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# Design, Development and Optimization of Hydraulic Press

Deepak Annasaheb More[1], N.K.Chhapkhane[2], Ravindra Kolhe[3]
*[1,2]Department of mechanical engineering*
*Rajarambapu institute of technology, Sakharale 415414, India.*
*[3]N. B. Technologies*
*MIDC, Chinchwad, Pune 411019, India.*

***Abstract*— A hydraulic press is a machine using a hydraulic cylinder to generate a compressive force. Frame, hydraulic cylinder and press table are the main components of the hydraulic press. In this project press frame, cylinder and press table are designed by the design procedure. They are analyzed to improve their performance and quality for press working operation. Using the optimum resources possible in designing the hydraulic press components can effect reduction in the cost by optimizing the weight of material utilized for building the structure. An attempt has been made in this direction to reduce the volume of material. So in this paper we consider an industrial application project consisting of mass minimization of H frame type hydraulic press. This press has to compensate the forces acting on the working plates and has to fulfill certain critical constraints. Here we use FEA implementation for analysis and optimization of hydraulic press.***
***Keywords*— Hydraulic press, Frame Structure, FEA, Optimization, Stress Analysis.**

## I. INTRODUCTION

Presses are one of the most commonly used machine tools in industry for the forming of different materials. In the past, for the pressing tasks in industry, mechanical presses were more frequently used, but nowadays hydraulic presses take precedence due to their numerous advantages, such as: full force throughout the stroke, moving parts that operate with good lubrication, stroke that can be fully adjustable which contributes to the flexibility of application, built in overload protection, can be made for very large force capacities, silent operation and more compact. Hence a hydraulic press is a machine that makes use of the pressure exerted on the fluids to crush, straighten or mould. The concept of the hydraulic press is based on Pascal's theory, which states that when pressure is applied on fluids in an enclosed system, the pressure throughout the system always remains constant. In hydraulic press, the force generation, transmission and amplification are achieved using fluid under pressure. The liquid system exhibits the characteristics of a solid and provides a very positive and rigid medium of power transmission and amplification. In a simple application, a smaller piston transfers fluid under high pressure to a cylinder having a larger piston area, thus amplifying the force. There is easy transmissibility of large amount of energy with practically unlimited force amplification. This paper describes design, development and manufacturing of multi-purpose H-frame hydraulic press. For mass minimization, we use standard steel sections instead of plates. Due to this, the fabrication of hydraulic press frame also becomes simple. ANSYS has been used for the analysis; the main aim is to reduce the weight of the hydraulic press without compromising on the quality of the output. This particular press is used for a variety of tasks from doing mechanical work to straightening or intentionally bending structural components. It is also used to take force related measurements such as spring rates of coil and leaf springs.

## II. DESIGN

The principal parameters of the design included the maximum load (200 kN), the distance the load resistance has to move (stroke length, 500 mm), the system pressure (250 bar), the cylinder area (bore diameter = 100 mm) and the volume flow rate of the working fluid. The critical components that require design includes the frame, the hydraulic cylinder and the press table.

### *A. Design of Press Frame*

Machine frame is the most important part of the machine. It transfers all the forces that are produced during working of machine to the ground. It provides strength and stability to the machine during operation. The size and shape of machine structure should be such that it not only provides safe operation but also working stress and deformation do not exceed specific limit. Before designing the frame structure all the DFMA, Ergonomics constraints should be well understood.

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*Material Selection*

The mild steel (IS2062) is selected for the frame because it is soft and ductile, they can be easily welded and machined.

| Grade Designation | Yield Strength | Tensile Strength |
|---|---|---|
| E250 | 250 MPa | 410 MPa |

*1) Platen:* The platens provide point of direct contact with the object being compressed. Hence, they are subjected to pure bending stress due to an equal and opposite couple acting in the same longitudinal plane.

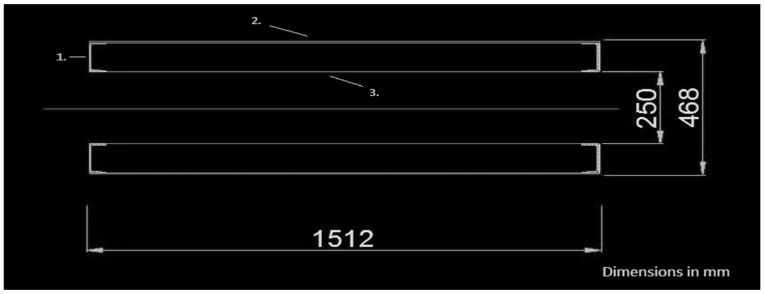


Fig. 1 Cross section of platen

Now the bending stress acting on platen is given by,

$$F_b = \frac{M}{I} \times Y$$

$$M = W \times L = 294.5242 \times 10^6 \text{ N-mm}$$

$$I_{total} = 2( I_1 + I_2 + I_3 ) = 2( 563.02 \times 10^6) = 1.12604 \times 10^9 \text{ mm}^4$$

Now

$$Fb = \frac{M}{I} \times Y = \frac{294.5242 \times 10^6}{1.12604 \times 10^9} \times 325 = 85.0061 \text{ N/ mm}^2$$

$$\text{So, Factor of Safety} = \frac{\text{Yield Stress}}{\text{Bending Stress}} = 2.9409$$

2) *Column:*

$$\sigma_t = \frac{F}{A} = \frac{P/4}{Ac} = \frac{196.3495 \times 10^3/4}{1170} = 42.7350 \text{ N/mm}^2$$

*B. Design Of Hydraulic Cylinder*

Hydraulic cylinder is actuated by hydraulic fluid at very high pressure. Any failure of cylinder may cause an explosion or ejection of a high velocity jet of oil, which may cause extensive damage to property and a fatal injury to human being.

*Material Selection*

Material selected for cylinder tube is carbon steel i.e. ST 52 with honed inner surface.

| Designation | Yield Strength | Ultimate Strength |
|---|---|---|
| ST 52 | 310 MPa | 650 MPa |

*1) Cylinder Tube:* In designing cylinder tube, we basically calculate it's inside diameter and wall thickness. Inside diameter and wall thickness depends upon capacity of cylinder and working pressure.

$$P = F/A = \frac{F}{(\pi \times d^2/4)} \qquad d^2 = \frac{4F}{\pi \times P} \qquad d = 100 \text{ mm}$$

*2) Thickness Of Cylinder Tube:* When the cylindrical shell of hydraulic cylinder is subjected to a very high internal fluid pressure, then the walls of cylinder must be made extremely heavy or thick.

$$t = r_i \times \left[\sqrt{\frac{\sigma t}{\sigma t - 2P}} - 1\right] = 50 \times \left[\sqrt{\frac{103.33}{103.33-2(25)}} - 1\right] = 19.5981 \text{ mm} = 20 \text{ mm (Appr.)}$$

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Hence the outer diameter of cylinder, $D = d + 2t = 100 + 2(20) = 140$ mm

3) *Stress Calculation In Cylinder:* Tangential stress is maximum at inner surface of shell. According to Lame's equation Tangential stress at inner surface (i.e. when $x = r_i = 50$ mm)

$$\sigma_{t\,(inner)} = P \times \left[\frac{ro^2 + ri^2}{ro^2 - ri^2}\right] = 25 \times \left[\frac{70^2 + 50^2}{70^2 - 50^2}\right] = 77.0833 \text{ MPa}$$

*C. Design Of Press Table*

Press table design is important because there is a die mounting for placing work piece to be pressed on press table.
Now calculating the stress induced in the press table,

$$\sigma_{max} = \frac{3}{4} \times \frac{W \times L}{b \times h^2} = \frac{3}{4} \times \frac{196.3495 \times 10^3 \times 605}{515 \times 40^2} = 108.1233 \text{ MPa}$$

The above calculations shows that the maximum stresses for platen, cylinder and press table are well within permissible limit.

## III.FINITE ELEMENT ANALYSIS

Finite element analysis (FEA) is a computer simulation technique used in engineering analysis; it uses a numerical technique called the finite element method (FEM). The main FEA objectives are changing the dimensions of press body elements to know the bending stresses developed in it to calculate factor of safety, the reduction of cost and improve safety.
There are six basic steps for doing the simulation in press machine to predict the maximum stress and deflection by applying the press load.
Create CAD model of press structure.
Import the CAD model in simulation software.
Pre-processing.
Apply boundary conditions.
Post processing.
Result and analysis.

## IV.RESULTS AND DISCUSSION

*A. Hydraulic Press Frame*

The CAD model of hydraulic press frame is drawn by using modelling software Solid Edge.

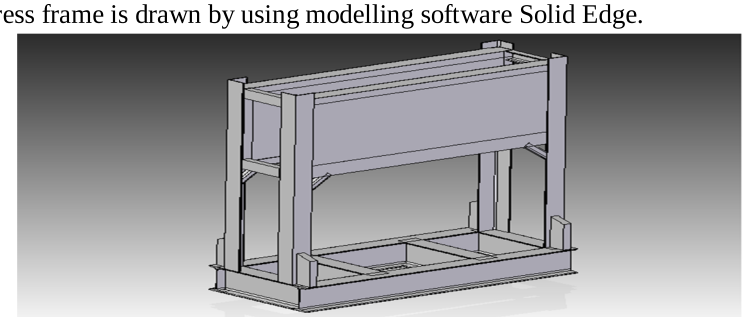

Fig. 2 Solid model of press frame

After creating the CAD model, the structural analysis is done by using ANSYS software.

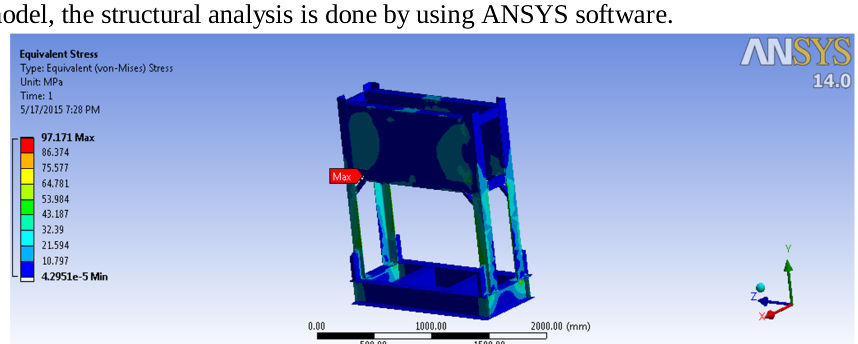


Fig. 3 Equivalent Von-Mises stress distribution in frame

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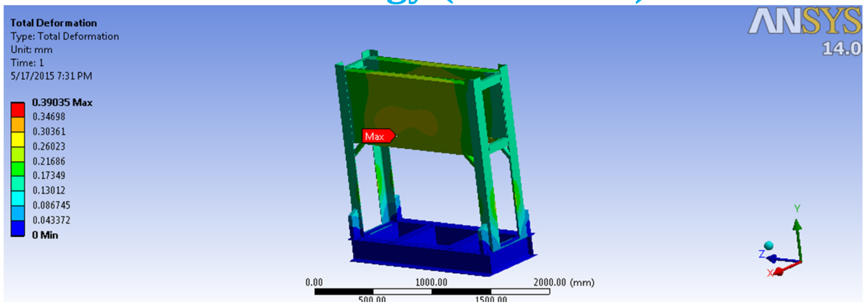


Fig. 4 Total deformation in frame

Fig. 3 and Fig. 4 shows ANSYS Workbench result window for Von-Mises stresses and maximum deformation for hydraulic press frame. It should be noted that maximum equivalent stress is 97.171 MPa. Hence Von-Mises stress developed is within yield strength of material. Also the total deformation of press frame is 0.39035 mm. It is within limit. So the design for press frame is safe.

B. *Hydraulic Cylinder*

The CAD model of hydraulic cylinder is drawn by using modelling software Solid Edge.

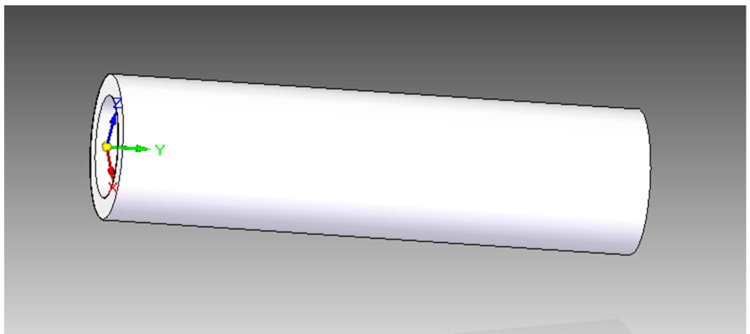

Fig. 5 Solid model of hydraulic cylinder

After creating the CAD model, the structural analysis is done by using ANSYS software.

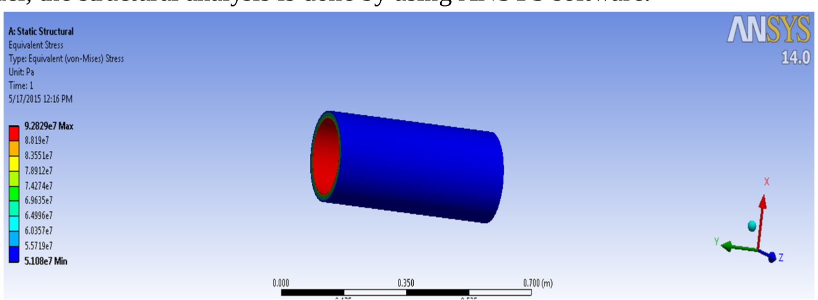


Fig. 6 Equivalent Von-Mises stress distribution in cylinder

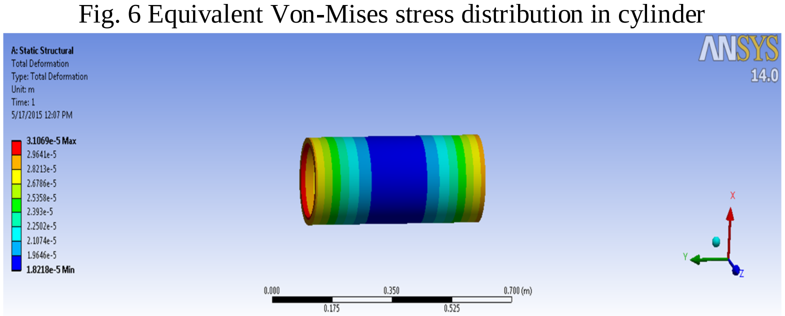


Fig. 7 Total deformation in cylinder

Fig. 6 and Fig. 7 shows ANSYS Workbench result window for Von-Mises stresses and maximum deformation for hydraulic cylinder. It should be noted that maximum equivalent stress is 92.829 MPa which is acting at inner face of cylinder. Hence Von-Mises stress developed is within yield strength of material.

Also the total deformation in hydraulic cylinder is 0.03106 mm. It is within limit. So the design for hydraulic cylinder is safe.

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*C. Press Table*

The CAD model of press table is drawn by using modelling software Solid Edge.

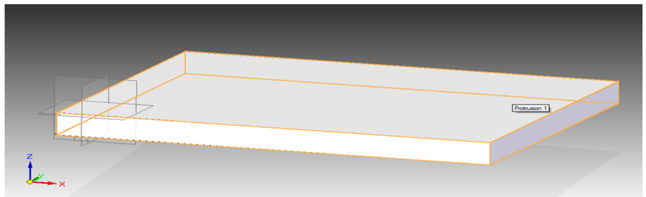

Fig. 8 Solid model of base plate

After creating the CAD model, the structural analysis is done by using ANSYS software.

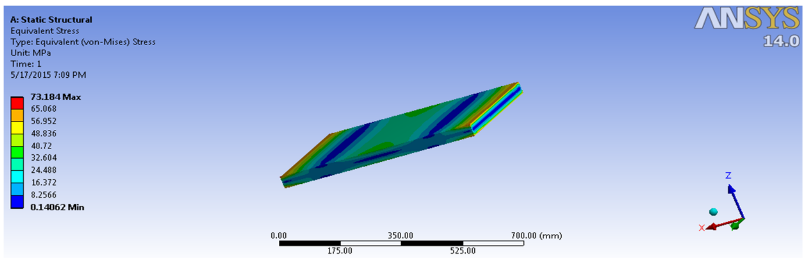


Fig. 9 Equivalent Von-Mises stress distribution in base plate

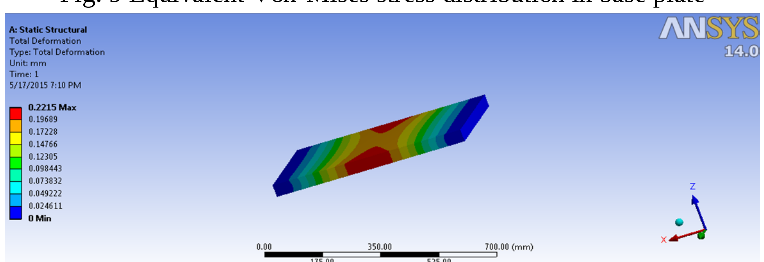


Fig. 10 Total deformation in base plate

Fig. 9 and Fig. 10 shows ANSYS Workbench result window for Von-Mises stresses and maximum deformation for press table. It should be noted that maximum equivalent stress is 73.184 MPa. Hence Von-Mises stress developed is within yield strength of material. Also the total deformation in press table is 0.2215 mm. It is within limit. So the design for press table is safe.

## V. CONCLUSION

In this work, the theoretical and analytical study has been carried out on the welded structure of a hydraulic press machine of a 200kN nominal operational load.

The theoretically predicted results and those obtained by analytical software have been compared with the design goal of the press structure.

It can be concluded that simulation software is the powerful tool for prediction of safe design at given load.

The analysis of model was thorough at a minimum cost of material and analysis time. Because of using standard sections for manufacturing of press frame, weight reduction takes place.

## REFERENCES

[1] B. Parthiban , P. Eazhumali, S. Karthi and P. Kalimuthu, “Design and analysis of C type hydraulic press structure and cylinder”, International journal of research in aeronautical and mechanical engineering, vol.2, pg. 47-56, March 2014.

[2] Muni Prabaharan and V.Amarnath, “Structural optimization of 5ton hydraulic press and scrap baling press for cost reduction by topology”, International journal of modeling and optimization, vol. 1, August 2011.

[3] Santoshkumar S. Malipatil, Prof. Yogita N. Potdar and Prof. A. C. Mattikalli, “Analysis and structural optimization of 5 ton h-frame hydraulic press”, International journal of innovative science, engineering & technology, vol. 1, issue 5, July 2014.

[4] H.N.Chauhan and M.P.Bambhania, “Design & analysis of frame of 63 ton power press machine by using finite element method”, Indian journal of applied research, Vol.3, Issue: 7, July 2013.

[5] Satish G Sonwane, S D Kshirsagar, Nitin Bagokar and Chetan Mahatme, “Structural optimization of hooping platen of 400ton cotton baling press for cost reduction”, International journal of pure and applied research in engineering and technology, Volume 2 (9), Pg. 379-389, 2014.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

[6] Manar Abd Elhakim Eltantawie, "Design, manufacture and simulate a hydraulic bending press", International journal of mechanical engineering and robotics research, Vol. 2, No. 1, January 2013.

[7] A. G. Naik, N. K. Mandavgade, "FEA implemention in analysis and optimization of top and bottom frame for hydraulic cotton lint bailing press", International journal of scientific & engineering research, volume 3, issue 7, july-2012.

[8] J. A. Ferreira, P. Sun and J. J. Grácio, "Design and control of a hydraulic press", Proceedings of the 2006 IEEE Conference on Computer Aided Control Systems Design, Munich, Germany, October 4-6, 2006.