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Design,Development And Manufacture of 14 Tonnes Hydraulic Press

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ABSTRACT: A Hydraulic Press is a power saving device with zero maintenance, trouble free operation due to adequate hydraulic design and selection of proper hydraulic elements of reputed make .
This Project is aimed at Design ,Development and Manufacture of 14 Ton Hydraulic Press. The entire press is made up of frame which has to withstand various forces and stresses developed when the operation is being carried out. The aim of this paper is to show various types of methods including theoretical calculations including the Finite Element Analysis of the entire frame which it can bear and later do optimization of the the frame by reducing its thickness and doing the same calculations as above thereby reducing the cost required to make the frame structure of the entire machine.
KEYWORDS: Frame, Force, Theoretical bending & tensile Stress, FEA Analysis ,Von Mises /Equivalent Stress, Deformation, Factor of Safety etc

I. INTRODUCTION

In this paper the entire press has C-type Frame Frame is main body in any kind of power press due to frame need to absorb shocks of strokes, to give a smooth and accurate slide control also support the drive system and other sub-assembly units. So frame is the structure that is to be designed ,analysed & Optimized.
The Objectives are as follows:
a)Determine the tensile and bendind stress in the frame theoretically.
b)Find the maximum strain.
c) Static analysis to find maximum Von Mises stress in Ansys.
d) Static analysis to find deformation plot in Ansys
e)Structural Optimization of Existing C-Frame according to FEA results.

II. METHODOLOGY

a)Developing the contribution of a particular part in the press i.e. frame body
b)Doing theoretical calculations of frame and validating it through available theories.
c)Doing Finite Element Analysis of the frame & finding the minimum to Maximum stresses involved thereafter along with deformation.
d)Modifying the Dimensions of the frame and again doing Finite Element Analysis with acceptable results.
e)Optimization Obtained by Modifying the Dimensions of the frame
h)Comparing the theoretical and Finite Element Analysis results in the end

III. THEORETICAL DESIGN OF 14 TONNES C-TYPE FRAME

A)Determination of forces

The weight of the cylinder and the cylinder load is the major forces acting on the frame
structure.
Press capacity P = 14 tonnes
=14000 x 9.81 = 137340 N

B) Selection of Materials

The mild steel (IS2062) is selected for the frame because it is soft and ductile they can be easily welded and machined.

C) Determination of dimensions

The frame consists of many number of plates fabricated to support the structure. The Table dimensions of the plates are listed below:

Plate no	Plate size (length× breadth× thickness)	Quantity
1	1550×1000×28	1
2	950×950×25	2
3	3537×1450×25	2
4	697×550×28	1
5	650×340×25	4
6	3537×650×50	1
7	650×550×63	1
8	600×550×40	1
9	734×100×28	2
10	850×550×25	2
11	1060×550×25	1
12	160×150×25	4
13	550×522×28	1
14	522×122×20	2

Assumptions
The material of the beam is perfectly homogeneous, isotropic & it obeys the Hook's law. The Young's modulus E is same in tension and compression.
Specification of machine frame
Press capacity = 14 tonnes
Dimensions Chosen for the frame with reference to the table
=1200 mm x 600mm x 25mm^2

Tensile strength= 410 x 10^6 N /mm^2
Density= 7850 kg/m^3
Young's Modulus= 2.1 x 10^5 N /mm^2 .

Poisons Ratio= 0.3.
Factor of Safety= 4.0

Max Allowable Stress σ = 410/4
σ = 102 N/mm^2
Formulas and calculations
The frame subjected to direct tensile stress and bending stresses

$$\sigma_{total} = \sigma_{tensile} + \sigma_{bending} \quad N/mm^2$$

$$\sigma = \frac{P}{A} + \frac{M_b Y}{I} \quad N/mm^2$$

Where

σ = Permissible stress in N/mm^2

P = Applied load/ Force in N

A= Area of the plate section in mm^2

M_b = Bending moment in N. mm

x= Perpendicular Distance in mm

y = Distance from the neutral surface to the extreme fiber in mm

I = Moment of inertia in mm^4

Applied Load P= 14 tonnes=14000 x 9.81 = 137340 N
Breadth b= 600mm

Here Thickness = 25 mm
Area = 600 x 25 = 15000mm^2

$\sigma_{tensile}$ ..=137340/15000 =9.156 N/ mm^2

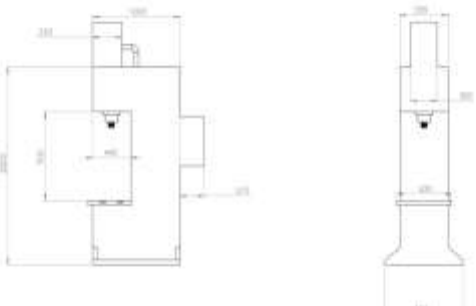
$\sigma_{bending}$ ..=M_b x (y/I) = P/2 (x _x') x (y/I)

(_x') is the perpendicular distance in mm.
= 137340/2 x 11850
M_b = 813.73 x 10^6Nmm
Y = 25 mm
I = b^3 x d/12
= 6003 x 25 / 12
= 450 x 10^6 mm^4
$\sigma_{bending}$ = 813.73 x 10^6 x 25/(450 x 10^6)
= 45.20 N/mm^2
σ_{total}= $\sigma_{tensile}$ + $\sigma_{bending}$
= 9.156 + 45.20

=54.76 N/mm^2

Maximum Allowable Stress = 102N/mm^2
Since 54.36< 102
It is allowed and the frame could be designed by the above dimensions.

Strain = Stress /Young's Modulus
Young's Modulus = 210000 N/mm^2
Strain(ε) = 54.36 /210000
= 2.6838 x 10^4



Fig[*]Drawing of the press structure

Analytical Solution: -

Stress analysis for trusses, beams, and other simple structures are carried out based on dramatic simplification and idealization.

Finite Element Analysis

Design geometry is a lot more complex; and the accuracy requirement is a lot higher. We need to understand the physical behaviours of a complex object (strength, heat transfer capability, fluid flow, etc.). It is need for light weight structures

In FEM various steps as:
Step 1: create model
Step 2: selection of element.
Step 3: discretization of variants
Step 4: define meshing.
Step 5: apply boundary condition & loading condition.
Step 6: result

Material Selected for the Analysis is Structural Steel

Properties of material

Density	7.85e-006 kg mm^-3
Coefficient of Thermal Expansion	1.2e-005 C^-1
Specific Heat	4.34e+005 mJ kg^-1 C^-1
Thermal Conductivity	6.05e-002 W mm^-1 C^-1
Resistivity	1.7e-004 ohm mm
Yield Stress	250 Mpa

Compressive Ultimate Strength (MPa)= 0
Compressive Yield Strength (MPa) = 250
Tensile Yield Strength (MPa) = 250
Tensile Ultimate Strength (MPa) = 460

Reference Temperature (C) = 22 Degree Celsius

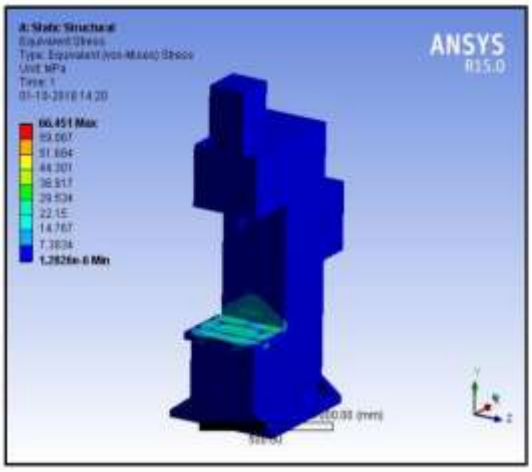


Fig [i]Modeled Structure of Press in Ansys for 25mm thickness.

WHEN THE THICKNESS OF THE FRAME IS 25 MM

Equivalent or Von Misses Stress varies from 1.2826 x 10-6 MPa to 66.451 Mpa is obtained by Finite Element Analysis method

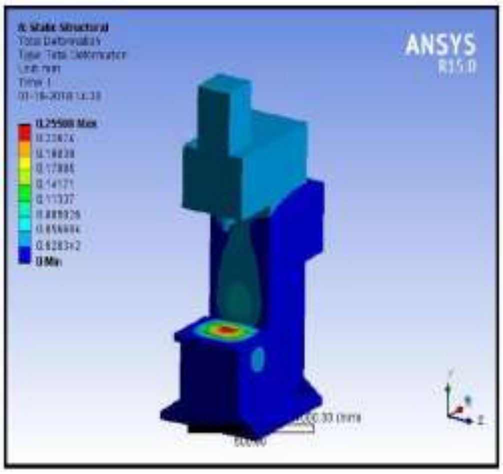


Fig [ii] :-Total Deformation with 25 mm thickness of Frame

Deformation varies from 0 to 0.25508 mm is obtained by Finite Element Analysis method

Again when thickness of the frame is 25 mm.

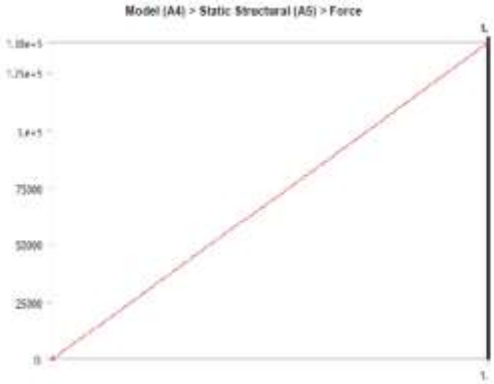


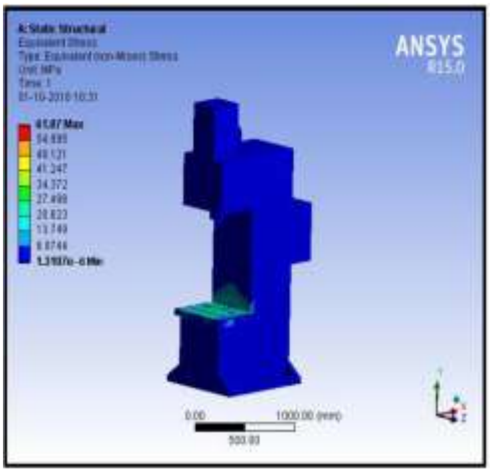
Fig [iii]:- Graph of Static Structural Force

THESE ARE THE OBTAINED FORCES AND STRESSES ON THE ASKED STRUCTURE OF THE PRESS TO BE MADE.

[4] EXPERIMENTATION

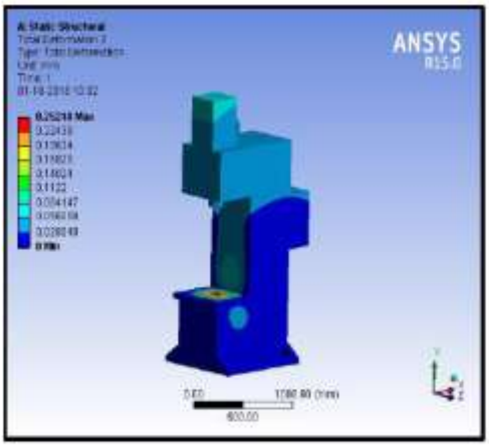
As has been seen ,the FEA results for Equivalent or VonMises stress have been obtained for the frame thickness to be 25mm.

Now modifying the thickness of the frame to 23 mm ,the result of the stress & deformation are shown below.



Fig[iv] Von Mises/Equivalent Stress & Deformation with 23 mm as the thickness of frame

Equivalent or Von Mises Stress varies from 1.3107 x 10^{-6} to 61.87 MPa



Fig[v]:-Total Deformation in 23 mm Thickness of Frame

Total Deformation varies from 0 to 0.25244mm when thickness of the frame is 23 mm.

TABLE [A] :- Stress & Deformation With Experimental Results with 25mm & 23 mm respectively as thickness of the frame

Sr.No.	Stress(MPA) with 25 mm as thickness of frame	Deformation(mm)	Stress(MPa) with 23mm as thickness of frame	Deformation(mm)
1	1.2826 x 10^{-6}	0	1.3107 x 10^{-6}	0
2	7.3834	0.028342	6.8744	0.028049
3	14.767	0.056684	13.749	0.056098
4	22.15	0.085026	20.623	0.084147
5	29.534	0.11337	27.498	0.1122
6	36.917	0.14171	34.372	0.14024
7	44.301	0.17005	41.247	0.15829
8	51.684	0.19839	48.121	0.19634
9	59.067	0.22674	54.995	0.22439
Max	66.451	0.25508	61.87	025244

[5]OPTIMIZATION

By reducing the thickness of the frame just by 2mm, & comparing various parameters of the structure of the frame optimization can be obtained as given below

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TABLE[B]:- Comparison of Different Parameters with different thickness of Frame

Sr.No.	Parameters	Thickness 23 mm	Thickness 25 mm
1	Material	Structural Steel	Structural Steel
2	Maximum Stress	61.87 MPa	66.451 MPa
3	Maximum Deformation	0.252 mm	0.255mm
4	Volume	2.41×10^8 mm^3	2.46×10^8 mm^3
5	Mass	1892.4 kg	1937.8 kg
6	Yield Stress	250 MPa	250 MPa
7	Factor Of Safety	2.5	2.5

As can be seen in the table[B] volume of the frame got reduced to 2.41 x 10^8 mm^3 from 2.46 x 10^8 mm^3

As reduction in Volume is 5 x 108mm3so mass was also reduced to 1892.4 kg from 1937.8 kg Reduction in mass = 1937.8 – 1892.4 = 45.4 kg

Cost of MS Steel = Rs. 60 /kg

So the amount which was saved by reduction in thickness of the frame was
60 x 45.4 = Rs. 2724

IV. RESULT AND CONCLUSION

After Completion of the project , the Objectives were met with the results obtained as shown below:

No.	Objective	Result	Conclusion
1	Determine the tensile & bending stress in the frame theoretically	$\sigma_{tensile}$ = 9.156N/ mm^2 $\sigma_{bending}$ = 45.20 N/mm^2 $\sigma_{total} = \sigma_{tensile} + \sigma_{bending}$ = 9.156 +45.2 = 54.36 N/mm^2	$\sigma_{total} < \sigma_{allowed}$ 54.36 <102 N/ mm^2 So Frame can be designed
2	Find the maximum strain. Strain = Total Stress /(Young's Modulus) $\epsilon = \sigma_{total}/Y$	Young's Modulus(Y) = 210000 N/mm^2 Strain = 54.36 /210000 = 2.6838 x 10^{-4}	Maximum Strain = 2.6838 x 10^{-4}
3	Static analysis to find maximum Von Mises stress in Ansys.	$\sigma_{VonMises}$ = 66.451 MPa	This is for 25mm thickness of frame
4	Static analysis to find deformation plot in Ansys	Deformation varies from 0 to 0.25508 mm	
5	e)Structural optimization of Existing C-Frame according to FEA results	$\sigma_{VonMises}$ = 61.87 MPa Deformation varies from 0 to 0.25244mm	This is for 23mm thickness of frame
	Optimization		
	Due to reduction of thickness of the plate from 25 mm to 23 mm volume of the frame got reduced to 2.41 x 10^8 from 2.46 x 10^8 As reduction in Volume is 5 x 10^6mm^{3}so mass was also reduced to 1892.4 kg from 1937.8 kg Reduction in mass = 1937.8 – 1892.4 = 45.4 kg Cost of MS Steel = Rs. 60 /kg **So the amount which was saved by reduction in thickness of the frame was 60 x 45.4 = Rs. 2724**		

To sum up the Results & conclusion, the results were obtained as desired & were in the same range for theroretical as well as finite element analysis of the given structure and optimization could be obtained with acceptable results by just varying the dimensions and following the same methods of analysis.As far as The Future Scope of the machine is concerned it also depends on the ambience of the place where the machine is to be installed. Varying with the environmental conditions different types of materials can be used other than mild steel like Iron or Stainless Steel can be used which would give a longer life to the machine .But it results in high cost of making the machine.Hydraulic Press Machines would continue to reduce the manual effort of workers and produce more efficient desired Products.

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