DESIGN AND ANALYSIS OF TRANSFORMER TANK WITH DIFFERENT SHAPE OF STIFFENER

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ABSTRACT

In electric power application, transformer device are required for transfer of electrical energy. The electrical energy transfer take place between two or more circuits due to electromagnetic induction. Transformer is used to step-up or step-down the voltage. The high voltage of transformer is 220kV while low voltage is 33kV. Transformers are huge bodies which consist of tank, radiator, OLTC chamber, and coil and core assembly with oil inside the tank. The size of typical housing/tank is large and having the weight of several tones (without coil assembly and oil). The housing contains coil assembly and the oil. The housing of a transformer comprises of various compartments fabricated from mild steel plates. Loaded transformer housing is subjected to its own weight plus coils and oil. It may be elevated to certain height. Strength and rigidity are the important criteria of design. Reduction in weight keeping the required strength for application will obviously result in to cost saving. Decrement in displacement by adding stiffeners will reduce the chances of failure. In order to improve the strength to weight ratio of transformer tank the loading condition and magnitude of load are the important parameters from which the nature of stresses are determined. Design criteria are required to carry out the design based on the standards codes. Analysis of the design, based on the design criteria and the modification are carried out if required and analysis of the model is carried out using FEA software.

Keyword : - *Transformer tank, Diamond Stiffener, Cylindrical Stiffener, Box Stiffener, Deformation of Transformer tank*

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1. Introduction

Transformer is a most expensive equipment of electrical power. In operating condition, failures such as tank deformation, oil leakage, explosion due to excessive pressure generated inside transformer tank. Hence, its fundamental requirement of transformer or power industry is to design and manufacture a tank with structural stability and security.

Power transformer optimization of the material and improvement is proposed based on an Experimental Analysis on transformer tank. The Tank's precision mechanical calculation belongings Simulation method is obtainable by the contrast of the experimental results and calculated outcome. Tank efficiency by design optimization method is presented by the calculation cases [1].

1.1 Literature Review

various shape of stiffener for reducing deformation by ANSYS. They applied for various similar tank assemblies where complete automated procedure of optimization using optiSLang and ANSYS has been used [2].

Optimization of the material and cost of transformer are using different type of stiffener as well as changed the shape of tank with respect to inner dimension. They are gave the conclusion as the strength and rigidity of transformer tank is based on the thickness of tanks plate thickness and stiffeners. So this review gives path to words the improvement of transformer tank without change in strength and rigidity. They apply the owl shape on end of the transformer to reduce stiffener at both side because the circular plate have uniform pressure. So no need to any stiffener [3].

1.2 Problem Identification

Transformer is a most expensive equipment of electrical power. In operating condition, failures such as tank deformation, oil leakage, explosion due to excessive pressure generated inside transformer tank. Hence, its fundamental requirement of transformer or power industry is to design and manufacture a tank with structural stability and security.

2. Methodology

It can be practical that the optimization learning for the entire tank is not easy due to dissimilar arrangement or structure of tank walls, since parameter increase with unusual arrangements on dissimilar walls. Hence it is possible to optimize entity wall individually. Further, confirmation is essential between stresses and deformation on wall. Entire tank is analyzed and when individual wall (separated) is analyzed. Each tank wall is modeled separately in CAD software tool with the inexact dimensions as of unique tank model. Together tank model and wall model are export in parasolid configure from CAD software device. Meshing is done to change finite element model from geometric model for more investigation. Here boundary conditions of tank wall are dissimilar from tank analysis, in this tank wall; each and every edges are fixed which is different to the whole tank simulation. This can be compare through the same wall even as analyzed entire tank. So, this is confirmed by the outcome. It is experiential that maximum deformation & maximum stresses value with acceptable difference or approximately equal.

As of the above investigation method and outcome it can be conclude that only tank wall can be think about optimization learning as an alternative of entire tank. It is beneficial that so many parameters will be concentrated, supplementary lessening in difficulty of the problem.

Material applied for the analysis of transformer tank is E250 as per the ISO:2626. As per the material properties os E250 is as table -1.

Table -1: Material Properties of E250as per the ISO:2626

Name:	E250
Model type:	Linear Elastic Isotropic
Yield strength:	2.4e+008 N/m^2
Tensile strength:	4.1e+008 N/m^2
Elastic modulus:	2e+011 N/m^2
Poisson's ratio:	0.3
Mass density:	7850 kg/m^3
Shear modulus:	3.189e+014 N/m^2
Thermal expansion coefficient:	1.2e-005 /Kelvin

2.1 Analysis on Different Types of Stiffeners

Stiffeners are secondary plates or sections which are attached to beam webs or flanges to stiffen them against out of plane deformations. A bar, angle, channel, or other shape attached to a metal plate or sheet to increase its resistance to buckling.

Here, I have shown analysis for different shape of stiffeners on flat plate with respect to the dimensions of the plate used in transformer tank. I have done theoretical and analytical method.

2.2 FEA model analysis of simple plate and simple plate with different shaped stiffeners

The FEM analysis of different stiffeners is done and the maximum displacement of all is compared in the graph.
Here the constraints given to the tank plates are fixed geometry at the edges, because as the welded joint is used to join the plates of the tank, this fixture is given to all the further study while changing the stiffener shape and dimensions.
The mass and the vertical height of all the different shaped stiffeners are kept constant and only other dimensional parameters are changed for better comparison.

2.2.1 Simple Plate

Theoretical Calculation
Dimensions for the simple plate are 4800 mm X 2661 mm.
All Side of plate are considered fixed.
Applied pressure, P = 15 psi = 0.103421 MPa
Theoretical calculation for maximum displacement

$$y_{max} = \frac{0.0284 * p * a^4}{E * t^3 * [1.056 * (a/b)^5 + 1]}$$

$$y_{max} = 697.7 \text{ mm}$$

Where, a = larger length of plate
b = shorter length of plate
t = thickness of plate

From theoretical equation I found the maximum displacement at the centre of plate to be 697.7mm.
Analytical Calculation

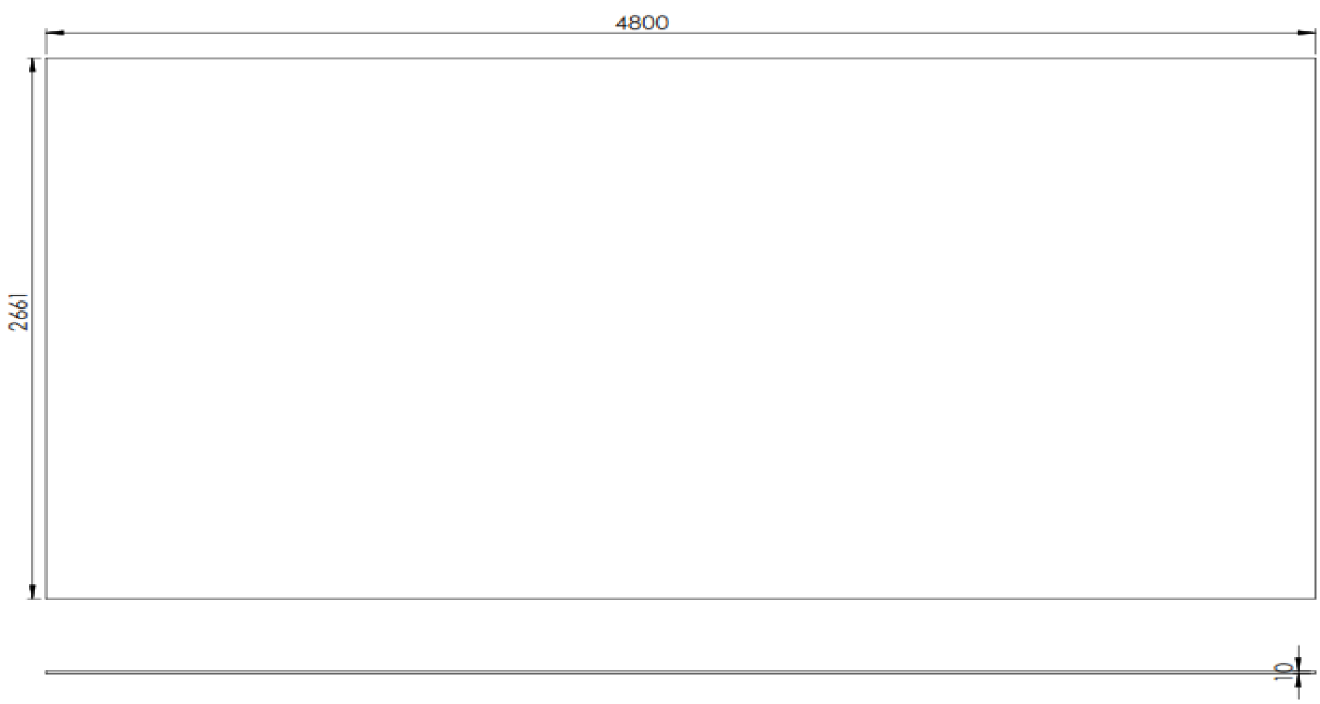

Fig -1: Simple plate with dimension

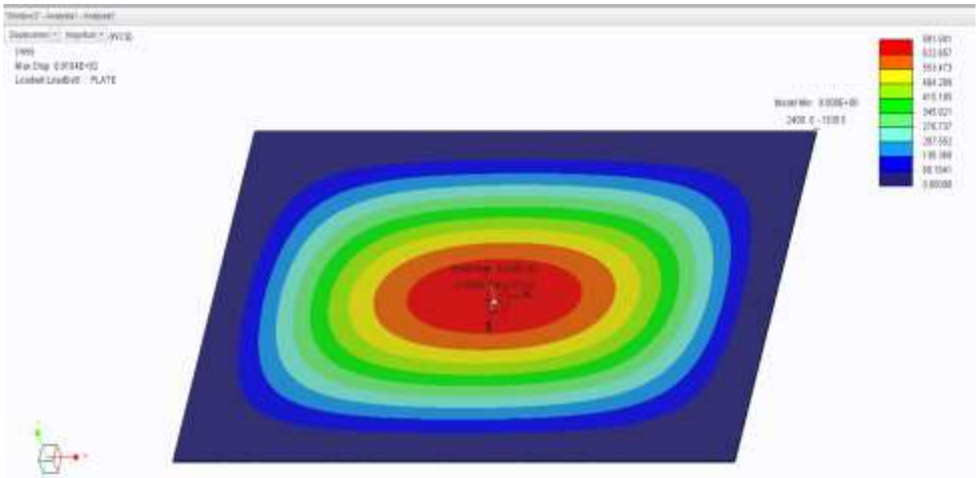

Fig -2: Displacement analysis of Simple plate

On doing FEM analysis and comparing both theoretical and analytical displacement results I get:

Table -2: theoretical and analytical results of displacement on Simple plate

	Theoretical	Analytical
Displacement	697.7	691.841

Table 2 show that the theoretical result and analytical result are approximately same. Figure 2 is the displacement result of plate (as per the dimension shown in figure 1). Figure 2 is obtained from the Solid Works software. Solidworks main idea is user to create drawing directly in 3D or solid form. From this solid user can assemble it directly on their workstation checking clashes and functionality of it. Creating drawing is pretty easy just drag and drop the solid to drawing block. Solidworks 3D Modeling, Engineering analysis, 2D Drawing, the boundary condition for the analysis of transformer wall as all wall edges are fixed and applied 15 psi pressure in surface of wall. Here, the 15 psi pressure is taken from the Central Board of Irrigation & Power [4]. Central Board of Irrigation & Power is the standard manual for the transformer parameter. The pressure 15 psi is also obtaining from the P=ρgh. (here h= distance from the lower plate of the transformer tank to horizontal centerline of conservator).

2.2.2 Flat Plate Stiffener

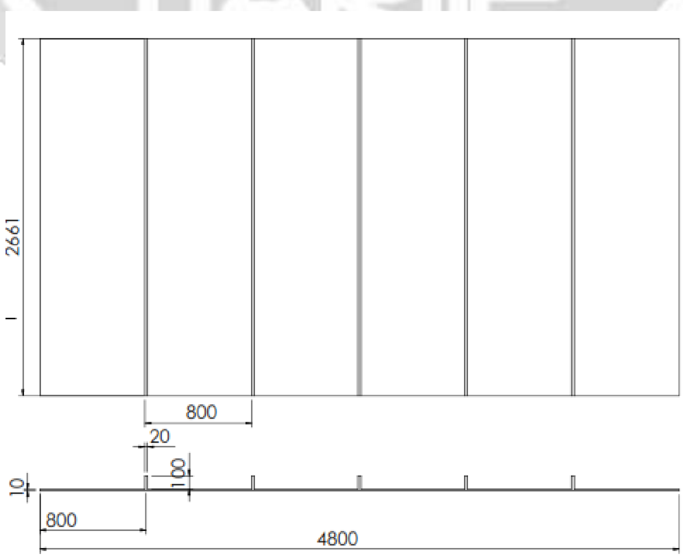

Fig -3: Arrangement of plate stiffener on plate

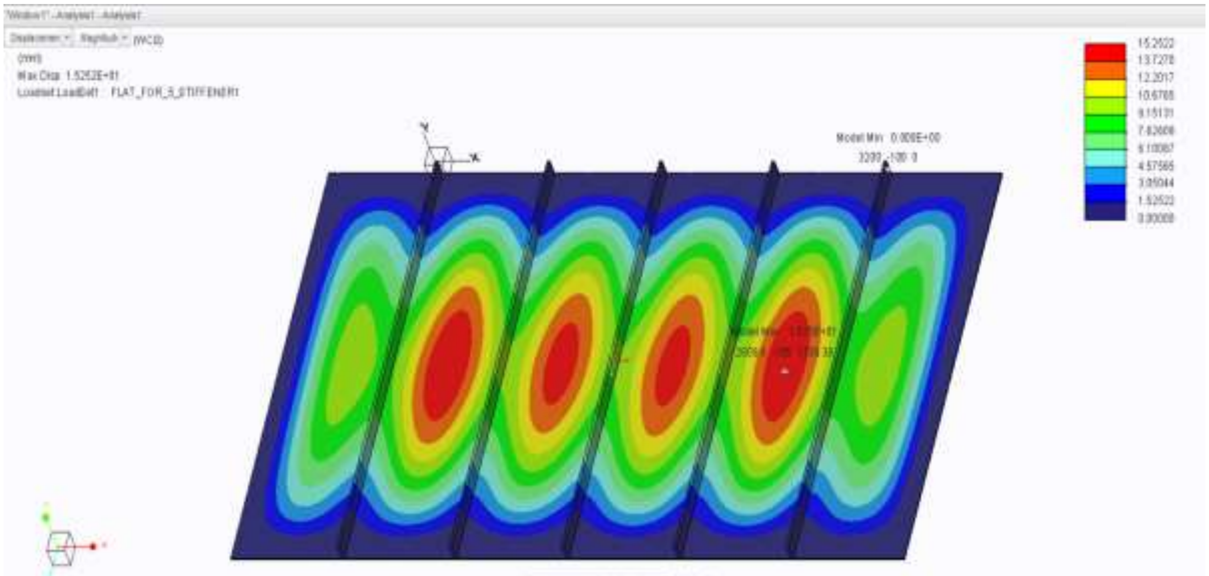

Fig -4: Displacement analysis of plate stiffener on Simple plate

Figure 3 and 4 are the arrangement of flat plate stiffener and displacement Analysis of plate stiffener on simple rectangular plate respectively. Figure 2 & 4 are concluded that Flat plate stiffener is provided stiffening to reduce the displacement of plate.

2.2.3 T-shaped Stiffener

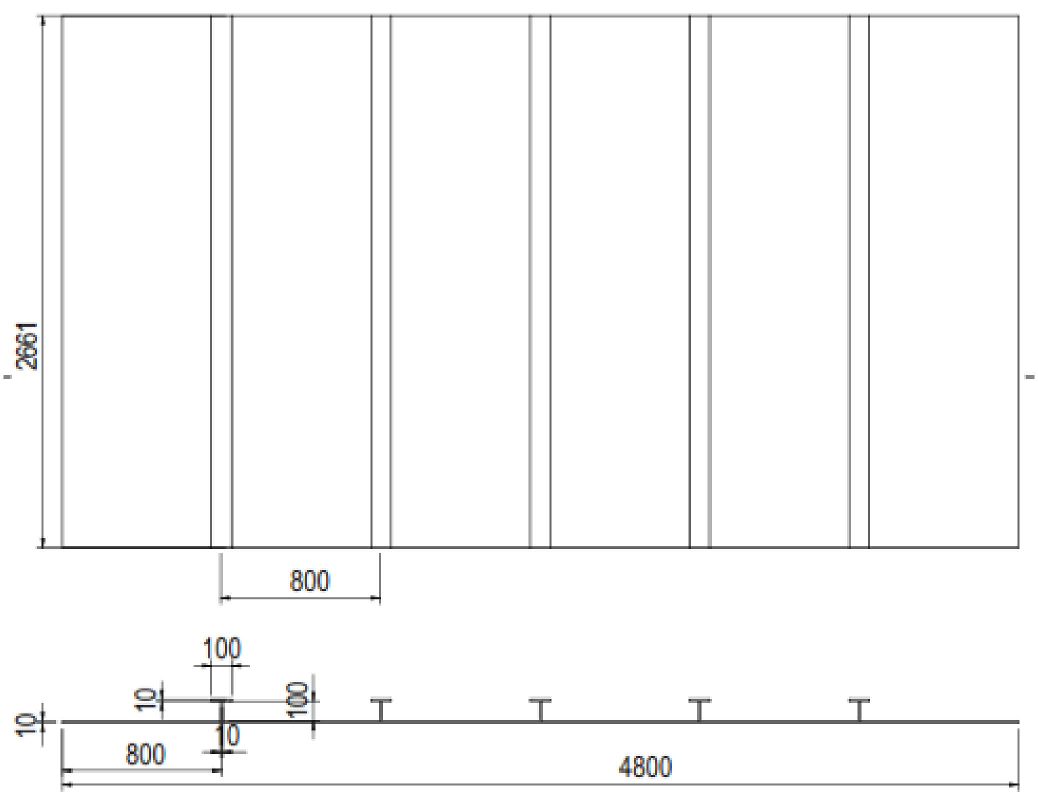

Fig -5: Arrangement of T- stiffener on plate

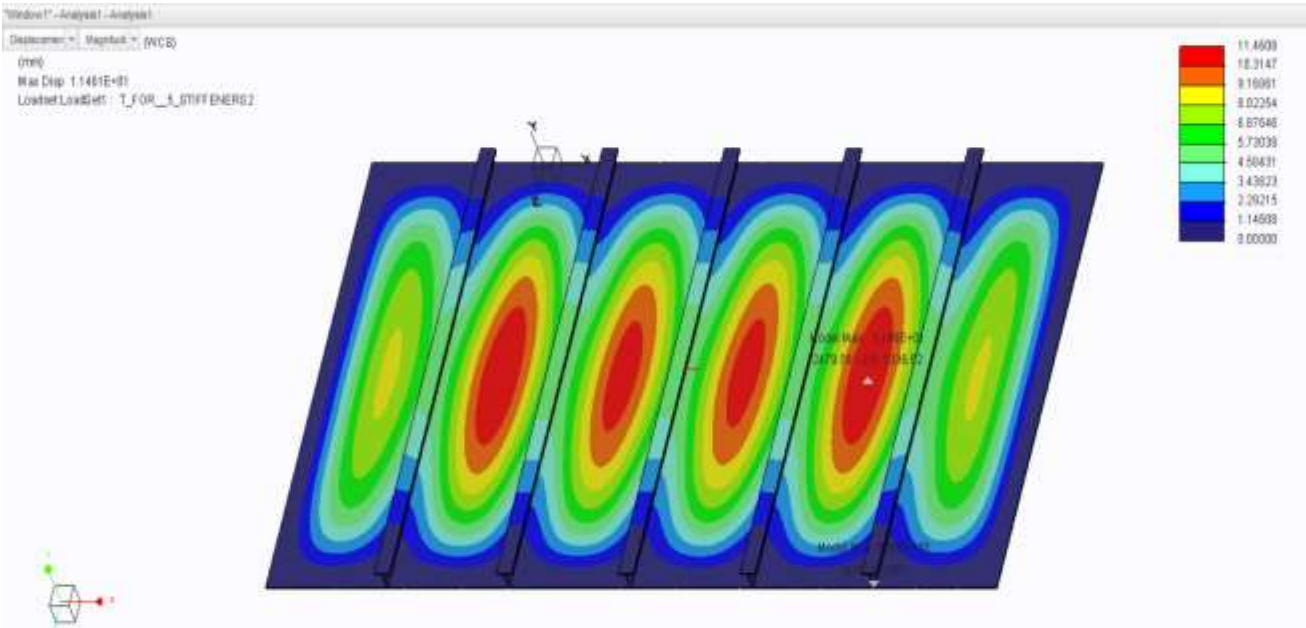

Fig -6: Displacement analysis of T-stiffener on Simple plate

Figure 5 and 6 are the arrangement of T-stiffener and displacement Analysis of T-stiffener on simple rectangular plate respectively. Figure 4 & 6 are concluded that T-stiffener is provide good stiffening to reduce the displacement of plate as compare to flat plate Stiffener.

2.2.4 Circular Stiffener

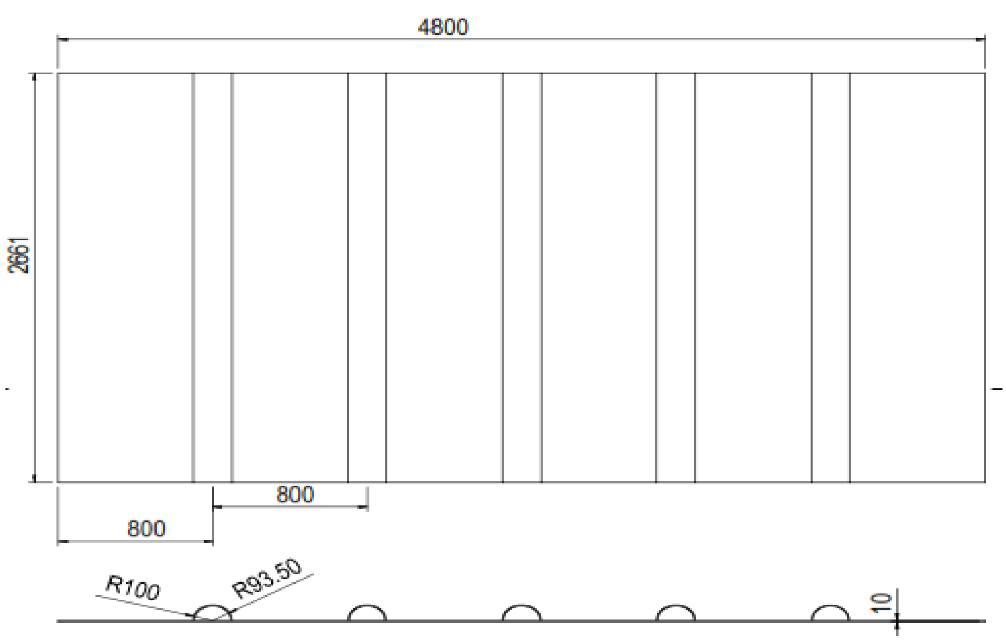

Fig -7: Arrangement of Circular stiffener on plate

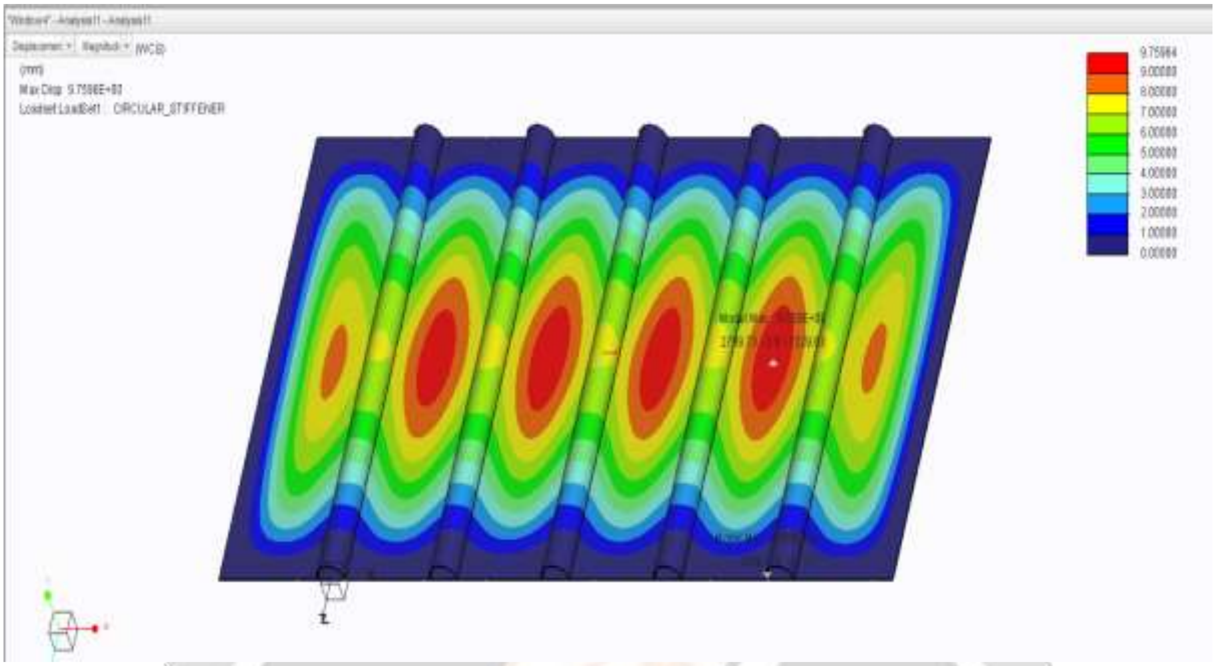

Fig -8: Displacement analysis of Circular stiffener on Simple plate

Figure 7 and 8 are the arrangement of Circular stiffener and displacement Analysis of Circular stiffener on simple rectangular plate respectively. Figure 6 & 8 are concluded that Circular stiffener is provide good stiffening to reduce the displacement of plate as compare to T- Stiffener.

2.2.5 Box Stiffener

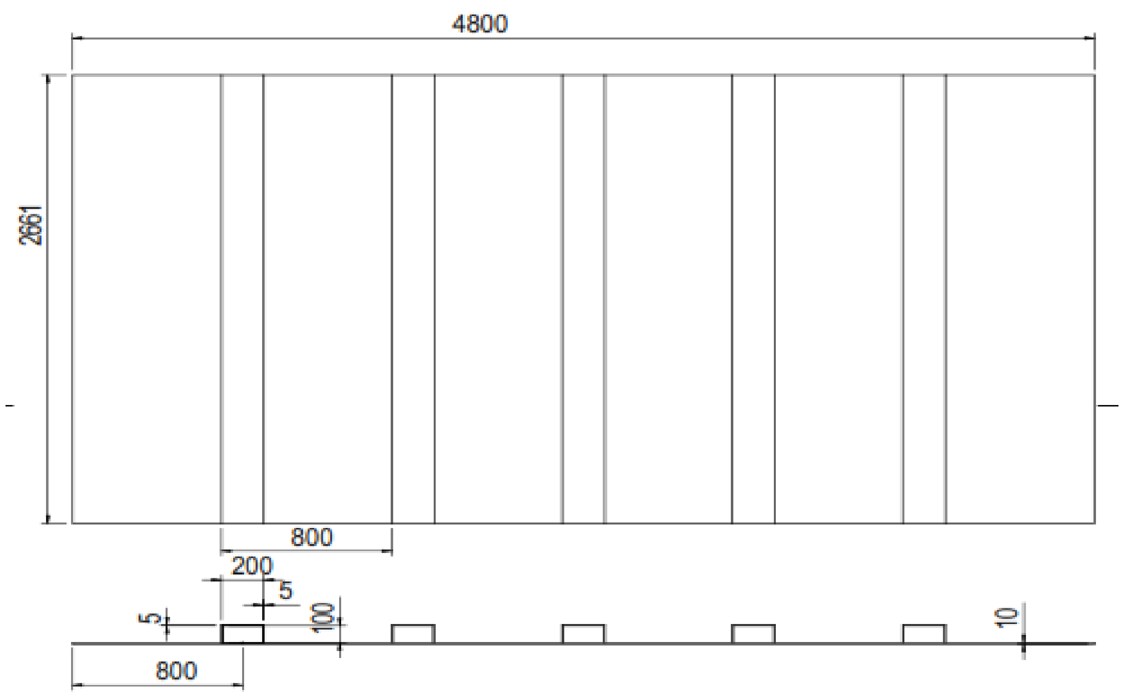

Fig -9: Arrangement of Box stiffener on plate

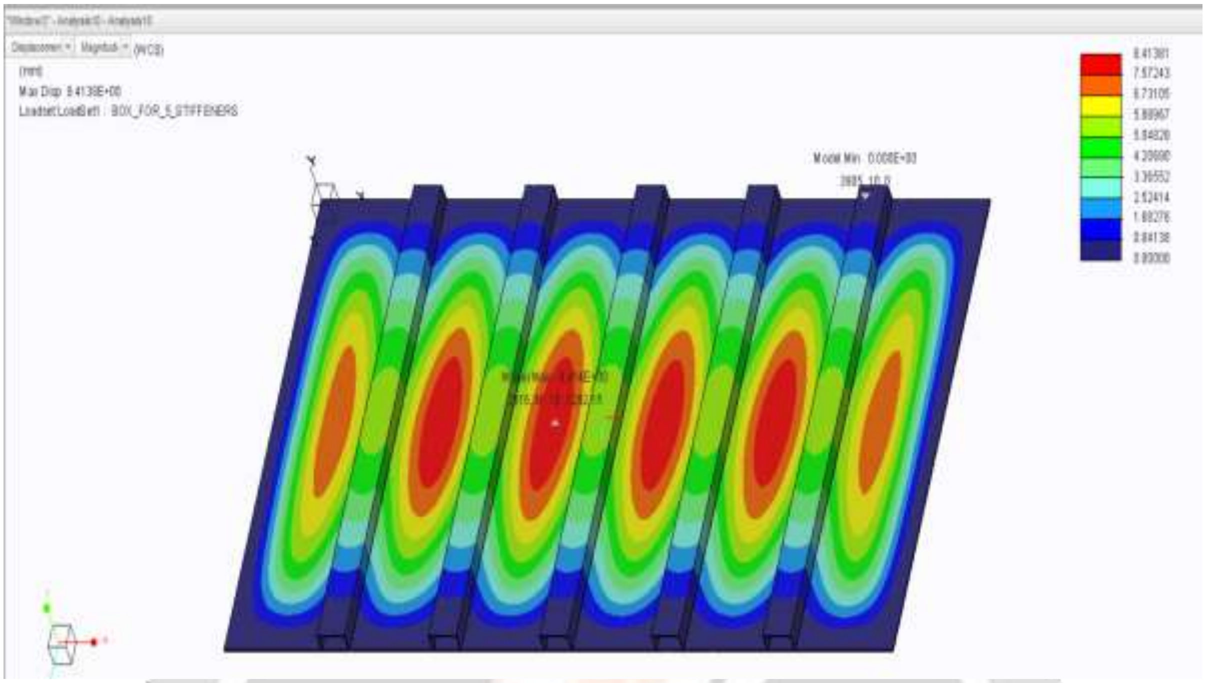

Fig -10: Displacement analysis of Box stiffener on Simple plate

Figure 9 and 10 are the arrangement of Box stiffener and displacement Analysis of Box stiffener on simple rectangular plate respectively. Figure 8 & 10 are concluded that box stiffener is provide good stiffening to reduce the displacement of plate as compare to Circular Stiffener.

2.2.6 Diamond Stiffener

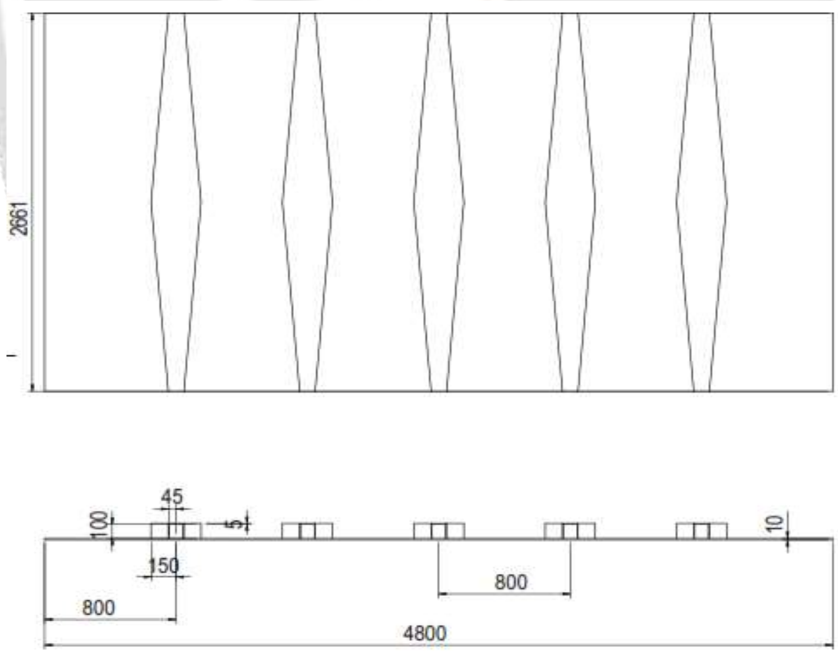

Fig -11: Arrangement of Diamond stiffener on plate

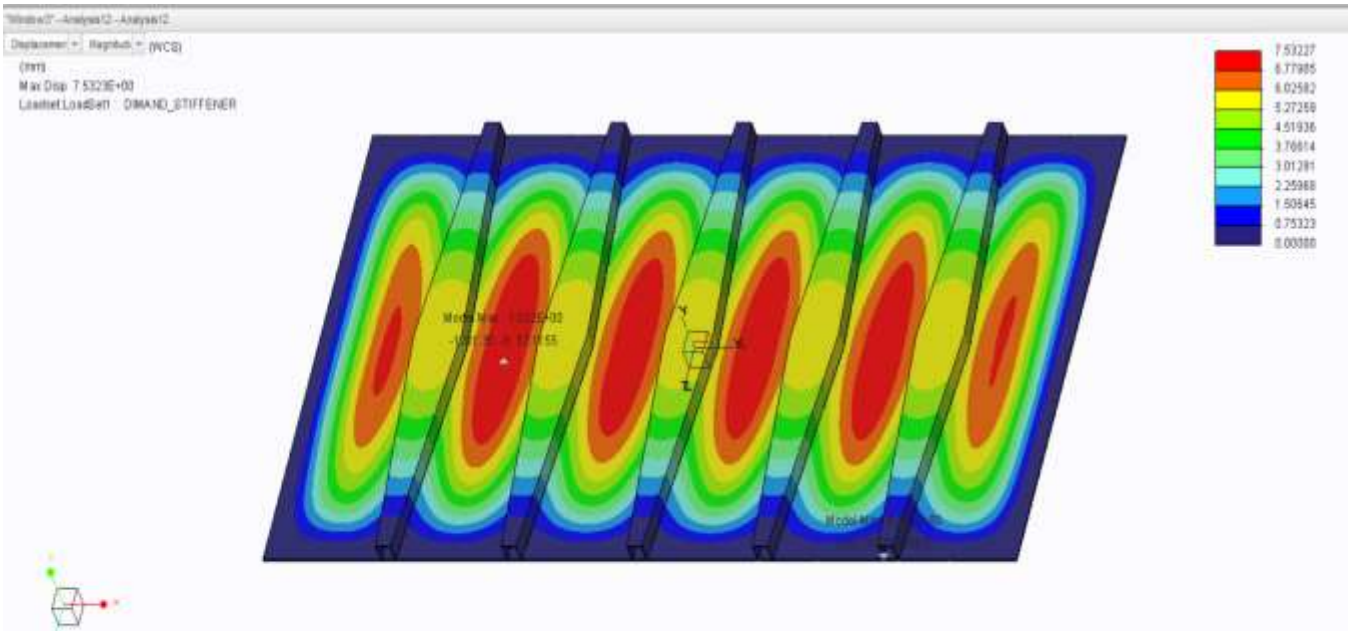

Fig -12: Displacement analysis of Diamond stiffener on Simple plate

Figure 11 and 12 are the arrangement of Diamond stiffener and displacement Analysis of Diamond stiffener on simple rectangular plate respectively. Figure 10 & 12 are concluded that Diamond stiffener is provide good stiffening to reduce the displacement of plate as compare to Circular Stiffener.

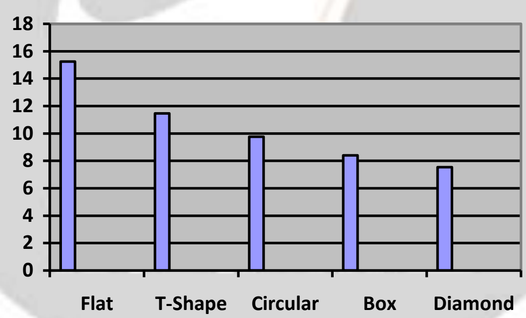

Chart -1: Comparison of stiffener's result

Chart- 1 show that the diamond stiffener is more suitable on transformer tank wall as compare to the box and circular stiffener because more displacement of wall is at the middle of the tank wall and minimum at the end of tank wall as compare to the middle of tank wall. So more structural arrangement as well as material requirement at middle of tank wall as compare to the end of tank wall.

3. CONCLUSIONS

Result comes from this experiment is shown in Table 4.1 that approximately 2% of the weight and 1.55 mm displacement is reduced by keeping stresses under limit. Hence structural stability was unaltered. Thus I infer from the above observed results that diamond stiffeners and circular stiffeners can be used to optimize transformer tank.
The box stiffener is provide the stiffening effect on plate but as per literature survey the stiffener are use to create structure to reduce the displacement with minimum material.
Stiffener is used to create the structural channel to reduce the displacement of the large plate and reduce the Buckling Effect. Stiffner is also use to minimize the cost (like as transportation, weight, foundation, etc.).

In transformer tank, the rim is welded with the wall. So, displacement of wall at edge side is less because the weld joint increase the strength. As per the structural point of view the stiffener width is required more on middle of wall. Diamond stiffener is a conceptual model to minimize the displacement with minimizing material cost. Fabrication is not complicated because the manufacturing process is almost same as the box stiffener. Fabricator required the unbend view of diamond stiffener and bending dimension to create the diamond stiffener as per the procedure of box stiffener.
The diamond stiffener is more suitable then box stiffner.manufacturing cost and ability of fabricator are same as box stiffner. Diamond stiffner is also suitable for the incresing space for the valves, DM box, Marshalling Box, cable wiring, etc.

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