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# Design and Fabrication of 3d Printing Filament Extruder by Recycling Plastic Waste

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**ABSTRACT:** Nowadays one of the biggest drawbacks in 3D printing is the relatively high cost of filament, i.e., the 3D printer (thermo-) plastic, the “consumable” for our 3D printer. Prices for 3D printers have been continuously dropping, but filament prices did not follow the same path. Agreed, filament availability is far better than 2 or 3 years ago, as are color choices. Even the materials for 3D printing are becoming more and more varied and readily available. This is where home or desktop filament extruders come into play. Some upcoming makers/inventors have been developing a way for private individuals to produce their 3D printer plastic at home, at only a fraction of its retail price.

We have decided to develop a “filament extruder” for home use, i.e., a machine capable of extruding out plastic filament which we can afterwards use in our 3D printer. Polymer materials have been found an application in many areas of daily life and industry. Along with their extended use, the problem of plastic wastes appeared because, after withdrawal from use, they became persistent and noxious wastes. The possibility of reusing polymeric materials gives a possibility of valorization—a second life—and enables effective waste utilization to obtain consumable products. The 3D printing market is a well-growing sector. Printable filaments can be made from a variety of thermoplastic materials, including those from recycling. This paper focuses on a review of the available literature on the production of filaments for 3D printers from recycled polymers as the alternative to present approach of central selective collection of plastics.

**KEYWORDS:** 3D printing, Filament, Recycling, Polymer, Plastic, Waste management, Extruder.

## I. INTRODUCTION

The main aim of this work is to reduce the plastic waste that is rising in the present world. Plastics are one of the most versatile materials that we make use of. They are all around us, whether we are at home, at work, when we go shopping or even when we are on holiday. However, the prevalence of plastics also means that we have large amounts to then dispose of. Moreover, recycling plastic is very important,

Here are some reasons listed below that why it is necessary to recycle plastic,

1. Plastics make up a huge amount of our solid waste
2. Plastic takes ages to break down
3. Not all types of plastics can be recycled
4. Recycled plastics can be put to good use
5. Plastic recycling conserves energy and the environment

A research by Mr. Branka Vuleta, March 31, 2022, has shown that nearly 300 million tonnes of plastic waste are produced every year.

Hence to overcome this and play our part in recycling some amount of plastic waste, and to achieve this; we are designing a system incorporating a plastic extruder which plays a prominent part in recycling waste plastic into useful products. This work uses waste plastics and converts them into building materials with the help of an extruder, thereby reducing plastic waste which is a key factor for environmental pollution. Presently waste plastics are effectively converted into useful building materials like bricks, interlocks, roof tiles, railway sleepers, paving slabs, retaining blocks, etc., using either single-origin plastic waste material or a mixture of different plastic wastes along with waste



rubber powder as filler. Thermoplastics can be heated up to form products and then if these end products are re-heated, the plastic will soften and melt again. These include PET, HDPE, LDPE, PP, PVC, PS, etc. Thermoset plastics can be melted and formed, but once they take shape after they have solidified, they stay solid and, unlike thermoplastics cannot be re-melted. These include Multilayer and Laminated Plastics, Bakelite, Polycarbonate, Melamine, Nylon Etc.

The aim of this work is to review the possibility of reusing polymeric materials for 3D printing. Attention is paid to the recycling potential, existing commercial solutions, and programs related to the promotion of the idea of reuse of waste materials. The work also includes possible changes in the polymer material, which may occur during subsequent extrusions.

## II. LITERATURE SURVEY

[1] Mark D Grooms et al (2016), their project is to develop a 3d printer filament extruder at low cost with the help of the materials and components that they got the scraps and they discussed to use easily available materials to finish the entire product. They wanted to design and build an extruder that was capable of converting waste plastic as is, in the state, size and shape it was removed from 3D printer. They wanted to make this extruder from “off the shelf” components available from hardware stores or on line and built and assembled using hand tools and basic mechanical skills. Their plan was to design an extruder that has a melting pot rather than a hopper where chunks of scrap plastic can be placed to melt and gravity feed into the auger to be extruded.

[2] Rina Abdullah et al (2017), they developed an automatic temperature control system for smart tudung saji (sweet) using Arduino microcontroller which helped us to know the design behind interfacing the microcontroller and the temperature sensor equipment. This system can also be used in 3d printing filament extruder to control temperature for the extruder automatically.

[3] Mazher Iqbal Mohammed et al (2017), in this project they have researched and studied about the different types of temperatures sensors that can be used in different applications to measure the desired temperatures.

[4] Bupe G Mwanza ET AL, Plastics have appeared in our daily lives around 100 years ago; still they are indispensable materials with various properties and applications used at home, at work, traveling, or in their spare time. Plastics are extremely versatile materials, so that the possibilities of their application are virtually limitless. Their unquestionable advantage is the high mechanical strength, low density, low weight, easy processing, and low cost. Due to these features, plastics have been found applications in the production of packaging, automotive industry, electricity, construction, and transport, as well as in medicine, agriculture, or other areas. The ubiquitous plastic is a source of huge amounts of waste, the management of which is a serious problem. Global production of plastics in 2018 amounted to 359 million metric tons (in EU 61.8 million metric tons). It is predicted that this number will double over the next 20 years.

[5] Seyeon Hwang et al (2015) , in this project he had studied and analysed about the different types of materials that can be used in the filament extrusion process and their different mechanical properties that has to be consider while selecting a filament. They stated that most popular and widely used 3D printing technology is fused deposition modeling (FDM) because of its reliability, simple-to-use process, and economical price. In contrast to the other 3D printing processes, FDM requires only a heating process to extrude the materials while the other processes use more expensive and complicated techniques such as laser sintering, photo-curing, and electron beam melting. The FDM uses thermoplastic wires as the material, and a large number of thermoplastic polymers can be used in the FDM 3D printing process. Some thermoplastic suitable for 3d printing are as follows:-

- Acrylonitrile Butadiene Styrene (ABS)
- Polylactic Acid (PLA)
- Aliphatic Polyamides (Nylon)
- Polyethylene Terephthalate (PET)



III. METHODOLOGY

This setup runs on Arduino microcontroller, temperature sensors and different systems. We implemented following study throughout designing and fabricating of this setup.

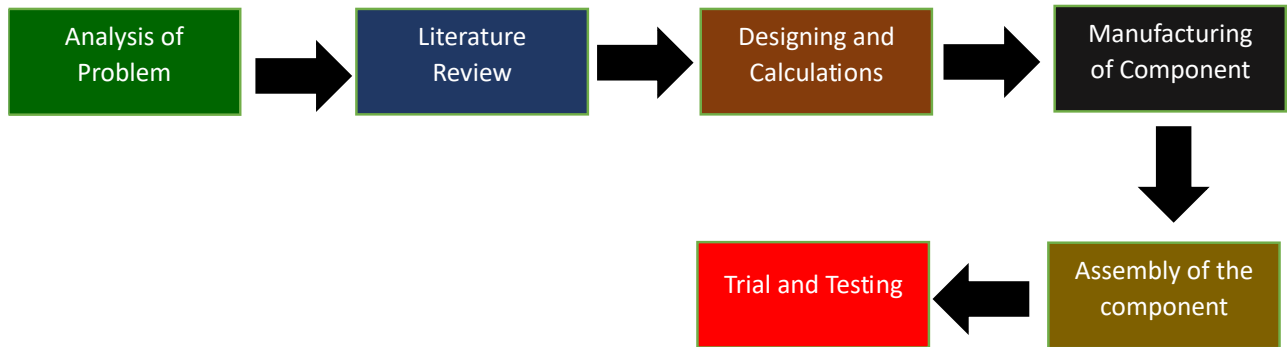


Fig.No. 3.1

IV. WORKING PRINCIPLE

3D printing filament extruder will consist of heater, nozzle, temperature sensors, Arduino, motor & spool arrangements. The device is developed in such a way that bottle strips get cut with the cutting mechanism and passes towards the heated aluminium block. Once the plastic strip reaches the aluminium block it is heated at a certain temperature of 200-250°C. After heating at certain temperature, the melted plastic passes through the nozzle of diameter 1.75mm (which is standard size of filament) in the shape of filament cooled by a cooling fan. This filament is passed towards spool and motor arrangement where filament is collected within the spool with the help of motor. The motor rotates at the lowest rpm slowly pulling and collecting the extruded filament within the spool.

The working of motor is controlled by Arduino microcontroller and temperature of heater is controlled by electronic current controller. A thermocouple is inserted in the aluminium block which detects the temperature and displays it on a LCD display with help of Arduino microcontroller.

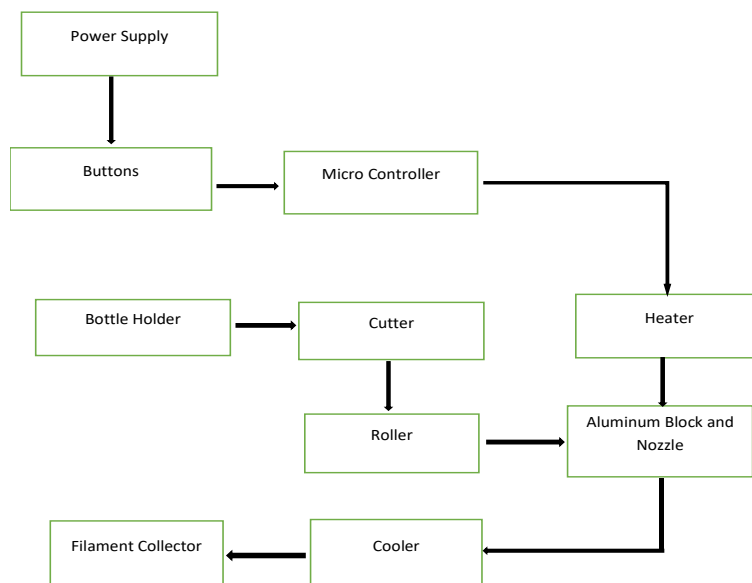


Fig.No.4.1





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### V. ASSEMBLY DRAWINGS

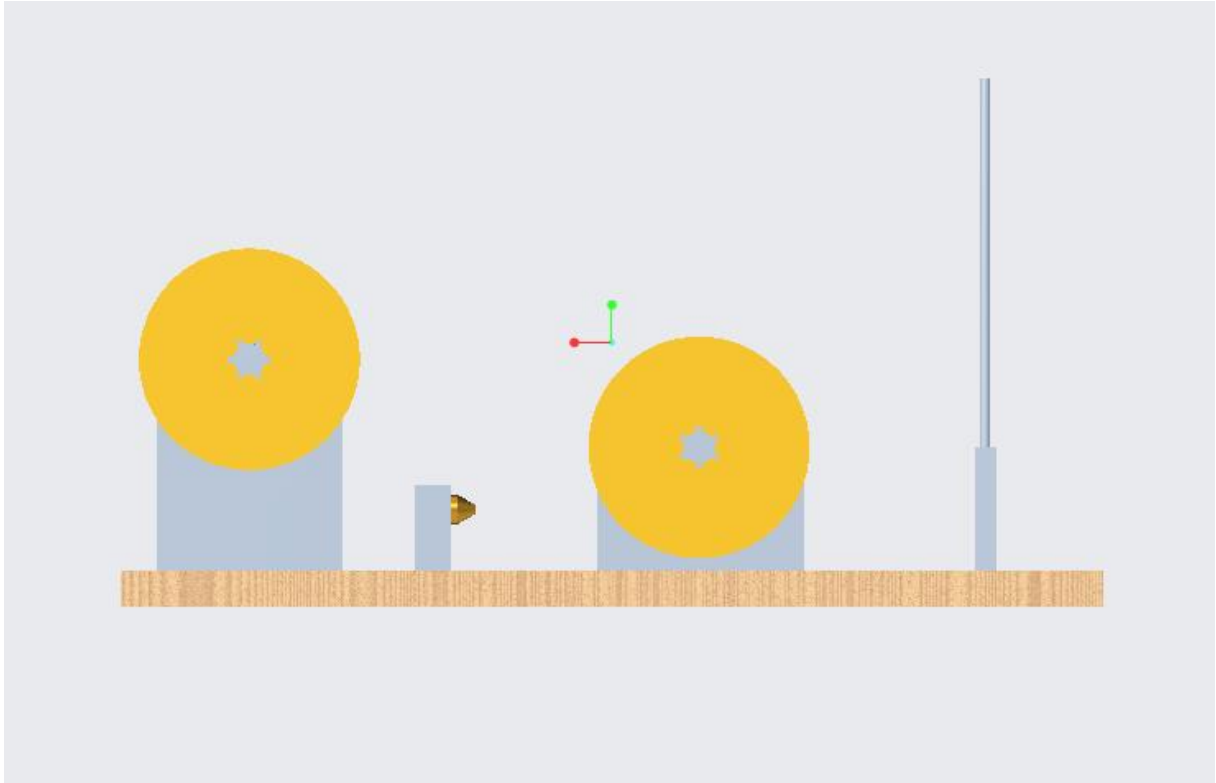


Fig.no.5.1

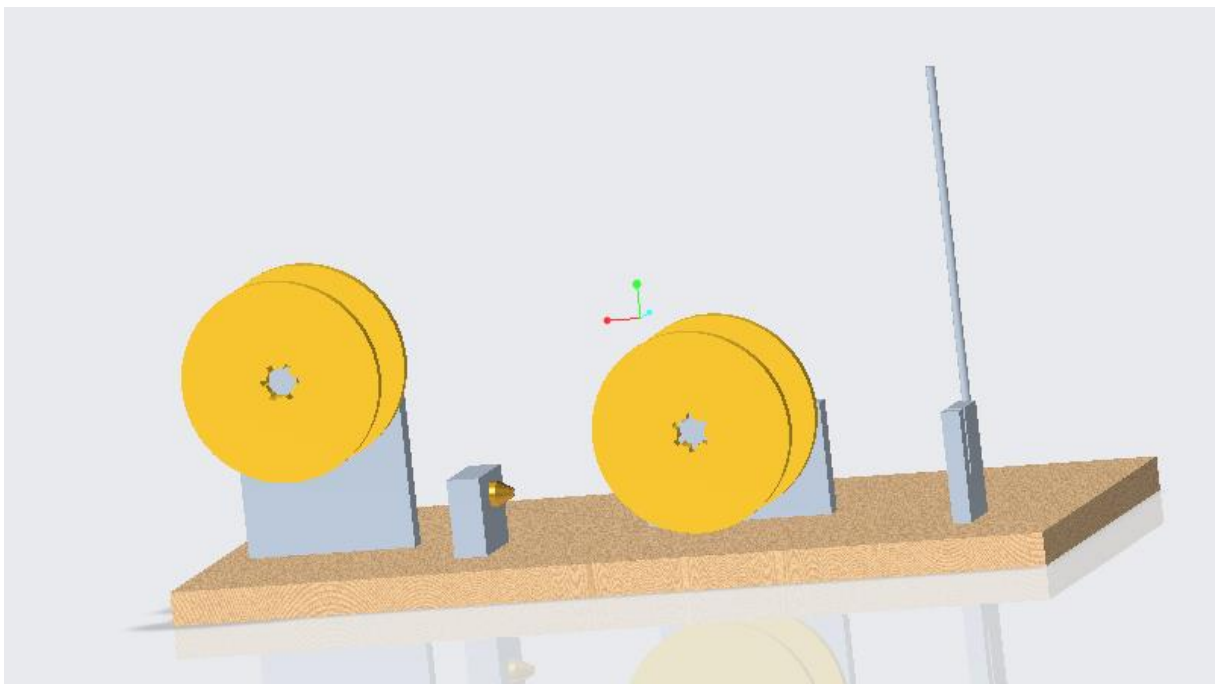


Fig.No.5.2



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## **VI. SCOPE OF WORK**

The current design for the prototype has the capability to produce plastic filaments with 1.75mm diameter. In order to change this diameter, the end cap with the extrusion hole can be swapped out with another end cap with the required hole size. This involves the removal of the heater and using wrenches to unfasten the tightly secured end cap. This process is not very fast and requires effort. This process could be improved with a differently designed end cap fastening system.

A system could be implemented to automatically move the spool sideways to ensure correct spooling of the extruded plastic along the entire horizontal length of the spool. The current system does this to an extent but still largely relies on the nature of the extrusion to spool the wire horizontally.

The bottle cutting mechanism could be improved by more in depth study as we still need to heat the bottle and cut it first and then pass it through the cutting mechanism to produce strips. This process should be automated and there should be less effort to produce strips before moving towards the filament.

## **VII. CONCLUSION**

Throughout this paper we conclude that it is possible to recycle the waste part of PET material i.e., plastic bottles and convert it into a filament by using our “3D Printing Filament Extruder by Recycling Plastic Bottles”. The developed extruder has the ability to produce 3D filament from the waste plastic bottles for the 3D printer. We have tried to miniaturize whole setup as much as possible to make it portable and can be adopted to small scale industries and to educational institutions. This developed setup reduces maintenance, no trained labours are required and overall, it reduces the operating cost and investment of the machine. It can also be used in daily applications such as house, schools and laboratories.

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