Design and Analysis of Hydraulic Mini Press Machine

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Abstract - This project presents the design, development, and analysis of a hydraulic small press machine. The project's main goal is to create a small, functional, and reasonably priced hydraulic press that can be used for a variety of tasks, including pressing, shaping, and assembling small work pieces. With the use of hydraulic power and Pascal's Law, the machine can produce large forces with little input. Choosing the right materials, parts, and sizes for hydraulic systems such as pumps, cylinders, and valves are all part of the design process. With a pump power consumption of roughly 1.167 kW, the machine's hydraulic system is intended to function at a pressure of 70 MPa and generate a force of 70 kN. To ensure safety and efficiency, a number of essential parts are chosen and examined for best performance, including the frame, hydraulic cylinder, piston, pump, and control valves. Because of its modest size, the machine is designed for research, educational displays, and small-scale industrial applications. The project also includes a thorough examination of the machine's power needs, force production, and operating parameters. To guarantee safe operation, safety features including emergency stop systems and pressure relief valves are included. The goal of this work is to present a prototype design that may be further refined for a range of industrial uses requiring small hydraulic presses.

This study advances the field of hydraulic machinery design by providing an effective solution for small-scale pressing operations by fusing theoretical design calculations with real-world insights

Key Words: Hydraulic Press Machine, Press tool, Solid works, drafting of machine, manufacturing tool, CAD, Design of Machine, CAE.

1.INTRODUCTION

Hydraulic press machines are the result of compact designs that require tremendous force, efficiency, and precision. Based on the basic ideas of hydraulics, hydraulic presses generate force and motion through the use of liquid pressure. They are extensively employed in manufacturing, industrial, and laboratory settings. The Hydraulic Mini Press Machine is a modification of conventional hydraulic presses that is intended to deliver a substantial force output in a more compact and smaller form factor. Small-scale pressing processes like bending, shaping, punching, and pressing components are crucial for producing precision parts in a variety of industries, particularly in the automotive, electronics, and prototyping sectors. For these uses, miniature hydraulic presses are the perfect answer since they combine the advantages of hydraulic force transmission with a smaller footprint. An effective and economical choice for small-scale activities, a well-designed hydraulic micro press may deliver significant force with little power usage. Pascal's Law, which states that pressure applied to a confined fluid is transferred undiminished throughout the fluid in all directions, allows a hydraulic press to generate a significant output force from a very small input force. The machine usually consists of a hydraulic pump, cylinders, valves, frame, and a control system, all of which work together to transmit pressure and force, converting hydraulic energy into mechanical work. The design and study of a hydraulic micro press machine is the major goal of this project, which aims to maximise performance, guarantee safety, and keep costs down for real-world industrial application. To guarantee dependable and seamless functioning, the design incorporates safety features, calculates the necessary forces and power, and carefully chooses materials and components. The machine is made to be small enough for simple installation and usage in a variety of small-scale manufacturing settings, and the hydraulic system is precisely proportioned to produce the required force output. The system's analysis includes a thorough examination of the forces at play, the hydraulic system's fluid dynamics, the pump's power needs, and the choice of materials for important parts to guarantee longevity and effectiveness. Furthermore, the design process incorporates safety considerations including emergency stop devices, pressure relief valves, and fluid leak protection.

By combining efficiency, accuracy, and safety in a small package, the project's ultimate goal is to create a hydraulic mini press machine prototype that provides solutions for small-scale production, educational demonstrations, and research applications. This paper advances hydraulic press technologies by offering insightful information about the use of hydraulic systems in small-scale industrial gear.

2. Objective

The creation of a small, effective, and useful hydraulic press that can carry out precise tasks in small-scale applications is the main goal of the Design and Analysis of Hydraulic Mini Press Machine project. These goals direct the machine's development, guaranteeing that it satisfies the necessary performance requirements while tackling real-world design, safety, and cost-effectiveness issues. The following is a summary of the project's specific goals:

- Design a Compact and Functional Hydraulic Mini Press Machine
- Determine the Required Force and Power Specifications
- Material Selection and Component Sizing
- Optimize Fluid Dynamics for Efficiency
- Develop a Reliable Safety Mechanism
- Implement a User-Friendly Control System
- Prototype Development and Performance Testing
- Analyze Operational Efficiency and Cost-Effectiveness

3. METHODOLOGY

Design Calculations and Force Requirements

The hydraulic cylinder capacity is the sole determinant of the machine's tonnage or capacity. The key element that generates the force needed to carry out the various press machine operations is the hydraulic cylinder.

- Machine Capacity Calculation

Calculation of Cylinder Capactiy

F= PXA

Where, F= Forced Developed

P- Pressure of hydraulic system

A- Effective Area

To calculate area

$$A = \pi r^2$$

Where, r- radius of piston

$$A = 0.19625\ m^2$$

And the pressure is

$$P = 35\ bar$$

$$P = 3500000\ pa$$

$$F = PXA$$

$$F = 3500000X0.19625$$

$$F = 686875.2\ N$$

$$F = \frac{686875.2}{9810}\ tons$$

$$F = 70.017\ tons$$

Force calculations are crucial to ensuring the press is operational and ready to carry out the necessary tasks. For tasks like cutting or punching, the force needed is established by:

- Material Strength: The processed material's tensile strength.
- Material Thickness: Greater force is needed for thicker materials.
- Die and Punch Geometry: The required force is determined by the size and shape of the die and punch.For instance, for **punching**, the force can be estimated using:

F=P×A

For Example,

If we have to cut stainless steel, then we have to consider the value of shear strength of stainless steel which is 320 mpa. Additionally, 78.5 mm2 would be the space with a 10 mm diameter.

F= 320 mpa x 78.5 mm^2

F= 25120 N

F= 25120/9810 bar

F= 2.56 tons

Where:

- F is the force required.
- P is the **shear strength** of the material.
- A is the **area** of the punch (diameter of the hole × thickness).

According the machine capacity, the cutting capacity required to cut the punch hole is 2.56 ton and the total capacity of the machine according to our calculation is 70 tons. Therefore, the cutting operation can be perform very well.

- CAD MODELLING

A crucial stage in the creation of mechanical systems is computer-aided design, or CAD. The parts and final assembly of a small hydraulic press machine were designed and visualised for this project using CAD modelling. Prior to actual manufacture, the 3D model helps with understanding fitting, part interaction, spatial linkages, and general ergonomics. In designing of mini press various module of solid works are used:

- Sketching
- Solid Modelling
- Assembly Modelling
- Drafting Modelling

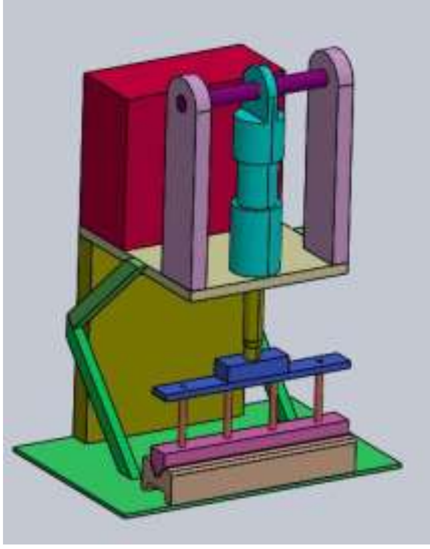


Fig. 1 Assembly of Mini Hydraulic press Machine

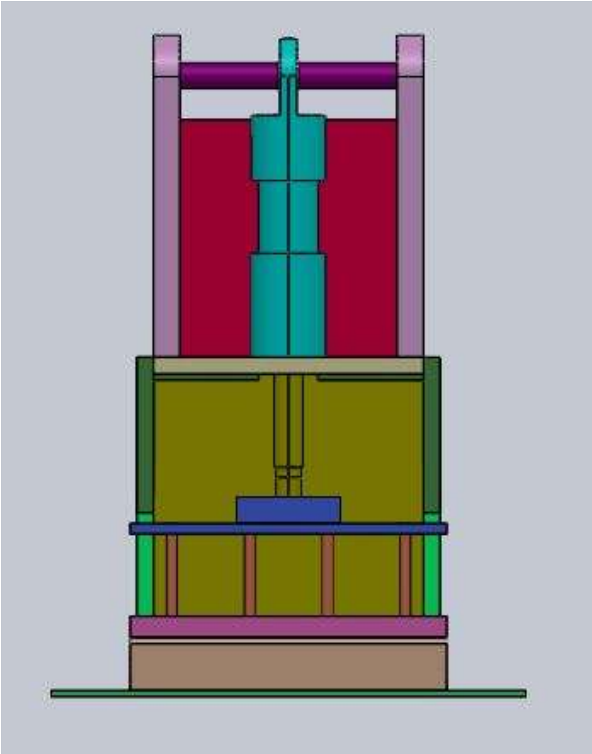


Fig. 2. Assembly Front View of Mini Hydraulic press Machine

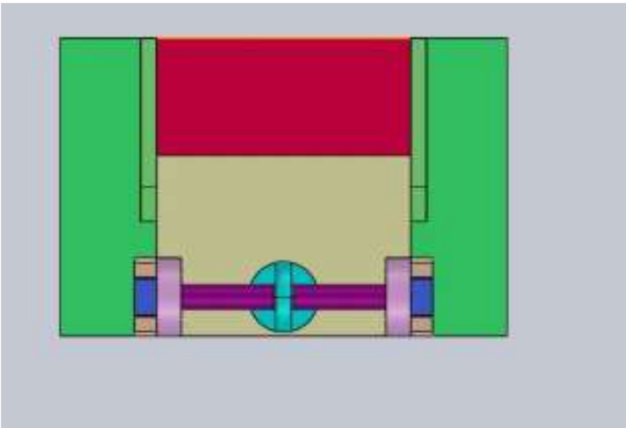


Fig. 3. Assembly Top View of Mini Hydraulic press Machine

Drafting is a tool which is used in drawing of the views of the machine that will be used for the manufacturing of the machine. In drafting, the detail dimensions is given that can be very useful for the manufacturing.

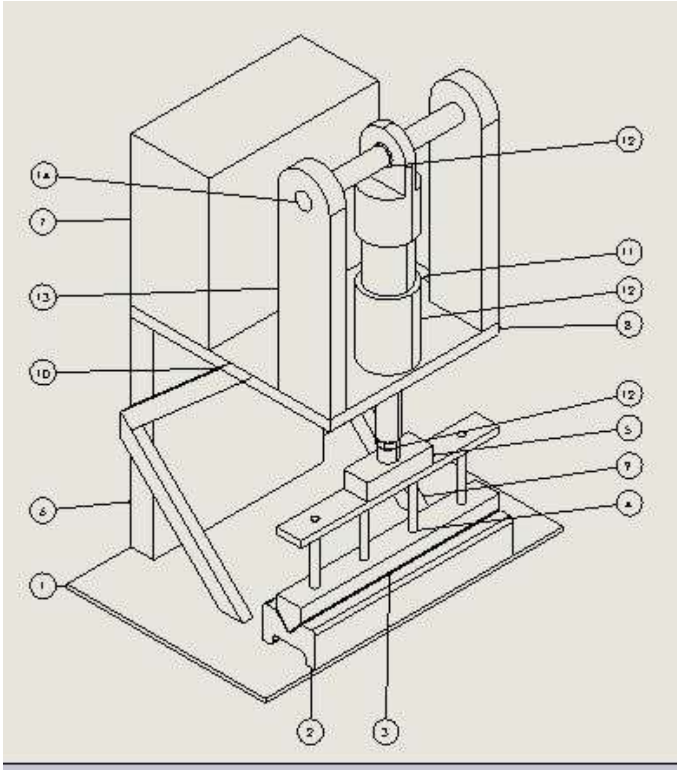


Fig. 4. Drafting Assembly View With Balloning of Mini Hydraulic press Machine

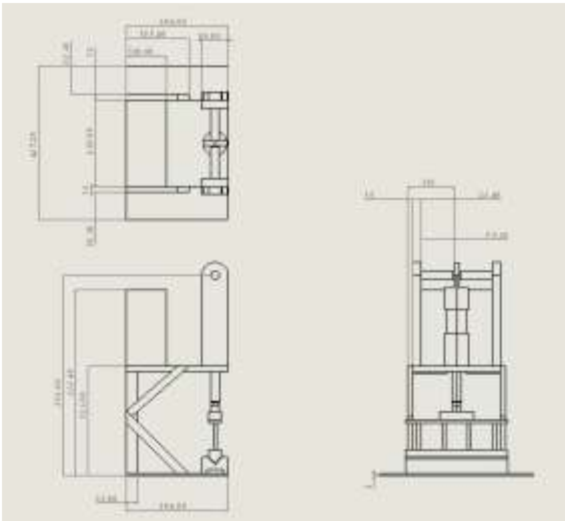


Fig. 5. Drafting Assembly Views of Mini Hydraulic press Machine

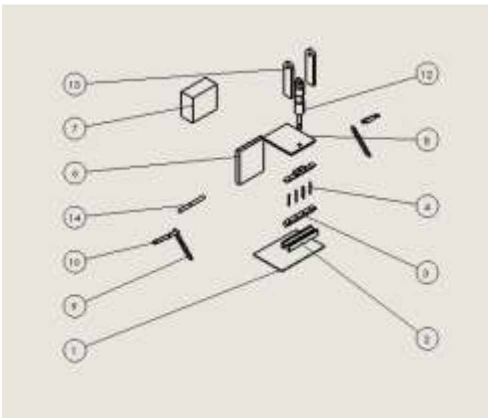


Fig. 6. Drafting Assembly Exploded Views of Mini Hydraulic press Machine

- Analysis of mini hydraulic press machine

Making sure the small hydraulic press machine can sustain the operational loads without failing is the main objective of the analysis. Using simulation tools, the analysis focusses on confirming the safety factor, deformation behaviour, stress distribution, and structural strength of crucial components.

- Finite Element Analysis (FEA)
  - Software Used: ANSYS / SolidWorks Simulation / Fusion 360
  - Steps:
    - Import CAD model of the complete assembly.
    - Assign material properties (e.g., Young's Modulus, Poisson's Ratio).
    - Apply boundary conditions:
    - Base fixed
    - Load applied on the ram (downward force = 100 kN)
    - Create mesh (fine mesh at high-stress regions).
    - Run static structural analysis.
    - Analyze results: von Mises stress, deformation, safety factor.

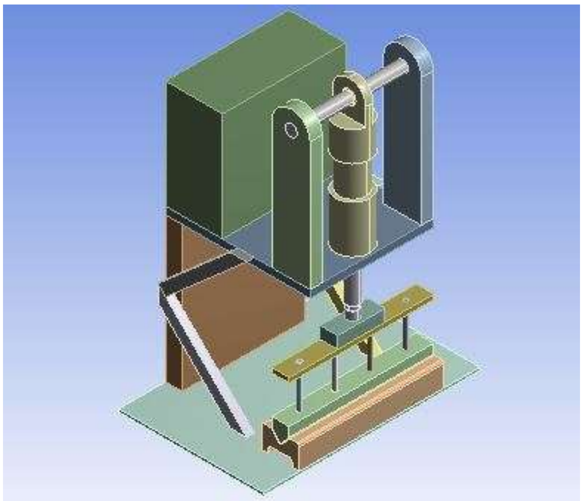


Fig. 7. Model

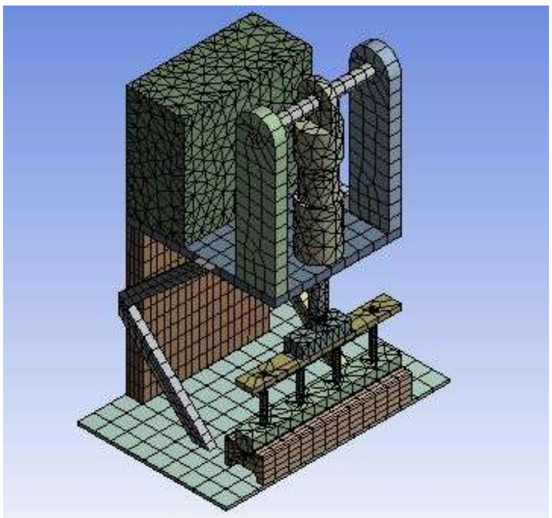


Fig. 8. Mesh Model

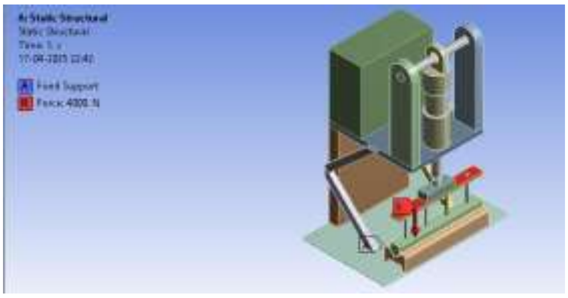


Fig. 9. Boundary Condition

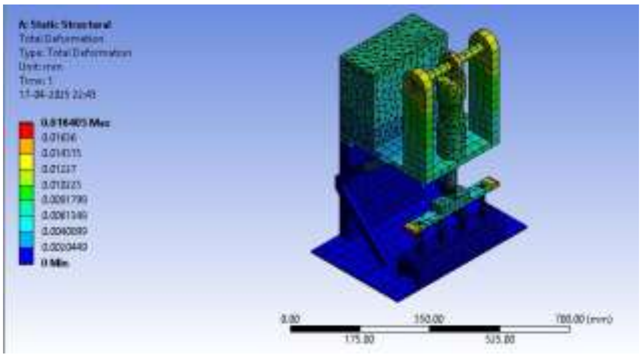


Fig. 10. Total Deformation

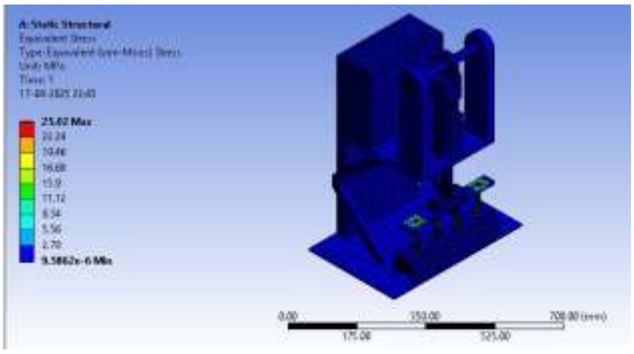
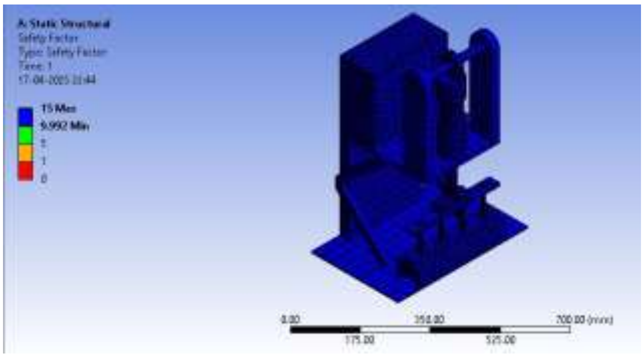


Fig. 11. Equivalent Stress



4. CONCLUSIONS

In this research, a mini hydraulic press machine was successfully designed and analyzed to meet the requirements of compactness, strength, and functionality for small-scale industrial and workshop applications. The CAD modelling process facilitated the precise development of all key components, ensuring accurate fitment and proper load distribution in the overall assembly. Structural analysis using finite element methods confirmed that the press can safely withstand the designed load of up to 70 tons without experiencing failure or significant deformation.

The maximum stress of 25.02 MPa, as shown by the simulation findings, is far less than the material's yield strength, which is normally 250 MPa for mild steel. The design is extremely robust and well within safe operating limits, as evidenced by the computed factor of safety (FOS), which was 9.92. Furthermore, there was very little deflection during operation and outstanding structural rigidity, as seen by the total deformation of only 0.018 mm.

These results demonstrate that the small hydraulic press is over engineered for its intended use, structurally robust, and able to resist applied loads with a significant margin of safety. The design works well for jobs like punching, shaping, and pressing in small workplaces or classrooms.

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