Structural Analysis and Optimization of 'C' Frame of Mechanical Press

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Abstract- *Power press working is defined as chip less manufacturing process. It is also called as cold stamping process. The machine used for press working is known as press. This Project work deals with the Structural analysis and optimization of Mechanical 100 Ton Press Machine. The aim is to reduce the Weight and cost of the Mechanical press without reducing the quality of the output. Using the best possible resources in design can affect decrease in the weight and cost of the press machine. One way of doing, it will be the optimizing the volume of material utilized for building the complete structure of machine .Here considers an industrial application project consisting of mass minimization of a Mechanical press. For reduction of volume of material Forming operation is consider. For analysis Purpose ANSYS has been used.*

Key Words: **FEA, Structural optimization, Weight reduction, ANSYS, 'C' Frame of press**

1. INTRODUCTION

Power press are used for producing large quantities of articles quickly, accurately and economically from the cold working of mild steel and other ductile materials. A Press Machine is a machine that supplies force to die used to form, blank or shape metal or non-metallic materials. The Metal forming manufacturing process is almost chip less. Press tools are used to carry out this operation. Deformation of work piece to desired size is done by applying pressure. Presses are considered best and most capable way to form a sheet metal into final finished products. Mechanical presses are commonly used for punching, forging, molding, clinching, blanking, deep drawing and metal forming operation. Pneumatic press is used for producing huge quantities of articles economically, quickly and accurately. The components which are produced range over a very wide field and are used all over industry. By means of particularly designed press tools and combination of operations, most of the sheet parts of any shape are produced. The selection of the proper press and design of die or tool to be mounted on it is very important for any operation to be carried out on the Press Machine.

1.1 Power Press Working:

There are mainly three types of power presses: mechanical, hydraulic, and pneumatic. Their control systems may be mechanical or electro-mechanical. Through these three major types of power presses share some common features, the mechanical power press is the most commonly used and researched. In power press two major are stationary bed and a moving ram. Mechanical power press works on the principle of reciprocating motion and the main components for power transmission are the flywheel, and crankshaft, clutch. A motor gives the rotation motion to flywheel and clutch is used for couple the rotation flywheel to the crankshaft. The crankshaft converts the rotary motion of the flywheel to the downward and upward motions of the press ram. A work piece is fed into the lower die, either automatically or manually, and the machine cycle is initiated. On the down stroke, the ram (with an upper die) moves toward the area of operation. When the upper and lower dies press together on the stock material, a re-formed piece is produced. Once the down stroke is completed, the formed work piece is removed and a new work piece fed to the machine and process repeated.

1.2 Specification of 'C' Frame of press

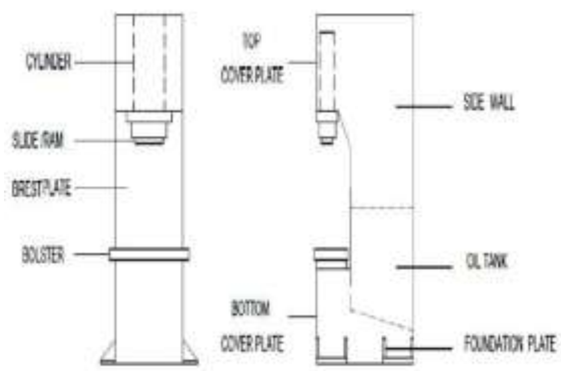


Figure 1: Line diagram of C frame of press

Table 1: Specification of frame

Type	**C Frame Mechanical Press**
Model	Manckoo MP 07
Material	SS
Motor used	7.5 HP
Mode of Operation	Manual
Stroke	335 mm
Capacity	100 tons
Ram Diameter	150mm
Height From bottom	3000 mm
Bed Size	1040 ×730 mm
Width of C frame	700 mm
Height of C frame from Bed	2100 mm
Thickness of frame	65 mm
Diameter of frame	530 mm
Thickness of punch	60 mm

2. LITERATURE REVIEW

D Ravi [1]: The objective of this study is to investigate the finite element modelling of 'C' frame power press of 10 tonne capacity and to analyse the power press under static condition

Bhushan V. Golechha, Prashant S. Kulkarni [2]: This Project work deals with the Design, analysis and optimization of Pneumatic 10 Ton Press Machine. The aim is to reduce the Wight and cost of the Pneumatic press without reducing quality of output

H. N. Chauhan [3]: 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 design specification, stress distribution, deflection.

Rucha.S.Khistiet [4]: The objective is to design c frame model for assembly operation known as hydraulic press machine. Using the concept of reverse engineering, by knowing the dimensions of the piston cylinder assembly and the product to be assembled, the C-frame has been designed keeping in mind the design specification, stress distribution, deflection.

3. PROBLEM DEFINITION AND METHODOLOGY

3.1. Problem Definition: The current design of the mechanical press is having heavy system. This heavy system increases the cost and material requirement to the machine. The low loaded components on press machine will be optimized which consist of frame and other components.

3.2. Objectives:

- To study the current system in detail with its specification and all required considerations
- To design, optimize press machine to save the overall weight of machine..
- The optimization of system will be according to one of the following cases:

a) Changing dimensions of system and keeping material same as it is.
b) Keeping same dimensions and changing material of components,
c) Changing both material as well as dimensions of component.

3.3 Methodology:

- Check design and specifications of existing press machine in the industry
- Creating geometric model and finite element model of existing press machine system using suitable CATIA software
- Static Analysis of the frame using ANSYS software.
- Simulations for Modal Analysis.
- Optimization of press machine assembly for weight reduction.
- Comparison between existing and optimized design.
- Validation of Results

4. DESIGN AND ANALYSIS OF EXISTING SYSTEM:

Theoretical design of frame assumption:- The material of the frame perfectly homogeneous and isotropic i.e. it is same material throughout and of equal elastic properties in all direction. The material used is mild steel. And the properties are described below:

Specification of press:-

Press capacity= 100 tones

Density= 7850 kg/m3

Syt= 590 Mpa

Considering uniformly distributed load & FOS as 2

Allowable Stress (σall) = Syt / Fs
= 590/2
= 295 Mpa.

Young's modulus= 2.1×10^5 Mpa

Poisons Ratio= 0.3

Formulas and calculation

The frame subjected to direct tensile stress and bending stresses at section x-x1.

σ total = σ tensile + σ bending Mpa.................... (1)

σ total = P/A + Mb / Z Mpa.................... (2)

Where,

σ = Permissible stress in Mpa
P= Applied load in N = 100 × 1000 × 9.81 = 981 KN
A= Area of frame section in mm2
Mb= Bending moment in N.mm
I= Moment of inertia in mm4
Z= Section modulus

Area: 2 × (400 × 80) = 64000 mm^2

Direct stress = P/A ……………. (3)

= (100 × 1000 × 9.81) / 64000

= 15.33 Mpa

Bending stress = M/Z ……………. (4)

M = Force * perpendicular distance ……. (5)

= 981000 * 2100.

= 2060100000 N-mm

Section modulus (Z) = B*H2/6 ……………. (6)

= $80 \times 2100^2 / 6$

= 58800000 mm^3

Bending stress = Mb/Z

= 2060100000 / 58800000

= 35.03 Mpa

Total stress = 35.03 + 15.33

= 50.36 Mpa

Weight of the system = L × W × T × ρ
= 2.1 × 0.4 × 0.08 × 7860

= 528.192 Kg

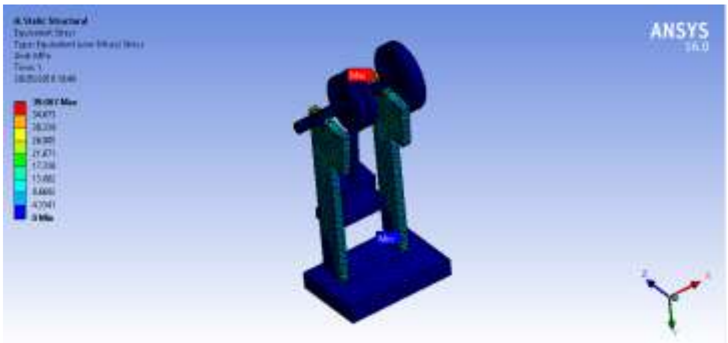


Figure 2: Stress on System

The above figure shows the stress on the system. After application of 981 KN force on the system, the maximum stress is 39.007 Mpa and minimum stress is 0 Mpa. The bluish colour shows that there is more work to do.

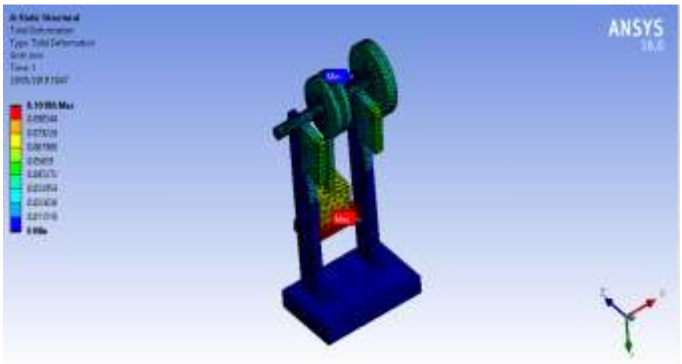


Figure 3: Defection of system

The above figure shows the maximum deflection of 0.10186 mm and minimum 0 mm, after application of the required force.

Design of optimum system: After study of existing system, design of that system for optimization will be started. Optimization of system will be according to one of the following cases:

1. Changing dimensions of system and keeping material same as it is.

2. Keeping same dimensions and changing material of components,

3. Changing both material as well as dimensions of component.

Case 1: Changing dimensions of system and keeping material same as it is.

The various dimensions are as below

Table 2: Iterations

Sr No	h	b	t	Total Stress	Weight	Difference with original
1	2100	400	80	50.36	528.1	0.00
2	2100	350	80	52.55	462.1	66.02
3	2100	300	80	55.47	396.1	132.0
4	2100	250	80	59.56	330.1	198.0
5	2100	500	70	54.06	577.7	49.52
6	2100	400	70	57.56	462.1	66.02

Case 2: Keeping same dimensions and changing material of components,

Two different types of materials are used here, they are

1. Mild steel
2. SS 304

Table 3: Changing materials

Sr No	Material	H	W	T	Total Stress	Weight	Difference with original
1	**MS**	2100	400	80	50.36	528.1	0.00
2	**SS304**	2100	400	80	50.36	539.6	-11.62

Case 3: Changing both material as well as dimensions of component.

In this case the both material as well as the dimensions are changed, the various iterations of this case was carried out. two materials , MS and SS304 was selected for the optimizations, the results are tabulated as below:

Table 4: Difference between two materials

Mater-ials	Sr No	h	b	t	Total Stress	Weight	Differen-ce with original
SS304	1	2100	400	80	50.36	539.63	0.00
	2	2100	350	80	52.55	472.1	67.02
MS	1	2100	250	80	59.56	330.1	198.0
	2	2100	500	70	54.06	577.7	49.52

After Studying the stresses and total weight reduction of the system, we have concluded the following dimensions will be the optimum solution

Material: Mild Steel

Height: 2100 mm, Width: 250 mm and thickness: 80 mm

The report of the analysis is as follows

Figure4: Meshing of model

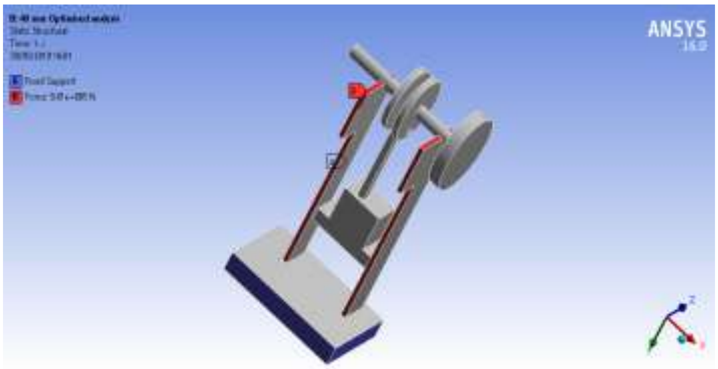


Figure 5: Optimized analysis

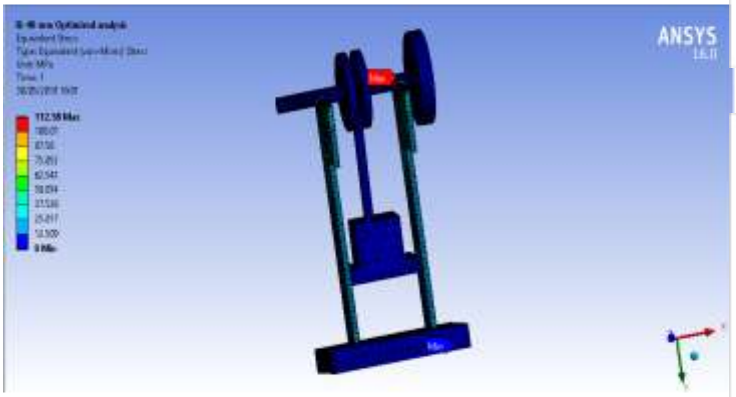


Figure 6:Optimized analysis

The above figure shows the stress on the system. After application of 981 KN force on the system, the maximum stress is 112 Mpa and minimum stress is 0 Mpa. The bluish colour shows that there is more work to do.

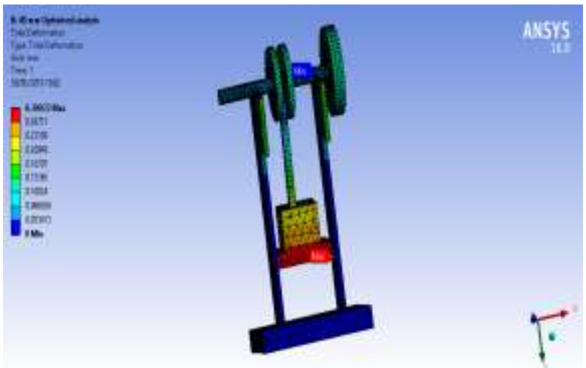
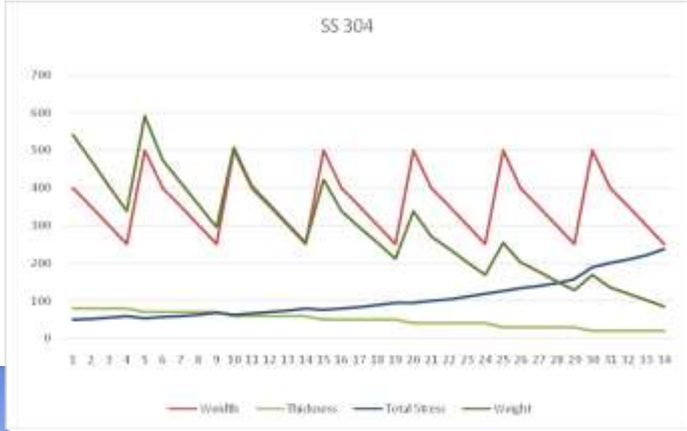


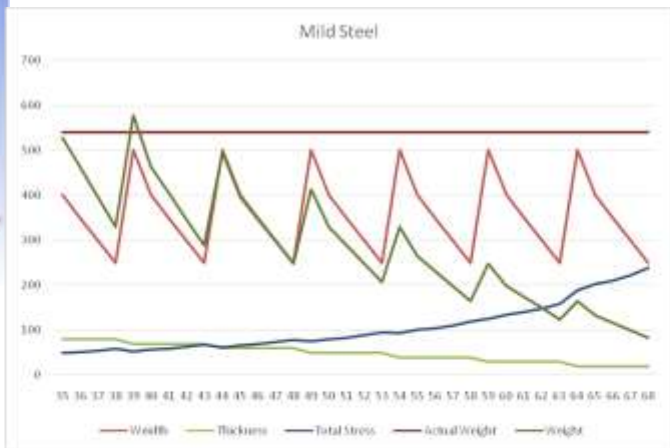
Figure 6:Maximum deflection

The above figure shows the maximum deflection of 0.300 mm and minimum 0 mm, after application of the required force.

5. RESULT AND DISCUSSION:

The material graph representation is given below





Comparison of Stress of Theoretical, Ansys and Experimentation results

Table 5: Results Comparison table

Dimensions	Design calculations Results	Ansys Results	Experimental Results
Length = 2100 mm Width = 250 mm and Thickness = 40 mm	Stress	Stress	Stress
	119 MPa	127.8MPa	130.5MPa

Comparison of weight of existing and optimized system

Table no.6: Comparison of existing and optimized system

Weight of Existing C Frame	Weight of optimized C Frame	Total Weight Reduction
530 Kg	165 Kg	363 Kg

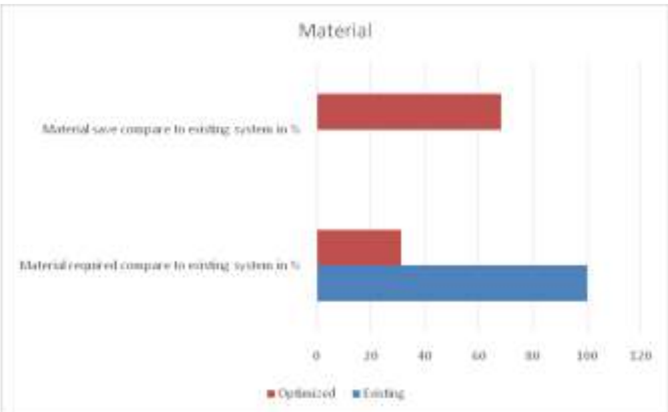
The existing system is optimized in this project. The summary of optimization is shown in above table. The weight of existing C Frame is 530 Kg and weight of optimized system is 165 Kg. Thus we achieved 363 Kg of weight reduction

Material Saving due to optimization

Table 7: Material saving in percentage

	Material required compare to existing system in %	Material save compare to existing system in %
Existing	100	-
Optimized	31.13	68

Thus material saving in optimized system is 68 % than that of existing system. Thus there is also cost saving in material due to optimization.



6. CONCLUSIONS

- The existing system from sponsored plant is heavier in weight. Optimized system is lighter in weight and is solution for disadvantages of existing system. Optimization was achieved on load bearing components of system like C Frame.
- Design calculations, analysis model, and experimental results of existing system and optimized system are compared on stress basis.
- 363 Kg weight reduction is achieved by optimize design than existing design.
- 68 % of material was saved on optimized system than existing system which further save cast of system.

7. FUTURE SCOPE

- Surface treatment on C Frame can be done for increasing strength of C Frame.
- The base and bed of press should be design; optimization can be achieved by changing its geometry or physical properties.
- Drive unit and drum pulleys of system can be design for optimization.
- Buckling analysis of support channels can be done to find maximum load.
- Advance material science can be used for weight reduction. In this system by considering composite materials weight reduction may be achieved.
- Vibration analysis of whole system can be increase working capacity of system

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