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Deflection Reduction in C-Structure of a 50 Ton Hydraulic Press Machine Used to Press Stainless Steel Plates to Get Desired Shape and Dimensions

Prof. S. V. Tawade[1], Dr. R. J. Patil[2], Prof. S. A. Chaudhari[3]

[1]*Asst.Professor, Dept. of Mechanical Engineering, Navsahyadri Engineering College, Pune, India*
[2]*Principal, Navsahyadri Engineering College, Pune, India*
[3]*Asst. Professor, Dept. of Mechanical Engineering, Navsahyadri Engineering College, Pune, India*

Abstract - *A hydraulic press machine with 50 Ton capacity having C-structure is used for pressing stainless steel plates for getting desired shapes of outer lid component of pressure vessels by a firm. The firm has a problem in getting desired shape of outer lid component of pressure vessels from the stainless-steel plates. The present work deals with the identifying and rectifying the problems in getting desired shapes of outer lid component of pressure vessels after pressing operation on stainless steel plates using the 50 Ton capacity hydraulic press machines. The desired overall dimensions of the outer lid component of pressure vessel are Diameter of 155 mm and height of 40 mm. The outer lid material is stainless steel. There were no any issues with the dies used in pressing operation. But it is observed that there were some dimensional errors and shape errors in pressed outer lid components. Also, we observed that there is more deflection in C-structure while in operation. So, the main objectives of the present work are solving the issues and also the reduction in deflection of the C-structure of 50 Ton capacity hydraulic press machine. We observed the response of loading conditions on the C-Structure of the Machine. Under operating conditions, the machine structure will undergo deflection. But the deflection should be very minute or negligible so that the pressing operation will be smooth. The ribs welded to structure have 25 mm of thickness. We modified the rib dimensions and their spacing. Two design calculations are done for the amount of deflection occurring in the structure. One by considering 30 mm thick ribs and another by considering 50 mm thickness, ribs of the same material as that of the main structure. The structure is analyzed for deflection by analytical method and also using Autodesk Inventor software. The deflection of the C-structure was reduced from 0.08mm to 0.025 mm. Deflection in the C-structure for 30 mm thickness ribs was 0.025 mm. The structure is modified by welding process by considering new dimensions of ribs i.e., 30 mm thick ribs. With this modified C-Structure in hydraulic press machine of 50 Ton Capacity again stainless-steel plates were pressed to get the desired shape and dimensions of outer lid component of pressure vessel. With this new C-structure in hydraulic press machine we got the desired shape of outer lid component of pressure vessels. The desired dimensions and shape were obtained. The results found was satisfactory and within the limits. Also, we become successful in reducing the deflection in C- structure from 0.08mm to 0.025mm. The objectives of the present work are fulfilled successfully.*

Key Words: C-Structure, Hydraulic Press, Ribs, Deflection

1. INTRODUCTION

Nowadays many pressure vessel components are manufactured by pressing operation i.e., by the use of hydraulic press machines. Since hydraulic press gives more pressing power. The desired shapes are obtained by pressing operation. Usually Hydraulic press machines having C-structures are used. The most important factors in getting desired shapes by pressing operation depends upon the accuracy of dies, the press force applied and the deflection in the C-structure of hydraulic press machine during operation. There must be very negligible amount of deflection in the C-structure of the hydraulic press machines; otherwise, it leads to the defective products. Our present work deals with reduction in deflection in C-structure of a 50 Ton hydraulic press machine to get the desired dimension and shape of outer lid component of a pressure vessel. The components manufactured by pressing operation undergoes different kinds of forces and pressures. So, it becomes very essential to get the desired dimensions and shapes with more accuracy. The deflection in C-Structure of hydraulic press machines also depends upon the amount of force applied, the stresses acting on the structural parts, thickness of plates used, types of welds and the number and positioning of ribs. In our present work we analysed the structure carefully and modified the positioning and thickness of ribs in C-structure of 50 Ton Hydraulic press machine. By these modifications we become successful in reducing the deflection of the C-structure of 50 Ton hydraulic press machine in operating conditions. Also achieved the results in getting desired shapes and dimensions of outer lid component of a pressure vessel.

The performance of a hydraulic press depends largely upon the behaviour of its structure during operation. However, these welded structures are becoming complicated and their accurate analysis under given loading conditions is quite important to the structure designer. Hence, it is found that optimal design of a hydraulic press in terms of its weight and the amount of deflection in operating conditions are the need of the hour. These hydraulic presses find ample applications in various industries. To count a few, the applications of hydraulic presses are Blanking, Clamping, Coining, Compacting, Compression Moulding, Drawing, Embossing, Forging, Forming, Injection Moulding, Powder Compacting, Punching, Spotting, Stacking, Stamping, Steel Rule Die Cutting, Full tonnage throughout the stroke unlike mechanical presses, hydraulic presses have the ability to deliver full pressing force anywhere in the range of stroke. It is easy to design the hydraulic press to meet the customers' specific requirements such as large bed sizes with little tonnage or high tonnage for small work area. In hydraulic press, users are able to adjust tonnage and maximize cycle time. More efficiency can be achieved by eliminating excessive ram movement or changing pressure or maintaining ram speeds. Hydraulic presses are the simplest in design with proven, readily available hydraulic components. Unlike mechanical presses where basic components are expensive and often custom built, hydraulic presses are much less expensive up-front in fabrication. C-structure is used in a hydraulic press machine. Press works on Pascal's principle, which states

- "pressure throughout a closed system is constant." In hydraulic press, there is a piston at one end of the system having a small cross-sectional area. The performance of hydraulic press depends upon the behaviour of its structure during operation. However due to complicated structure and variation of load, complete structural knowledge is essential to develop fail proof system. A very efficient fluid power transmission system is used in hydraulic cylinders. Present conventional power transmission systems are being replaced and being changed over to fluid power-based systems [1]. In hydraulic press machines, press-body is of C-structure. When free space required from three sides of press table to work for loading and unloading of pressed component then this type of presses is designed. As main cylinder placed eccentric to central axis of press-body, it applies eccentric load on press-body hence heavier press body is required as compared to same capacity of other type of press [2]. A hydraulic press is a mechanical machine used for lifting or compressing various parts and components. The force is generated by the use of hydraulic fluids to increase the pressure inside the cylinder. The hydraulic press machine works on Pascal's principle [3]. The hydraulic cylinder is a device which used to convert fluid power to mechanical power by Pascal principle. The Pascal principle states that pressure exerted anywhere in a compressible fluid is transmitted equally in all direction through the fluid. In hydraulic cylinder a confined incompressible fluid pressure exert on three surfaces, cylinder wall, cylinder base plate and piston head [4]. In ANSYS we can apply loads on the model in a variety of ways. By using load step option, during solution we can control use of loads. A C type hydraulic press is a machine that supplies force to die used to, form, blank or shape metal or non-metallic materials. The Metal forming manufacturing process are almost chip less. Press tools are used to carry out this operation. Deformation of work piece to desired size is done by applying pressure. In this project C frame type hydraulic press are mainly used for sheet metal punching. It consists of bed, frame or bolster plate and a reciprocating member called as slide or ram [9]. Because of continuous impact load, frame of press machine always experiences continuous tensile stress. Press machine continuous deals with stress and because of that frequently structural failure problem occurred in machine. It is also helpful to reduce thickness of plate of frame structure so that material saving and cost benefit will be considerable. It can be concluded that simulation software is the powerful tool for prediction of the thickness of plate required for given load [10]. To develop the C-structure of the machine, Autodesk Inventor software is used. With the help of this software a 3D CAD model was developed along with the simulation of the C-Structure. Structural analysis of the C-structure is carried out using FEM technique. Press machine always subjected to heavy impact load condition.

2. DESIGN CALCULATIONS OF C-STRURCTUE [8]

By using rib thickness as a 30mm

Area $A_1 = 1000×30 = 30{,}000\ mm^2$

Area $A_2 = 125 × (400-30) = 46{,}250\ mm^2$

Area $A_3 = 50 × (750-400) = 17{,}500\ mm^2$

y = Distance of C.G. of the section from bottom

$y_1 = 15mm$, $y_2 = 215mm$, $y_3 = 575mm$

$\bar{y}=(A_1y_1+A_2y_2+A_3y_3)/ (A_1+A_2+A_3)$

$=(30000×15+46250×215+17500×575)/ (30000+46250+17500)$

$\bar{y} = 218.2mm$

$I = Ixx_1 + Ixx_2 + Ixx_3$

$Ixx_1 = IG_1+ A_1h^2$

$= (1000×30^3)/12 + (30000 × (218.2 − 15)^2)$

$= 1240.95× 10^6$ kgmm2

$Ixx_2= IG_2 + A_2h^2$

$= (125×370^3)/12 + (46250 × (218.2-215)^2)$

$= 528.109× 10^6$ kgmm2

$Ixx_3 = IG_3 + A_3h^2$

$= (350^3×50)/12 + (17500 × (575-218.5)^2)$

$= 2406.505× 10^6\ kgmm^2$

$I = 4175.564 × 10^6\ kgmm^2$

$σ = M\bar{y}/I$

$=(50000×500×218.2)/ (4175.564×10^6)$

$= 13.06N/mm^2$

$δ =Pl^3 /3EI$

$=50000\times500^3/(3\times200000\times4175.564\times10^6)$
$= 0.0249mm$

By using width of 50mm
Area of section 'a' = $1000\times50 = 50{,}000\ mm^2$
Area of section 'b' = $125\times450 = 56{,}250\ mm^2$
Area of section 'c' = $50\times500 = 25{,}000\ mm^2$
y = Distance of C.G. of the section from bottom
$y_1 = 25mm$, $y_2 = 275mm$, $y_3 = 750mm$
$\bar{y} = (A_1y_1+A_2y_2+A_3y_3) / (A_1+A_2+A_3)$
$=(50000\times25+56250\times275+25000\times750)/(50000+56250+25000)$
$\bar{y}= 270.23mm$
$I = Ixx_1 + Ixx_2 + Ixx_3$
$Ixx_1= IG_1+ A_1h^2$
$= (1000\times50^3/12) + (50000 \times (270.23 - 25)^2)$
$= 3017.29\times106\ kgmm^2$
$Ixx_2= IG_2+ A_2h^2$
$= (125 \times 4503/12) + (56250 \times (275 - 270.23)^2)$
$= 950.48\times106\ kgmm^2$
$Ixx_3= IG_3 + A_3h$
$= (50 \times 500^3/12) + (25000 \times (750 - 270.23)^2)$
$= 7234.48\times106 kgmm^2$
$I = 11202.25 \times10^6$
$\sigma = M\bar{y}/I$
$= (500350\times270.23) / 11202.25\times10^6$
$= 6.03\ N/mm^2$
$\delta = Pl^3/3EI$
$=500350 \times 500^3 / 3 \times 208000 \times 11202.25 \times 10^6$
$\delta = 0.008947\ mm$

3. DESIGN CALCULATIONS OF HYDRAULIC CYLINDER [7]

Force = Pressure x Area
$F = P \times A$
Were,
F = Applied force = $50x10^3$ kg
P = Pressure = $100kg/cm^2$
A = Piston Area = $\pi\, d^2/4$
Now $F = P \times A$
$50 \times 10^3 = 100 \times \pi\, d^2/4$
$500\ X\ 4 = \pi\, d^2$
$d^2 = 636.6197$
$d = 25.23 \approx 30.00$ cm

4. STRESS AND DEFLECTION ANALYSIS OF C-STRUCTURE

4.1 Meshing:

The modeling of solid C-Structure is set to generate the finite element mesh. The element size, element shape and midsize placement of node is used in meshing of the solid model and is established by using meshing controls. This step is one of the most important parts of our entire analysis, for the decisions we make at this stage in our model development will profoundly affect the accuracy of our analysis. To mesh the machine, 8 nodes with 2 Degree of Freedom are used.

4.2 Boundary Conditions:

Either on the finite element model entities or on the solid model entities we can apply the majority of the boundary conditions and excitations to a harmonic high-frequency analysis. Since applying boundary conditions to the solid model is beneficial. We observed the response of loading conditions on the C-Structure of the Machine. Specifying the correct load conditions is very important step in our analysis. In Autodesk Inventor we can apply loads on the model in a variety of ways. By using load step option, during solution we can control use of loads. In this case load is applied to cylinder ram and impact force in applied to the bed or work table along with the base of the hydraulic press in fixed. 50-ton load is applied on the structure where the hydraulic cylinder ram is to be placed.

4.3 Analysis:

In this case we applied most of the loads either on finite element model (on elements and nodes) or on the solid model (on lines, key points and areas). Thus, on key points or on a node force can be specified. After applying boundary condition, Structural analysis is done to find stress and deflection. The main aim of the customer was to get the product of good quality with desired shape and dimension. We modified the C-structure by varying spacing and thickness of ribs. Model is created in Autodesk Inventor. To mesh the C-structure of the machine, 8 nodes with 2 Degree of Freedom is used.

After applying boundary condition, Structural analysis is done to find stress and deflection. An attempt was made to analyze the 50 Ton C-type hydraulic press using Autodesk Inventor software. It is successfully designed to meet the requirements as per the constraints. The C type hydraulic press frame is carefully designed and cross checked where it does meet the requirements. The stresses and the displacements are shown in figures (Fig.1 to Fif.4)

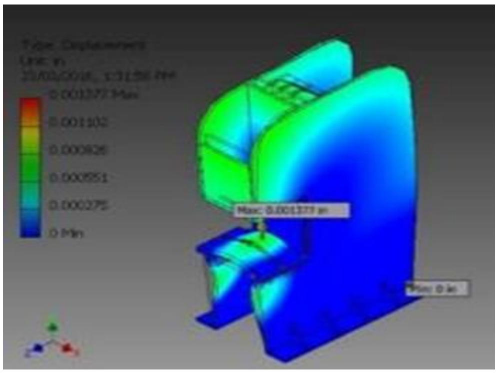

Figure 1. Displacement Analysis of C- Structure

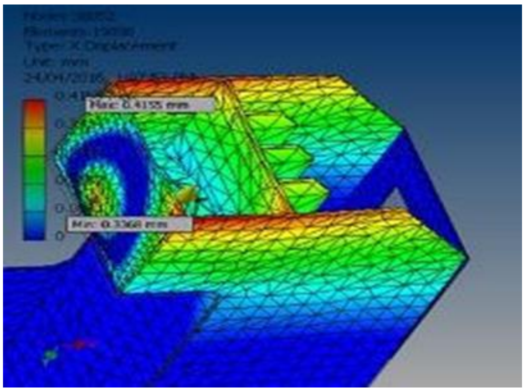

Figure 2. Stress Analysis of C-Structure

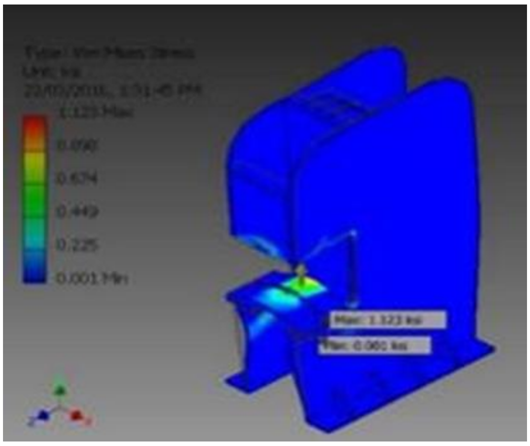

Figure 3. Displacement Analysis of C- Structure

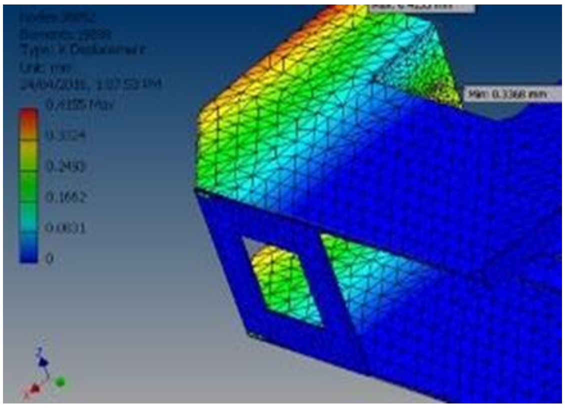

Figure 4. Displacement Analysis of C- Structure

5. RESULTS AND VALIDATION

Table 1. Materials of construction [6]

Sr. No	Mild Steel Parameters	Value	Units
1	Density	7800	Kg/m 3
2	Young's modulus	200	GPa
3	Poisson's ratio	0.3	-
4	Yield stress	410	MPa
5	Ultimate Tensile Strength	650	MPa

Table 2. Results Comparison [5]

Description	Theoretical result		Analysis Results from Autodesk Inventor	
	Maximum Stress	Maximum Deflection	Maximum Stress	Maximum Deflection
C-Structure	6.03 N/mm 2	0.0249 mm	7.74 N/mm^2	0.034798 mm

6. CONCLUSIONS

Hydraulic press is the most efficient among the different types of industrial presses. Hydraulic presses operate on the principles of hydrostatic pressure to transmit power. Minimal deflection design for rigidity and long life of structure is required. Deflection in structure depends upon the applied amount of force and the bending stresses developed in the structure. C-Structure of the machine is subjected to different types of loading conditions and is analyzed using Autodesk Inventor tool. The material of the structure is mild steel. The C-structure of a 50 Ton capacity hydraulic press is modified by welding 30mm thickness ribs to the structure to make the structure strong enough and reduce the deflection. Initially the rib thickness used was of 25mm thick but we modified the thickness to 30mm. Our aim was to control deflection of C-structure under 0.0100 mm and we become successful in reducing deflection of C-structure from 0.08 mm to 0.025 mm by varying thickness of ribs form 25 mm to 30 mm. Our one more objective was to get the desired dimension and shape of stainless material outer lid component of pressure vessel. The desired dimensions are 155 mm diameter and 40 mm height. We achieved these desired dimensions after reducing the deflection in C-Structure from 0.08mm to 0.025mm. From theoretical analysis we got the stress value in C-structure of 50 Ton hydraulic press machine as 6.03 N/mm2 and by analytical method we got the stress value as 7.74 N/mm2 for 50 Ton Loading. The maximum deflection in C- structure of hydraulic press machine by theoretical analysis, we got 0.0249mm and by analytical analysis we got the maximum deflection in C-structure of hydraulic press machine used as 0.034798mm. The C-Structure was tested for performance with a load of 50 Ton and the results were found to be satisfactory. The dimensions of the stainless-steel outer lid component of pressure vessel achieved were also satisfactory.

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