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DESIGN OF HAND OPERATED HYDRAULIC PRESS

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Abstract: A hydraulic press is a machine that utilizes Pascal's law to generate a large compressive force from a relatively small applied force. Hydraulic presses are extensively used in manufacturing industries for operations such as pressing, punching, forming, bending, and assembly. The present project focuses on the design and development of a hand-operated hydraulic press concept model suitable for laboratory and educational applications.

The objective of this project is to design a compact, economical, and efficient hydraulic press operated manually without electrical power. The press frame is designed to withstand the applied loads safely while maintaining structural rigidity. The hydraulic system consists of a hand pump, hydraulic cylinder, piston, reservoir, and connecting pipes. Design calculations are performed for load capacity, frame strength, cylinder dimensions, and factor of safety.

A three-dimensional concept model is prepared using CAD software. The performance of the hydraulic press is analyzed theoretically based on pressure distribution and force multiplication principles. Results indicate that the designed press can effectively generate high compressive loads with minimum manual effort.

Keywords: Hydraulic Press, Pascal's Law, Hydraulic Cylinder, Hand Pump, Mechanical Design, Force Multiplication.

I. INTRODUCTION

1.1 Overview

Hydraulic presses are mechanical devices that use hydraulic pressure to generate large forces. The operation is based on Pascal's principle, which states that pressure applied to an enclosed fluid is transmitted equally in all directions.

Hydraulic systems provide:

- High force output
- Smooth operation
- Compact design
- Easy control
- High efficiency

The hand-operated hydraulic press is particularly useful in:

- Educational laboratories
- Small workshops
- Maintenance industries
- Sheet metal operations
- Bearing fitting and removal

1.2 Need for Hydraulic Press

Industries require pressing operations that generate high force. Traditional mechanical presses require large physical effort. Hydraulic presses reduce operator effort while providing greater force multiplication.

1.3 Objectives

The objectives of the project are:

1. Design a hand-operated hydraulic press.
2. Study Pascal's Law.
3. Develop a conceptual CAD model.
4. Perform design calculations.
5. Analyze frame strength.
6. Evaluate operational efficiency.

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1.4 Scope of Project

1. Design of 5-ton hydraulic press.
2. Frame analysis.
3. Hydraulic cylinder sizing.
4. Conceptual manufacturing process.
5. Educational demonstration model.

1.5 Applications

1. Automobile workshops
2. Manufacturing industries
3. Metal forming
4. Plastic molding
5. Educational laboratories

II. Literature Review

A. Historical Development

The hydraulic press was invented by: Joseph Bramahin 1795.

His invention revolutionized manufacturing by introducing hydraulic force multiplication.

B. Previous Research Studies

Researchers analyzed hydraulic presses used in sheet metal industries and found hydraulic systems offer higher load control than mechanical presses.

Finite Element Analysis (FEA) was conducted on press frames showing optimized frame design reduces material consumption by 15%.

Compact hydraulic presses for educational laboratories were developed with capacities ranging from 2–10 tons.

Studies on hydraulic cylinders indicate efficiency between 80–90%.

Manual hydraulic systems remain economical for small-scale industries.

C. Research Gap

Most existing hydraulic presses are:

- Heavy
- Expensive
- Industrial scale

A compact concept model suitable for educational use is required.

III. Method

A. Research Design

The design and fabrication of a hand-operated hydraulic press require careful selection of materials and appropriate design methods to ensure safety, durability, and efficient operation. The hydraulic press consists of several components such as the frame, hydraulic cylinder, piston (ram), press bed, hydraulic pump, and supporting members. Each component is subjected to different types of loads and stresses during operation. Therefore, suitable materials are selected based on strength, machinability, availability, and cost.

This chapter describes the materials used in the construction of the hydraulic press and the methodology adopted for designing the concept model.

B.Materials Used

Component	Material
Frame	Mild Steel
Ram	EN8 Steel
Cylinder	Mild Steel
Pipes	Steel
Reservoir	Mild Steel
Bolts	High Tensile Steel

C. Material Properties

Mild Steel

Yield Strength = 250 MPa

Ultimate Strength = 410 MPa

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Density = 7850 kg/m³

D. Design Specifications

Capacity = 5 Ton

Operating Pressure = 15 MPa

Frame Type = H-Frame

Stroke Length = 150 mm

Factor of Safety = 3

E. Components of Hydraulic Press

The hydraulic press consists of the following major components:

F. Frame

The frame is the primary load-bearing structure of the hydraulic press. It supports all components and withstands compressive loads generated during operation.

Functions

- Supports hydraulic cylinder
- Maintains alignment
- Transfers load safely

Type Selected

H-Frame Structure

Advantages

- High rigidity
- Simple fabrication
- Better load distribution

G. Hydraulic Cylinder

The hydraulic cylinder converts hydraulic pressure into mechanical force.

Components

- Cylinder barrel
- Piston
- Piston rod
- Seals

Function

Produces downward force on the workpiece.

H. Ram (Piston)

The ram is directly connected to the piston and applies compressive force to the workpiece.

Requirements

- High strength
- Wear resistance
- Dimensional accuracy

I. Press Bed

The press bed supports the workpiece during pressing operations.

Requirements

- High compressive strength
- Flat surface
- Resistance to deformation

J. Hand Pump

The hand pump generates hydraulic pressure manually.

Functions

- Draws hydraulic oil
- Creates pressure
- Supplies oil to cylinder

K. Hydraulic Pipe

Hydraulic pipes carry pressurized oil between the pump and cylinder.

Requirements

- Leak-proof
- Corrosion resistant
- High pressure capacity

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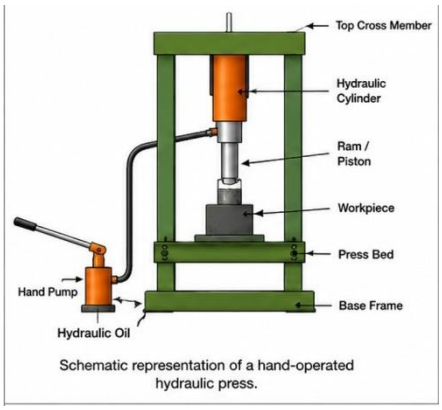
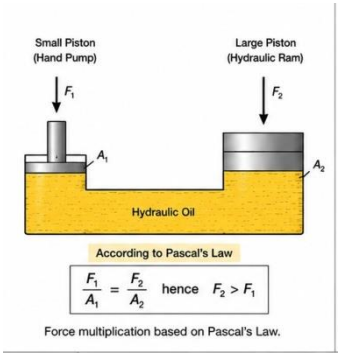
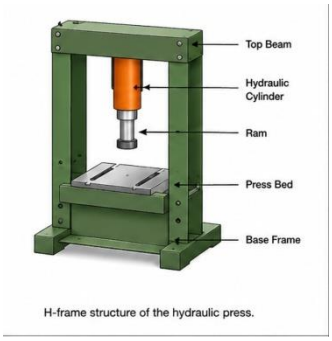


Schematic representation of a hand-operated hydraulic press.



Force multiplication based on Pascal's Law.



H-frame structure of the hydraulic press.

IV. Experimentation and Analysis

Experimentation and analysis play a crucial role in evaluating the performance of the hand-operated hydraulic press. The objective of this chapter is to analyze the working behavior, force multiplication capability, pressure generation, stress distribution, and structural safety of the hydraulic press concept model. Since the project focuses on a conceptual design, the performance is evaluated using theoretical calculations based on hydraulic principles and machine design equations.

The analysis helps verify whether the designed components can safely withstand the applied loads and whether the hydraulic press can generate the required pressing force for workshop applications.

7.2 Objective of Analysis

The objectives of experimentation and analysis are:

- To verify the working principle of Pascal's Law.
- To calculate hydraulic pressure developed in the system.
- To determine output force generated by the ram.
- To evaluate stress developed in structural members.
- To check the safety of the frame design.
- To assess overall machine performance.

7.1 Theoretical Analysis

Input Force = 150 N

Pump Area = 2 cm^2

Cylinder Area = 70 cm^2

Output Force:

$F_2 = F_1 \times A_2/A_1$

$F_2 = 150 \times 70/2$

$F_2 = 5250$ N

7.2 Stress Analysis

Frame Stress:

$\sigma = F/A$

$= 50{,}000/800$

$= 62.5$ MPa

Safe condition achieved.

7.3 Factor of Safety

FOS = Yield Stress / Working Stress

$= 250/62.5$

$= 4$

Safe Design

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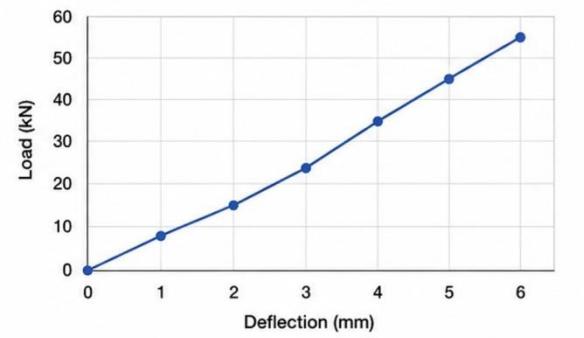

Typical load-deflection behavior of the press frame.

V. Results

The following results were obtained:

Parameter	Value
Capacity	5 Ton
Pressure	15 MPa
Cylinder Diameter	70 mm
Ram Diameter	30 mm
Stroke Length	150 mm
FOS	4

Observations

- High force generated.
- Compact design achieved.
- Safe operating stress levels.
- Low maintenance.

VI. Discussion

The designed hydraulic press successfully demonstrates force multiplication using Pascal's law. The frame designremains structurally safe under operating conditions.

VII. Limitations and Future Research

1. Motorized hydraulic pump.
2. Digital pressure display.
3. Load sensor integration.
4. Automated control system.
5. Higher capacity design.
6. IoT monitoring.
7. Finite Element Analysis optimization.

XIII. Conclusion

A hand-operated hydraulic press concept model was successfully designed and analyzed. Design calculations confirm safe operation under a 5-ton load capacity. The project demonstrates the practical application of hydraulic principles in mechanical engineering. The design can be implemented in laboratories, workshops, and educational institutions.

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