

# Design Optimization of Frame of Mechanical Press Machine

G. J. Pol<sup>1</sup>, A. R. Jadhav<sup>2</sup>, S. J. Kadam<sup>3</sup>, S. V. Kumbhar<sup>4</sup> and J. G. Shinde<sup>5</sup>

<sup>1,2&5</sup>Assistant Professor, <sup>3</sup>Head & Associate Professor

<sup>1,2,3&5</sup>Department of Mechanical Engineering, Bharati Vidyapeeth's College of Engineering, Kolhapur, Maharashtra, India

<sup>4</sup>Assistant Professor, Department of Mechanical Engineering, S.I.T. College of Engineering, Yadrav, Maharashtra, India

E-mail: [gajendrapol@gmail.com](mailto:gajendrapol@gmail.com), [arjmesa@gmail.com](mailto:arjmesa@gmail.com), [s.kad@rediffmail.com](mailto:s.kad@rediffmail.com), [sujit.kumbhar64@sitcoe.org.in](mailto:sujit.kumbhar64@sitcoe.org.in)

(Received 27 December 2020; Revised 22 January 2021; Accepted 13 February 2021; Available online 20 February 2021)

**Abstract** - Power presses are used for the simple, accurate, and economical production of large quantities of articles quickly, accurately, and economically from the cold working of mild steel and other ductile materials. The components produced range over an extremely wide field and are used throughout the industry. Sometimes the pressings may be complicated and more than one pressing operation may be required. The press purpose is to shift one or more sources and movements to a tool or to die to shape or blanch a piece of work. Press design calls for the application of special knowledge about the production process. The press is designed either to perform a specific process or for primarily universal use. The manufacturing process for the metal formation is almost chip less. To perform these tasks Press tools are used. Job component deformation to the desired size is achieved by applying pressure. Presses are regarded as the best and most efficient way of shaping sheet metal into finished products. Pneumatic presses are widely used for operations such as punching, grinding, molding, clinching, blanking, deep drawing, and metal shaping.

**Keywords:** Frame of Mechanical Press Machine, Press Design Press Tools

## I. INTRODUCTION

We recognize there are three types of electric, hydraulic and pneumatic power presses. These may have mechanical or electro-mechanical control systems. Through these three main types of power presses share many common features, the mechanical power press is the most widely used and researched. Mechanical power press works on the principle of reciprocating motion and the flywheel, and crankshaft, clutch are the main components for power transmission. A motor gives flywheel rotational motion and a clutch is used to couple the flywheel rotation to the crankshaft. The crankshaft transforms the flywheel's rotational motion into the press rams down and upward motions. A piece of work is fed, either automatically or manually, into the lower die and the system process is started. The ram (with an upper die) on the down stroke travels towards the area of operation. A re-formed piece is produced when the upper and lower dies press together onto the stock material. Once the down stroke is complete, the work piece created is removed and a new work piece is fed into the machine and process again [1].

A mechanical power press is a machine used to provide force to a die used to shape, blank, or shape metal or non-metallic material. Thus, a press is a component of a

manufacturing system that combines to produce a part the press, die, material, and feeding method. The production system designer must also provide sufficient point-of-service guards for safeguarding the staff in the press room. Every part of this production system is important and will be discussed later in this article.

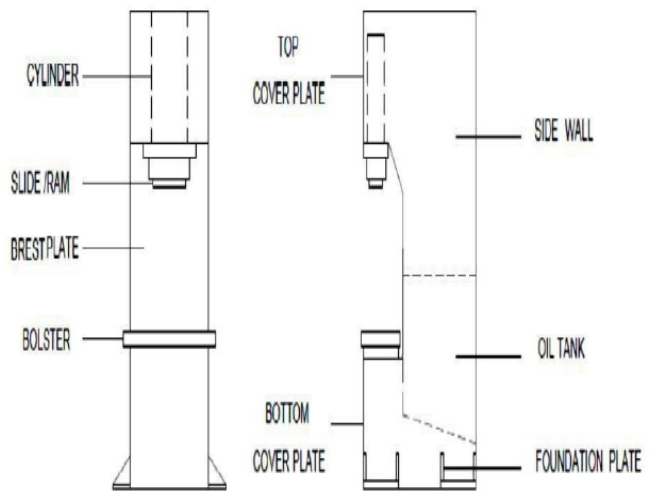


Fig. 1 Block Diagram of Hydraulic Press

A mechanical power press is a machine used to provide force to a die used to shape, blank, or shape metal or non-metallic material. Thus, a press is a component of a manufacturing system that combines to produce a part the press, die, material, and feeding method. The production system designer must also provide sufficient point-of-service guards for safeguarding the staff in the press room. Every part of this production system is important and will be discussed later in this article.

## II. THEORY

The various hydraulic and pneumatic presses are designed from all the various articles. We are working on the mechanical press inside my group. Here we focus primarily on reducing low-charged components such as frame and other low-charged components.

Scope

The current industry scenario is the high-weight mechanical pressing machine that causes various problems such as machine base, machine repair, and exhaustion for workers. Because of such large machines, the machine costs are also higher. This improves resource consumption and isn't good for new start-ups. Therefore there is room to reduce the machine's weight without altering its efficiency and retaining the necessary strength as it is. Current machine study is needed for this. The new system is also built with various necessary parameters changing. CATIA software is used for 3 D modelling of the system, and ANSYS software is used for analysis [2].

III. CONSTRUCTION AND WORKING

A. Working Principle and Construction

We have recognized there are three types of electric, hydraulic and pneumatic power presses. Their control systems are theoretically mechanical or electro-mechanical. Through these three major types of power presses share some common characteristics; the most widely used and studied is the mechanical power press. There are two main beds and a moving ram in the power press. Mechanical power press works on the principle of reciprocating motion and the flywheel, and crankshaft, clutch are the main components for power transmission. A motor gives flywheel rotational motion and clutch is used to couple the flywheel rotation to the crankshaft. The crankshaft transforms the flywheel's rotational motion into the press ram's downward and upward motions. A piece of work is fed, either automatically or manually, into the lower die and the system process is started. The ram (with an upper die) on the down stroke travels towards the area of operation. A re-formed piece is created when the upper and lower dies press together on the stock material. Once the down stroke is complete, the work piece created is removed and a new work piece is fed into the machine and repeat [3].

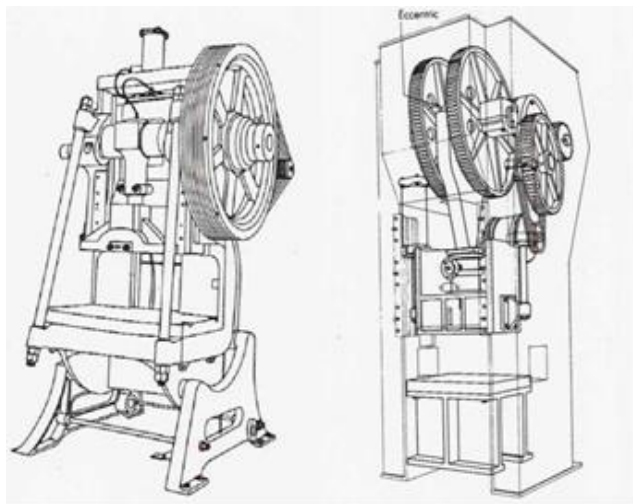


Fig. 2 Press Frame

IV. DESIGN OF EXISTING PRESS MACHINE

Check design and specifications of existing press machine in the industry.

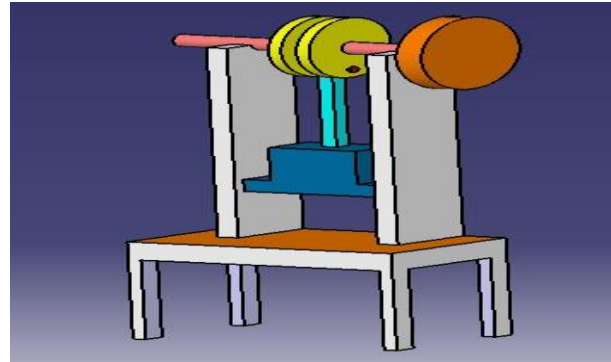


Fig. 3 3D Model of Existing Design

TABLE I SPECIFICATIONS OF PRESS MACHINE

Sl. No.	Parameters	Dimensions
1	Height from bottom	3000 mm
2	Bed size	1040×730 mm
3	Width of C Frame	700 mm
4	Height of C Frame from bed	2100 mm
5	Thickness of C Frame	65 mm
6	Diameter of Punch	530 mm
7	Thickness of punch	60 mm

V. THEORETICAL STRESSES ON DIFFERENT MACHINE COMPONENT

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/m<sup>3</sup>

Syt = 590 Mpa

Considering uniformly distributed load & FOS as 2

Allowable Stress ( $\sigma_{all}$ ) = Syt / Fs

= 590/2

= 295 Mpa.

Young's modulus= 2.1 x 10<sup>5</sup>Mpa

Poisons Ratio= 0.3

Formulas and calculation

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

$$\sigma_{total} = \sigma_{tensile} + \sigma_{bending} \text{ Mpa} \dots\dots\dots (1)$$

$$\sigma_{total} = P/A + Mb / Z \text{ Mpa} \dots\dots\dots (2)$$

Where,

$\sigma$  = Permissible stress in Mpa

P= Applied load in N = 100 × 1000 × 9.81 = 981 KN

A= Area of frame section in mm<sup>2</sup>  
 Mb= Bending moment in N.mm  
 I= Moment of inertia in mm<sup>4</sup>  
 Z= Section modulus

Area:  $2 \times (400 \times 80) = 64000 \text{ mm}^2$   
 Direct stress =  $P/A$  ..... (3)  
 $= (100 \times 1000 \times 9.81) / 64000$   
 $= 15.33 \text{ Mpa}$

Bending stress =  $M/Z$  ..... (4)  
 M = Force \* perpendicular distance ..... (5)  
 $= 981000 * 2100$   
 $= 2060100000 \text{ N-mm}$

Section modulus (Z) =  $B \cdot H^2 / 6$  ..... (6)  
 $= 80 \times 2100^2 / 6$   
 $= 58800000 \text{ mm}^3$

Bending stress =  $Mb/Z$   
 $= 2060100000 / 58800000$   
 $= 35.03 \text{ Mpa}$ .

Total stress =  $35.03 + 15.33 = 50.36 \text{ Mpa}$

### VI. STRESS ANALYSIS OF MODEL

The figure shows the stress on the system

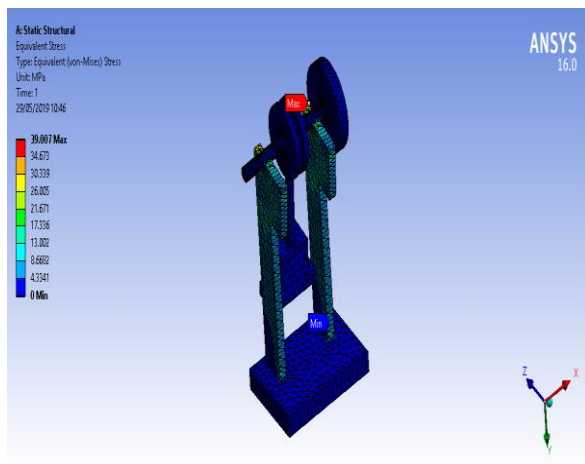


Fig. 4 Stress Analysis of Model

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

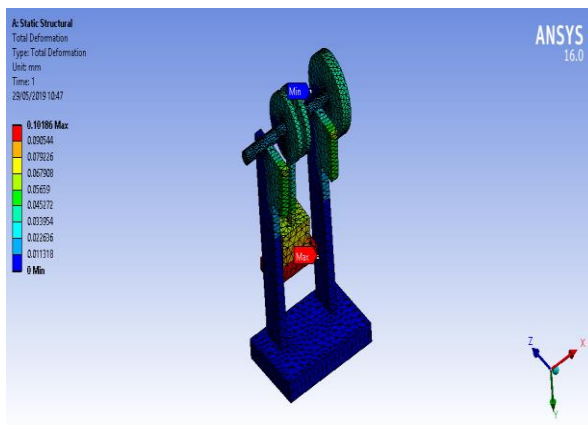


Fig. 5 Deflection of Model

The above figure shows the maximum deflection of 0.10186 mm and minimum 0 mm, after application of the required force [4].

### VII. DESIGN OF OPTIMUM SYSTEM

The design of this system for optimization will be started after the study of the existing system. System optimization will be according to one of the following cases:

1. Changing system dimensions and keeping the material exactly as it is.
  2. Keeping the same dimensions and modifying component material,
  3. Change of both material and component dimensions.
- 8.1 CASE1: Changing system dimensions and keeping the material exactly as it is

Allowable Stress ( $\sigma_{all}$ ) =  $S_{yt} / F_s$   
 $= 590/2$   
 $= 295 \text{ Mpa}$ .

Young's modulus=  $2.1 \times 10^5 \text{ Mpa}$

Poisons Ratio= 0.3

Formulas and measurement

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

$\sigma_{total} = \sigma_{tensile} + \sigma_{bending} \text{ Mpa}$ ..... (1)

$\sigma_{total} = P/A + Mb / Z \text{ Mpa}$ ..... (2)

Where,

$\sigma$  = Permissible stress in Mpa

P= Applied load in N =  $100 \times 1000 \times 9.81 = 981 \text{ KN}$

A= Area of frame section in mm<sup>2</sup>

Mb= Bending moment in N.mm

I= Moment of inertia in mm<sup>4</sup>

Z= Section modulus

Area:  $2100 * 80 * 2 + (400 \times 80) = 288000 \text{ mm}^2$

Area:  $2 \times (400 \times 80) = 64000 \text{ mm}^2$

Direct stress =  $P/A$  ..... (3)  
 $= (100 \times 1000 \times 9.81) / 64000$   
 $= 15.33 \text{ Mpa}$

Bending stress =  $M/Z$  ..... (4)

M = Force \* perpendicular distance ..... (5)  
 $= 981000 * 2100$   
 $= 2060100000 \text{ N-mm}$

Section modulus (Z) =  $B \cdot H^2 / 6$  ..... (6)  
 $= 80 \times 2100^2 / 6$   
 $= 58800000 \text{ mm}^3$

Bending stress =  $Mb/Z$   
 $= 2060100000 / 58800000$   
 $= 35.03 \text{ Mpa}$

Total stress =  $35.03 + 15.33$   
 $= 50.36 \text{ Mpa}$

**VIII. STATIC STRESS ANALYSIS ON ANSYS SOFTWARE**

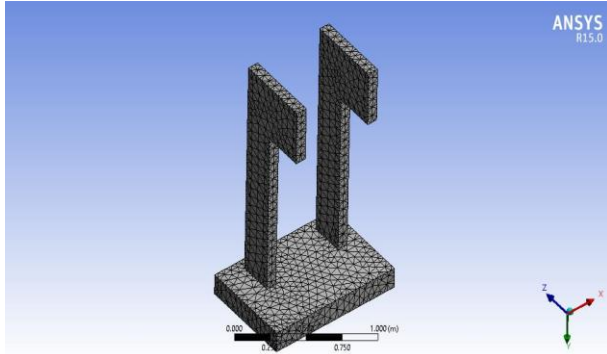


Fig. 6 Meshing of Changed C Frame Dimension

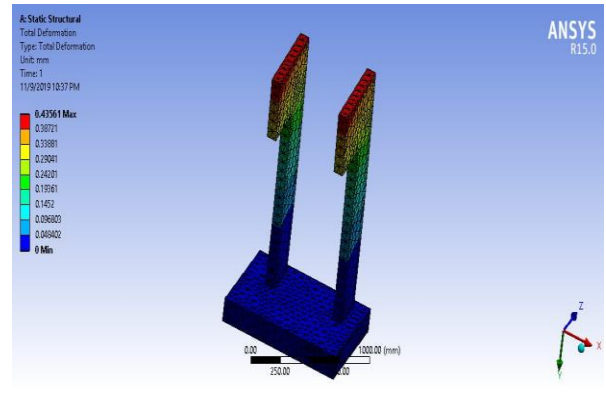


Fig. 7 Analysis of Changed Dimension C Frame

As above 34 such iterations were carried out, the following are tabulated.

TABLE II RESULTS OF ITERATIONS

Sl. No.	Height	Width	Thickness	Direct Stress	Bending Stress	Total Stress	Weight	Difference with original
1	2100	400	80	15.33	38.04	50.36	528.19	0.00
2	2100	350	80	17.52	35.04	52.55	462.17	66.02
3	2100	300	80	20.44	35.04	55.47	396.14	132.05
4	2100	250	80	24.53	35.04	59.56	330.12	198.07
5	2100	500	70	14.01	40.04	54.06	577.71	-49.52
6	2100	400	70	17.52	40.04	57.56	462.17	66.02
7	2100	350	70	20.02	40.04	60.06	404.40	123.79
8	2100	300	70	23.36	40.04	63.40	346.63	181.56
9	2100	250	70	28.03	40.04	68.07	288.86	239.34
10	2100	500	60	16.35	46.71	63.06	495.18	33.01
11	2100	400	60	20.44	46.71	67.15	396.14	132.05
12	2100	350	60	23.36	46.71	70.07	346.63	181.56
13	2100	300	60	27.25	46.71	73.96	297.11	231.08
14	2100	250	60	32.70	46.71	79.41	247.59	280.60
15	2100	500	50	19.62	56.06	75.68	412.65	115.54
16	2100	400	50	24.53	56.06	80.58	330.12	198.07
17	2100	350	50	28.03	56.06	84.09	288.86	239.34
18	2100	300	50	32.70	56.06	88.76	247.59	280.60
19	2100	250	50	39.24	56.06	95.30	206.33	321.87
20	2100	500	40	24.53	70.07	94.60	330.12	198.07
21	2100	400	40	30.66	70.07	100.73	264.10	264.09
22	2100	350	40	35.04	70.07	105.11	231.08	297.11
23	2100	300	40	40.88	70.07	110.95	198.07	330.12
24	2100	250	40	49.05	70.07	119.12	165.06	363.13
25	2100	500	30	32.70	93.43	126.13	247.59	280.60
26	2100	400	30	40.88	93.43	134.30	198.07	330.12
27	2100	350	30	46.71	93.43	140.14	173.31	354.88
28	2100	300	30	54.50	93.43	147.93	148.55	379.64
29	2100	250	30	65.40	93.43	158.83	123.80	404.40
30	2100	500	20	49.05	140.14	189.19	165.06	363.13
31	2100	400	20	61.31	140.14	201.46	132.05	396.14
32	2100	350	20	70.07	140.14	210.21	115.54	412.65
33	2100	300	20	81.75	140.14	221.89	99.04	429.15
34	2100	250	20	98.10	140.14	238.24	82.53	445.66

The figure below indicates a maximum deflection of 0.300 mm and a minimum of 0 mm, after the necessary force has been applied [5].

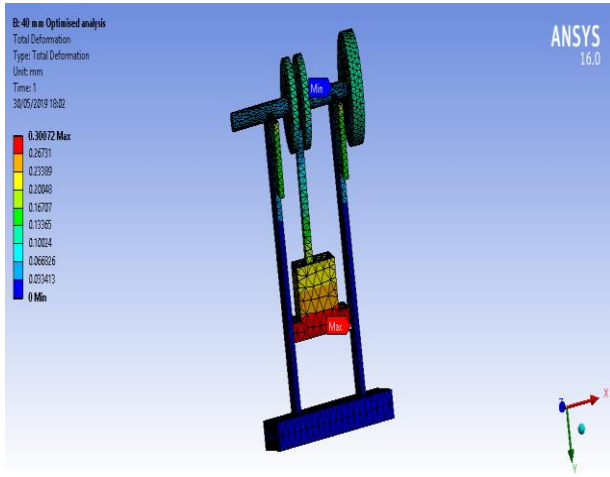


Fig. 8 Deflection of Model

This deflection model will gives results with following data.

TABLE III UNIT SYSTEM

Unit System	Metric (mm, kg, N, s, mV, mA) Degrees rad/s Celsius
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Celsius

TABLE IV MODEL (B4) > GEOMETRY

Bounding Box	
Length X	1139. mm
Length Y	2050.5 mm
Length Z	799.8 mm
Statistics	
Bodies	1
Active Bodies	1
Nodes	29253
Elements	15617
Mesh Metric	None

TABLE V MODEL (B4) > MESH

Object Name	Mesh
State	Solved
Display	
Display Style	Body Color
Defaults	
Physics Preference	Mechanical
Relevance	0
Sizing	
Use Advanced Size Function	Off
Relevance Center	Fine
Element Size	Default
Initial Size Seed	Active Assembly
Smoothing	High
Transition	Fast
Span Angle Center	Fine
Minimum Edge Length	2.0 mm
Patch Conforming Options	
Triangle Surface Mesher	Program Controlled
Patch Independent Options	
Topology Checking	No
Statistics	
Nodes	29253
Elements	15617
Mesh Metric	None

TABLE VI MODEL (B4) > ANALYSIS

Object Name	Static Structural (B5)
State	Solved
Definition	
Physics Type	Structural
Analysis Type	Static Structural
Solver Target	Mechanical APDL
Options	
Environment Temperature	22. °C
Generate Input Only	No

TABLE VII MODEL (B4) > STATIC STRUCTURAL (B5) > LOADS

Object Name	Fixed Support	Force
State	Fully Defined	
Scope		
Scoping Method	Geometry Selection	
Geometry	7 Faces	8 Faces
Definition		
Type	Fixed Support	Force
Suppressed	No	
Define By	Components	
Coordinate System	Global Coordinate System	
X Component	0. N (ramped)	
Y Component	9.81e+005 N (ramped)	
Z Component	0. N (ramped)	

TABLE VIII MODEL (B4) > STATIC STRUCTURAL (B5) > SOLUTION (B6) > RESULTS

Object Name	Equivalent Stress	Total Deformation
State	Solved	
Scope		
Scoping Method	Geometry Selection	
Geometry	All Bodies	
Definition		
Type	Equivalent (von-Mises) Stress	Total Deformation
By	Time	
Display Time	Last	
Calculate Time History	Yes	
Identifier		
Suppressed	No	
Results		
Minimum	0. MPa	0. mm
Maximum	112.58 MPa	0.30072 mm

## IX. RESULTS AND DISCUSSION

Comparison of Theoretical Stress and Ansys Results  
The following table shows these results.

TABLE IX COMPARISON RESULT

Dimensions	Design calculations Results	Ansys Results
Length = 2100 mm Width = 250 mm and Thickness = 40 mm	Stress 119 MPa	Stress 112.58

The table above shows results of optimized Press deformation. It also indicates some variance in tests that are inferior to 10 per cent and marginal.

In this step, the existing system is optimized. The optimization description is shown in the table above. The current C Frame weight is 530 Kg and the optimized machine weight is 165 Kg. And we reached a weight reduction of 363 kg [6][7].

TABLE X COMPARISON OF WEIGHT OF EXISTING AND OPTIMIZED SYSTEM

Weight of Existing C-Frame	Weight of optimized C - Frame	Total Weight Reduction
530kg	165kg	363kg

## X. CONCLUSION AND PERSPECTIVES

1. The existing system is heavier in weight than the supporting frame. An optimized system is lighter in weight and is a workaround for existing system drawbacks.
2. Optimization on device load-bearing components such as C Frame was achieved.
3. Calculations of architecture, model of study, and experimental results of the existing system and optimized system are compared based on stress.

C Frame surface treatment may be done to increase C Frame strength. Pressure base and bed should be built, optimization can be accomplished by modifying its geometry or physical characteristics.

## REFERENCES

- [1] D. Ravi, "Computer Aided Design and Analysis of Power Press," *Middle-East Journal of Scientific Research*, Vol. 20, No. 10, pp. 1239-1246, ISSN: 1990-9233, 2014.
- [2] Bhushan V. Golechhal and Prashant S. Kulkarni, "design, analysis and optimization of 10 ton pneumatic press machine," *IJARIE-ISSN (O)*, Vol. 3 No. 1, pp. 2395-4396, 2017.
- [3] Weiwei Zhang, Xiaosong Wang, Zongren Wang and Shijian Yuan, "Structural optimization of cylinder-crown integrated hydraulic press with hemispherical hydraulic cylinder," *International Conference on Technology of Plasticity, ICTP*, pp. 19-24 October 2014, Nagoya Congress Center, Nagoya, Japan, 2014.

- [4] Rucha, S. Khisti, Abhijeet V. Pawar, Manoj, M. Budhi, Shriganesh, K. Mangalvedhe and Mandar V. Padman, "Design and Analysis of C Frame for Hydraulic Press," *International Journal on Recent Technologies in Mechanical and Electrical Engineering (IJRMEE)*, ISSN: 2349-7947, Vol. 2 No. 5, pp. 059-062.
- [5] Nikhil Mahajan and S. B. Tuljapure, "Design of C- Frame Type Hydraulic Punching Machine," *International Journal of Engineering and Management Research* Vol. 6, No. 2, pp. 129-133, March-April 2016.
- [6] Akshay Vaishnav, Path Lathiya and Mohit Sarvaiya, "Design Optimization of Hydraulic Press Plate using Finite Element Analysis," *Int. Journal of Engineering Research and Applications*, ISSN: 2248-9622, Vol. 6, No. 5, pp. 58-66 (Part - 4) May 2016.
- [7] Rangraj S. More, "Shreenidhi R. Kulkarni, Finite Element Analysis and Optimization of 'c' Types Hydraulic 200ton Press," *International Research Journal of Engineering and Technology (IRJET)*, Vol. 02, No. 03, e-ISSN: 2395-0056, p-ISSN: 2395-0072, June-2015.