RESEARCH ARTICLE OPEN ACCESS

Conventional Design Calculation &3D Modeling of Metal Forming Heavy duty Hydraulic Press.

Abhijeet S Khandekar
DepartmentofMechanicalEngineering,AbhaGaikawadPatilCollege ofEngineering, Nagpur, India,

Abstract

The design optimization & structure frame analysis of a heavy duty metal forming hydraulic press has been proposed. In this paper the structural analysis & design optimization of hydraulic press has been done and a comparative study of results of finite element analysis of a press with 300 ton capacity has been conducted. It is not possible for the real experimental studies to take into consideration the influence of the connections between the main beams and the rest parts of the construction, the influence of the long it udinal and transverse ribbings as well as the influence of the supports on the overall stressed state of the construction. Moreover, the research esthatuseforthemajorityofthetestcasesdifferentstrainmeasurementsturnouttobequitehardandexpensive.Alltheseproblemscouldbesolvedsuccessfullybytheuseofcomputermodelingprocedures.Itispossibletoperform2Dor 3Dcomputerstudies.The2Dcomputerstudiesgiveideaoftheplanarbehavioroftheconstructionandlacktheopportunity ofshowingtheinfluenceofsupportsortheconnectionsoftheconstruction.Itisonlythe3Dmodelsthatcouldsatisfyalltherequirementsfor examiningthegeneralstressedstateofthecarryingmetalconstruction.Withregardtothis,thecreationof3-Dmodelsforresearchingandanalyzingthebehaviorofametal forming hydraulic press,becomesthemaingoalofthepresentwork.Intheinitialphaseof thestudy,conventionaldesigncalculationsproposedbyIndianStandardRuleswereperformed.Thepressdesignwasmodeledwithsolids,Loadsandboundaryconditionswereappliedtosolidmodel.Assignmaterialtothesolidmodel.FiniteElementmesheswereggeneratedfromthesolidmodel.Afteracomparisonofthefiniteelementanalyses,andtheconventionalcalculations,theanalysiswasfoundtogivethemostrealisticresults.Asaresultofthis study,adesign optimizationfor a heavy duty meal forming hydraulic presshasbeendone.

I. Introduction

Press working techniques utilizing large quantities of economical tooling equipment design and it quickly, accurately and economically cold working of mild steel and other ductile materials. The component produced range over an extremely wide field and is used throughout industry for economical production of quantities of pressing; consideration has to be given to the rate of production, the cost of the press tool to be employed. Press may be defined as the chip less manufacturing process by which various components are made from sheet. Mostly press use fabricated parts of incite shape with thin walls. It uses large force by press tools far short time interval which results in cutting a shaping the sheet metal. In the early days, metal forming press use simple crank and lever mechanism that convert rotating motion into linear motion with the help of punch/ram. The rotating motion achieved by motor and linear motion achieved by punch or ram, punch applied on work piece. In the most function of press frame is absorb the force which generated by rotating parts and processing, to provide a precision guidance of other part and support the main drive system and other necessary auxiliary system. In press machine larger area of press frame and also it's higher weight of all among parts. Press machine total area of frame 60-70%. So the more importance of press frames and it's design parameter. According to IS 8064:2002 standard, press classified into two principle categories as hydraulic presses which operate on the principle of hydrostatic pressure. Mechanical press which utilized kinematic linkage of elements to transmit power. Press mainly divides into two categories.

A) Indexing Press.
B) Column Press.

II. Hydraulic Press.

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. 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.

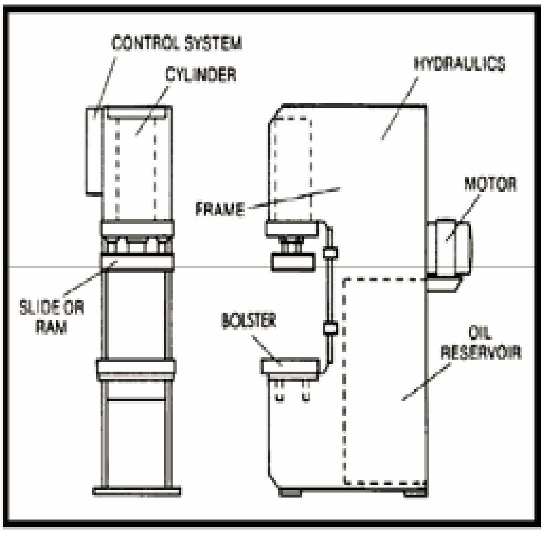


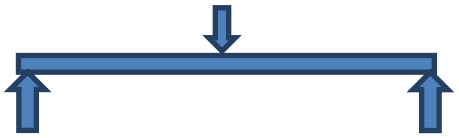
Figure 1 cross section of typical C-type press

III. Introduction to Finite Element Method

The finite element method (FEM), sometimes referred to as finite element analysis (FEA), is a numerical technique used for finding the approximate solution to the complex engineering problems. It consist of two main parameters i.e. nodes and elements. The method essentially consists of assuming the piecewise continuous function for the solution and obtaining the parameters of the functions in a manner that reduces the error in the solution. The process of representing a physical domain with finite elements is referred to as meshing, and the resulting set of elements is known as the finite element mesh. The finite element method can analyze any geometry, and solves both stresses and displacements with respect to the known applied loads. In this study finite element meshing, is carried out by means of the Autodesk Inventor commercial package.

IV. Conventional Design Calculation:

Step: - 1. Prepare a Load Diagram:-



Step: - 2. Calculate the Bending moment i.e. M

$M=\frac{w \times l}{4}$

$M=\frac{F \times l}{4}$

$M=\frac{300 \times 1000 \times 3000}{4}$kg.mm

M=225000 x 10^3 kg.mm x 9.81

M=2207.25 x 10^6 N-mm

Step:-3. Now the bending moment equation can be written as,

$\frac{M}{I}=\frac{бb}{Y}$

Re arranging above,

$\therefore бb=\frac{M}{\frac{I}{Y}}$

But $\frac{I}{Y}$= Z ×X (i.e. section modulus)

Allowable бb i.e. yield strength is 125 N/Seq.mms

$125=\frac{2207.25 \times 10}{ZXX}$

$ZXX=\frac{2207.25 \times 10\ 6}{125}.\frac{Nmm \times mm\ 2}{N}$

$\therefore$ZXX=17658000mm^3

We know that the section modulus of a rectangle hallow pipe as per Tata Structure pipe standard catalogue is,

Pipe section =300 X 200

Section Modulus i.e. Z=890390 mm^3

If we divide our calculated section modulus i.e.

$Z=\frac{17658000}{2}$ mm^3 by 2

We will get Z=8829000 mm3

This value is less than standard section modulus

If we make the standard rectangular pipe section double in size, it can withstand the 300 tons load. Therefore, our final beam size will be,

600 X 400 mm in size

But, we cannot use a standard pipe as a beam & Hydraulic press, so we rearrange our final section size as under & make it as Wedded

When we, calculated the section modulus of the above section, we will get the same values.

The final size of the beam of plats as under,

Dim pl. 1=400 x 3000 x 12 mm

Dim pl.2=600 x 3000 x 12 mm

Dim pl3= 400 x 3000 x 12 mm.

Design hydraulic cylinder for 300 ton force:-

Force= 300 Tons

W. Pressure=250 kg/cm2

Design Pressure= 375 kg.cm2.

Calculate the area/bore of cylinder:-

$\therefore Pressure=\frac{Force}{Area}$

$\therefore P = \frac{F}{A}$
Area i.e. A=F/P
Area (A) = $\frac{\pi}{4} \times d^2 = \frac{300\ X\ 1000}{375} \cdot \frac{Kg}{Kg} \times cm^2$
$\therefore \frac{\pi}{4} \times d^2 = 800\ cm^2$
$\therefore\ d^2 = \frac{800}{0.7853} cm^2$
$d^2 = 1018.59\ cm^2$
$\therefore d = 31.91$ cm =319mm
Calculate the wall thickness of cylinder to withstand design pressure of 375 kg/cm^2.

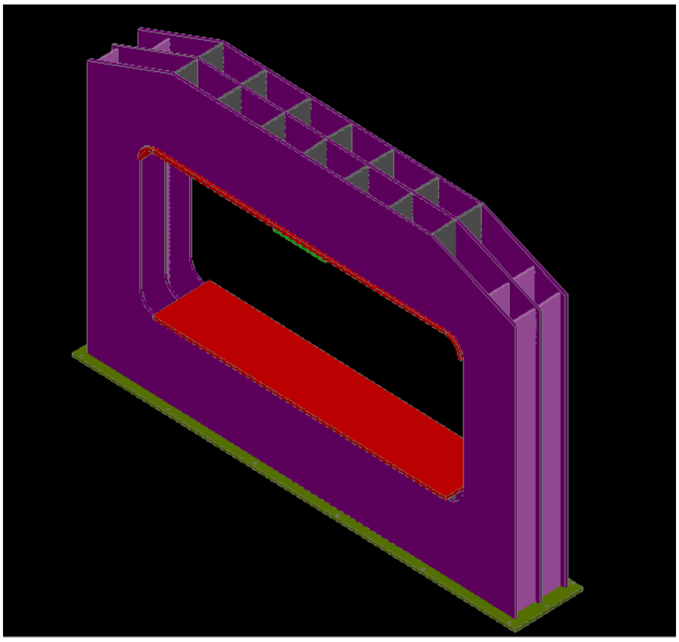
$$Thickness\ t = \frac{P\ \times R}{2\ \times S\ \times E - 0.6\ \times P}$$

Here P=design pressure=375 kg/cm^2
R=radius of cylinder i.e. I.D. =159.5 mm
S=Yield strength of ASTM 106 Gr. B. Material
S=2460 kg/cm^2 = 241.326N/mm^2
SA=Allowable Y.S=120.663 N/mm^2
E=1.
$\therefore\ t = \frac{36.78\ \times 159.5}{2\ \times 120.663 \times 1 - 0.6 \times 36.78}$
$\therefore$ t = 26.75 mm=28 mm
$\therefore$ Final Diameter of Barrel is
D_B = 159.5+159.5+28+28
D_B = 375 mm
Design of End Cap for Hydraulic Cylinder:-
Internal Pressure=375 kg/cm^2
=36.78N/mm^2
Inside Dia i.e. Di=319 mm
Material of Plate = IS:2062 E 250 B
i.e. Mild Steel
Y.S=250 N/mm^2
Allowable Y.S б a= 165 N/mm^2
$\therefore$ Force F=300 tons
= 2943 KN
$\therefore$ Thickness of end Plate /cover can be calculated as,
$t_{cap} = \sqrt{K\ X \frac{P}{ft}\ or\ \sigma a}$
Where k= Constant
k=0.162
$t_{cap} = \sqrt{(0.162\ \times \frac{36.78)}{165}}\ \times 319$
t_{cap}=0.19 X 319
$\therefore t_{cap}$= 60.61mm
$t_{cap} \cong$ 65 mm

Ratio of $\frac{R}{r}$	1.25	1.5	2	3	4	5
Value of 'C'	0.592	0.976	1.44	1.88	2.08	2.196

Design of Gland:-
The Empirical Formula is given by,
$t^2 = \frac{C\ X\ W}{\sigma a}$
Where, t= Thickness of Gland bush
W or F = Load acting on Gland
$\sigma t = Allowable\ tensile\ stress$
C=Empirical Constant
Value of "C" could be selected from following table.
$\therefore\ C = \frac{R}{r}$
$\therefore$ Where, R= Pitch circle Dia where, gland to be batted to Cylinder Flange.
$\therefore$R =375 +50 +50 =475 MM
$\therefore$ r= Diameter of piston rod
$\therefore$ r= 180 mm (say)
$\therefore \frac{R}{r} = \frac{475}{180}$
$\therefore \frac{R}{r}$=2.63 So C=1.66
Now, $t^2 = \frac{1.66\ x\ 3000\ x\ 9.81}{205}$
t^2= 23831.12
$\therefore$ t= 154 mm
Now, calculate the stress produced in the beam due to 300 ton applied load.
1} the cylinder mounting should be equal to or slightly smaller than beam plate in width and length of the plate depends upon the End Cap Diameter of Cylinder.
2} the place where cylinder is fitted should be machined properly so that central axis of cylinder should be as per requirement of press body.
3} where cylinder applies load on component to be process it equally pushes back the plate on which it is mounted. If the plate on which it is mounted is perfected matching to cylinder, this cylinder will apply a uniformly distributed load. And if surface is not matching properly then will apply a concentrated load.
Therefore, in our case, the cylinder mounting plate dimensions are,
400 X 500 X 12 mm thk
$\therefore$Area of plate i.e. Am=400 x 500
Am=200000 mm^2
$\therefore$ Stress i.e. $б = \frac{Force}{Area}$
$\therefore\ б = \frac{300\ \times 1000\ \times 9.81}{200000}$
$\therefore\ б = \frac{2943000}{200000} \frac{N}{mm\ 2}$
$\therefore$ б = 14.715 N/mm^2
$\therefore$ б=150 kg/cm^2

5) 3-D Model of Metal Forming Press:



V. Conclusion.

In this paper, conventional design calculation of Metal Forming Heavy duty Hydraulic Presshas been defined& 3D modeling of the press has been done. Stress obtained by conventional design calculation is б=150 kg/cm^{2}Further Finite element method will be used to calculate design for the optimization.

References / Bibliography:

[1] IS 8064:2002, "Method of Designation of Mechanical & Hydraulic Presses" published by Bureau of Indian Standards, New Delhi, April 2002.
[2] Muni Prabaharan and V.Amarnath, "Structural Optimization of 5Ton Hydraulic Press and Scrap Baling Press for Cost Reduction by Topology", International Journal of Modelling and Optimization, Vol. 1, No. 3, August 2011.
[3] Zhicheng Huang, Nanxing Wu, Xingguo Wang, "Contact Analysis on the Whole Frame of 32.8MN PRESS", TELKOMNIKA, Vol. 11, July 2013.
[4] H. N. Chauhan, M.P. Bambhani "Design & Analysis of Frame of 63 Ton Power press Machine by using Finite Element Method", Indian Journal of Applied Research, Engineering, Volume-3, July 2013.
[5] B.N. Khicadia, D. M.Chauhan "A review on Design & Analysis of Mechanical Press Frame" -International Journal of Advance Engineering and Research Development, Volume 1, June 2014.