Design & Optimization of Crown in Four Column Type Hydraulic Press

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Abstract - *In this paper, a four-column type hydraulic press of one hundred tons is optimized by taking into consideration factors like the structural design of the component and the weight of the component. The work focuses on the optimization of the crown of the hydraulic press. The crown carries a hydraulic cylinder that can generate a load of one hundred tons. The design is based on the optimization of size and the results are validated by using solid-edge stimulation and analysis software by considering proper boundary conditions.*

Key Words: Solid Edge, Crown, Structural design, Design optimization, Analysis.

1. Introduction

The hydraulic press operates on the principle of Pascal's law, the work of this press is to generate compressive force by means of hydraulics. The uppermost part of hydraulic press is a crown which ensures uniform distribution of reaction load of cylinder and resulting in more accurate and consistent forming of material.

2. Literature Review

D. Ravi et al. (2014) made significant strides in hydraulic press technology by leveraging PRO/ENGINEER and ANSYS software to develop and analyze a C-frame power press. Their approach successfully achieved weight reduction while ensuring structural integrity, marking a notable advancement in press design optimization [2].

N.A. Anjum et al. (2017) contributed to the field by designing a hydraulic press tailored for equal channel angular pressing. Through experimental validation, they demonstrated the press's ability to perform satisfactorily under a working load of 40 tons, showcasing its effectiveness in specialized metalworking applications [3].

Mohammed Iqbal Khatib et al. (2020) introduced a manual-operated 5-ton hydraulic press, emphasizing its user-friendly features such as interchangeable molds and dies without the need for ram assembly disassembly. This innovation enhances operational efficiency and versatility in various manufacturing processes [4].

Akshay Vaishnav et al. (2016) focused on optimizing hydraulic press crown design through Finite Element Analysis (FEA) using ANSYS software. Their rigorous analysis identified the safest design among multiple variants, contributing to enhanced structural robustness and operational safety in hydraulic press applications [5].

3. Problem Statement

In a hydraulic press, the crown refers to the uppermost part of the press assembly, which carry a hydraulic cylinder at the middle of the it. The crown is supported by the four columns which are fixed to the base of press. As cylinder in working condition generate the indirect load (reaction force) on crown. This load causes bending and compression in the part.

Table 1: The required dimensions and load conditions

Constrains	Values
Breadth (b)	1500 mm
Height (h)	300 mm
Width (d)	750 mm
Working load	100 Ton
Testing load (w)	150 Ton

4. 3D Design Model

The crown has been designed from the fundamental calculations. In present work, the design is done to withstand the maximum deformation of 1mm/m. here there are three different Design of crown are present using sizing optimization method, with varying internal structural design.

At working condition, the crown should withstand the load of 100 Ton. For this evaluation, the factor of safety is taken as 1.5 (i.e., testing load 150 Ton). The hydraulic cylinder is mounted on the crown in the middle so, it will carry the amount of the reaction force from the cylinder. There are three unique design Designs from which the optimum design is selected. For this work, Solid Edge stimulation software is used for 3D modelling and analysis.

Design 1

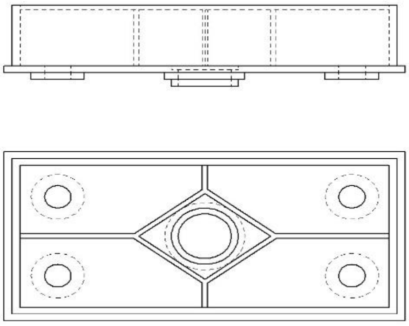

Figure 3a: design 1 sketch

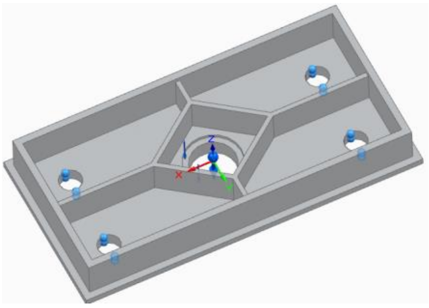

Figure 3b: design 1 CAD model

Design 2

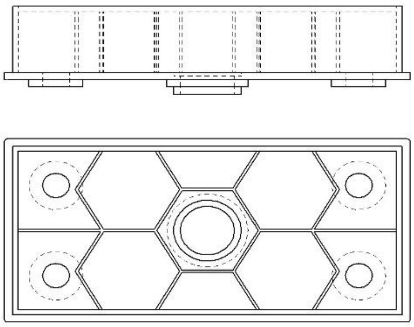

Figure 4a: design 2 sketch

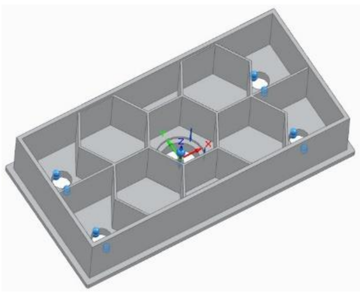

Figure 4b: design 1 CAD model

Design 3

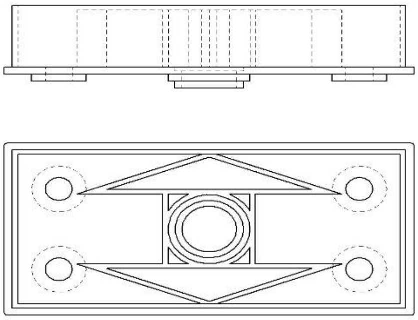

Figure 5a: design 3 sketch

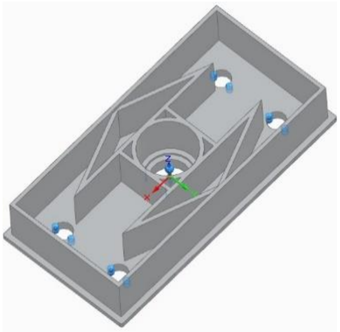

Figure 5b: design 1 CAD model

5. Results & Discussion

In this Design, a 150 Ton of load applied at the middle of the crown, where the cylinder is placed. All the remaining holes are taken as the fixed as the constrains because the pillars are the support to the machine. For FEA, Solid Edge software is used.

There are two primarily output obtained from analysis, total deformation and maximum von-mises stress. Based on the results, the suitable design is selected as requirement.

Table 2: Material properties used in the problem.

Material	Structural Steel
Density	7850 kg/m³
Passion ratio	0.3
Tensile yield strength	262 Mpa
Young's module	358 Mpa

Design 1

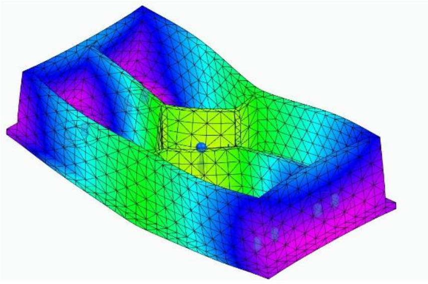

Figure 6a: Total deformation

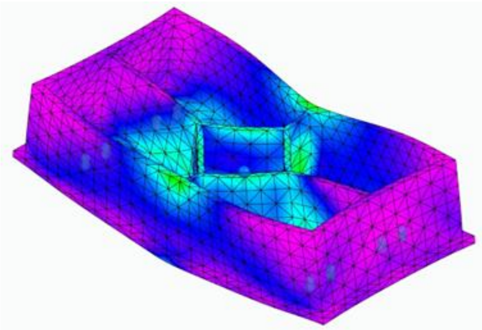

Figure 6b: Von-Mises stress

Design 2

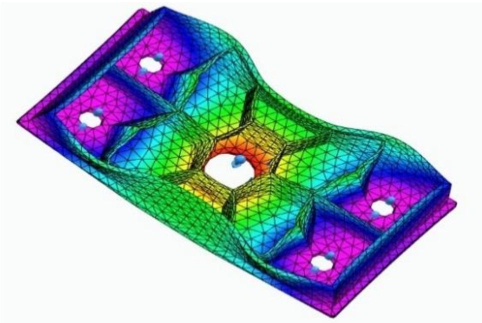

Figure 7a: Total deformation

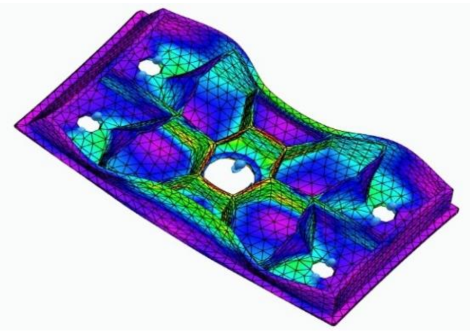

Figure 7b: Von-Mises stress

Design 3

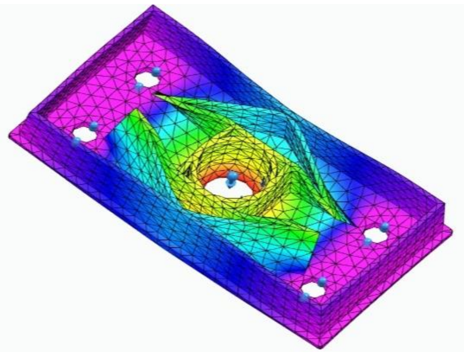

Figure 8a: Total deformation

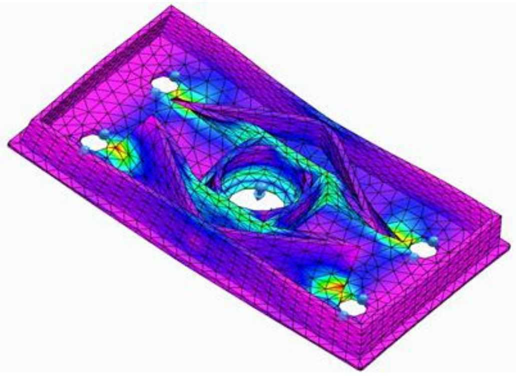

Figure 8b: Von-Mises stress

The following are the results obtained from above Designs at 300 mm of height for all 3 Designs. The results are as follows: -

Table 3: Result

Crown	Max Stress (Mpa)	Deformation (mm)	Weight (kg)
Design 1	260	0.956	678.828
Design 2	252	1.2	574.957
Design 3	245	0.709	687.868

By varying height of crown, the following results are obtained to achieve minimum deformation.

Design 1

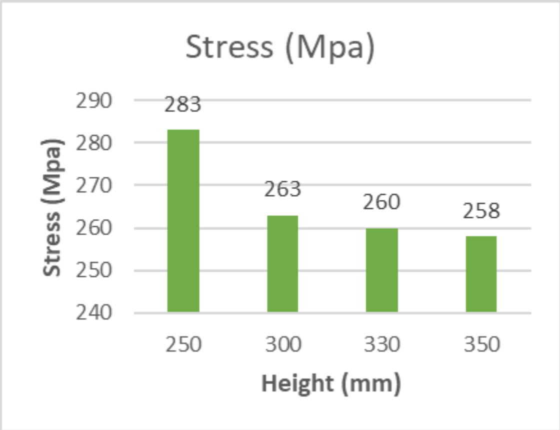

Figure9a: Stress Vs Height

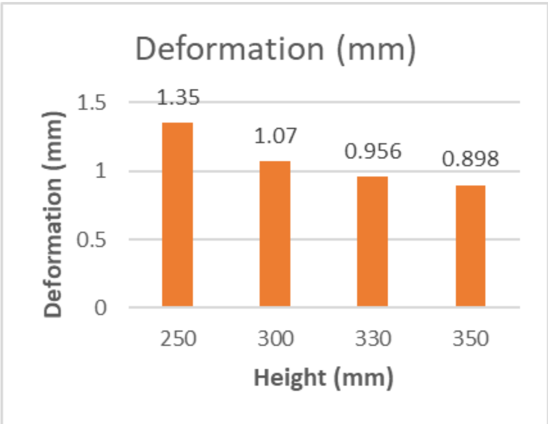

Figure9b: Deformation Vs Height

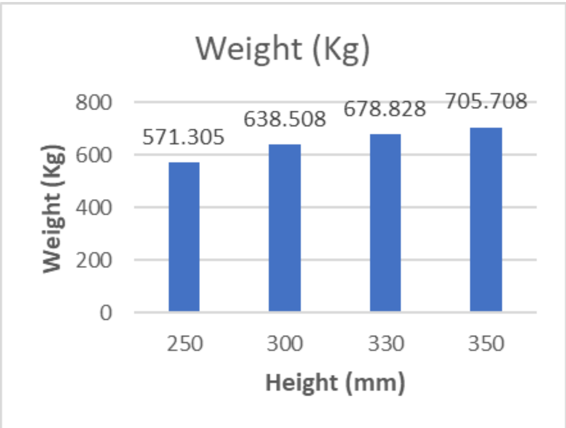

Figure 9c: Weight Vs Height

Figures 9a, 9b, 9c show the result of stress, deformation and weight obtained with when there is a dimensional change (height) in design 1.

Design 2

Figure10a: Stress Vs Height

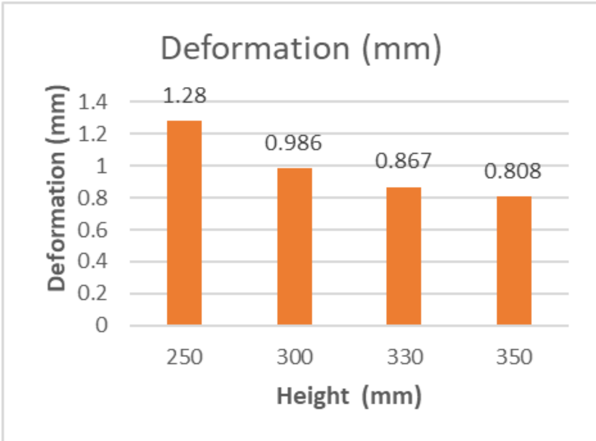

Figure10b: Deformation Vs Height

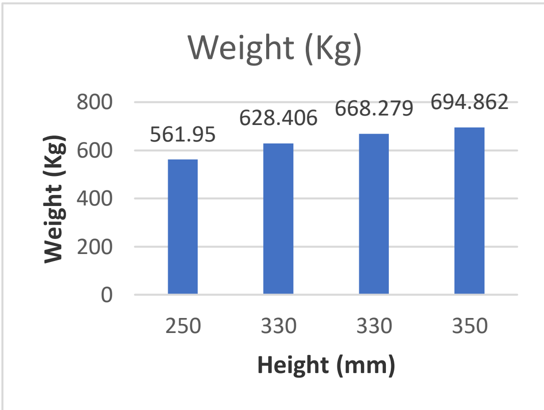

Figure 10c: Weight Vs Height

Figures 10a, 10b, 10c show the result of stress, deformation and weight obtained with when there is a dimensional change (height) in design 2.

Design 3

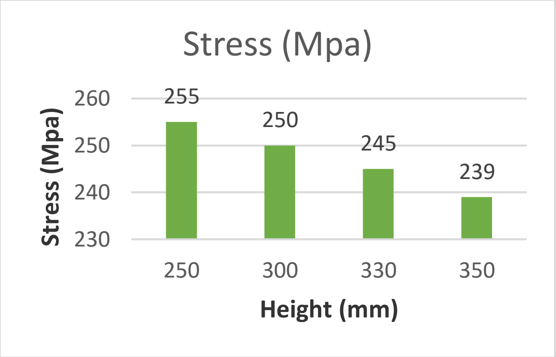

Figure11a: Stress Vs Height

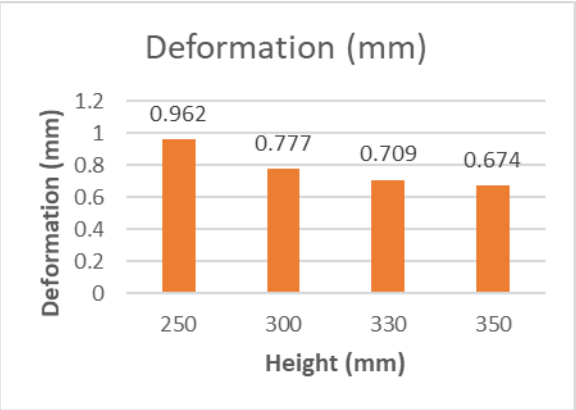

Figure11b: Deformation Vs Height

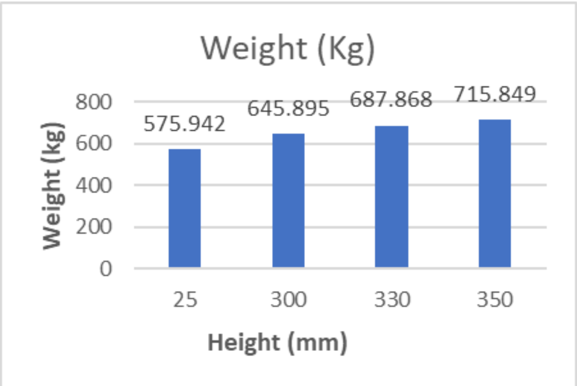

Figure 11c: Weight Vs Height

Figures 11a, 11b, 11c show the result of stress, deformation and weight obtained with when there is a dimensional change (height) in design 3.

6. Conclusions

- For optimization, the design is modified by changing demission and structural design. The 2nd design with 300 mm height, under FEA the result obtained are under desired values.
- Also, the value of maximum stress is less than the ultimate stress of the material. So, the design is under safer conditions.
- By comparing the Figures it's clear that 3rd design has less deformation. But comparing with the weight, the 2nd design has less weight with acceptable range of stress and deformation.
- So, from the above result, it is concluded that 2nd design can be proposed for manufacturing.

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