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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.

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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.

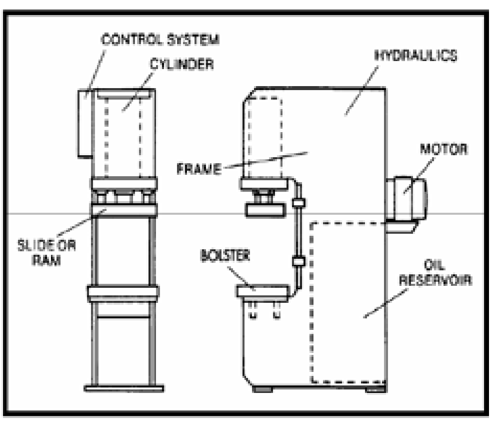

Figure 1 cross section of typical C-type press

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. Inclinable 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 1. Information about press machine

Description	Dimension
Model	SNX-63
tonnage	63
Fixed stroke (mm)	50
Adjustable stroke (mm)	8-50
Rating point (mm)	2.3
Die hight (mm)	300
Slide adjustment (mm)	70
Slide area (mm^2)	500 X 400
Tool bore (mm)	50.8
Bolster area (mm^2)	900 x 520
Main motor (hp x P)	7.5 x 4
Slid adj. motor (kW)	0.4

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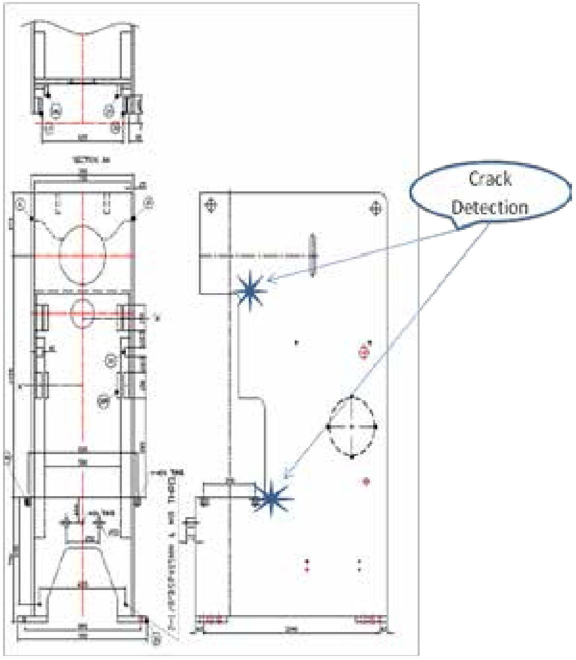

Figure 3 Affected area due to impact loading

Figure 2 press machine SNX-63

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/m^3.
Young's Modulus: 2.1 x 10^5 N/mm^2.
Poisons Ratio: 0.3.
Factor of Safety: 4.
For impact loading
Stress Concentration Factor: 1.25.
Max Allowable Stress [σ_{max}]: 420/4 = 105 N/mm^2.

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

$$\bar{y} = \frac{a1x1 + a2x2 + \ldots\ldots}{a1 + a2 + \ldots\ldots}$$

$$\bar{y} = \frac{126.197\ X\ 10^6}{149.17\ X\ 10^3}$$

$\bar{y}$ = 846 mm.

a = 1435-846

a = 589 mm.

4.1.1 Ixx for each side of the section

$I_{xx} = \frac{1}{12} bd^3$ for rectangular section

$I_{xx} = \frac{\pi}{64} d^4$ for solid section

$$I_{xx} = \frac{1}{12} 35\ X\ 1435^3 + \frac{1}{12} 35\ X\ 352^3 + \frac{1}{12} 50\ X\ 210^3 + \frac{1}{12} 55\ \ 35^3$$

I_{xx} = 8784.67 X 106 mm^4

$$\sigma_t = \frac{P}{A}$$

σ_t = 2.11 N/mm^2

4.1.2 Bending Moment

Mb = P (L + a)

Mb = 315000 (610 + 527).

Mb = 358.155 X 106 N-mm.

$$\sigma_b = \frac{Mb}{Zxx}$$

$$Z_{xx} = \frac{Ixx}{a} = \frac{8784.67\ X\ 10^6}{16.669\ X\ 10^6}$$

$$\sigma_b = \frac{358.115\ X\ 10^6}{16.669\ X\ 10^6}$$

σ_b = 21.48 N/mm^2.

σ_{max} = σb + σt

σ_{max} = 2.11 + 21.48

σ_{max} = 23.59 N/mm^2.

The maximum stress induced 23.59 N/mm^2

& maximum allowable stress is 240/4 = 60 N/mm^2

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

$$R=\frac{2.1\times10^{6}\,X\;8784.67\times10^{6}}{3580.155\times10^{6}}$$

$$R=5.15\times10^{6}$$

$$\delta=\frac{1220\,(270+527)}{5.15\,X\,10^{6}}$$

$$\delta=0.1888\text{ mm.}$$

The maximum deflection at the extreme end B.

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

$$\frac{\delta max}{0.1888}=\frac{270+227+527}{270+527}$$

$$\delta_{max}=0.2425\text{ mm.}$$

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.

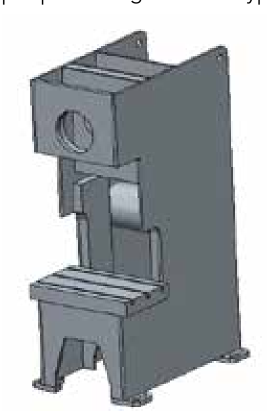

Figure 4 Model of power press frame structure

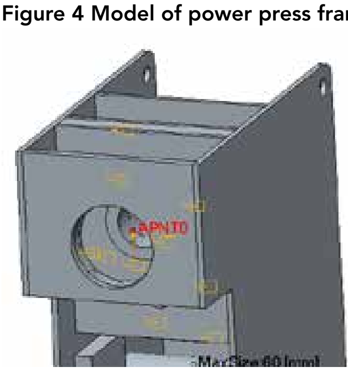

Figure 5 Application of load at the crank shaft

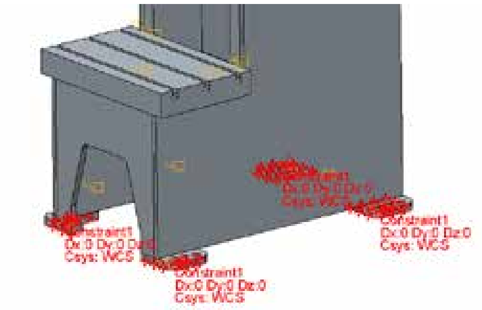

Figure 6 Appling boundary condition

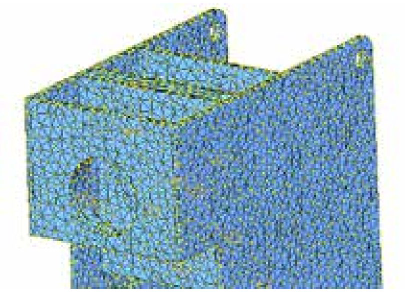

Figure 7 Meshing of model

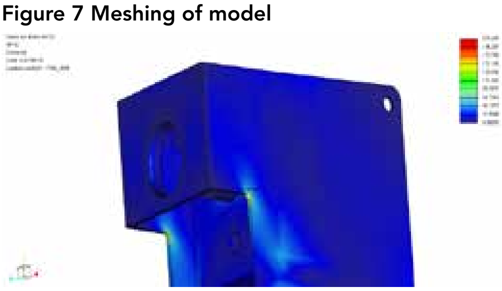

Figure 8 Stress affected area

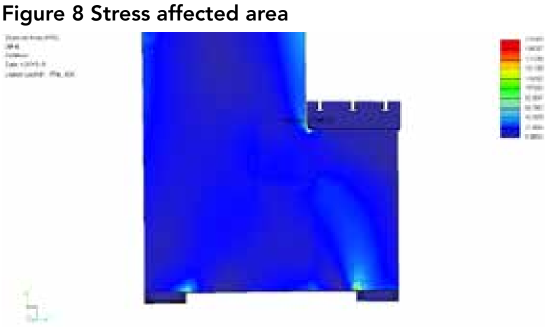

Figure 9 Maximum stress generated

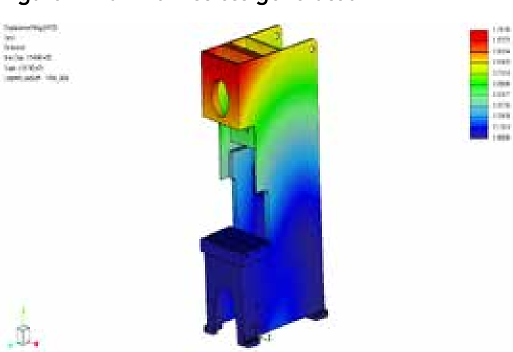

Figure 10 Deflection of frame

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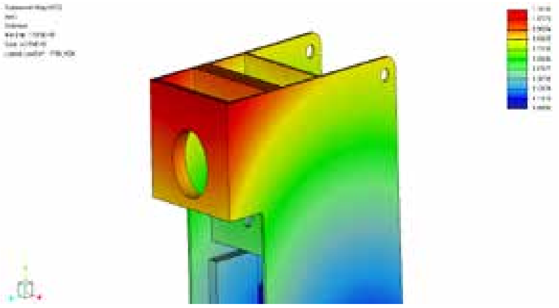

Figure 11 Deflection of frame

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.

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