Investigation on Reduction of Crack Propagation on C type Hydraulic Press Frame

Rajesh B. Vekariya[1], Vasim G. Machhar[2], Bhavesh N. Khichadia[3]

[1] *Scholer, Mechanical Department, NGI-Junagadh , Gujarat, India*
[2] *Assistant Professor, Mechanical Department, NGI-junagadh , Gujarat, India*
[3] *Assistant Professor, Mechanical Department, BEC-junagadh , Gujarat, India*

ABSTRACT

Generally press machine works basis on dropping of ram by ring lever. Due to tend to impact on press frame continuous cyclic motion to impact loading acts on press frame. The impact loading through press frame deals with tensile stress. This tensile stress through press frame goes to structural failure and major failure as a crack generated at the sharp corner of the C type hydraulic press frame. Solutions of the press frame given with inclined ribs, C Plate and Right angle Plate. Combination of c-fillet plate and ribbed body plate get more accurate result and stress concentration on the press frame reduce. So, here give the solution for better rigidity and stiffness in C-type frame of hydraulic press machine to minimize the crack formation in the corner of frame. Structural failure analyze by the FEA tool. This solution obtained by a mathematical model and simulation model. ANSYS-15.0 is used for a simulation process. This result compare with the analytical result.

Keyword: - *C-frame; stress concentration; crack; analytical analysis; FEA.*

1. INTRODUCTION

Hydraulic presses are widely used in automotive industry for e.g. sheet metal forming. In press machine basic element of press frame, which is supporting all the kinematic and force transmission from press machine to the work piece. [1, 2]

In this paper is considering the frame for C-type hydraulic press, one of the most common types of such machines. In the most function of press frame is absorb the force which generated by transmission and processing.

In order to better understand undesirable effect on the press frame, a systematic analysis of their static behavior is needed, to construct presses more stiff, various investigation of presses and of components have been done based on finite element method.[3-6] finite element method to investigation provide useful results for improving structural components of press.

This paper presents an alternative approach to analyze the static behavior of press machine frame using computer simulation of press frame.

2. BASIC DESIGN

2.1 Analytical solution

Hydraulic press calculation is based on the determination of stress and deflection that occur under full load, for the nominal force of 400kN [7]. Catalin ianu[8] specified calculation by considering all cross section of the frame from 15º to 15º for providing more information of maximum value of stress.

It also state that due to the symmetry of press frame will be performed the calculation for half the consider section A-A.

Tensile stress on consider section A-A

$\sigma_t = P/A = 14.28$ N/mm2

Bending Moment

$$\sigma_b = \frac{M_b}{Z_{AA}} = \frac{P \times E}{Z_{AA}} = 91.83 \text{N/mm}^2$$

$Z = \frac{1}{6} \times b \times h^2 = 816666.67\ mm^3$

Maximum stress to outer fiber of considers section will be:

$\sigma_{max} = (\sigma_b + \sigma_t) = (91.83 + 14.28) = 106.11\ N/mm^2$

$\sigma_{min} = 77.55\ N/mm^2$

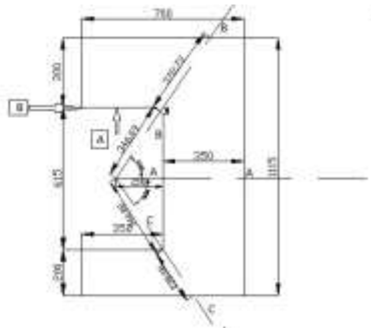

Fig -1. Scheme for calculating of press frame

Form fig-1, calculation is performed in other sections of calculation considered A-A...C-C, determining for each: area and center of gravity of the section, moment of inertia and resistance modulus; force component acting on the section considered, the maximum stress for considering sections. These elements are summarized in Table 1.1

Table 1. Calculation of considering section.

Section	Area mm2	Section modulus Mm^3	Force N	σt N/mm2	Σc N/mm2
A-A	14000	816666.67	200000	106.11	77.55
B-B	14908.8	926134.65	106899.97	68.62	54.28
C-C	9543.2	379469.44	109044.88	151.11	128.25

Maximum deflection at load axis = 1.6818 mm

Maximum deflection of frame at the extreme end 2.0242 mm

2.2 FEA solution

In a first stage of the research, 3D model of press frame developed by using Pro-Engineering Wildfire 5.0 software which shown in fig.2. Stress and deformation analysis analyzed with the help of FEA software ANSYS workbench 14.0. It was mesh with triangular type elements. It results 205725 elements and nodes 494173 as shown in figure 2B.

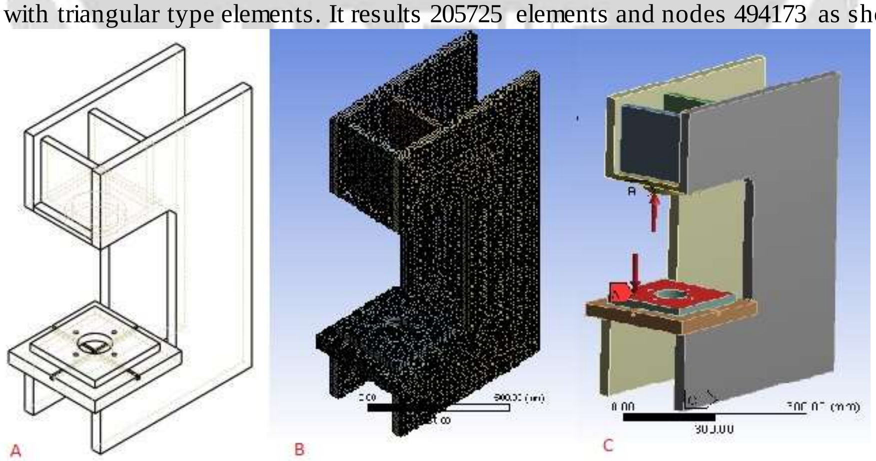

Fig-2 A. Geometry model of basic press frame, B. Meshing, C. Boundary condition of press frame

The base plate is totally fixed and there is no degree of freedom left. Applying loading condition, as we have 40 tone load on structure but it apply in particular area P1 = 29.11 N/mm^2 is apply on upper side of frame and P2 = 4.87 N/mm^2 is apply on bolster plate.(see figure 2-c)

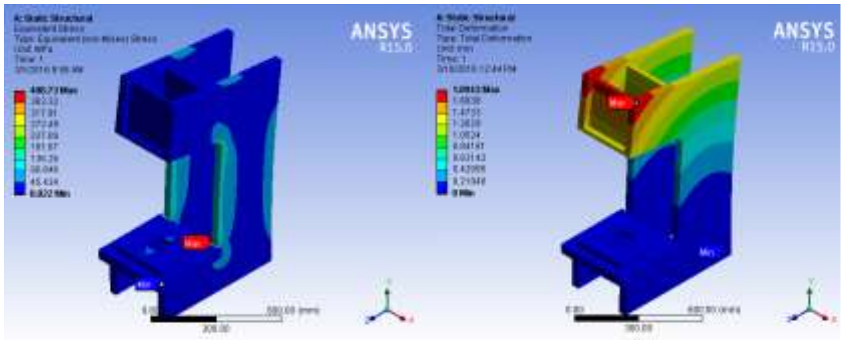

Fig-3 A. Von-mises stress and B. deformation of basic press frame

It is observed static analysis of press model shows in figure. Maximum Von-mises stress 408.73 Mpa which is generated at the corner of bolster plate and body plate and Maximum deformation is 1.894 mm.

3. ALTERNATIVE DESIGNS

In order to increase the stiffness and reduce tensions in the cast C-frame of hydraulic presses, four directions have been considered:

1. C-fillet plate
2. The ribbing of the side walls of the frame
3. By Right angle plate
4. Inclined plate at upper side

3.1 C-fillet plate

In preliminary hydraulic press machine frame is constructed with two C-fillet at the middle of press frame and two boss plates at the center of the frame. C-fillet plates and boss plates both are attached with the frame at the both side wall of the press frame, (see figure 4 A).

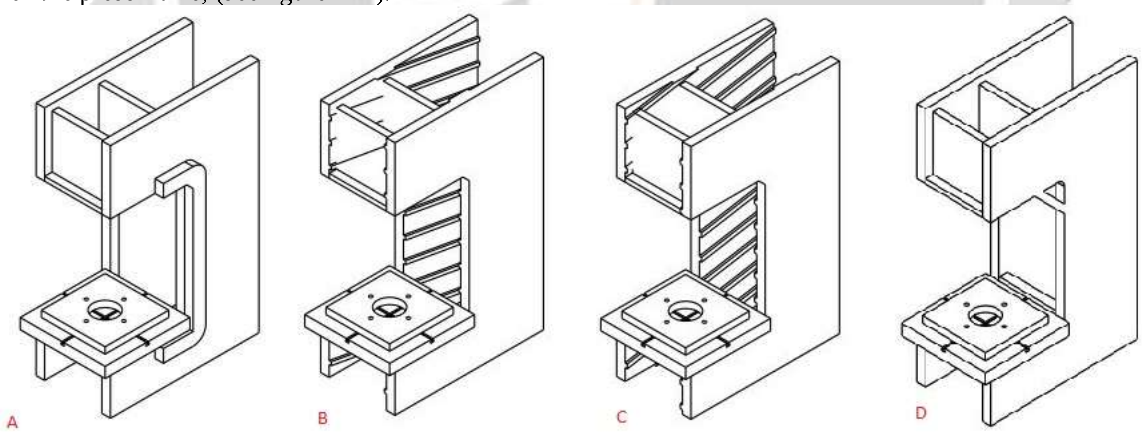

Fig-4 Press Frame **A**. C- Fillet Plate **B**. Right angle Ribbing. **C**. Left angle Ribbing **D**. Inclined plate at upper side

3.2 The ribbing of the side walls of the frame

Keeping constant sidewalls thickness of frame, there have been developed models with differently oriented ribs according to IS 1730:1989[9], equidistant in-between at 50, 75 and 100 mm.

From Figure 6B shows the arrangement of right angle ribs at 10º. In this design numbers of ribs are arranged at the 10º with respect to the horizontal axis of the frame with equidistance.

From Figure 6C shows the arrangement of Left angle ribs at 20º. In this design numbers of ribs are arranged at the 20º with respect to the horizontal axis of the frame with equidistance.

3.3 By Right angle plate

The right angle plate basically used for supporting the bloster plate and body plate. It is attach with a side wall of press frame by means of a welding. The main purpose of right angle plate is improving the stiffness of frame. Right angle plate is made of mild steel

3.4 Inclined plate at upper side

Figure 4D shows that the press machine frame at inclined plate. It is similar procedure follow as compare with basic frame in ANSYS-15.0.

3.5 Combination of inclined rib and C-fillet plate.

Another alternative, model of frame with combination of C-fillet plate, crank mounting plate and inclined ribbing of side wall.

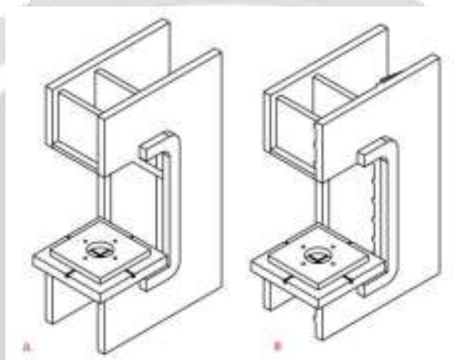

Fig-5 A. Combination of C-fillet plate and right angle plate. **B.** Combination of C-Fillet plate and rib.

4. Result and Discussion

In basic model of the plate which is already in use, maximum von-mises stress generated is 408.73 MPa in FEA and by analytical methodology internal and external stresses obtained are 151.11 MPa and 128.25 MPa respectively. Deformation obtained in basic model is 1.8943 mm. Table 2 shows the comparison of stress values obtained from analytical methodology and FEA.

Table 2: Comparison between analytical method and FEA

Section	Area	Force	σ_t	σ_c	FEA
C-C	9543	109045	151.11	128.25	408.73

It can be noticed that stress value obtained by analytical method is lower than FEA, confirming the assumption that using only a FEA based on simplified structure, the FEA method being used for verification.

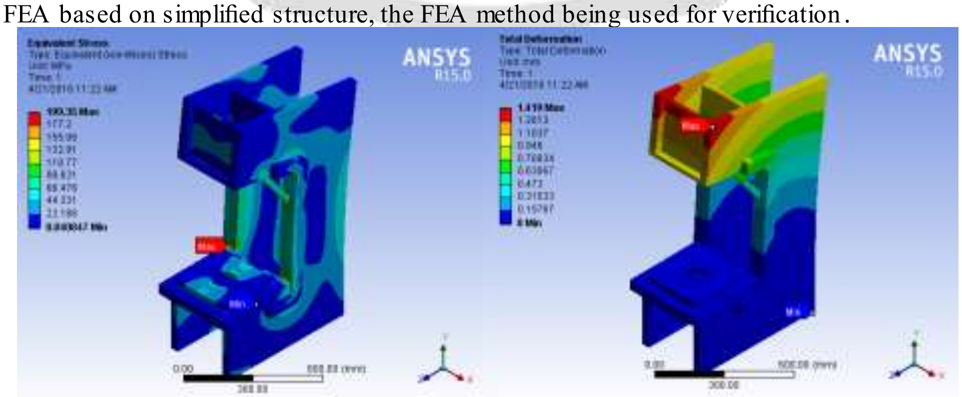

Fig-6 A. Von-mises stress and **B**. Deformation of press frame with combination of c-fillet and inclined plates

Comparing C-fillet plate and inclined plate design with preliminary model, it concludes that von-mises stress obtained in C-fillet plate and inclined plate design by FEA is 18.22% less as compared to the preliminary model and deformation is 23.03% less as compared to preliminary model(see figure 6). It concludes that ribs arranged at 100 mm produces less von-mises stress and deformation as compared to the ribs arranged at other distances. Ribs inclined at 10 and arranged at 100 mm apart produce least stress and deformation (see figure 7).

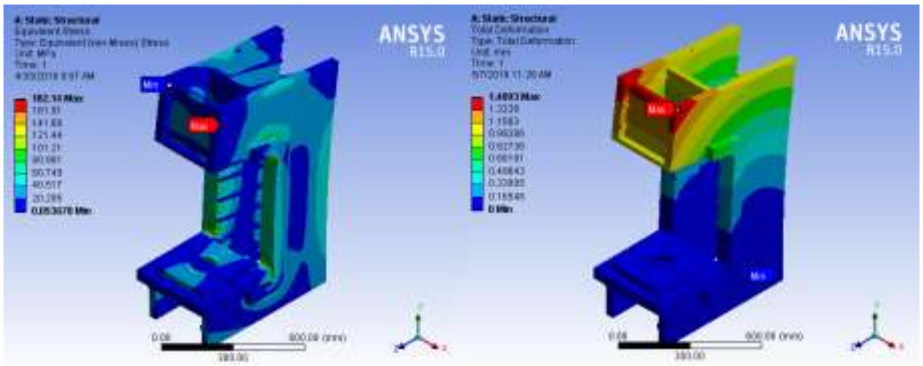

Fig-7 A. Von-mises stress and B. Deformation of press frame with combination of c-fillet and ribs.

Comparing Combination of inclined rib and C-fillet plate design with preliminary model, it concludes that von-mises stress obtained in Combination of inclined rib and C-fillet plate design by FEA is 31.162% less as compared to the preliminary model.(see figure 7) .

Table 3: Comparison between preliminary design and alternative designs

Sr. No.	Designs	Von-mises stress	Deformation
1	Preliminary Design	408.73	1.8943
2	C-fillet plate	190.7	1.01316
3	The ribbing of the side walls of the frame	350.63	1.864
4	By Right angle plate	368.22	1.846
5	Inclined plate at upper side	387.37	1.7209
6	Combination of inclined rib and C-fillet plate	199.7	1.419
7	combination of c-fillet and ribs	182.14	1.4893

Table 3 shows the comparison of preliminary design, Alternative design. In Combination of rib and c-fillet plate, crank mounting plate design, stress generated is minimum as compared to others while deformation is more as compared to C-fillet plate and crank mounting plate design and Modification in c-fillet plate design and less compared to preliminary design. In this design, maximum stress generated is not at the corner where crack is initiated. So by comparison, it is clear that Combination of rib and c-fillet plate, design is safe design amongst all these design.

4. CONCLUSIONS

Crack initiation in the inner corners of the junction of two plate, and also in other locations. Crack initiation could be most probably caused by overloading during the operation and improper design. Another possible reason for crack initiation was also low purity of the press frame material.

The present work explores an alternative solution: increasing the stiffness and strength by C-fillet plate and ribbing of the sidewalls of the press frame. When studying virtually, it is aimed to identify that constructive design solution that provides to the frame the best stress and deformation state, including in relation to the reference basic press frame design solution. First analytical analysis through obtained maximum stress value 151.11 Mpa at C-C section of the press frame and FEA through obtained von mises stress value 408.73 Mpa.

Solutions of the press frame with Combination of C-fillet plate and ribbed body plate get more accurate result as 182.14 Mpa Analyzing the stress and deformation state in the frames with ribbed walls and C fillet plate, most often it is found that the increased resistance of ribbed walls causes a migration of tensions to the front side areas of body plate. It can be noticed that analytical method is time consuming and obtained stress value only on the cross-section of the press frame. While FEA analysis is fast and more accurate then analytical method. This alternative design through increasing rigidity and stiffness of the press frame but also increasing consumption of material and manufacturing cost.

5. ACKNOWLEDGEMENT

I express my deep sense of gratitude to Prof. Vasim G. Machhar, Assistant Professor in Mechanical Department for his valuable guidance, careful and concerted effort in carrying out this work. His encouragement and whole hearted cooperation at each step of the work in providing valuable suggestion, book, and international journals in giving shape to the seminar is gratefully acknowledge.
I am thankful to Prof. Bhavesh N. Khichadia, Assistant Professor in Mechanical Engineering department for providing necessary facilities and support.

6. REFERENCES

[1] "Metal forming handbook", Schuler Springer-Verlag Berlin Heidelberg, 1998.

[2] P.C Panday, C.K. Singh, "Production Engineering and Science", chapter -19 press tool design, pp.477-527.

[3] Frantisek Trebuna, Frantisek simcak, Jozef Bocko, Peter Trebuna, Miroslav Pastor, Patrik Sarga, "Analysis of crack initiation in the press frame and to ensure its further operation", ELSEVIER, Engineering Failure Analysis, Published online, 30 October 2010.

[4] M Fulland, M Sander, G Kullmer, H A Richard, "Analysis of fatigue crack propagation in frame of a Hydraulic press", ELSEVIER, Engineering Fracture Mechanics, Published online, January 2007.

[5] Ioan DAN, Romeo CIOARA, " Pre-tensioned c-frame for the crank mechanical press", Proceeding in manufacturing System, Volume 7 Issue:4, 2012.

[6] Romeo Cioara, Ioan Dan, " Increased Rigidity Solution For C- Frame Mechanical Press", Study of The Stress And Strain State, Proceeding in manufacturing System, Volume 6 Issue:2, 2011.

[7] Keval K Pujara, B L Juneja, "A course in Machine design", Dhanpatrai & sons, New Delhi.

[8] Catalin Iancu, " Comparison between Analytical Calculus and FEM for a mechanical Press Bed", American Journal of Mechanical Engineering, Vol. 1, No. 1, 2013.

[9] IS 6652:1986, Bureau of Indian Standards, Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002.