# Design and Development of Plastic Filament Extruder for 3D Printing

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**Abstract** - 3D printing is a form of additive manufacturing technology where a three dimensional object is created by laying down successive layers of material. It is mechanized method whereby 3D objects are quickly made on a reasonably sized machine connected to a computer containing blueprints for the object. As 3D printing is growing fast and giving a boost to product development, the factories doing 3D printing need to continuously meet the printing requirements and maintain an adequate amount of inventory of the filament. As the manufactures have to buy these filaments from various vendors, the cost of 3D printing increases. To overcome the problem faced by the manufacturers, small workshop owners, the need of 3D filament making machine arises. This project focuses on designing and fabricating a portable fused deposition 3D printer filament making machine with cheap and easily available components to draw 1.75 mm diameter ABS filament.

**Keywords:** ABS, 3D printing, Extrusion, Single Screw Extruder

## 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. But most of the 3D printer is based on the fused Deposition Method, which uses mostly PLA and ABS as the printer material. This extrusion based 3D printer uses a wired filament of diameter 1.75mm or 3mm for printing. So most of the manufacturing units, companies, colleges who have the 3D printer in-house are dependent on 3rd party supplier, and need to buy the 3D printer filament from these suppliers.

This paper will make you go through the design and development of a portable 3D printer filament making machine for small manufacturing units and colleges.

The new designed portable filament making machine should be able to make the wired filament from the plastic granules.

With the development of the portable filament making machine, the dependency of the manufacturing units and other organization on 3rd party supplier for filament will be reduced.

## 2. OBJECTIVES

1. To design and develop a plastic filament extruder for 3D printing
2. The focus was specifically on creating 1.75 mm diameter filament from ABS pellets.
3. To develop a 3D printing filament making extruder that can be used by small scale manufacturing units, companies, colleges who have portable 3D printer in-house.
4. To Perform design calculations to base the development of filament making extruder

## 3. MOTIVATION

3D printing is growing technology and is used worldwide. 3D printing requires filament to process and the cost of filament governs the cost of 3D printing product. Filament extrusion machines are usually available for industrial use, capable of creating hundreds of feet of long filament in a day. So these filaments are expensive for many end users.

This work will make easily available filament extruder to small scale industries and colleges.

## 4. EXTRUSION PROCESS

The process of extrusion is simple, and can be divided into six different processing steps:

1. Feeding
2. Melt
3. Melt conveying
4. Mixing
5. De-volatilization
6. Die forming

The extruding unit generally contains screw, barrel, heat control unit and the die, while extruding. Due to the gravitational force the resin or the plastic granules drops in the rotational screw of extruder. The screw rotates and creates friction which generates shear heat. In order to melt the plastic additional heating barrel are attached in the extruder. The electric heat control act as a thermal energy for the process. It also prevents the escaping of heat from the system by insulating the barrel radially nozzle through which molten plastic is injected through the die.

Then the molten plastic goes through the small hole which is attached with a filter and plastic has to get through in order to get rid of impurity which then passes to die for customized final product. Extrusion is a continuous process of making or manufacturing products in large scale. It is very important to keep in mind the right operating control inputs and temperature measurements for required polymers and resins. The precise and satisfied product can only be produced if every step in this process goes right. During this extrusion process, there might come many errors in final product, for example if temperature setting is not set properly or incorrectly, no matter how good resin is our product will be not as good as it should be.

## 5. Equipment Description

### 5.1 SCREW

Fig 1. (screw)

The screw plays a vital role in extruding. The screw is needed to push the material which is feed to the system from the hopper. The rotating screw pushes the granules in to the barrel. The screw is the critical part to optimize .the improper design if the screw may result instabilities and improper product result. The speed of the screw can be determined from the control unit.

The diameter we decide to work with is 5/8'' and the length is 14''. The reasons to take these measures and not any others are based basically on the fact that the screw has to be the smallest size possible without increasing very much the price. So we consider 5/8'' to be the smallest diameter with reasonable price and with precise usefulness. In addition, we choose 222/5''for the relation L/D because we consider 14'' the maximum length keeping a light screw in terms of weight, taking into account that if the relation L/D is bigger, the price will be lower. Therefore, I have defined the first parameters of our screw D =5/8'' and L=14''. Also they have been taken into account other options of diameters and length.

Helix Angle (Φ)
Also one of the first things we can determine of our extruder is the helix angle of the screw. For general purpose screws, the gap between 2 crests or the pitch (t) usually coincides with the diameter. So t=D=16mm So the helix angle is 17.65°.

### 5.2 Barrel or Cylinder

Fig 2. (Barrel)

Just as for the screw, the material chosen for the cylinder is stainless steel, for the same reasons. The cylinder must also be able to handle with high temperatures and be hard enough to resist degradation due to the friction generated between the inner face of the cylinder and the plastic flow.

The cylinder is the part in charge of keeping the material inside while going throughout the screw. For this reason, its inner diameter is the sum of the screw diameter and the clearance calculated above, to a total of 36.08 mm.

### 5.3 Die or Nozzle

Fig 3. (Nozzle)

The material most commonly used for Nozzle is S.S. because it has to withstand high temperatures. Likewise, is a good conductor of heat, quality that is needed to heat fast and uniform the nozzle as the printing material needs to be printed around 200ºC. S.S. is one of the material with best characteristics and this is why we are choosing it for the nozzle. The nozzle is also one of the most important elements of extruder, as it defines the final

shape of the plastic. Between its characteristics we are going to remark its hardness and the fact that it perfectly keeps its conditions for a long period of time. Also, it doesn't get affected by the external conditions. Its characteristics make it one of the best materials in the market but with a lower price. The die that is used is S.S. plug with 1.75mm hole.

### 5.4 Hopper

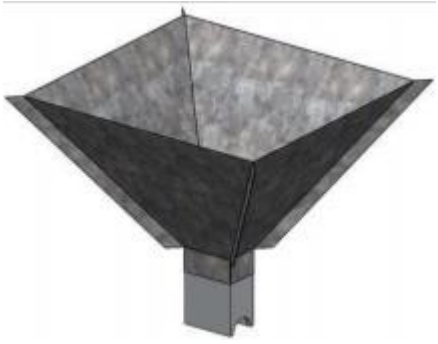

Fig 4. (Hopper)

Hopper is made up of galvanized steel sheet metal. There are no specifications for hopper design. Its size varies depending on the application or quantity of production. So the hopper design is just to fulfill the requirement of this project. Hopper is designed as gravity fed hopper. Hopper is wedge type and the flow of solid in the hopper is mass flow. It is cut and manufactured from 6"x4".

### 5.5 Power Source (Electric motor)

The motor for the system is a 150RPM geared motor with stall torque of 30 kg-cm. This motor is controlled by speed controller. This controller is wired in series with the power source from 240V AC supply and the motor. This was the simplest control system. It is a variable speed control system with the RPM is selected by varying the duty cycle.

### 5.6 Solid state Relay (SSR)


Fig 4. (SSR)

SSR is the device in which the temperature can be controlled with the help of PID. For controlling the electric circuit to maintain the temperature. The temperature can be controlled by controlling electricity. So this device acts as the gate keeper for the electricity .Which means when the temperature is insufficient the SSR will transmit electricity to the heater and when the temperature reaches the required level it cuts of the electricity with the help of PID and thermostat (Metro physics inc, 1964).

### 5.7 PID controller

PID is the device which provides the Information to SSR when to turn on and when to turn off. ID reads the temperature of any system with the help of thermostat. It functions as the input panel to the system.


Fig 5. (PID)

General-purpose of temperature controllers are used to control most typical processes in industry. Typically, they come in a range of DIN sizes, have multiple outputs, and programmable output functions. These controllers can also perform PID control for excellent general control situations. They are traditionally placed in the front panel with the display for easy operator accessibility. These controllers have a pre-tune function to initially calculate the PID temperature for a process, and a continuous tune function to constantly refine the PID temperature. This allows for quick setup, saving time and reducing waste."

### 5.8 Thermocouple

Fig 6. (Thermocouple)

The sensor which is used to measure the temperature is known as thermocouple.it consist of two wires made from different metals. When the two material are subjected to the heat, it produces some electric voltage

which determines the reading of the temperature in the system. The thermocouple are used for low cost, durable and high temperature range.

## 6. CONCLUSION

The developments in 3D printing have led to the production of objects made from materials such as plastic, metal, paper and even food. This has given end users the opportunity to explore their creativity. 3D printing is being used by universities, manufacturing companies, and everyday users as a quick method of prototyping designs, exploring the capabilities of this technology and seeking ways to improve it. Because of the quick emergence of this technology, leaps have been made towards improving manufacturing.

The development of screw extrusion will hopefully open doors to new ideas for 3d printing. Screw extrusion will allow users to have access to a wider variety of materials with a high resolution for their 3d printed parts.

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