Design and Fabrication of a Compression Moulding Machine

PROJECT REPORT

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Mechanical Engineering

SUBMITTED BY

Abhishek Mishra – 20213075

Mechanical Engineering Department
MOTILAL NEHRU NATIONAL INSTITUTE OF TECHNOLOGY ALLAHABAD
PRAYAGRAJ - 211004, INDIA

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एक संपीड़न मोल्डिंग मशीन का डिजाइन और निर्माण

प्रोजेक्ट रिपोर्ट

की डिग्री के पुरस्कार के लिए आवश्यकता की आंशिक पूर्ति में प्रस्तुत किया गया

प्रौद्योगिकी स्नातक

मैकेनिकल इंजीनियरिंग

द्वारा प्रस्तुत किया गया

अभिषेक मिश्रा- 20213075

यांत्रिक इंजीनियरी विभाग

मोटिलाल नेहरू नेशनल इंस्टीट्यूट ऑफ टेक्नोलॉजी इलाहाबाद प्रयाग्राज 211004,भारत

मई 2025

Candidate's Declaration

We hereby certify that the work which is being presented in the project report entitled *"**Design and Fabrication of Compression Moulding Machine**"* in partial fulfillment of requirements for the award of degree of Bachelor of Technology in in Mechanical Engineering Department at MOTILAL NEHRU NATIONAL INSTITUTE OF TECHNOLOGY ALLAHABAD is an authentic record of our work carried out during a period from August 2024 to December 2024 under the supervision of **Dr. Binayak Nahak**, Associate Professor, MNNIT .The matter embodied in the thesis has not been submitted to any other University / Institute for the award of any degree.

Signature of the Students

Abhishek Mishra – 20213075

This is to certify that the above statement made by the candidates is correct to the best of my knowledge.

Date: Dr. Binayak Nahak

Place: Assistant Professor

Acknowledgements

I would take this moment to express our heartfelt thanks for all the mentorship, motivation, and support that we have received over the period of our project, ***"Design and Fabrication, of a Compression Moulding Machine."*** This project has provided us with a very rich experience of learning, and we would not have completed it without the contributions of many individuals and organizations.

I begin by placing on record my deep sense of gratitude to **Dr. Binayak Nahak**, Assistant Professor in the Department of Mechanical Engineering at MNNIT Allahabad, for the constant guidance, helpful criticisms, and insightful suggestions that made the whole exercise possible. Their expertise and encouragement inspired me to work with perfection in each phase of the research work.

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Abhishek Mishra-20213075

Abstract

This project centers on the plan and creation of a bottle cap utilizing the compression molding prepare with a thermoplastic fabric. Compression molding may be a broadly utilized fabricating method for creating strong plastic components beneath warm and weight. The objective of the venture is to get it and execute the total workflow from shape plan and fabric choice to the real shaping process using a custom form setup and a 3-ton pressure driven jack. Key handle parameters such as molding temperature (180 °C), weight (5 MPa), and cooling time were optimized for productive forming and cementing of the bottle cap. Due to drive restrictions of the jack, the form measure and weight were carefully calculated to stay inside secure working limits. The venture too highlights security safety measures, challenges faced, and potential advancements for future cycles. The ultimate yield illustrates the possibility of low-cost, small-scale compression molding for plastic item fabricating.

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Chapter 1

1.1 Introduction

Compression molding is a venerable and common molding method for thermosetting plastics. It also finds use in rubber tires and other polymer matrix composite parts. The procedure for a TS molding compound, referred to as the charge, into the bottom half mold; (2) closing the mold halves together compressing the charge, causing it to flow and meeting the shape of the cavity; (3) charging the hot mold to polymerize and cure the material into a solidified part; and (4) opening both mold halves and ejecting the part from the cavity (Refer Figure 1.1). The primary molding compound appears in different forms like powders or pellets, and fluid structure. The polymer exist in its form to maintain the consistency in manufacturing of product structure. It is essential to preheat the raw material before its position into the mold; this softens the polymer and decreases the production life span.

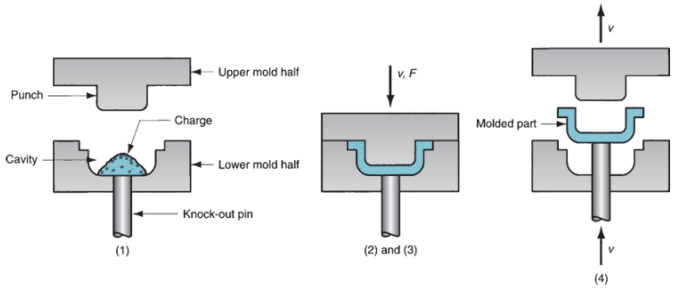


Figure 1.1: Compression Moulding Machine

This is one process that's helpful when it comes to turning pre-impregnated intermediate products into semi-structural and structural composite components. It's also key for developing fibrous materials that have been impregnated with thermoset and thermoplastic matrices. Not only

Figure 1.2 :Typical Compression Moulding Machine

that, but compression molding is a great process for companies looking to cut costs, minimize waste, and make numerous products. Compression molding is also better suited for manufacturing certain part geometries, such as thick walls.

Initially developed for making composites for replacing metal , compression molding is used to make plane or reasonably curve products .Method is widely used for making motorized parts. The material which is required to be molded are put in the mold cavity and the heated platens are closed by hydraulic ram .This molding process is unique in that it employs thermoset plastics, which either take the form of granules or pre-formed shapes. These materials are normally weighed precisely and pre-heated prior to molding. This process is significant inasmuch as it initiates the

chemical reaction that provides thermosets with their final heat-resistant and strong form—something that differentiates this process from most other molding processes.

1.2 Problem statement

With the developing requirement for low-cost and feasible fabricating strategies within the plastic bundling industry, there's a demand for proficient methods to create straightforward plastic components such as bottle caps. Infusion molding, although common, requires costly molds and complex apparatus, making it less reasonable for small-scale or prototype-level production.

This extension addresses the challenge of planning and fabricating a cost-effective compression molding setup employing a manual water-powered press to fabricate plastic bottle caps from thermoplastic materials. The center is on optimizing prepare parameters, such as temperature, weight, and molding time to guarantee great dimensional precision, surface finish, and fabric execution, while utilizing open assets and negligible vitality input.

1.3. Objective:

The objective of this extend is to plan and manufacture a bottle cap utilizing the compression molding handle with a manual pressure driven press. The venture points to:

1. Select a reasonable thermoplastic fabric for molding.
2. Design and machine the form and pass on for bottle cap geometry.

3. Establish ideal handle parameters such as molding temperature, weight, and time.
4. Demonstrate the possibility of creating plastic parts employing a low-cost, small-scale compression molding setup.
5. Evaluate the ultimate item based on shape exactness, surface wrap up, and basic astuteness.

1.4 Scope of Project

This venture centers on the plan, creation, and testing of a plastic bottle cap utilizing the compression molding prepare. The scope includes:

- **Material Determination:** Choosing a reasonable thermoplastic fabric (e.g., polypropylene) based on properties such as dissolution temperature, accessibility, and reusability.

- **Mold and kick the bucket Plan:** Making a straightforward form geometry appropriate for manual operation utilizing standard machining tools.

- **Machine Setup:** Utilizing a manual pressure-driven press (up to 3 tons) for applying the essential drive amid the molding process.

- **Process Parameter Ponder:** Testing with different temperatures, weights, and molding times to decide ideal values for quality output.

- **Fabrication and Testing:** Creating the cap and analyzing its dimensional precision, surface wrap up, and useful performance.

- **Feasibility for Small-Scale Generation:** Illustrating the utilization of low-cost and energy-efficient fabricating strategies that may well be utilized in educational labs or bungalow industries.

- **Safety and Natural Contemplations**: Distinguishing essential security measures and assessing the recyclability of thermoplastics utilized.

Chapter 2

2.1. Literature Review

The manufacturing of plastic parts through compression molding has been widely recognized as a cost-efficient and dependable technique, particularly for thermosetting materials. Nevertheless, as the demand for environmentally friendly and efficient manufacturing techniques grows, the utilization of thermoplastics in compression molding has received renewed interest. This chapter offers an overview of the existing literature and research on the process, materials, and applications involved in compression molding for plastic product manufacturing.

2.2. Overview of Compression Molding

Compression molding is a manufacturing technique that involves heating polymer material, placing it in a heated mold cavity, applying pressure to compress it, and subsequently cooling it to create a solid component. Originally designed for thermosets, this technique has been modified for thermoplastics such as hdpe and pp, particularly in prototyping and small-scale production due to its simplicity and cost-effectiveness. According to pozza (2020), although compression molding has experienced a decline in popularity for large-scale production, it still holds value for certain applications and materials where simplicity and affordability are key considerations [1].

2.3. Material Selection

Materials like high-density polyethylene (hdpe) and polypropylene (pp) are frequently employed in the production of bottle caps because of their recyclability, mechanical strength, and ease of processing. Unlike thermosets, thermoplastics do not need a chemical reaction to solidify,

but rather, they become solid when cooled. Pozza's research emphasizes the benefits and drawbacks of employing pa12 and composites in compression molding, underscoring that factors like filler dispersion and cooling conditions play a crucial role in determining the quality of the final product.

2.4. Process Variables.

In compression molding, important factors to consider are the molding temperature, pressure, material charge, and cooling time. By effectively managing these variables, it is assured of consistent product quality and dimensional accuracy. According to the literature, the recommended molding temperatures for hdpe typically fall between 160 and 200 degrees Celsius, with pressures ranging from 3 to 10 megapascals, depending on the part's shape and the material used. Pozza's comparative analysis encompassing sls, injection molding, and compression molding revealed that compression molding could achieve similar mechanical performance when process parameters were carefully managed.

2.5. Utilization In Economic and Labor-Intensive Setups.

In recent years, there has been a focus on engineering education and small-scale manufacturing, particularly in manual compression molding setups that utilize hydraulic jacks or presses. These setups are particularly beneficial for testing prototypes, evaluating materials, and manufacturing in environments with limited resources. Although industrial presses provide automation and precision, manual setups, such as the one used in this project with a 3-ton jack,

showcase that functional parts like bottle caps can still be manufactured with reasonable accuracy and finish.

Figure 2.1: Compression Molded rubber boots

2.6. Uses of compression molding.

Compression molding is extensively utilized in the automotive, aerospace, and consumer goods sectors because of its simplicity, affordability, and capability to create intricate shapes with consistent material distribution. It is particularly well-suited for producing fiber-reinforced polymer composites, panels, enclosures, caps, and housings. Natural fiber polymer composites (nfpcs), owing to their lightweight, biodegradability, and strength, are being manufactured using compression molding. Chauhan *et al.*, (2021) highlighted its suitability for recycling thermoplastics reinforced with natural fibers, particularly in the production of automotive battery covers and other large components. When it comes to smaller plastic parts like bottle caps,

compression molding provides a cost-effective solution, especially in situations where tooling expenses or production quantities are minimal.

2.7. Analysis of Compression moulding Process.

Numerous studies have been conducted to enhance compression molding processes, aiming to enhance product quality and minimize defects like warpage or short shots. The results of their research indicated that the temperature at which the plastic melted had the most significant impact (48.12%), followed by mold temperature, compression time pressure. The ideal conditions determined were a melting temperature of 180 °c, a mold temperature of 60 °c, a compression time of 60 s, and a pressure of 2.12 kn. Selamat *et al*., discovered that pineapple fiber-pp composites achieved their highest tensile strength at 175 °C and 4 minutes of compression, confirming the effectiveness of taguchi doe for natural each process parameter, facilitating improved control over part quality during compression molding. size of the fibers and the temperature fiber composites. Shekeil and his colleagues conducted experiments to improve the manufacturing process of kenaf-reinforced polyurethane composites. They impact of these studies emphasize the significance of parameter optimization, particularly when working with composite materials or recycled thermoplastics. It was found that the during processing had a significant impact on the strength of the final product. Numerous researchers have employed anova and s/n ratio analysis to statistically assess the strength of the product.

Chapter 3

Project Work

3.1. Selection of Materials and Bottle cap design:

Due to easy liquefying and processing, thermoplastics plastic were used as raw material for production purpose. Generally, thermoplastics provides consist characteristics of resistance, strength, ease of processing, and stability. On the basis of good properties, numerous thermoplastics materials such as Polytetra-fluoroethylene, Polyether Ether Ketone, Nylon, Fibers were selected for the manufacturing of different product as per customer requirement. type and number of cavities they have. They have been classified into three types: single-cavity mold, dedicated multiple-cavity mold, and family multiple-cavity.

3.2. Single-cavity Mold

One of the simplest mold concept is the single mold cavity. It is only used to produce a single part in one production cycle. The mold design is simple, and the cost is low. This mold is ideal for low-volume production and large plastic part designs.

3.3. Materials Used For Die-

In this current fabrication of compression molding machine, carbon steel was selected as mold material because of its strength,durabilty, toughness and good compressive strengthe.

3.4. Self Fabricated Compression molding machine:

In figure 3.1 and 3.2, it showing the fabricated machine with its different parts and the CAD design of the prototype with labelled parts . The machine has various components such as die , jack , heater, frame and battery.

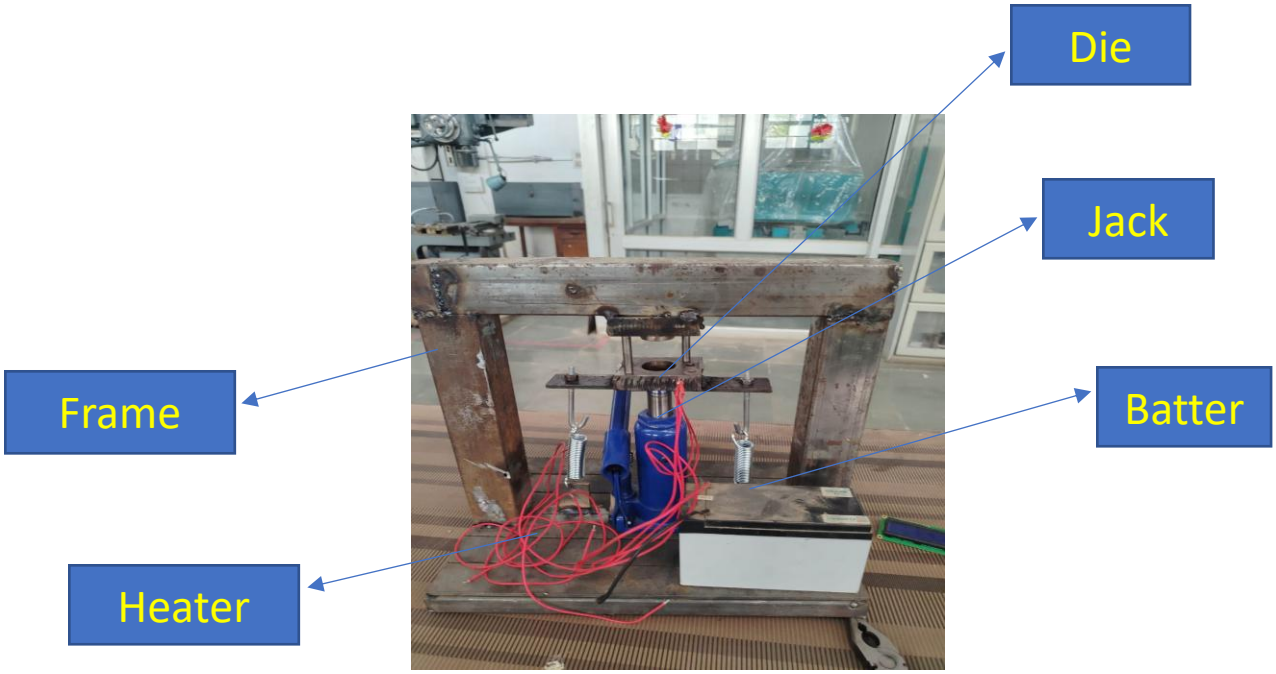
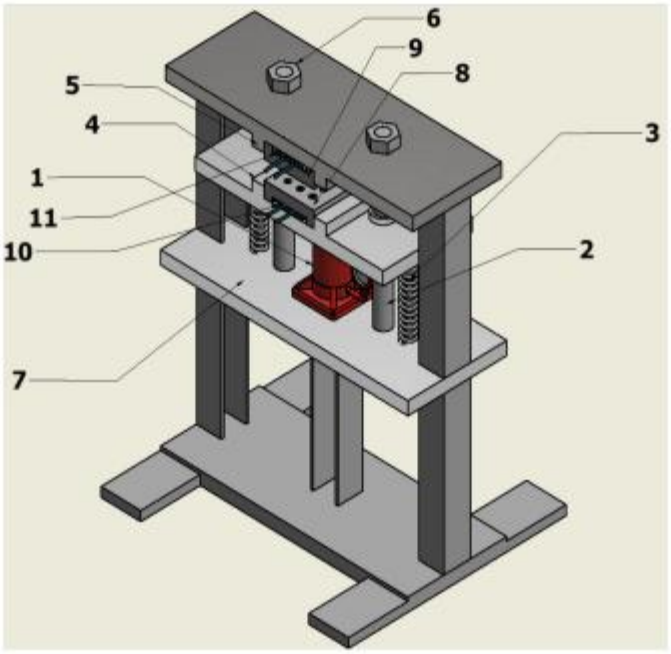


Fig. 3.1 Self-fabricated Machine



Note: 1. Bottle jack with 2 Ton pressure gauge; 2. Shaft; 3. Spring; 4. Bottom mold holder; 5. Top mold holder; 6. Locking Bolts Shaft; 7. Tables; 8. Bottom mold; 9. Top mold; 10. Bottom mold heater; 11. Top mold heater

Fig. 3.2 Proposed CAD Model

3.5. Process Parameters

Molding Parameters	Values
Mold temperature (°C)	180
Heating rate (W)	80
Holding time (min)	6
Molding load (kN)	2.12
Cooling rate (W)	30-50

3.5. Machine Parts and their specifications

Part Name	Values
Cartridge Heater(X2)	80 W , 12V
Hydraulic Jack	3 Ton
Frame	25 X 30 cm
Battery	12 volt
Die	7.5 X 3 cm

3.6. Calculations

- Moulding Pressure(Mpa) : 3 -10 Mpa = 3 Mpa
- Moulding Force (N) : PXA

Area of Cross Section = πxD^(2)/4 = 7.07cm^2

Force = Pressure X Area = 2.12 kN (<3)

3.7. Fabrication Steps

1) Fabrication of Frame : The frame was fabricated by using CS steel strips and rectangular cross section steel pipes .

2) Fabrication of Die and Punch : Two rectangular HSS blocks were taken .One was bored for making die and the other was welded with cylindrical specimen for punch .

Figure 3.3 Die

Figure 3.4 Punch

3) Attaching Guide Pins : Two pins were attached for alignment during compression process .

4) Integrating the Machine : The jack , frame , base and the die – punch were fitted together with the help of screws and fasteners and welded .

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