

TOPOLOGY OPTIMISATION OF HYDRAULIC PRESS STRUCTURE

P.S Burli¹

¹Assistant Professor, Mechanica Dept, KLE College of Engg&Tech, Chikodi, Karnataka, India

Abstract

Topology optimisation is carried out to find the zones of material removal on final size optimised structure. The results are represented and density plots are presented. The zones represented by blue can be removed for better material saving. The density plots are represented showing convergence of solution rapidly in the beginning and slowly in the later iterations. Finally wolf's law is applied for material removal and addition for better strength. After iterations, the results are presented for vonmises and displacements. The results shows a vonmises stress of around 105 N/mm² and a displacement value of 1.457mm. The final weight is observed to be around 15501kgs. The results shows efficiency of combination of three techniques in reducing the weigh of machine structures efficiently and useful for industrial applications as a combination. All the results are represented with necessary graphical pictures. The geometry is removed based on topology optimization and results are obtained based on wolff's law. The structural results are presented.

Keywords: Topology1, optimisation2, vonmises stress3, Hydraulic press4 etc...

1. INTRODUCTION

A Hydraulic press is a machine in which a large force is exerted on the larger of two pistons in a pair of hydraulically coupled cylinders by means of a relatively small force applied to the smaller piston. Whereas, a Mechanical press is a machine that exerts pressure to form or shape or cut materials or extract liquids or compress solids Hydraulic presses are custom designed to individual specifications and features, with the highest quality materials to withstand hard use and to offer a wide range of engineering and operational advantages to the users along with the longer trouble free operation life.

2. DEFINITION

Optimization is quite an interesting aspect of engineering practice that cuts across all branches of engineering. In the production sector, for example, the reduction of material (Figure 1.1) used in manufacturing is possible when optimization is incorporated beforehand.

Integrated study of usage of design optimisation, Topology optimisation and Wolf's law in reducing the weight of structure within the functional requirements (displacement and stress) of the problem.

3. PROBLEM REQUIREMENTS

Present day design is for optimum things like cost, weight etc. Reduction of weight within the allowable stress and deflection range is very important to reduce the effect of dynamic loads on the structure.

3.1 Main Objective

Modelling of the problem for the given dimensions Representation of the problem using APDL Iterating the problem for the best design sets Application of topology

optimisation for volume reduction Wolff's law in reducing the weigh Integrated study of the problem

4. ELEMENTS USED

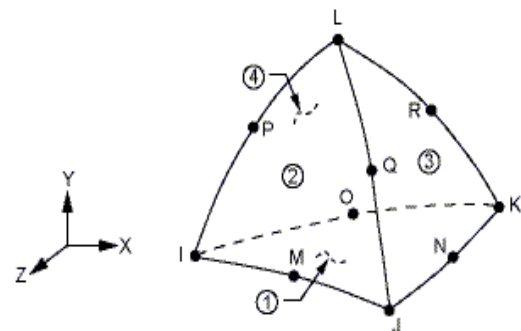


Fig -1:8 noded solid45

5. DESIGN REQUIREMENTS

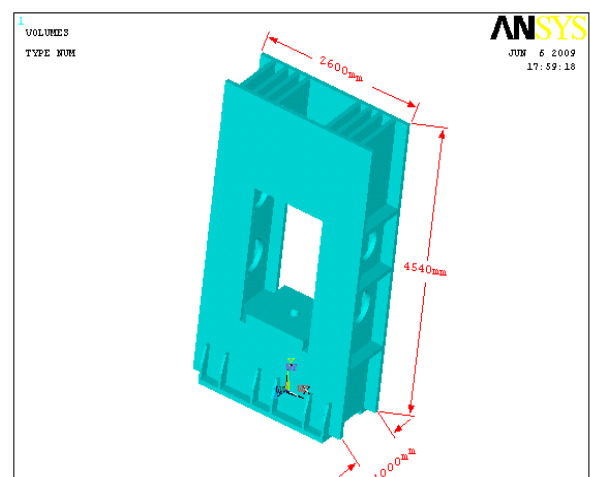


Fig -2: 800 tone press structure for forge welding

Maximum deformation allowed = 3 mm
 Allowable stress = 180 N/mm²

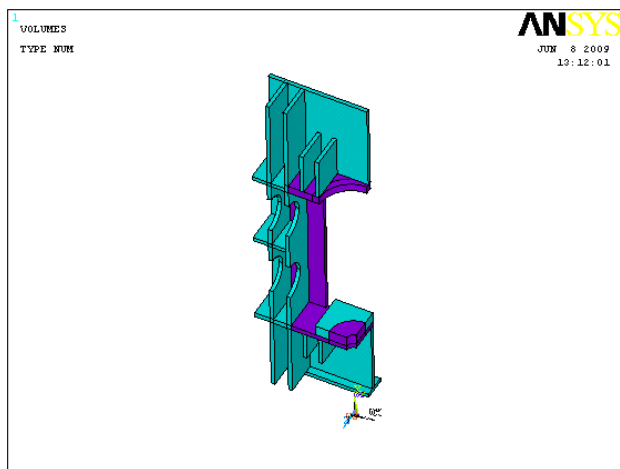


Fig -3: Topo Geometry

The above picture shows geometry to be optimised for topology optimisation. Topology optimisation is similar to shape optimisation. Two colours are shown in the picture. The inner colours represents the geometry which is necessary for load application and other geometry will be optimised for topology

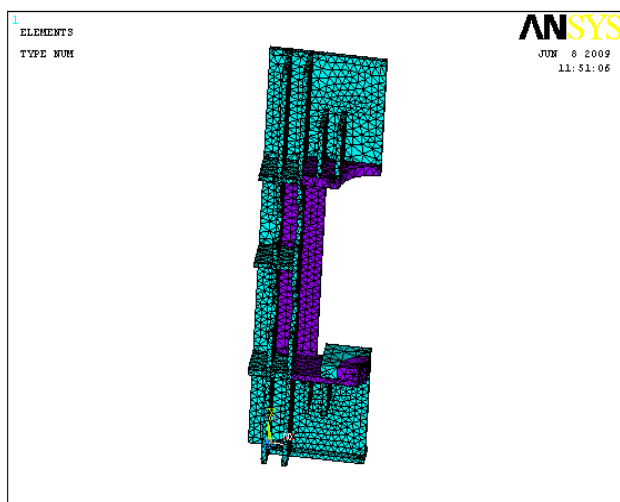


Fig -4: Topology geometry

The above picture represents meshed plot for topology optimisation. The above picture shows topology geometry with different colours. The blue colour geometry is meshed with solid92 for topology optimisation and the other colour shows the minimum required geometry which includes loading, constraint geometry.

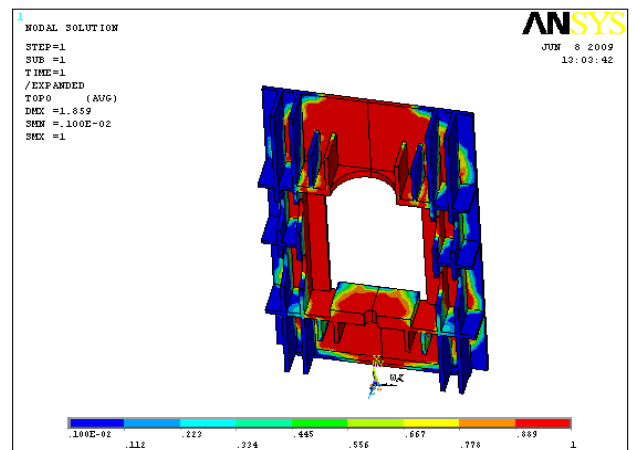


Fig -5: Density plot

The above picture represents stiffness plot from topology optimisation. The blue represents the material which can be removed.

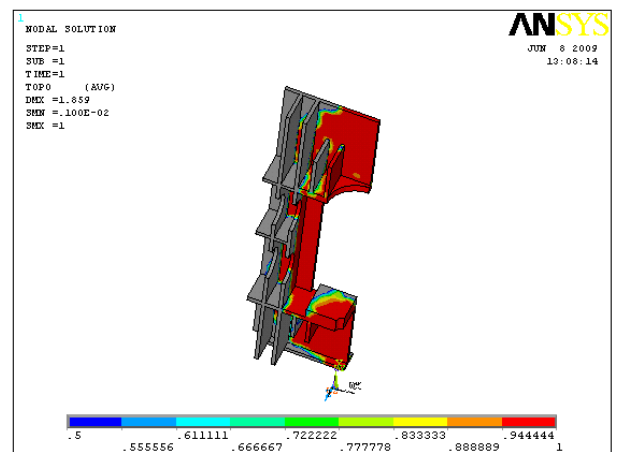


Fig -6: Density plot between 0.5 to 1 stiffness

The above picture represents stiffness plot between 0.5 to 1. The material requirement is shown above.

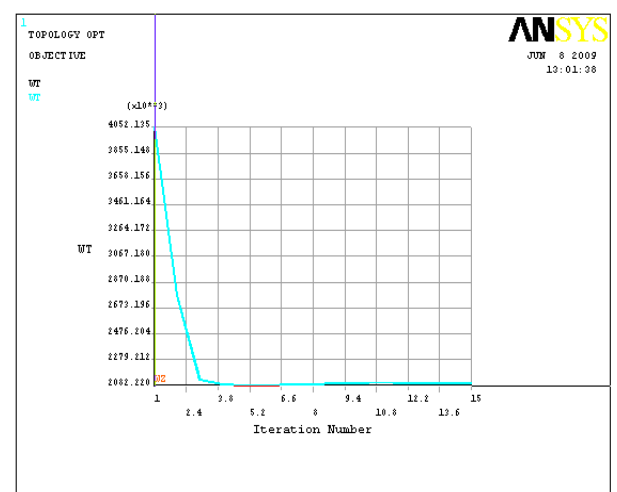


Fig -7: Weight vs Iteration number

The above plot represents variation of objective function with reference to iteration numbers. More drop of weight can be observed in the beginning and later almost negligible drop as convergence is taking place.

9	0.21008E+07
10	0.21030E+07
11	0.21063E+07
12	0.21058E+07
13	0.21053E+07
14	0.21049E+07
15	0.21050E+07

The above volume values are not the real values, as each element is assigned with dummy volume, density for stiffness calculations to get uniform strength. It represents iteration values from the initial value to the final value. This optimization history is to plot the various compliance in the system.

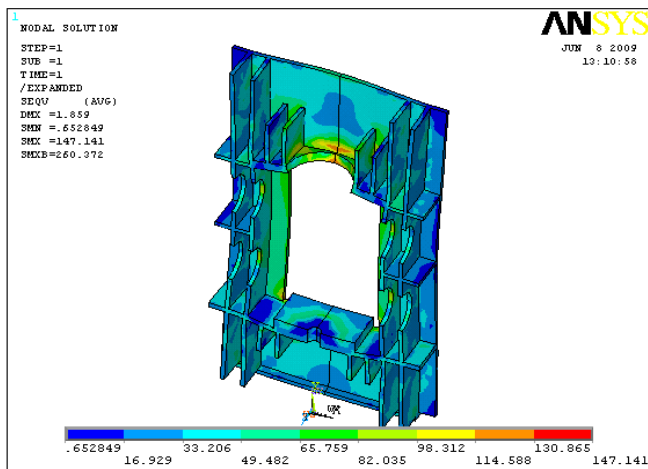


Fig -8: Vonmises Stress plot

The above picture represents vonmises stress in the structure. The maximum stress equal to 147.141 Mpa which is less than the allowable stress of the material. So structure is safe from stress point of view.

6. STATISTICS FROM TOPOLOGY OPTIMISER

Objective Function:

Reference name = wt

Initial value = 0.405214e+07

Current value = 0.210496e+07

Constraint function(s):

Reference name = volume

Number of elements considered for optimization = 12638

Dimensionality = 3d

Total number of iterations performed = 15

Accuracy used for termination check = 0.100000e-03

Convergence status = converged

Active solution approach = oc

The above values represented converged history of the problem. The problem is converged within the tolerance of .0001. Within 15 iterations, the problem is converged. The volume reduction can be observed to be almost 48%. The volume history is shown below.

Table -1: Volume history of the problem

Iteration Number	Volume (mm ³)
1	0.40521E+07
2	0.27675E+07
3	0.21260E+07
4	0.20915E+07
5	0.20822E+07
6	0.20831E+07
7	0.20894E+07
8	0.20957E+07

7. APPLICATION OF WOLFF'S LAW

Wolff's law is further applied to reduce the material requirement and for uniform stress generation. So the structure is further designed based on Wolff's law. The results are summarised as follows.

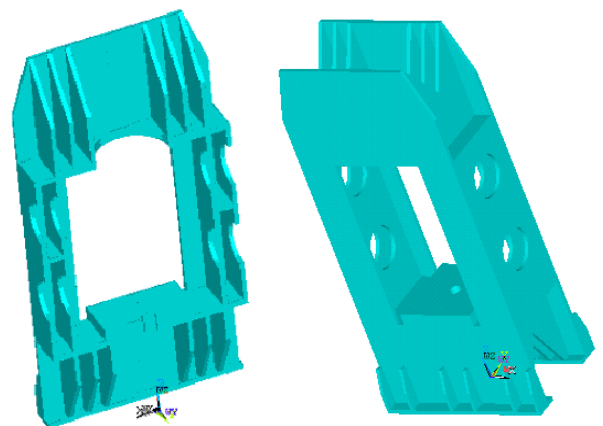


Fig -9: Geometry of the optimized model

The above picture shows edge geometry of the problem. The material removal is based on the topology optimization for uniform strength of the structure.

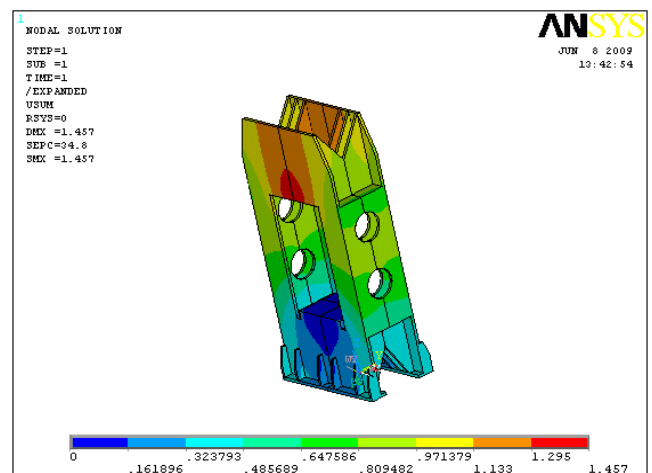


Fig -10: Displacement plot on the structure

The above picture represents displacement plot of the problem. Maximum displacement is around 1.457 from the final optimization using Wolff's law. The color red shows maximum displacement position. This displacement is much smaller than the allowable deflection of the problem.

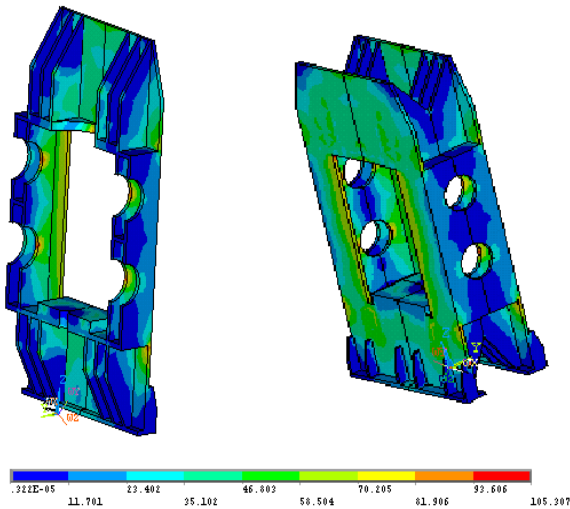


Fig -11: Vonmises stress after application of Wolff's law

The above picture shows vonmises stress obtained in the problem. The geometry is optimized for stress and weight keeping functional requirements under satisfaction. Maximum stress observed to be around 105.387 N/mm² which is well under the safety for the material. From the calculation from ansys volume of the geometry is around 0.19874E+10 which shows a weight of around 15501 kgs.

8. DISCUSSION

After observation of the final size optimisation, still much scope can be observed on the sketches for material optimization. So topology optimization is carried out to observe the stress zones. The topology optimization results are presented for density variation. The results shows higher drop of weight in the beginning and almost flat variation in the lateral iterations showing the convergence of the problem. By observing the topology stress distribution, Wolff's law is applied to reduce the material and some material is added to improve the stiffness of the member. After iterations, the final solution results are presented which shows a maximums vonmises stress of 105 N/mm² and 1.457mm deflection. The total weight I is observed to be 15501 kgs. So by these three optimization techniques, more drop can be observed in the total weight of the structure

9. CONCLUSION

The hydraulic pressing structure used for forging operation is optimized using three techniques namely design optimization, Topology optimization and Wolff's law. The conclusions are as follows

The hydraulic pressing machine for 800 tones load is modeled using Ansys parametric design language using scalar parameters.

Due to symmetry only quarter section is built

The boundary conditions are applied and problem is solved in static domain. The results shows maximum vonmises stress of around 71.851 N/mm² and displacement of around 0.7077mm. The structure is optimised for weight using design optimiser which is based on size optimisation. The design and state variables are set and weight is set as objective function.

A total of 13 feasible sets are obtained and best set weight is observed to be around 4625.7 kg for quarter section and 18502 kgs for full structure. The optimised structure vonmises stress is around 136 N/mm² and deflection of around 1.67mm. Graphs are represented for variation of geometry (Weight), vonmises and deflection with reference to number of iterations. The graphs shows drop of weight with reference to increased number of iterations. Also stress and deflection can be observed in the structure. But finally around 23% weight reduction can be observed at the end of size optimisation. Further topology optimization is carried out to find the zones of material removal. The results are represented and density plots are presented. The zones represented by blue can be removed for better material saving. The density plots are represented showing convergence of solution rapidly in the beginning and slowly in the later iterations. Finally Wolff's law is applied for material removal and addition for better strength. After iterations, the results are presented for vonmises and displacements. The result shows a vonmises stress of around 105 N/mm² and a displacement value of 1.457mm. The final weight is observed to be around 15501kgs. The results shows efficiency of combination of three techniques in reducing the weigh of machine structures efficiently and useful for industrial applications as a combination. All the results are represented with necessary graphical pictures. The geometry is removed based on topology optimization and results are obtained based on Wolff's law. The structural results are presented

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BIOGRAPHIES



Working as Asst.Professor in Mechanical Dept, in KLE college of Engineering& Technology, Chikodi, Dist-Belgaum, Karnataka state. Total Teaching experience is 15 years. Attended many workshops, published Three papers in international Journals and presented papers in conference