DESIGN AND FINITE ELEMENT ANALYSIS OF A TRANSFORMER TANK A REVIEW PAPER

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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. 15MVA transformers are generally used in railways and they are step down transformer. The high voltage of transformer is 66kV while low voltage is 11.5KV.

Transformer 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.

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 [4].

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1. INTRODUCTION

A transformer is an electrical device that transfers electrical energy between two or more circuits through electromagnetic induction. Electromagnetic induction produces an electromotive force across a conductor which is exposed to time varying magnetic fields. Commonly, transformers are used to increase or decrease the voltages of alternating current in electric power applications

A varying current in the transformer's primary winding creates a varying magnetic flux in the transformer core and a varying magnetic field impinging on the transformer's secondary winding. This varying magnetic field at the secondary winding induces a varying electromotive force (EMF) in the secondary winding due to electromagnetic induction. Making use of Faraday's Law in conjunction with high magnetic permeability core properties, transformers can thus be designed to efficiently change AC voltages from one voltage level to another within power networks.

Since the invention of the first constant potential transformer in 1885, transformers have become essential for the transmission, distribution, and utilization of alternating current electrical energy. A wide range of transformer designs are encountered in electronic and electric power applications. Transformers range in size from RF transformers less than a cubic centimetre in volume to units interconnecting the power grid weighing hundreds of tons.

fig – 1 transformer at a power station

2 LITERATURE REVIEW

This review is for transformer tank optimization. Since this is a customized design particularly for transformer tank, hence the application specific literature is difficult to find. Hence the related literature of transformer tank is presented over here.

Shantanu R Torvi, Prachi Khullar, Deosharan[1] Roy CG Global has concluded that OptiSlang uses non deterministic optimization method such as genetic algorithm and evolutionary strategy for providing global optimum solutions with specified constraint functions with combination of existing finite element analysis. Optimized values are as follows

Equivalent stress (MPa) initially 688 after optimization 568.9 percent decreased 7.31 %, Equivalent deflection (mm) initially 9.86 after optimization 9.8, percent decreases 0.5 % Tank mass (kg). Initially 5370.82, after optimization 4838.57 percent decreases 9.91 %.Reduction in tank mass (kg) 532.25

Fig 2 Initial tank [1]

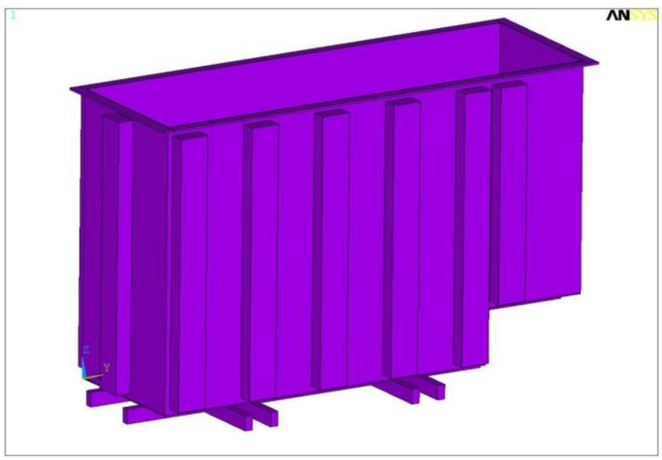
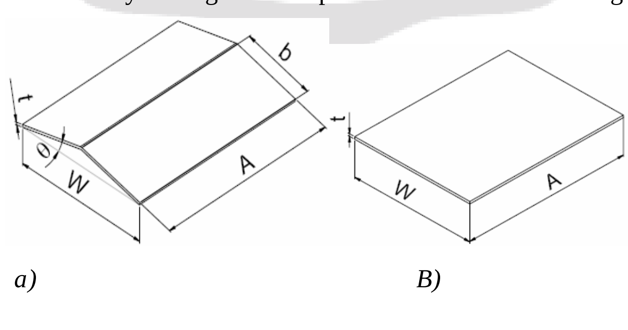


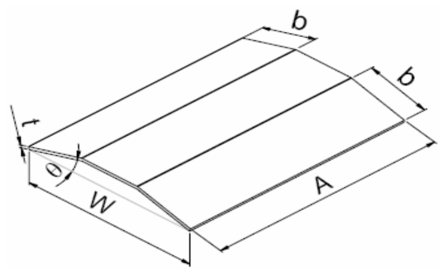
Fig 3 Optimized tank [1]

Fernando batista, helder mendes[2], and emanuel almeida has concluded that Taking the geometrical factor into consideration during the mechanical design stage clearly yields more economical covers. For example, it is clear to see from Figure 2 (for a 20mm plate thickness) that for a cover width of less than 2500mm, the 2-sided cover is the most economical; from then on the 3-sided cover is the best choice. These results are in agreement with the "common sense" rule that a 2-sided cover becomes unstable quicker than a 3-sided cover, and also that for a very large width all geometries tend to a flat cover configuration.

For EFACEC, the end result of this study is a significant optimization of the cover weight.



a) *B)*



c)

fig 4 a) Flat cover, b) 2-sided cover, c) 3-sided cover [2]

Alexander Hackl[3], Peter Hamberger has concluded that

A. Elastic material model.

For the elastic material model the volumetric flexibility of the tank is constant for all pressure values and can be identified with a pre simulation with P0 = 2 bar. The resulting volumetric flexibility C = 0.0018 m3 / kPa and their energy of E =4000 kJ are inserted into formula to calculate the corresponding internal static pressure PS = 4.7 bar. The simulation results show von-Mieses stresses in the tank of up to 1800 N/mm² on the top cover weld. This value is larger as the yield stress and larger than the tensile strength so the elastic material model is not the right approach to predict realistic stress values. However with the quick, 0.5 hours, calculation the weakest part is found. The simulation shows that the possibility of leaking oil, in case of a tank rupture, is minimized, because the weakest part is on top of the transformer.

B. Plastic material model

In the plastic material model the volumetric flexibility of the tank depends on the internal pressure. With a Fixed Point iteration, started at P0 = 2 bar, the internal pressure is adapted until formula (1) corresponds to the simulation results. After the iteration process, which takes some hours, the pressure PS = 2.2 bar and volumetric flexibility C = 0.0068 m3 / kPa is found and resulting stresses of the tank wall where calculated for an arc Energy of 4000 kJ.

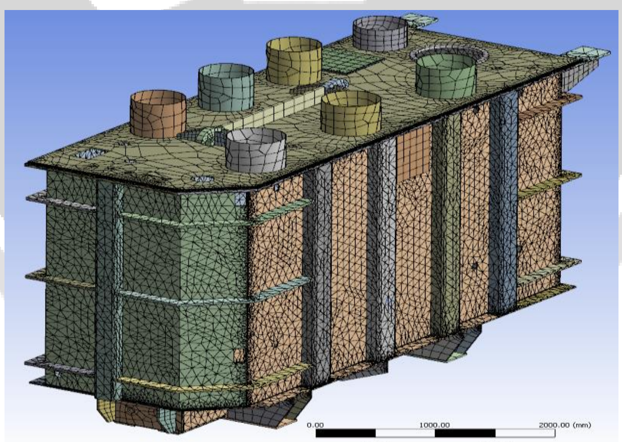


fig 4 Meshing [3]

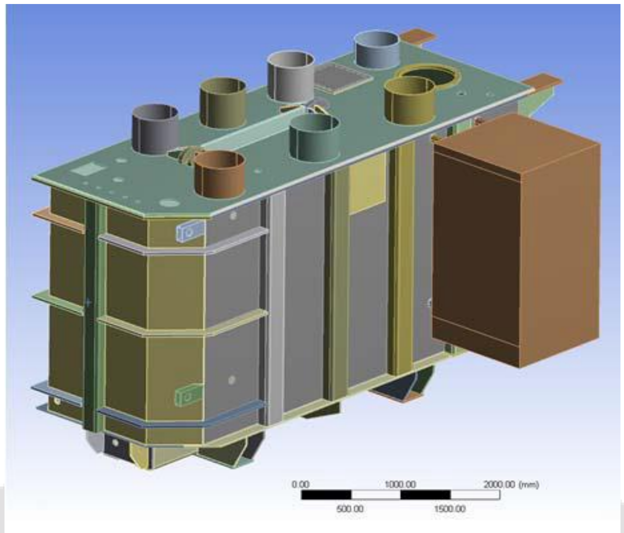
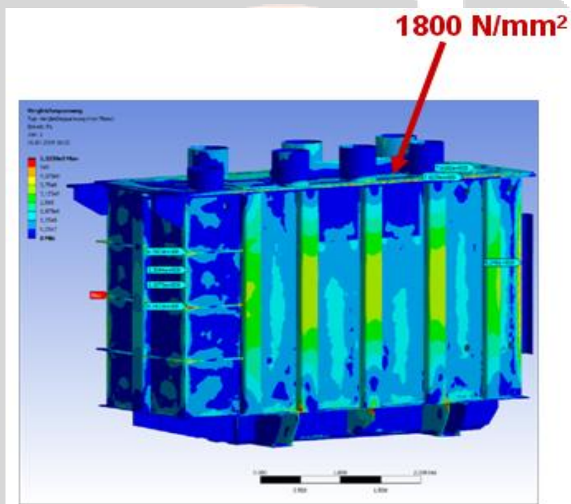


fig 6Constraints[3]



Elastic material [3]

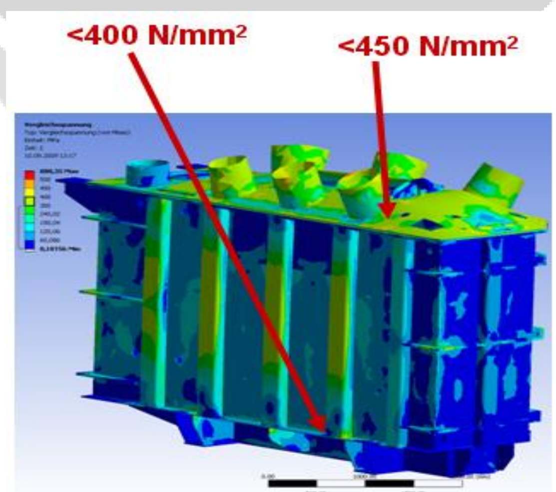


Fig 7 Plastic deformation [3]

The von-Mises stress rise up to approximately 400 N/mm² along the welds on the bottom tub and 450 N/mm² on the top of the transformer. These values are smaller than the tensile strength of steel, but larger than the yield stress, so the tank is plastically deformed but not ripped. With the plastic material model the simulation shows the weakest part on the top cover weld, as assumed with the elastic material model. Additionally it is possible to get realistic von-Mises stress values which allow an evaluation of the stability of the welds.

With the common PC-hardware the computation time is about 5 to 10 times longer than with the elastic material model

3. CONCLUSION

The strength and rigidity of transformer tank is based on the thickness of tanks plate thickness and stiffeners. So this review give path to words the improvement of transformer tank without change in strength and rigidity. Then the impact of improvement in tank can lower the production cost.

4. REFERENCES

[1] Shantanu R Torvi, Prachi Khullar, Deosharan Roy "Structural Design Optimization of 25 MVA 132 kV Power Transformer Tank Assembly" CG Global R&D Centre
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[4] chiplumkar. A book on "TRANSFORMER DESIGN".