Design & Analysis of Frame of 63 Ton Power Press Machine by Using Finite Element Method

**KEYWORDS**
Mechanical Press frame, crack, stress concentration, FEM, numerical and experimental analysis.

**ABSTRACT**
Metal forming is one of the manufacturing processes which are almost chip less. These operations are mainly carried out by the help of presses and press tools. These operations include deformation of metal work pieces to the desired size and size by applying pressure or force. Press machine always working under impact load condition. Because of continuous impact load, frame of press machine always experience continuous tensile stress. Press machine continuous deals with stress and because of that frequently structural failure problem occurred in machine. Instead of sharp corner in C-plate fillet is provided, then it is useful to reduce failure in structure. Amount of fillet is depends on load condition experienced by frame and that can be analyzed by using FEM Tool. It is also helpful to reduce thickness of plate of frame structure so that material saving and cost benefit will be considerable.

1. **Introduction**

Metal forming is one of the manufacturing processes which are almost chip less. These operations are mainly carried out by the help of presses and press tools. A mechanical power press is a machine used to supply force to a die that is used to blank, form, or shape metal or nonmetallic material. Thus, a press is a component of a manufacturing system that combines the press, a die, material and feeding method to produce a part. A mechanical power press is a machine used to supply force to a die that is used to blank, form, or shape metal or nonmetallic material. Thus, a press is a component of a manufacturing system that combines the press, a die, material and feeding method to produce a part.

![Figure 1 cross section of typical C-type press](image)

2. **Phenomena of Power Press Machine**

Basically in this, work is on the C-frame type press machine but presses fall into two predominant types: gap frame and straight side presses. The frame types used in hydraulic presses are similar to those used in many mechanical presses. Most power presses are actuated by electrical motor driven mechanical or hydraulic energy. However, gravity drop hammer and foot powered kick presses are also used. The drive systems, clutches, brakes, counterbalance systems, die cushions, electrical, hydraulic and pneumatic features are similar in both the gap frame and straight side types.

The major advantages of an open frame press design are economy of construction and unhindered access to the die area. Inclined models and those with moveable beds or tables also offer a great deal of versatility, making them particularly useful for short run production or job shop applications.

The drawback of the open frame design is the fact that such presses are generally limited in practice to the use of single dies. This is a result of several factors including the lack of stiffness and the typically small force capacity and die area of open frame presses.

3. **Case study**

In one of the industry, they are manufacturing power press they have found the defect after the punching process. Due to the impact loading at the end of the bolster plate they are having crack at the corner and stress generated is more due to continuous loading and stress concentration following table shows the specification & fig shows the affected area now they are having 35 mm plate for frame so the weight & cost is very high and to reduce that it should be reduction in thickness.

**Technical specification**

<table>
<thead>
<tr>
<th>Table 1. Information about press machine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
</tr>
<tr>
<td>Model</td>
</tr>
<tr>
<td>tonnage</td>
</tr>
<tr>
<td>Fixed stroke (mm)</td>
</tr>
<tr>
<td>Adjustable stroke (mm)</td>
</tr>
<tr>
<td>Rating point (mm)</td>
</tr>
<tr>
<td>Die hight (mm)</td>
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<tr>
<td>Slide adjustment (mm)</td>
</tr>
<tr>
<td>Slide area (mm²)</td>
</tr>
<tr>
<td>Tool bore (mm)</td>
</tr>
<tr>
<td>Bolster area (mm²)</td>
</tr>
<tr>
<td>Main motor (hp x P)</td>
</tr>
<tr>
<td>Slid adj. motor (kW)</td>
</tr>
</tbody>
</table>
4. Design Procedure

Material used by the industry SINGHAL POWER PRESS PVT. LTD. is “St 42 W” from WESTERMANN TABLE for the metal trade.

Specification of Material
Designation: St 42 W.
Tensile strength: 420 to 540 MPa.
Density: 7850 kgf/m³.
Young’s Modulus: 2.1 x 10⁵ N/mm².
Poissons Ratio: 0.3.
Factor of Safety: 4.
For impact loading
Stress Concentration Factor: 1.25.
Max Allowable Stress \( \sigma_{max} \): \( 420/4 = 105 \) N/mm².

4.1 Assumption / Consideration
As the frame is having the symmetrical cross section area, one side is to be consider for the purpose of analysis.

The maximum stress are expected to be induced across the cross section X-X at the inner most edge.

Maximum deflection take place at the maximum load at point “A” that is 63 Ton and then also checked at the extreme end at point “B”.

“C” web has been consider as integral with the frame.

4.2 Calculations
As a section is symmetrical, one side of the frame has been considering for the analysis.

\[ \bar{y} = \frac{ax^{2} + ax^{2} + \ldots}{a + a + \ldots} = \frac{126.197 \times 10^6}{149.17 \times 10^3} \]
\[ \bar{y} = 846 \text{ mm} \]
\[ a = 1435 - 846 = 589 \text{ mm} \]

4.1.1 Ixx for each side of the section
\[ I_{xx} = \frac{bd^3}{12} \text{ for rectangular section} \]
\[ I_{xx} = \frac{h^4}{64} \text{ for solid section} \]
\[ I_{xx} = \frac{1}{12} 25 \times 1435^2 + \frac{1}{12} 35 \times 352^2 + \frac{1}{12} 50 \times 210^3 + \frac{1}{12} 55 \times 35^3 \]
\[ I_{xx} = 8784.67 \times 106 \text{ mm}^4 \]
\[ \sigma_t = \frac{P}{A} \]
\[ \sigma_t = 2.11 \text{ N/mm}^2 \]

4.1.2 Bending Moment
\[ M_b = P (L + a) \]
\[ M_b = 315000 \times (610 + 527) \]
\[ M_b = 358.155 \times 106 \text{ N-mm} \]
\[ \sigma_b = \frac{M_b}{Z_{xx}} \]
\[ Z_{xx} = \frac{I_{xx}}{a} = \frac{8784.67 \times 10^6}{16.669 \times 10^6} \]
\[ \sigma_b = 21.48 \text{ N/mm}^2 \]
\[ \sigma_{max} = \sigma_b + \sigma_t = 2.11 + 21.48 \]
\[ \sigma_{max} = 23.59 \text{ N/mm}^2 \]

The maximum stress induced 23.59 N/mm² & maximum allowable stress is 240/4 = 60 N/mm².
The maximum deflection at the extreme end B.

\[ \delta = \frac{2200 (270+527)}{5.15 \times 10^6} \]

\[ \delta = 0.1888 \text{ mm} \]

By applying same load this can be done analytically in simulation software then result is as follows. then change the size of the frame in decreasing order and get the result

5 Analysis for power press machine design

There are six basic steps for doing the simulation in press machine to predict the defects by applying impact load.

Step 1- create CAD model of press frame structure.
Step 2- Import the CAD model in simulation software
Step 3- Pre processing
Step 4- Apply boundary conditions
Step 5- Post processing
Step 6 – Result and analysis

After creating the CAD model, import the CAD file in simulation software in .IGES or .STL format. Define number of nodes, number of materials, and number of elements for pre-processing. Element type is tetrahedral.

Figure 4 Model of power press frame structure

Figure 5 Application of load at the crank shaft

Figure 6 Applying boundary condition

Figure 7 Meshing of model

Figure 8 Stress affected area

Figure 9 Maximum stress generated

Figure 10 Deflection of frame
6. Conclusion
It can be concluded that simulation software is the powerful tool for prediction of the thickness of plate required for given load it is only 25mm thickness of plate required for this machine so it will be helpful to reduce the thickness of plate within the limit. Modification in thickness can give the size which is 29% reduction in raw material.

Figure 11 Deflection of frame