

Cooling Effect Analysis of Transformer with Varying Shape of Fins

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Abstract—Electricity supply transformer is a static instrument which, without electrical clear connections and by means of the collective link between two coils, turns energy from one place to the next. Without altering the rate but at different tensions, it changes power from module to module. A power transformer is an electrical device that is used in electric power systems to adjust the power output of AC. In the 1840s, the world's first transformer was developed. Oil tank with oil charging, cooling equipment on the tank wall, and active component inside the tank make up modern large and medium power transformers. The operating theory of a transformer is very straightforward. Faraday's rule of electromagnetic induction governs this. The transformation action in an electrical appliance is ultimately induced by primary coil between two or more windings. "The induced EMF in a conductor or coil is directly proportional to the rate of change of flux linkage with respect to time," according to Faraday's laws. An ideal transformer, as one type of electrical element, seems to have no power loss. In fact, however, a transformer will never be 100 percent effective. The winding resistance thermal loss, eddy current loss, and hysteresis loss are the main losses. The active component of a liquid immersed transformer, which includes the cores and windings, is immersed in an insulating liquid, usually transformer oil, which fills the transformer. Convection can transfer the heat produced by the windings and cores to the transformer wall. Radiation and convection would then dissipate the heat into the atmosphere. Fins and radiators are widely used to boost the cooling capacity of certain large transformers. The broad oil immersed transformer, which has a blower mounted to force the flowing air to maximize the cooling effects, is an example of a liquid immersed transformer.

Keywords—Electrical Transformer; Cooling Performance; Distribution Transformer; Transformer Cooling.

I. INTRODUCTION

Electric inverter is an electronic instrument that, without significant electrical connections and by mutual interaction between two windings, turns the electric power from circuit to circuit. Without changing its frequency but at different tensions, it transforms power from circuit to circuit. A transmission line is an energy amplifier used in the utility grid to change the AC voltage. In the 1840s, the world's first transformer was invented. Modern transformers with large and medium power consist of oil tanks with oil filling, tank walls cooling systems and the efficient element within the tanks. The transformer job concept is very straightforward. The law of electromagnetic induction of Faraday is important. In effect, the transformation action in an electrical transformer is responsible for mutual induction between two or more windings. "The induced EMF in a conductor or coil is directly proportional to the rate of change of flux linkage with respect to time," according to Faraday's laws".

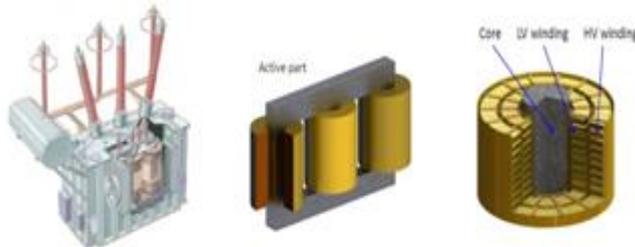


Fig. 1. Structures of disc winding transformer

As shown in Fig. 1, the effective portion of a transformer comprises of two major parts: a set of coils or windings (at least comprising a low voltage, high voltage, and a regulating winding) and an iron core. The primary coil of a step-up transformer is low voltage (LV) input, and the secondary coil is high voltage (LV) output. For a step-down transformer, the condition is the polar opposite. The magnetic field is the component that causes the flux to differ in intensity. In the long-range high-voltage power transmission, transformers currently play key roles.

A. Operating principle of transformer

An working method normally exists for the transformer because the main coil changes its capacitance and creates a different magnetic flux is produced. Then, this varying magnetic flux induces a voltage at the secondary spindle. As Figure 2, wrapping cables are made of materials having high dielectric strength on either side of the fundamental frame. The main curve is the left curve, and the right curve is the secondary curve. The electromagnetic field is triggered in the center whenever the AC is linked to the left. The magnetic stream passes the right side of the secondary coil and causes voltage. This theory is based on Faraday's law of induction, also known as the induction law in Eq. (i).

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

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

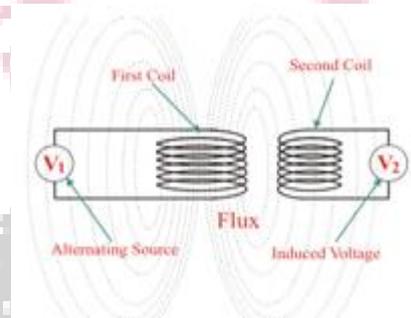


Fig. 2: Operating principle of transformer

There is a link between the voltage levels and the amount of wires from both ends of an ideal transformer, as shown in Eq (ii). The ratio of the primary coils number to the secondary coils number defines the output voltage to input voltage ratio, according to this equation. According to this rule, a transformer may be selected based on the output voltage within a certain power capacity.

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

II. STEPS OF WORKING METHOD

A. Defining material properties

The main things that must be defined before moving further analysis are for any kind of analysis material property. The ANSYS environment contains thousands of materials and the new Material Directory can be established according to requirements if the library is not available in ANSYS. Iron was used as the material for the Transformer tank, fin, and core in this project. The microstructures of this case are: Specific heating: 502,48 J/kg k. Densities: 8030 kg m/3, Isotropic thermal conductivity: 16,27 w/m k.

B. Boundary condition

1. The maximum generated temperature on the transformer coil is 390 k, while 370 k on the core.
2. All of the transformer's outer walls, including the fins' surfaces, are exposed to natural convection and radiation, with a convection heat transfer coefficient of 1000 W/m².K and an external emissivity of 1.
3. The transformer oil is used between the transformer spindle, core and inner walls as a convective fluid medium.
4. For the current analysis, the FLUENT solver is used.

C. Computational fluid dynamics

The temperature distribution of the actual Transformer Geometry was determined using CFD analysis at 30°C atmospheric temperature. The highest temperature is 390°C at the coil and the minimum temperature is 312°C at the tip of the fins. The findings show that the temperature distribution over the Fluid domain is subject to minute variations.

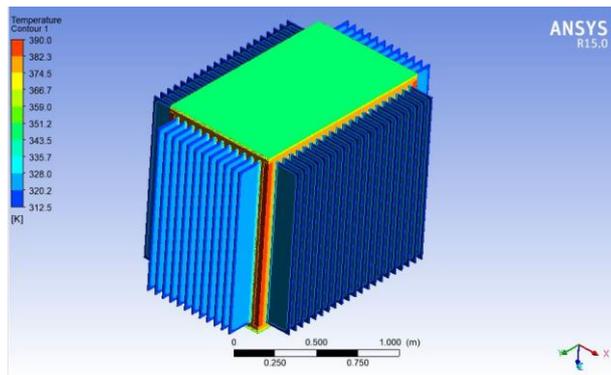


Fig. 3. Temperature Contour of Original Transformer Geometry

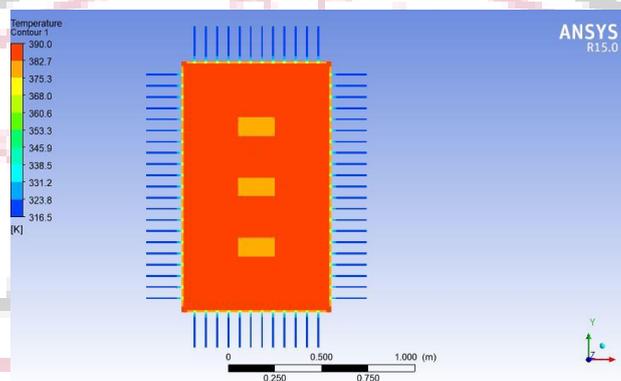


Fig. 4. Temperature Contour for Transformer at XY plane at midpoint

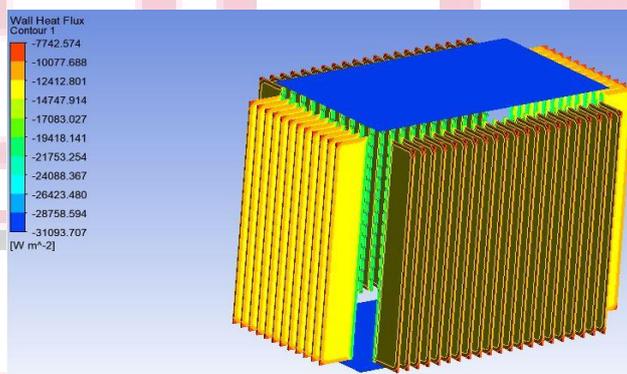


Fig. 5: Wall Heat flux Obtained for Fins

In fig 5, the heat flux obtained for the transformer fins and the exposed walls is shown; the wall heat flux of the fine ranges between -7741 W/m^2 , and -31089.5 W/m^2 , as can be seen.

III. RESULT ANALYSIS

The Computational Fluid Dynamics were led utilizing ANSYS workbench in light of CFD approach the impacts of various essential geometrical parameters on the Convective warmth exchange From both genuine and proposed Design of transformer blades.

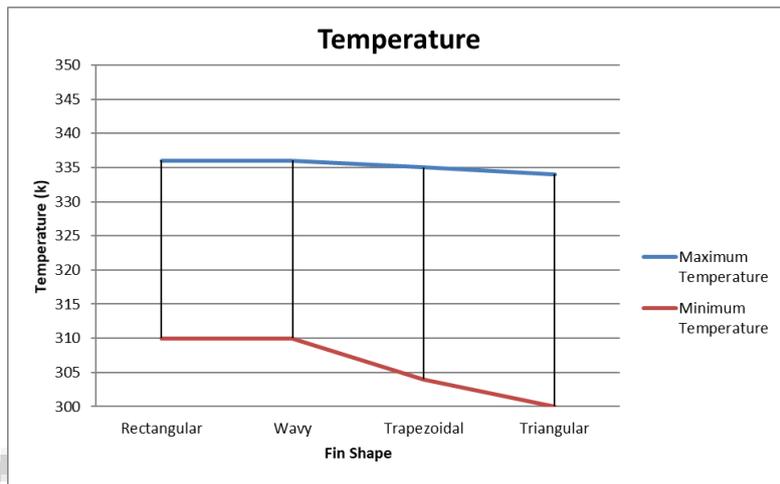


Fig. 6: Maximum and Minimum Temperature Obtained From Analysis

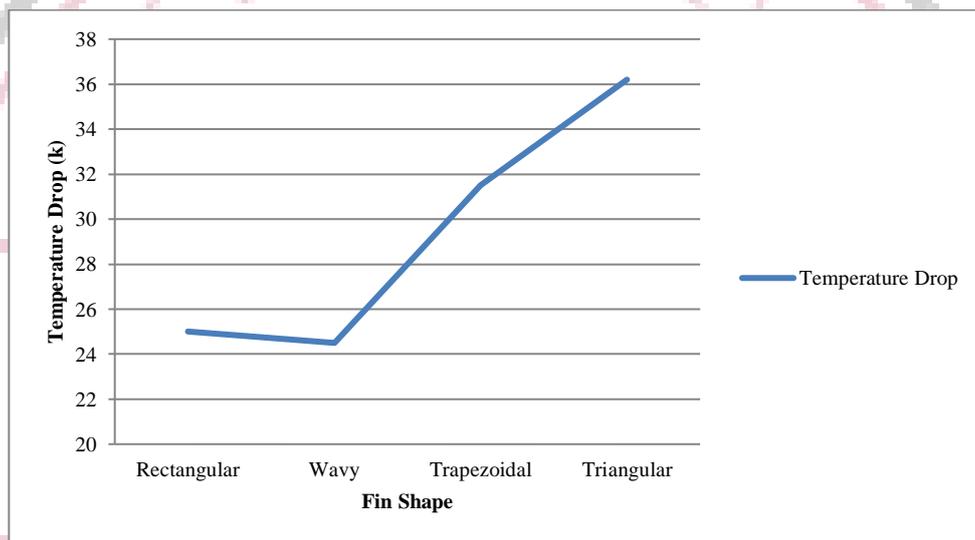


Fig. 7. Temperature Drop Obtained For Various Fin Shape

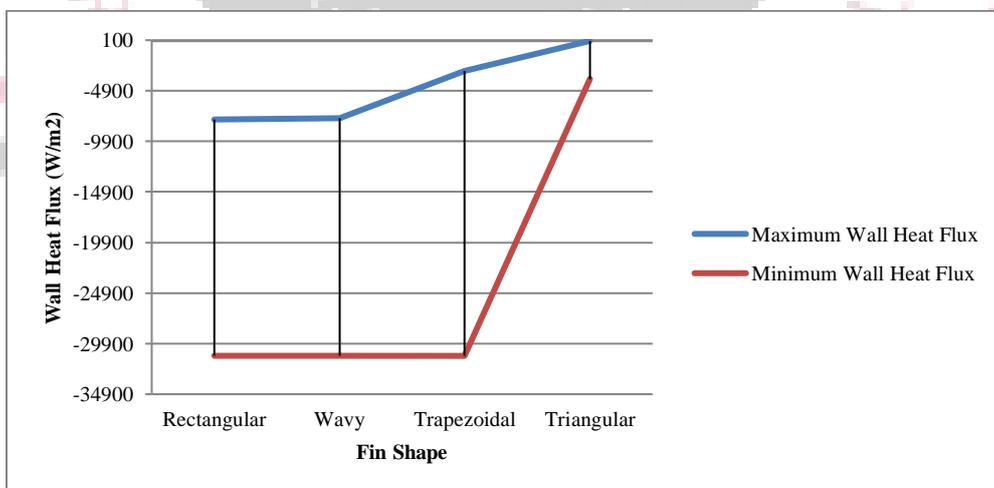


Fig.8. Wall Heat Flux Obtained For Different Fins

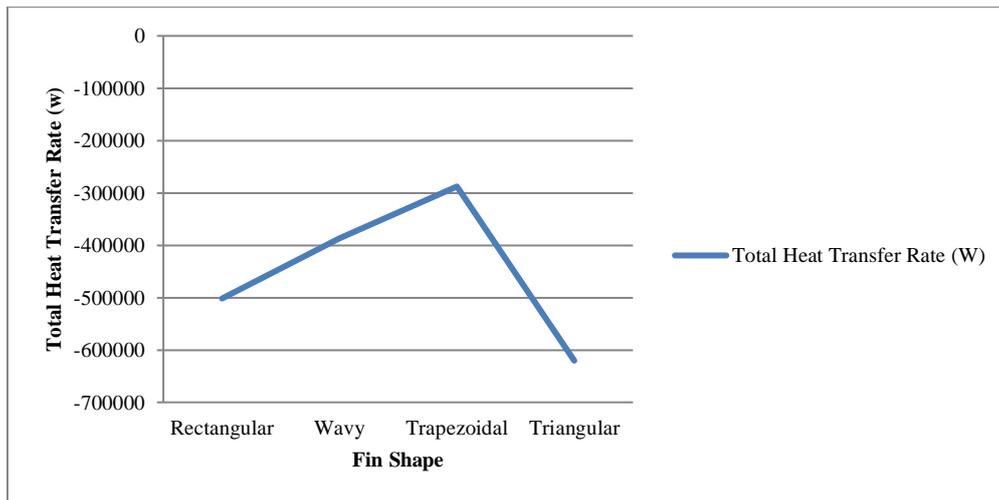


Fig.9. Heat Transfer Rate Obtained For Different Fin

IV. CONCLUSION

Numerical and investigative examinations were performed with a specific end goal to advance geometrical parameters for normal convective warmth exchange from Transformer tank and proposed plan of different balances for transformer get together for geometrical enhancement. Computational Fluid Dynamic examination was performed on Four Fin Geometry; i.e. unique rectangular, wavy, Trapezoidal and triangular. The finish of the investigation is introduced underneath:

- The temperature drop got for the first transformer geometry toward the finish of the blade was 25k.
- The Wavy balances demonstrated similar outcomes with temperature drop of 24.5k between the finish of balances.
- The temperature drop got at the tip of trapezoidal balance was around 31.5k.
- While triangular blade demonstrated maximum temperatures drop of around 36.2k at between the closures of balance.
- The heat flux got for rectangular balance was found to shift from - 7741 W/m² to - 31089.5 W/m².
- The heat flux got for Wavy blade was found to change from - 7637 W/m² to - 31089.5 W/m²
- The heat flux got for Trapezoidal balance was found to shift from - 2927 W/m² to - 31111 W/m²
- The heat flux got for Triangular blade was found to differ from 25 W/m² to - 3734.52 W/m²
- On playing out the CFD examination on transformer with rectangular blades and transformer with wavy balances there were no progressions found in the estimations of greatest and least temperature form and temperature drop of transformer outlines. In any case, in different outlines of transformer with trapezoidal and triangular plan which were made by shifting the thickness of rectangular outline there were different changes found in the scope of most extreme and least temperature and temperature drop.
- On the premise of the investigation exhibited one might say that the triangular blades are much appropriate for the application in transformer tank gathering.

REFERENCES

1. Mushtaq Ismael Hasan-“Using the transformer oil-based nanofluid for cooling of power distribution transformer” International Journal Of Energy And Environment Volume 8, Issue 3, 2017 pp.229-238
2. Jackwin Vincent K, Dr V.V.Prathibha Bharathi-“Simulation and Optimization of Cooling Tubes of Transformer for Efficient Heat Transfer” International Journal of Advanced Engineering, Management and Science (IJAEMS) [Vol-3, Issue-2, Feb- 2017]
3. Sachin. B. Paramanea,, Wim Van der Vekenb, Atul Sharmac, Joris Coddé-“Effect of fan arrangement and air flow direction on thermal performance of radiators in a power transformer” Journal of Power Technologies (Accepted Manuscript) (2016) 1–8
4. S Anishek*, Sony R#, Jayadeep Kumar JS , Pradeep M Kamath-“Performance Analysis and Optimisation of an Oil Natural Air Natural Power Transformer Radiator” International Conference on Emerging Trends in Engineering, Science and Technology (ICETEST - 2015) Procedia Technology 24 (2016) 428 – 435
5. Robert Sitar, Zarko Jani, and Zeljko Stih, “Improvement of thermal performance of generator step-up transformers”, Applied Thermal Engineering 78 (2015) 516-524

6. PanitanTampinyo*, ChainarongSrikunwong-“Numerical Simulation of Heat Transfer Process in Oil-Immersed Transformer”The 5th TSME International Conference on Mechanical Engineering17-19th December 2014, The Empress, Chiang Mai
7. KuberDwivedi-“Influence Of Geometrical Parameters Ofmpfhs With Four Fin Geometry (Square,Triangular, Circular And Diamond) Onthe Thermo Hydraulic Characteristics”ISSN 2319-5991 www.ijerst.comVol. 3, No. 4, November 2014
8. M.-g. Kim, S. M. Cho, J.-K. Kim, Prediction and evaluation of the coolingperformance of radiators used in oil-filled power transformer applicationswith non-direct and direct-oil-forced flow, Experimental Thermaland Fluid Science 44 (2013) 392–397.
9. S. Lee1, J. Y. Lee1, J. C. Yun1, J. Y. Park1 & J. H. Woo2-“Development of thermal and structuraldesign technology for a hermetically sealedoil transformer”WIT Transactions on The Built Environment, Vol 126, © 2012
10. Marina A. Tsili, Eleftherios I. Amoiralis ,Antonios G. Kladas, Athanassios T. Souflaris-“Power transformer thermal analysis by using an advanced coupled 3D heattransfer and fluid flow FEM model”International Journal of Thermal Sciences 53 (2012) 188e201

