# 3D printer filament length monitor

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**Abstract**: There have been many technological innovations. But only selective have been as revolutionary as 3D printer. It enables consumers to follow their own acquisition strategy. 3D printers has not only immersed into industrial design, footwear, engineering and construction, education but to medical application also. Although 3D printer is a great technological innovation, there still lays many problem, while operating with it. This paper focuses on the problem which is caused by 3D Printer filament. Filament is a very important and expensive part of 3D Printer. The filament is to be use carefully while printing an object in 3D Printer. This Paper will focuses on 3D Printer filament length monitor, which will update the user with the length of the filament, while printing and hence reduce the waste of filament by 90%.

**Keywords:** 3D Printer, Filament

## 1. Introduction

3D printers have the capacity to make three-dimensional solid objects from digital designs. 3D printing is also known as additive manufacturing, as 3D printing is achieved by additive process, through additive process an object is created by layer down successive layers of materials.

Charles Hull invented a printing process called Stereolithography, in 1984 [1]. Through stereolithography digital data can be turned into tangible 3-dimensional objects. Charles Hull created the first stereolithography apparatus, which created complex 3D objects from photopolymer, though it was imperfect, but was the first step to the future of 3D printing. In 2011, Dr. Adrian Bowyer founded an open source 3D printers named as Reprap[2].

Today many 3D printers have immersed into the market such as Reprap Prusa i2, Reprap Prusa i3, Flashforge, Velleman, Printrbot and many more. Many of the 3D printers have open source models, and there are many open source firmwares, available for 3D printers such as marlin, sprinter and many more. So it has become very easy to manufacture the 3D printer now. That's the reason, today 3D have transformed almost all the fields.

People are giving a 3D shape to their imagination, with the help of the 3D Printer. To shape one imagination, filaments play an important role in that, it's because of different filament only, one can think of making different types of objects according to their needs and specifications.

Filaments are available in many varieties, and each filament has different properties. Filament performance is based on properties such as toughness, durability and moisture resistant. The most common filament, that are being use by 3D printers are PLA (Polylactic acid) and ABS (Acrylonitrile butadiene styrene). ABS has high strength and is malleable at 250 degrees Celsius, whereas PLA is brittle and shiny in nature and malleable at 60 degree Celsius only [3] [4]. Hence ABS can be use in printing parts for engineering design, whereas PLA can be use in printing jewellery parts, so according to the requirement filaments are to be chosen accordingly.

No doubt filaments are expensive and in many countries like India, Bangladesh, and Srilanka, Nepal and Pakistan, the 3D printing filament is not easily available. So filaments are to be use very carefully not only in the above mentioned countries but in all countries, since the filaments like PLA, Polycarbonate, and Nylon cannot be recycled. In this paper filament length monitor will be discussed through which the wasting of filament can be saved to 90%.

## 2. Methodology

### 2.1. Overview

Whenever, we require printing an object through 3D printer, first we need to install the spool of filament into it

and then power on the 3D printer, so that 3D printer can print as many as objects one needs. Many times 3D printer stops in between the printing, this happens because of many reasons, such as power cut off and shortage of filaments, which leads to wastage of filament.

The power cut off issue can be solve by installing UPS between main power and 3D printer and the shortage of filament issue can be handled by Filament length monitor.

Filament Length Monitor will keep monitoring the length of the filament being used by the 3D printer and hence will keep updating the remaining length of the filament. According to which we can make a judgment in selecting a suitable object which can get printed completely without any shortage of filaments.

## 3. Design and Development

The device Filament length monitor is based on the Arduino Uno board. The other main components, which are being used in filament length monitor, are:

1)    Circular Bearing and Circular bearing Mount:

The role of circular bearing in the filament length monitor is to pass the filament and accordingly update the filament being used or the remaining filament available for printing.

Circular bearing of 4mm diameter is used in the device, which is mounted on the circular bearing mount as shown in the figure1 given below.
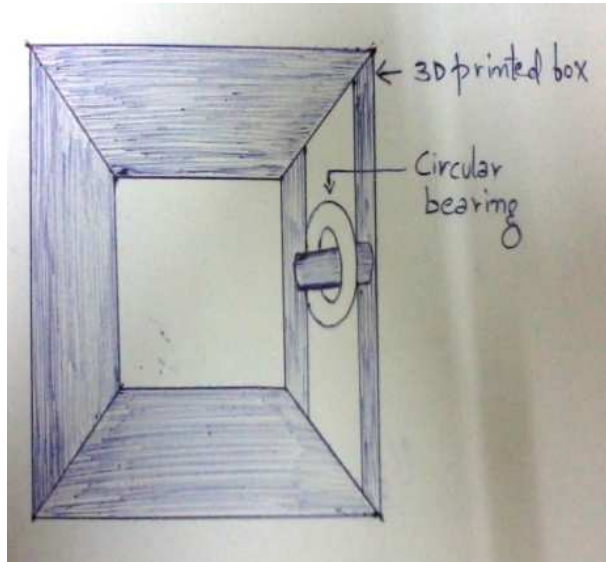


*Figure 1. Circular bearing mount*

Circular bearing mount is basically a 3D printed part, which act as a support to the circular bearing and to the screw. On one side of the circular bearing a limit switch is mounted. Which when will get pressed by a screw mounted on the opposite side of the bearing mount, will indicate the completion of one rotation and filament length will get updated. The screw and limit switch mounted on bearing mount is shown in the figure 2 as given below.
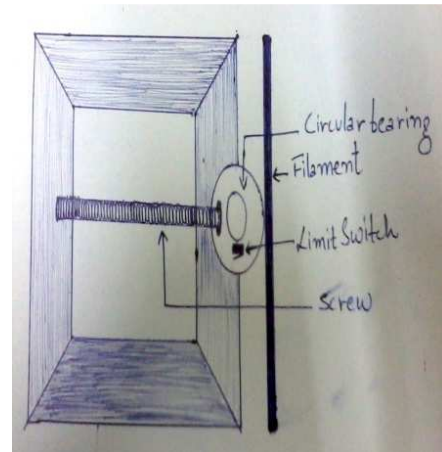


*Figure 2. Circular bearing mount connecting to screw and limit switch*

2)    Limit switch and LCD(16x2 or 20x4)

The limit switch is of 3 pins will be mounted on one side of bearing, which when will get pressed by a screw will indicate the completion of one rotation. After each rotation the length of the filament will get updated on the LCD. The lcd and limit switch both are connected to the arduino Uno board as shown in the figure 3 given below.
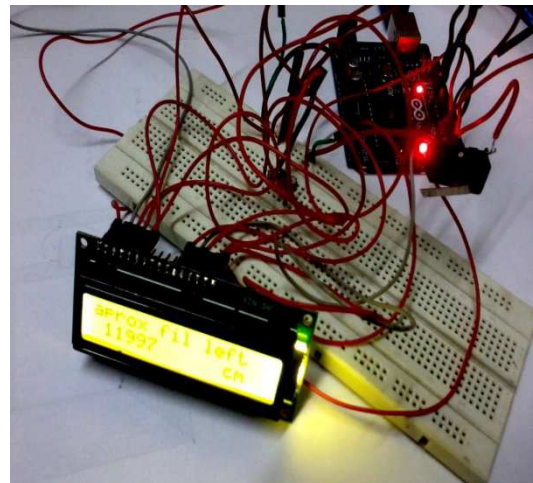


*Figure 3. Arduino Uno connected to LCD and limit switch*



*Figure 4. Closer view to the LCD of the filament length monitor*

### 3.1. Procedure

Different filament comes in different length with the spool. The filament diameter also affects the length of the filament in a given spool, since there are two different diameters of every filament that are 1.75mm and 3.00mm.

Whenever we get a filament its density, volume and weight are always given. So by taking given amount, we can calculate the approximate filament length by, using the formulas given below.

$$Radius = diameter/2 \qquad (1)$$

Diameter can be 1.75mm or 3.0mm depending upon the diameter of the filament.

$$Area = 3.1415*radius*radius \qquad (2)$$

$$Length\ of\ filament = weight / Area*density \qquad (3)$$

The length of the filament can be taken as a reference for further calculation for updating the filament available for printing.

The filament is made in contact to the circular bearing. So that when the filament will move for extruding, the circular bearing will also move along with the filament. When the circular bearing will complete one rotation (when switch will get pressed by screw, it indicates one rotation) by moving along with the filament, then the used filament can be calculated by the formula given below.

$$Circumference\ of\ bearing = 2*3.1415*radius\ of\ bearing \quad (4)$$

In the hardware, it is mentioned that 4mm diameter circular bearing is being used by the filament length monitor. So according to the calculation approximately 1cm of filament should get extruded after each rotation. Now after each rotation 1cm of filament can be deducing from the reference length of the filament, which we calculated using formula 3. The deducted filament length will act as a reference for next rotation and the LCD will keep updating the approximate filament length which is left for printing.

### 3.2. Software

The software is made open source, so that the user can make the changes in the software according to their requirement. In the software the two most common filaments is taken into account that are PLA and ABS, although the user can add more filament types to it. The main part of the program is given below.

```
//1 = 3.0mm
//2 = 1.75mm
#define size 2 // select the size according to the above table
//1= PLA
//2= ABS
#define filament 1// select the filament according to above table
int buttonPushCounter ; // counter for the number of button presses
int buttonState = 0; // current state of the button
int lastButtonState = 0; // previous state of the button
int filament_left; // current state of filament length
void setup() {
lcd.begin(16,2); // LCD type can be 16x2 0r 20x4
lcd.setCursor(0,0);
lcd.print("aprox filament left");
if(size == 1 && filament == 1)
{
filament_left = 33000;
//filament legth of 3.0mm PLA
}
if(size == 1 && filament == 2)
{
filament_left = 40000;
//filament length of 3.0 ABS
}
if(size == 2 && filament == 1)
{
filament_left = 11000;
//filament length of 1.75mm PLA
}
if(size == 2 && filament == 2)
{
filament_left = 13000;
//filament length of 1.75mm ABS
}
}
void loop() {
buttonState = digitalRead(buttonPin);
if (buttonState != lastButtonState) {
if (buttonState == HIGH) {
buttonPushCounter++;
filament_left--;
```

In the above program the reference filament length is already given for PLA and ABS for 1kg of weight, by following the standards. The filament lengths which have been referred are:

PLA
1.75mm filament length for 1kg of spool: 330m
3.00mm filament length for 1kg of spool: 1100m
ABS
1.75mm filament length for 1kg spool: 400m
3.00mm filament length for 1kg spool: 130m

The lengths of the filaments are taken in centimeter, in the program, and are taken as reference length of the filament. Now after completion of one rotation, 1cm (according to above calculation using formula 4. by taking radius of bearing as 2mm) of filament will get deduce from the reference length of the filament.

The user can make changes in the size and filaments and in the filament length, by using formula 3. The user can add more no. of filament types and according to that can add more conditions to the program given above.

## 4. Results

Filament length monitor approximately saves the filament, by updating with the filament length available for printing and according to which one can chose a suitable object to print.

It can be observed that the filament length monitor is not 100% accurate. But it can be made approximate by using the formulas given above. It can save 90% of wastage of filament, which takes places due to shortage of filament.

## 5. Conclusion & Future Scope

Filament length monitor can successfully saves the wastage of filaments by 90%. The filament length monitor can be made smarter by adding a memory card to it, through which it can, saves the amount of filament left in the memory card for further use.

## References

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