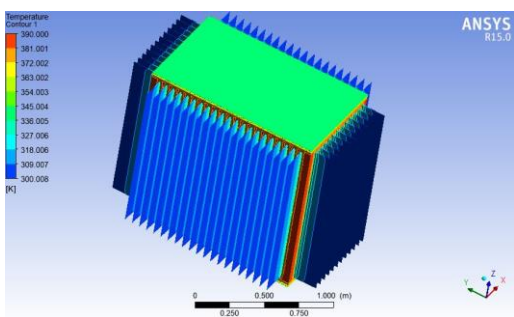


Fig.21: Temperature distribution over the Transformer of proposed design-1

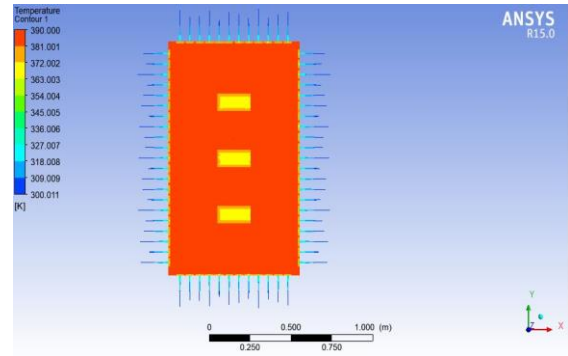


Fig.22: Temperature Contour for Transformer at XY plane at midpoint

The result of transient thermal analysis of Transformer for proposed design-3 at 30°C ambient temperatures indicates the temperature distribution of Triangular Fins Transformer tank the maximum temperature is 390K at coil and minimum temperature is 300K at tip of fin. Figure 21 Show the temperature distribution over the Transformer Tank for proposed design-3 with different color contours.

The obtained heat flux for the fins and exposed walls of the transformer is shown in the fig above; as it can be seen the wall heat flux of the fin varies from 31 W/m^2 to -38915.2 W/m^2 .

VI. RESULTS

The Computational Fluid Dynamics were conducted using ANSYS workbench based on CFD methodology the effects of different important geometrical parameters on the Convective heat transfer From both actual and proposed Design of transformer fins.

Table IV: Maximum and Least Temperature Obtained From Analysis

Fin Shape	Maximum Temperature	Minimum Temperature
Rectangular	338 k	312 k
Wavy	338 k	312 k
Trapezoidal	338 k	306 k
Triangular	338 k	300 k

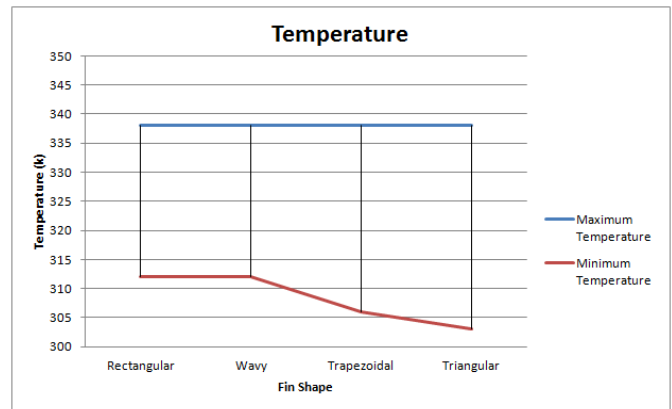


Fig. 23: Results Obtained from Analysis

Table V: Temperature Drop Obtained For Various Fin Shape

Fin Shape	Temperature Drop
Rectangular	26 k
Wavy	26 k
Trapezoidal	32 k
Triangular	38 k

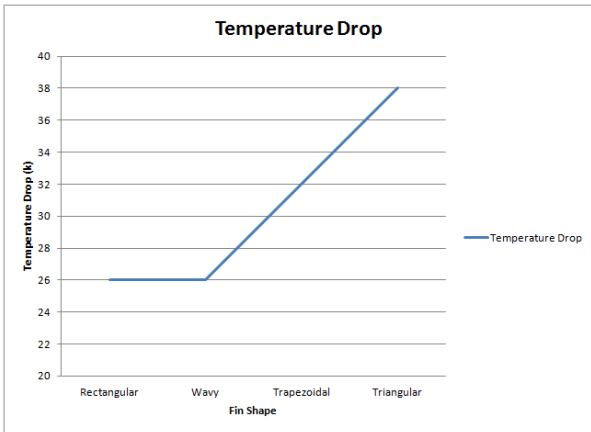


Fig. 24: Temperature Drop Obtained For Various Fin Shape

Table VI: Heat Transfer Rate Obtained For Different Fin

Fin Shape	Total Heat Transfer Rate (W)
Rectangular	-501386.19 W
Wavy	-386712.51 W
Trapezoidal	-287693.92 W
Triangular	-620426.14 W

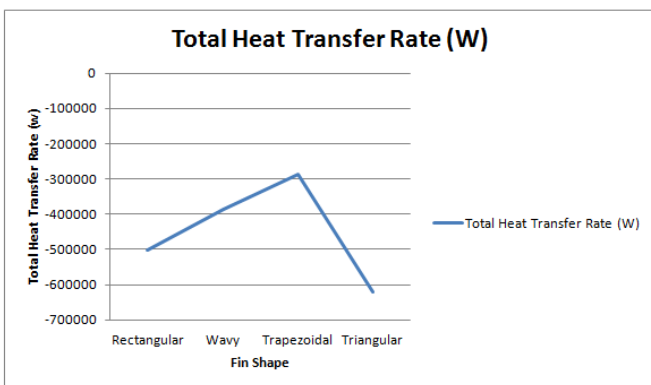


Fig. 25: Heat Transfer Rate Obtained For Different Fin

Mathematical and analytical studies were performed in order to optimize geometrical parameters for natural convective heat transfer from Transformer tank and proposed design of various fins for transformer assembly for geometrical optimization. Computational Fluid Dynamic analysis was performed on Four Fin Geometry; i.e. original rectangular, wavy, Trapezoidal and triangular. The conclusion of the study is presented below:

1. The temperature drop obtained for the original transformer geometry at the end of the fin was 26k.
 2. The Wavy fins showed the same results with temperature drop of 26k between the end of fins.
 3. The temperature drop obtained at the tip of trapezoidal fin was about 32k.
 4. While triangular fin showed maximum temperatures drop of about 38k at between the ends of fin.
 5. The wall heat flux obtained for rectangular fin was found to vary from -7742.5 W/m^2 to -31093.7 W/m^2
 6. The wall heat flux obtained for Wavy fin was found to vary from -7642 W/m^2 to -31091 W/m^2
 7. The wall heat flux obtained for Trapezoidal fin was found to vary from -2930 W/m^2 to -31101 W/m^2
 8. The wall heat flux obtained for Triangular fin was found to vary from 31 W/m^2 to -38915.2 W/m^2
 9. The total heat transfer rate obtained were -501386.19 W for rectangular, -386712.51 W for Wavy, -287693.92 W for Trapezoidal and -620426.14 W for triangular fin shape.
 10. On performing the CFD analysis on transformer with rectangular fins and transformer with wavy fins there were no changes seen in the values of maximum and minimum temperature contour and temperature drop of transformer designs. But in other designs of transformer with trapezoidal and triangular design which were made by varying the thickness of rectangular design there were various changes seen in the range of maximum and minimum temperature and temperature drop.
- The present work concerned only the redesign of Fins of Transformer from the point of heat transfer rate. There are some possible recommendations which may be possible for adoption in future;
1. CFD analysis was conducted to test the effect of various fin shapes on transformer cooling.
 2. The flow of air was not considered in this study, the effect of air flow rate on the efficiency of various fin design in cooling the transformer could be studied in future.
 3. The effect of various materials on the efficiency of the fins could also be studied as a future scope.
 4. Further for the improvement of surface area in the fins of transformers a study based on the perforation in fins

VII. CONCLUSION

can be carried out to have the more improved performance and efficiency of transformers.

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