DESING AND FABRICATION OF SINGLE SCREW EXTRUDER MACHINE

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ABSTRACT

The project titled "Design and Fabrication of Single Screw Filament Extruder Machine" aims to develop an efficient, cost-effective system for producing thermoplastic filaments used in 3D printing applications. The single screw extruder is a widely used machine in the plastic processing industry for converting raw polymer granules into a continuous, uniform filament. This project focuses on designing and fabricating a single screw filament extruder machine capable of producing filaments of various diameters with a consistent quality.

The key components of the extruder include the hopper, screw, barrel, heating zones, die, and puller system. The screw is designed to provide efficient melting and mixing of the polymer granules while ensuring uniform extrusion. The heating zones control the temperature of the material to prevent degradation while allowing for optimal extrusion. A precision die is used to form the filament, which is then cooled and wound into spools by the puller system.

The machine's design considers factors such as material throughput, temperature control, energy efficiency, and ease of operation. The fabrication process involves machining, assembly, and testing of the components to ensure that the extruder meets the required performance specifications.

This machine provides a practical solution for small-scale production of 3D printing filaments, allowing hobbyists and small businesses to manufacture their own filament at a lower cost. Additionally, it opens opportunities for research and development in the field of filament extrusion and 3D printing.

Key Words: Single screw, filament, PLA, Temperature control

1.INTRODUCTION

Due to the large scope of 3D printing this technology has experienced in the recent decades a great development. The access to 3D printers is becoming easier as the prizes are going down. Nowadays both companies and regular users can develop their own parts in a relatively simple and quickly way. That is why there is more and more interest in evolving this technology which has already revolutionized manufacturing processes. Today there are plenty options when choosing a printer and a lot of different companies that manufacture and sell these printers.

In conclusion, while PLA is often marketed as a sustainable solution to plastic waste, its potential can only be fully realized if effective recycling and reuse systems are in place. This project serves as a step toward that goal by demonstrating how localized PLA recycling can be achieved using relatively simple tools and techniques. Through this effort, we aim not only to reduce waste but also to inspire more sustainable practices within the growing 3D printing community.

2.LITERATURE REVIEW

In contrast, open-source projects like Precious Plastic and Recycle Bot provide more affordable and customizable alternatives. These DIY systems aim to empower users to recycle plastic at a local level. However, they often face technical limitations, such as inconsistent filament diameter, lack of real-time temperature feedback, and inadequate control over the extrusion process. These shortcomings can result in poor-quality filament that may clog printers or produce unreliable prints.

The behavior of PLA during extrusion further underscores the importance of precise thermal and mechanical control. PLA is sensitive to both under- and overheating, and its flow characteristics require a consistent, torque-driven feed mechanism to avoid jamming or inconsistencies in the extruded filament.

I. A.I. Vakis a [1]

Polymer extrusion is considered one of the key processes in product processing nowadays, and its optimization is considered of the utmost importance in order to deliver proper products minimizing the use of resources. This paper presents the first part of a complete CFD study of a 3D single screw extruder model.

II. W.R. Leal de Silva [2]

This paper aimed at Design and Development of metallic 3D printer. The main focus is design the basic analysis of present 3D printers, their parts and mechanism. The requirements that are of metallic 3D printer and its applications. The study on design of 3D printer involves suitable for working of 3D printer. 3D printing machine is designed and developed with different parts like extruders, nozzle, stepped motors, Teflon tube etc., which are assembled, tested and also printed some objects. The development involves the preparation of the filament that could print the metallic object.

3.PROJECT OBJECTIVES

1. Temperature Control:

Design an effective heating and cooling system to maintain optimal processing temperatures throughout the extrusion process.

2. Screw and Barrel Optimization:

Optimize screw geometry and barrel design for maximum throughput, proper mixing, and reduced energy consumption.

3. Design Efficiency:

Develop a cost-effective and efficient single screw extruder machine capable of continuous plastic (or material-specific) extrusion with consistent output.

4. METHODOLOGY

I. Design Finalization:

The first step involves developing a comprehensive 3D model of the filament extruder using CAD software CATIA V5. This allows precise visualization of all components including the hopper, barrel, screw, motor mount, and spooling system. It enables designers to conduct virtual simulations and mechanical interference checks, ensuring proper alignment and space optimization. Adjustments to geometry and fit can be made at this stage before any materials are procured. Finalized CAD drawings also serve as reference for fabrication and assembly.

II. Material Procurement:

Once the design is finalized, the necessary materials and components are sourced based on the design specifications. This includes PLA pellets, high-torque DC or geared motors, nichrome heating coils, thermocouples, an aluminum or stainless-steel barrel, and supporting structural elements. Quality and compatibility are major criteria for selection to ensure long-term system reliability. Sensors, wires, insulation, and electronic controllers are also procured during this phase. Each item is verified for its specifications such as size, voltage, current rating, and material properties.

III. Testing:
After assembly, an initial test is conducted using a small quantity of PLA pellets to evaluate system performance. Parameters such as filament extrusion rate, dimensional accuracy (typically 1.75 mm or 2.85 mm), surface smoothness, and flow consistency are monitored. The system is fine-tuned based on observed results, such as adjusting motor speed or heater setpoints. Tests also help identify mechanical issues like vibrations, blockages, or uneven heating zones. Data from these trials informs calibration and performance optimization.

5.CONCEPTIONAL DESIGN

In the initial stage, the filament extruder is distinguished in many parts where some parts like extrusion components, heating elements and electronic devices are fixed. The designable parts include the structure material, coupling mechanism, hopper mount and housing design are listed as different options in the concept generation and concept evaluation. Based on the past studies of filament extruder, there are some critical factors that must be determined to build a valuable extruder compared to the available products in the market. The cost rating is related to the material selection and the manufacturing process for the extruder and must be low cost. The safety of the extruder is also important where the strength of the material and stability will be considered.

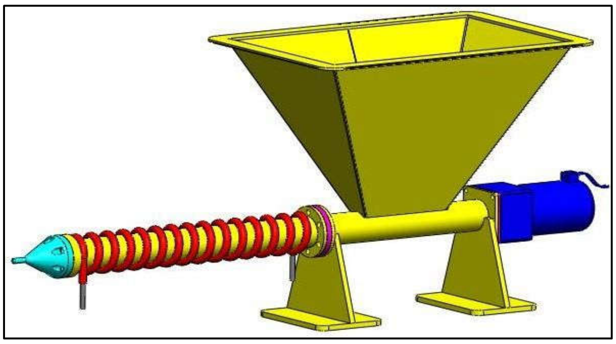

Fig1: Plastic Injection Assembly

6.DESINGN CALCULATIONS

DESINGN OF BARREL

Inside Volume of barrel = Vi= 114298.9mm^3

Total volume= V = 22868mm^3

Outside volume of barrel= Vo = 137106.95mm^3

SCREW DESIGN

Helix angle=13.42^0

Clearance =4mm

DC MOTOR TORQUE

Torque, T=68.68 N-mm

DESIGN OF HOPPER

Area of hopper= 28125mm^2

7.MANUFACTURING PROCEDURE

WORKING PRINCIPLE

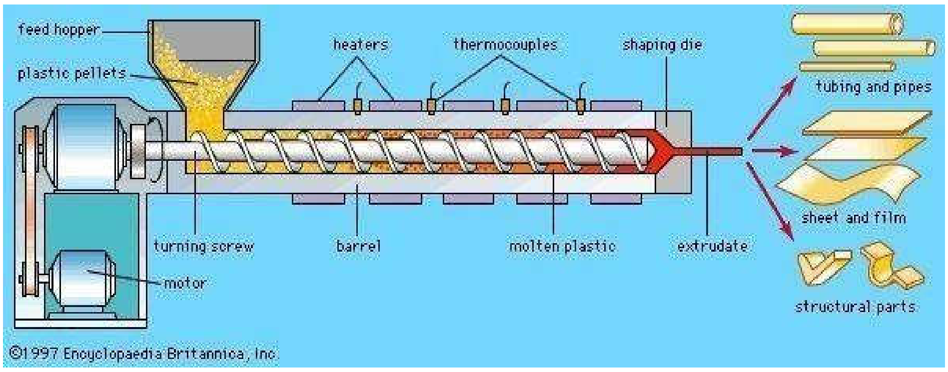

Fig:2:Working Principle – Line diagram

The PLA pallets will get soften and melt because of the heat from heating band that is evenly distributed by using asbestos ribbon and are then pushed mechanically through a die. Pushing the soft ABS through the die will cause it to form a continuous filament strand with the diameter of die.

Screw is used to control the flow and strainer is used to smoothen the flow. Air fan cool down mechanism is used to cool down the filament after coming from the die. The filament will be stretched out of die till the end wheel and it will be rolled using 12 V DC motor.

MATERIAL SELECTION

HOPPER:

Fig:3: Hopper

The hopper is constructed from **stainless steel** to ensure durability, resistance to heat, and ease of cleaning.

SCREW CONVEYOR:

Fig:4: Screw Conveyor

The screw is designed with an increasing pitch, which gradually compresses the PLA pellets as they move along the barrel.

MOTOR:

Fig:5: Motor

A geared motor operating at around 100–200 RPM is chosen to provide high torque at low speeds, which is essential for pushing the viscous molten PLA through the barrel. The motor's power is crucial for maintaining a steady feed rate and avoiding jams.

8. PRODUCT TESTING AND RESULT DISCUSSION

Fig:6 Material Output

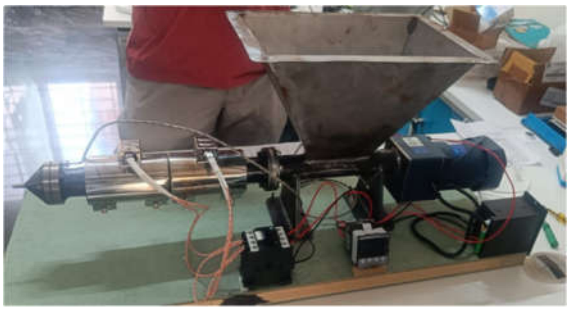

Fig:7 Single Screw Extruder Machine

After assembly, an initial test is conducted using a small quantity of PLA pellets to evaluate system performance. Parameters such as filament extrusion rate, dimensional accuracy (typically 1.75 mm or 2.85 mm), surface smoothness, and flow consistency are monitored. The system is fine-tuned based on observed results, such as adjusting motor speed or heater setpoints. Tests also help identify mechanical issues like vibrations, blockages, or uneven heating zones. Data from these trials informs calibration and performance optimization.

9.PRODUCT COST EXPENDITURE

Table 1: Product Cost Expenditure

Particulars	Amount in Rs
Wages of Labour	5000
Cost of Materials	15000
Cost of Machinery	8000
Electricity and Water Charges	3000
Maintenance Charges	2000
Miscellaneous Charges	2000
Total Cost Expenditure	**35000**

11.CONCLUSION

In conclusion, the PLA Pallet to Filament Maker is a valuable innovation that not only promotes recycling but also empowers users to become self-reliant in material sourcing. It demonstrates how a relatively simple mechanical and thermal system, when carefully designed and implemented, can deliver impactful results. The project encourages a shift toward circular manufacturing in the maker community and aligns well with the global goals of sustainability, resource efficiency, and technological empowerment.

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