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Design of C-Frame for Assembly of Mechanical Power Press

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Abstract

The aim is to generate the model for assembly operation known as mechanical press machine. Using the concept of reverse engineering, the C-frame has been designed considering stress distribution, deflection, and design specification. Thus, a reciprocating piston is used which apply force upon component with the help of a special tool mounted on the piston. The optimum objective of this study is to observe the finite element modeling of 'C' frame of mechanical power press of 50 tons capacity and to analyze the assembly of press under static condition. Press is made up of a frame, a base plate and resources possible in designing the mechanical presses frame can effect reduction in the cost of the presses. By optimizing the weight of material utilized for the structure an attempt have been done in this direction to decrease the volume of material. So, here we can consider an industrial application. This project consist of minimizing the mass of C-frame type assembly press so, it can be checked in the stress then the material required and finally the thickness of plate.

Keywords: *Analysis of assembly press, modeling, reduction in material weight, analysis in static condition*

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INTRODUCTION

The objective of a press is to convert one or more forces and movements to a tool or a die with the purpose of blanking or forming a work piece. Depending upon the intended application, the presses are designed either to execute specific processes or for mainly the combined use. In a "special purpose production line", by considering economic production, the output is the most important issue with regular maintenance of the desired part quality. Material-related influences such as the more deep drawing speed or work piece related influences such as the transportation, ergonomics and working safety all have to be taken into consideration [1–5].

PRESS FRAME

The objective of the press frame is to absorb forces, to provide precise slide guidance and to support the auxiliary units, drive system and others. The structural design of the frame depends mainly upon the pressing force.

- This indicates the required rigidity,
- The dimensions of dies affecting the size of the tool area,
- Accessible work area that determines on the shape of the press frame,
- The degree of precision.

This influences both the shape and the rigidity of the frame. Presses with relatively low press forces upto 2,500 kN, frequently make use of the open-front press design, this construction is characterized particularly by the easy access to the tool area. However, its drawback lies in the asymmetrical deflection of the frame which contributes to reductions in a part accuracy and die life, particularly in the blanking applications. Inclined or horizontal designs permit faster part rejection making the use of gravity following the forming process, for example when forging or coining open-front presses mare used in the conjunction with single dies [3–7].

APPLICATIONS

In its modern form hydraulic press is well adapted to press work of:

- Forging presses
- Stamping machines
- Rolling power presses
- Blanking and punching machines

Structure

Depending on the application as different frame structures are available, while performing the operation as the 'H' type or fabricated 4-column type, 'C' type and 4-pillars (hard chrome pillars type).

Need of the Project
The operation of assembly was initially carried out by hand operated power press. And this operation required more manpower and good inspection. To reduce the human error and the fast production mechanical power press was taken into consideration. The C-frame was considered for support of the press as standard C-frame presses are accurate and easy in achieving the most of applications like bending, forming, punching, blanking, drawing and other's assembly work. The frame is rigid and maintenance cost is low as compared to the others because of large structure increase in material and cost so, this project mainly targets on material reduction and reduce wastage.

Methodology
The dimensions and specifications for a C-frame assembly press are provided by manufacturer is taken. As per the specification load is applied on the frame, deflection and stress acting on the structures are calculated. A new design is created to reduce the material required without any compromising in design specification and quality. Main aim is to reduce the bending of frame reduced material and maximize the profit without affecting quality.

Design Specifications
Outer diameter of the ram= 55 mm
Inner diameter of the ram= 45 mm
Stroke length= 260 mm

Design Check for Top Plate
Input Data
Outer diameter of piston rod= 55 mm
Inner diameter of piston rod= 45 mm

Material Selection

Designation	Yield Stress		Tensile Stress
	(N/mm^2)		(N/mm^2)
EN 24	680		800

Direct tensile or compressive stress is due to an axial load as:

$$fc_{act} = \frac{W}{A}$$

$$fcact = \frac{50X\ 10^3}{\pi / 4(55^2 - 45^2)}$$

$$fc_{act} = 63.66\ N / mm^2$$

$$fc_{all} = \frac{Tsut}{F.O.S}$$

$$fc_{all} = \frac{800}{4}$$

$$fc_{all} = 200$$

Piston rod is safe in compression hence, the material selected is mild steel.

Material: Mild steel
Modulus of elasticity (E): 2.1×105 N/mm^2
Poisson's ratio (nu): 0.3
Density (ρ): 7860 Kg/m^3
Thermal expansion (α): 0.000017 μ

Checking for the Deflection
Deflection along the axis of application of force at "A" and "B" the extreme ends as shown in Figure 1.

R= Radius of gyration

$$H = R\varphi \qquad \varphi = \frac{H}{R} \qquad (1)$$

$$H + \delta = R_1 \varphi \qquad \varphi = \frac{H + \delta}{R1} \qquad (2)$$

Where, $R_1 = R + a + L$
Equating both the equations as:

$$\frac{H}{R} = \frac{H + \delta}{R + a + L}$$

$$\delta = \frac{H(L+a)}{R}$$

In order to determine the increase in throat height i.e., δ it is considered that the natural axis bends under the load 'P' to consider arc of radius 'R'. In unloaded condition, the natural axis does not bends and in loaded condition, the angle of inclination become φ.

Now,

$$\frac{M}{I} = \frac{\sigma}{Y} = \frac{E}{R}$$

$$R = \frac{E\ X\ Ixx}{M}$$

Here, Mb= 376.426 x 10^6 N mm
I_{xx}= 5031.31 x 10^6 mm^4
E= 2.1 x 10^5 N/mm^2

$$R = \frac{2.1 \times 10^5\ X\ 5031.31 \times 10^6}{376.425 \times 10^6}$$

R= 2.80 x 10^6

$$\delta = \frac{H(L+a)}{R}$$

Where, H= 1220 mm

$\delta = \frac{1220\ (270+585)}{2.80\ X\ 10^6}$

L= 270 mm

δ= 0.3725 mm.

a= 585 mm

R= 2.80 x 10^6 mm

The maximum deflection at the extreme end 'B' is:

$\frac{\delta max}{\delta} = \frac{(2L+a)}{(L+a)}$

$\frac{\delta max}{0.1888} = \frac{270+227+585}{270+585}$

δ_{max}= 0.4712 mm

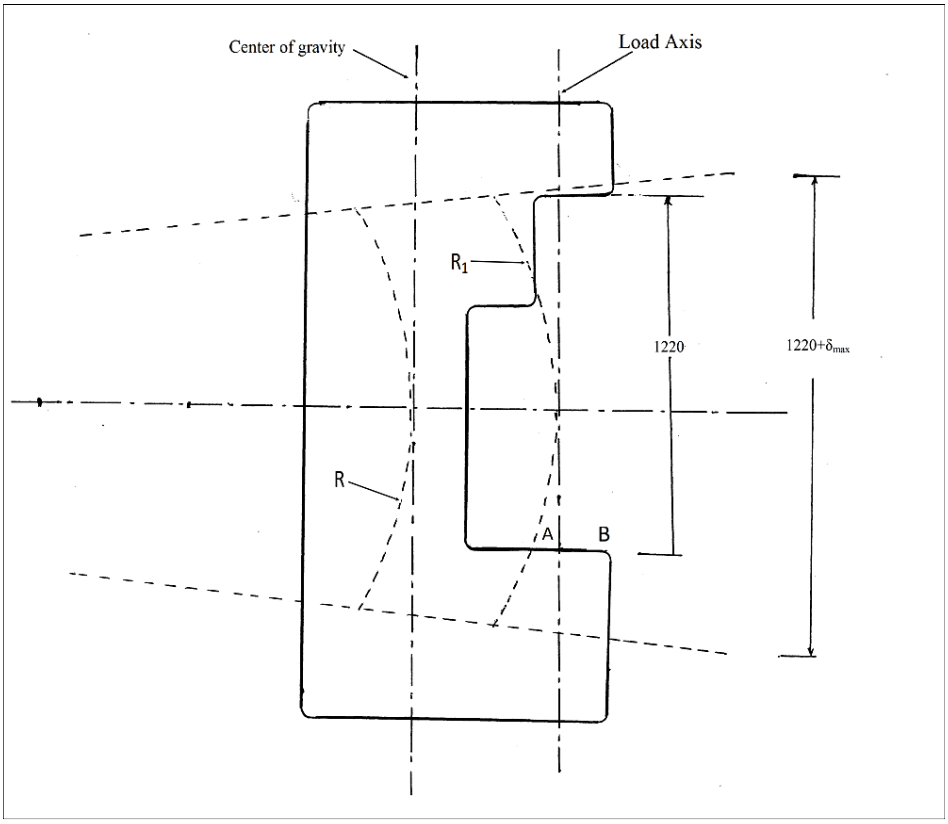

Fig. 1: *Frame of Press for Radius of Gyration.*

COMPONENTS LIST (Table 1)

Table 1: *List of the Components Along with Their Dimensions.*

S. No.	Components	Dimensions
1.	Bottom Plates	180*180*10
2.	Supporting Plates	350*10*10
3.	Fixture Plate	150*8*8
4.	Base Plate 2	550*300*10
5.	Base Plate 1	550*450*10
6.	Top Plate	550*150*10
7.	Rib 2	150*100*8
8.	Rib 1	180*130*8
9.	C Channel	100*50*5

Hydraulic Circuit

The counter balance valve is used. This is a pressure control valve. Counter balance or back-pressure is used to keep the vertically mounted hydraulic cylinder in upward position while pump is idling. It prevents the vertical cylinder from descending due to weight of its load.

Analysis (Figure 2 a, b)

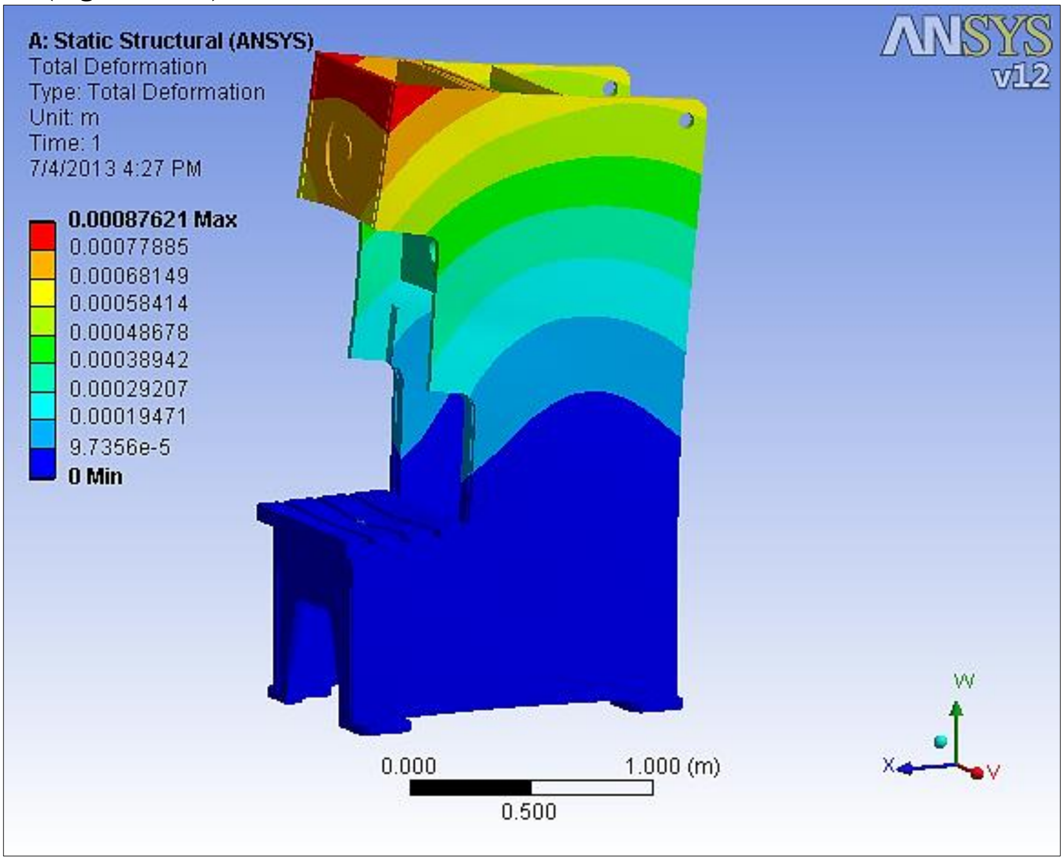

Fig. 2: *(a) Effect of Plate Thickness on Deformation.*

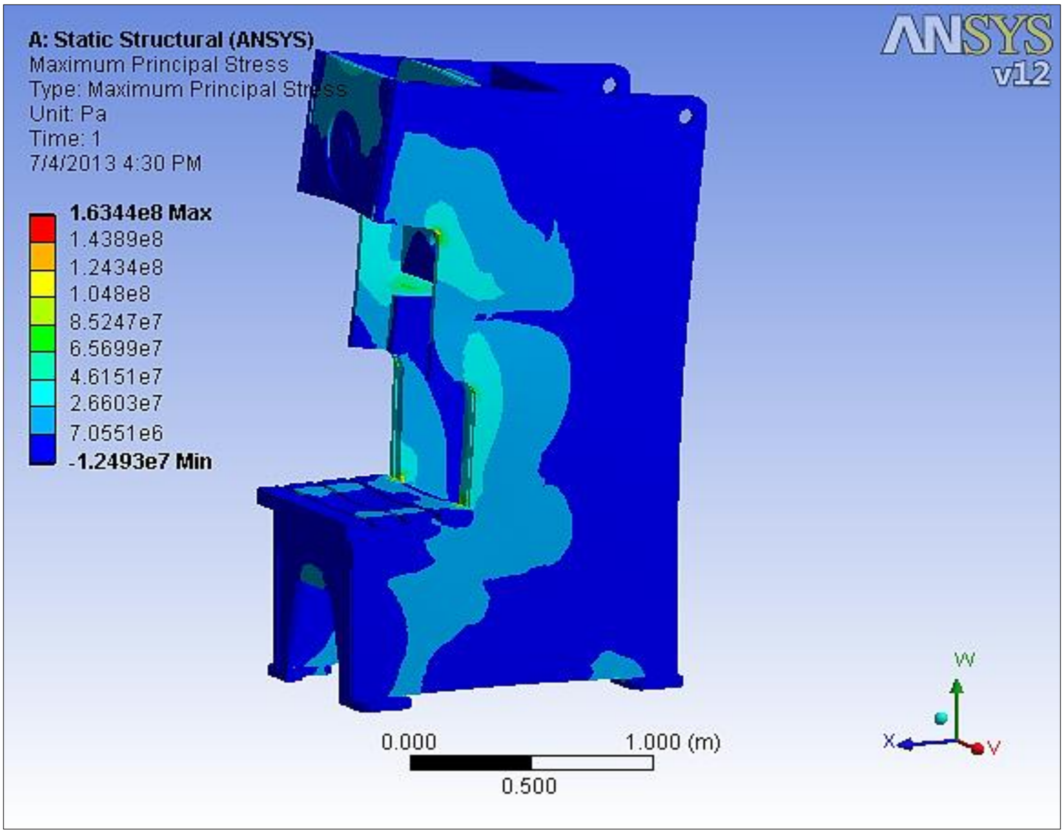

Fig. 2: *(b) Effect of Plate Thickness on Stress.*

Mesh Independency (Figure 3)

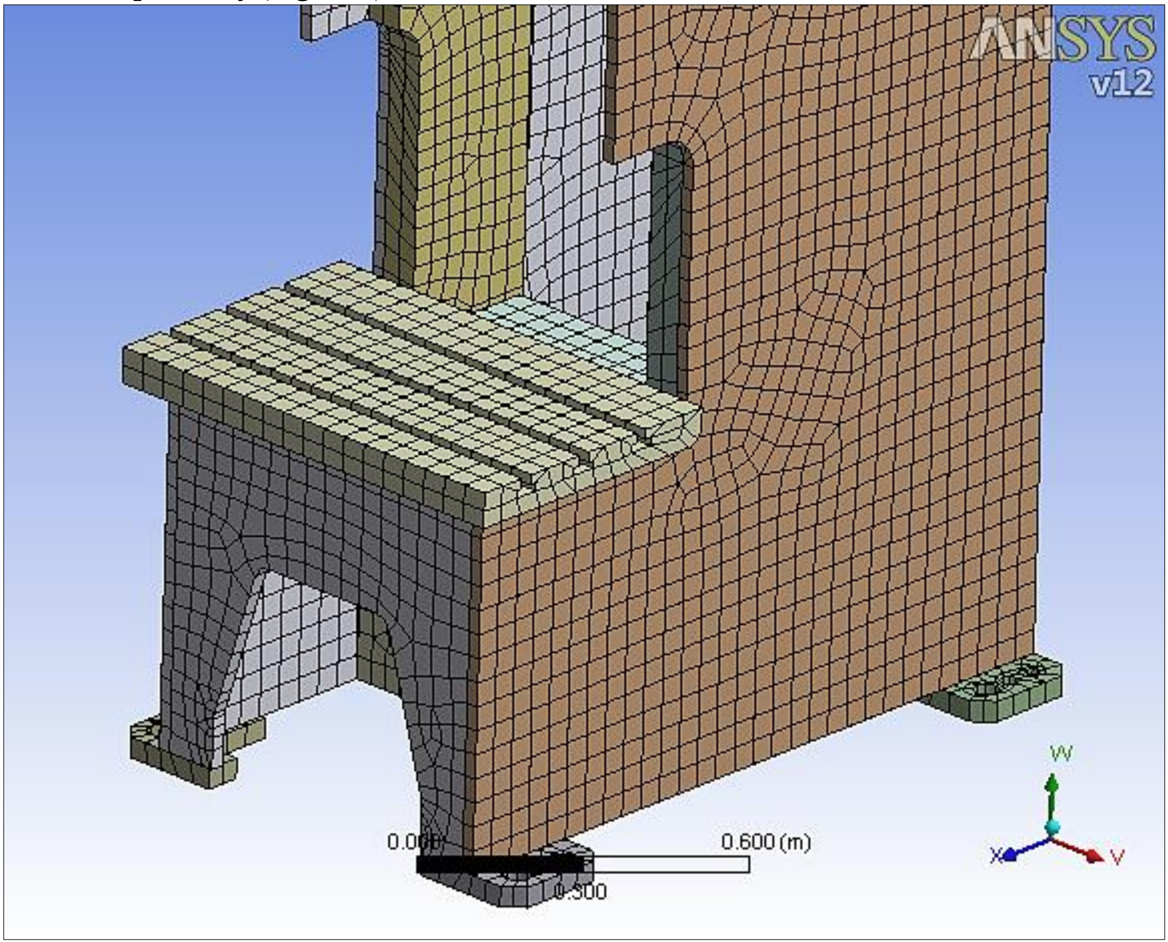

Fig. 3: *Mesh Size and Independency.*

Validation of Deformation and Stress Calculation (Table 2)

Table 2: *Effect of Plate Thickness on Deformation.*

Plate Thickness	Analytical (mm)	Practical (mm)	Difference
20 mm	0.699	0.876	0.177
25 mm	1.139	1.279	0.140
30 mm	0.8158	0.877	0.061
35 mm	0.3466	0.877	0.530

CONCLUSIONS

The above project describes assembly of press and the design of the 'C' frame performed as per the requirements by following the process of reverse engineering. The modeling of the 'C' frame has been done in software. Design is done for the 'C' frame to reduce the amount of material used without causing the material wastage. The position where the stresses were not acting, at that point the extra material was removed thus, optimizing the design without compromising. The results obtained from analysis software are within the limits.

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