The goal of structure optimization is to decrease total mass of hydraulic press while assuring adequate stiffness. Structural optimization tools and computer simulations have gained the paramount importance in industrial applications as a result of innovative designs, reduced weight and cost effective products. A method of structure optimization for hydraulic press is proposed in order to reduce mass while assuring adequate stiffness. Key geometric parameters of plates which have relatively larger impacts on mass and stiffness are extracted as design variables. In order to research relationship between stiffness, mass and design variables, common batch file is built by CREO and analysis is done in ANSYS. Top plate, movable plate and column design and analysis done.

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Main objective of project is to modify major component of “one cylinder four post hydraulic press” so rigidity and strength of the components are increase by using optimum material. The function of the major component like frame, bottom plate, bed, top box are to absorb forces, to provide precise slide guidance and to support the drive system and other auxiliary units. The structural design of the component depends on the pressing force this determines the required rigidity.

**ABSTRACT**

The goal of structure optimization is to decrease total mass of hydraulic press while assuring adequate stiffness. Structural optimization tools and computer simulations have gained the paramount importance in industrial applications as a result of innovative designs, reduced weight and cost effective products. A method of structure optimization for hydraulic press is proposed in order to reduce mass while assuring adequate stiffness. Key geometric parameters of plates which have relatively larger impacts on mass and stiffness are extracted as design variables. In order to research relationship between stiffness, mass and design variables, common batch file is built by CREO and analysis is done in ANSYS. Top plate, movable plate and column design and analysis done.

**Keywords**: FEA, Hydraulic press, Optimization platen (top, movable, bottom), Stress analysis

**I. INTRODUCTION**

**HYDRAULIC PRESS**

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. It has also a very low inertia effect.

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# LAYOUT OF HYDRAULIC PRESS

![Hydraulic Press Machine Layout](image)

> **Figure 1** Hydraulic press machine layout

<table>
<thead>
<tr>
<th>SR NO</th>
<th>SPECIFICATION</th>
<th>CAPACITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Type</td>
<td>300 Ton 4 Column Hydraulic Press</td>
</tr>
<tr>
<td>2</td>
<td>Application</td>
<td>Metal Forming</td>
</tr>
<tr>
<td>3</td>
<td>Rated Nominal Pressure:</td>
<td>3000000 N</td>
</tr>
<tr>
<td>4</td>
<td>Ram Stroke Length</td>
<td>700 mm</td>
</tr>
<tr>
<td>5</td>
<td>Weight of the press machine</td>
<td>15000 KN</td>
</tr>
<tr>
<td>6</td>
<td>Motor Power(W)</td>
<td>22 KW</td>
</tr>
<tr>
<td>7</td>
<td>Work Table size</td>
<td>1500 × 1200</td>
</tr>
<tr>
<td>8</td>
<td>Opening height</td>
<td>600 mm</td>
</tr>
<tr>
<td>9</td>
<td>Knock Out Force</td>
<td>500 KN</td>
</tr>
<tr>
<td>10</td>
<td>Power source</td>
<td>Hydraulic</td>
</tr>
<tr>
<td>11</td>
<td>Slide Speed</td>
<td>Idle Stroke 100 mm/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pressing 5-10 mm/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Return 60 mm/s</td>
</tr>
<tr>
<td>12</td>
<td>Ejecting Speed</td>
<td>Eject 50 mm/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Return 150 mm/s</td>
</tr>
</tbody>
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</tbody>
</table>

Table 1 SPECIFICATION OF PRESS MACHINE
II. Analysis

A. Analysis of Top Platen

- Top platen is a steel cast structure located upper side of a vertical press, and withstand compressive and bending load developed by hydraulic cylinder. As shown in figure, plate is fixed at four nut having diameter of 225 mm. Shown in figure, force of 3000000 N is acting on diameter of 430 mm at bottom part.

![Top Platen Diagram](https://example.com/top_platen_diagram.png)

Figure 2 Drawing and 3D view of Top plate

Now show figure is represent Von-Mises stress. Maximum von- Mises stress is induced at the fixed support is approximate 120 Mpa. In the figure shows deflection of top platen is approximate 0.18 mm.

![Von-Mises Stress and Deflection](https://example.com/von_mises_stress_deflection.png)

Figure 3 Von-Mises stress and deflection of top plate

- The properties of structural steel are,
  - Tensile yield stress: 250 Mpa
  - Ultimate tensile stress: 460 Mpa
  - Poisson ratio: 0.3
  - Young modulus: 200000
So as per material specification induced stress is in analysis gate approximately 120MPa.

So from above data clear that design is safe.

A. Analysis of Movable Platen

Moving platen is also a cast structure, Located between main hydraulic cylinder and pressing table. It is attached to Ram of cylinder and guided by side columns of press. Moving platen exert force on the job placed on press–table. Drawing view of Movable platen. As shown in figure, Movable plate is fixed at bottom side because die is placed at bottom side of plate. Figure shows cylindrical support at four holes because movable plate is guided by four columns.

Figure 4 Drawing and 3D view of movable plate

Figure shows stress von-Mises stress. Maximum von- Mises stress is induced at the fixed support is approximate 30 Mpa. Figure shows total deflection is almost 0.04 mm which is within permissible limit.

Figure 5 Force apply on movable plate
A. Analysis of Columns

Columns are round Bar or fabricated structure. It binds top and bottom platen together firmly. Round bars are threaded at ends and nuts are provided to hold platen in position, check-nuts are provided to avoid loosening of main nuts. When force is acting from ram on bottom plate for deep drawing operation at that time reaction of ram is acting on top platen and this top platen is resisted by nut and column in the upward direction. That means, tensile force is acting on the column in working condition.

As shown in figure, stress induced in the column is 230 which is very near to the yield point of the steel structure material. So this component should be redesign. Safe deflection limit is $< 0.003 \times \text{Length}$ So $0.003 \times 1950 = 5.85$ mm. That means this design can be safe if considering only fracture criteria. As shown in figure, total deflection in the component is almost 1.8 mm which is under limit.
An urgent and realistic need in designing structures, e.g., top platen, movable platen, column and bottom platen is to find an optimal design for minimizing weight and deflection, maximizing safety, minimizing the cost of products, etc.

The simplest idea for optimizing a structure is to modify the sizes of structural members, i.e., use size parameters (plate thicknesses, bar cross-sectional areas, etc.) as design variables in the optimization process. This approach is called the sizing optimization method.

OPTIMIZATION OF BOTTOM PLATEN

Initial dimension of bottom platen is shown in figure which is fully solid component.

Figure 9 Drawing and 3D view of initial bottom plate

Modified dimension of bottom platen 1

Now modified dimensions for sizing optimization as shown in figure. Here box is made...
of 25 mm thickness of plate thickness and 65 mm of bottom plate thickness.

![Figure 10 Drawing and 3D view of initial bottom plate 1](image)

- **FEA of bottom platen 1**
  - Apply fixed support at four nuts. Also apply 3000000 N of force at top surface and 1000000 N of force at bottom plate as shown in figure.
  - As shown in figure the equivalent stress is approximate 487 Mpa which is more than safe limit and shown in figure.

![Figure 11 Von-Mises stress and deflection of bottom plate 1](image)

- The total deflection is about 0.95 MM.

- **Modified Dimension of Bottom Platen 2:**

  Now modified dimensions for sizing optimization as shown in figure. Here box is made of 25 mm thickness of plate, 50 mm of horizontal plate and 80 mm of bottom plate thickness.
As shown in figure the equivalent stress is approximate 484 Mpa which is more than safe limit.

As shown in figure the total deflection is about 0.21 MM.

**Modified dimension of bottom platen 3:**
- Now modified dimensions for sizing optimization as shown in figure. Here box is made of 25 mm thickness of plate, 50 mm of horizontal plate and 80 mm of bottom plate thickness.
Figure 14 Drawing and 3D view of initial bottom plate 3

○ **FEA of modified bottom platen 3:**

  Now shown in figure the fixed support and forces applied on bottom plate.

Figure 15 Von-Mises stress and deflection of bottom plate 3

○ As shown in figure the equivalent stress is approximate 144Mpa which is more than safe limit

○ As shown in figure the total deflection is about 0.22 mm.
RESULT

V ☑ COMPARISON OF BOTTOM PLATEN

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>PARAMETER</th>
<th>OLD BOTTOM PLATEN</th>
<th>MODIFIED BOTTOM PLATEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Von-mises Stress</td>
<td>104 Mpa</td>
<td>144 Mpa</td>
</tr>
<tr>
<td>2</td>
<td>Total deflection</td>
<td>0.055 mm</td>
<td>0.22 mm</td>
</tr>
<tr>
<td>3</td>
<td>Weight</td>
<td>2263 Kg</td>
<td>1303 Kg</td>
</tr>
</tbody>
</table>

V ☑ FINAL VALUE OF ALL RESULT OF BOTTOM PLATEN

<table>
<thead>
<tr>
<th>SR. NO.</th>
<th>MASS(KG)</th>
<th>VON-MISES STRESS (MPA)</th>
<th>DEFLECTION(MM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>987.6</td>
<td>486.82</td>
<td>0.94</td>
</tr>
<tr>
<td>2</td>
<td>1230.6</td>
<td>483.92</td>
<td>0.22</td>
</tr>
<tr>
<td>3</td>
<td>1695.3</td>
<td>144</td>
<td>0.22</td>
</tr>
</tbody>
</table>

CONCLUSION

By comparing result of old bottom platen and modified final bottom platen we get weight reduce that 2263 Kg to 1303 Kg. Deflection increases 0.055 mm to 0.22 mm but it is in permissible limit. It is not effect to component. Von-mises stresses increases 104 Mpa to 141 Mpa and it also doesn’t cross permissible limit and our bottom plate is safe under working condition.

REFERENCES