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"3D Printing Using Recycled Filament"

Dr. Sathish K R[1], Mrs. Sowmyashree K S[2], Shwetha N[3]

[1]Assistant Professor, Department of Electrical and Electronics Engineering, ATME College of Engineering Mysuru, India
[2]Assistant Professor, Department of Electrical and Electronics Engineering, ATME College of Engineering Mysuru, India
[3]UG Student, Department of Department of Electrical and Electronics Engineering, ATME College of Engineering Mysuru, India

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ABSTRACT:3D Printer is a Desktop Fabrication process that builds up a three-dimensional object from computer-aided design. This is generally done by the additive manufacturing process. Here the material is successively added layer by layer. The filament used is of a thermoplastic material such as ABS, PLA or Nylon. These materials have high tensile strength. These could be recycled using the extrusion process.

The first 3D Printing model was done in 1981 with an application of rapid prototyping. After than many varieties of 3D printing have been developed and have introduced a way of simplifying the work to be done. This change in the era has led to many developments in society. In today's time, nearly 48 % of the manufacturing companies use 3D Printers as the base for their productivity. The produced product is lightweight, cheap and has good strength. Although 3D models are also used in Education. Models developed can be used in demonstration and learning purposes. This enhances the creativity of civilization.

The models produced are of better quality hence most of the manufacturing adopts these methods. In this project, we have designed a recyclable filament unit for the 3D printing process and a 3D printer using fused deposition methodology (FDM).

Keywords: 3D Printer, Extrusion, Filament, Fused Deposition Method

I. INTRODUCTION

The three-D printing process builds a 3-dimensional item from a computer-aided design (cad) model, generally via successively including cloth layer via layer, that is why it's also called additive manufacturing, not like conventional machining, casting and forging approaches, in which fabric is eliminated from a stock item (subtractive production) or poured into a mildew and fashioned by means of dies, presses, and hammers. That is additionally termed as desktop fabrication.

The term "three-D printing" covers a ramification of tactics wherein material is joined or solidified beneath pc control to create a three-dimensional item, with the fabric being added together (inclusive of liquid molecules or powder grains being fused together), usually layer by layer. In the Nineties, three-D-printing techniques had been considered appropriate most effective for the manufacturing of purposeful or aesthetic prototypes and a extra appropriate term for it turned into fast prototyping. As of 2019 the precision, repeatability, and cloth variety have extended to the point that a few 3-D-printing approaches are considered feasible as an business-production technology, wherein the time period additive manufacturing may be used synonymously with "three-D printing". One of the key blessings of 3-D printing is the ability to produce very complicated shapes or geometries, and a prerequisite for generating any 3-D printed component is a virtual three-D version or a CAD record.

The term "three-D printing" at the beginning referred to a process that deposits a binder material onto a powder mattress with inkjet printer heads layer by means of layer. More currently, the famous vernacular has commenced the usage of the term to encompass a greater variety of additive-manufacturing techniques such as electron-beam additive production and selective laser melting.

Statistics

- Product development in the highest priority companies is relying on 3D printing. In 2017, 29 % of the economy used 3D modelling and in 2018 the numbers have raised to 39 %.
- In 2018, 3D printing application was mostly used for Prototyping (55 %), Production (43 %) and Proof of Conceptual models (41 %).
- 70 % of investor has increased their investment in 3D printing in 2018.
- 58 % of companies using 3D Printing in 2018 are able to gain competitive advantages including reducing time to market and increasing short production runs for customers.

II. NECESSITY OF 3D PRINTER

We have all seen new generation advanced in addition to looking numerous inventions fall by the wayside. The most tremendous development in our concern, in terms of producing, is the creation of pc aided manufacture. CAM is that terrific acronym carried out to any tool which can produce something from a drawn layout and covers the whole thing from easy vinyl cutters to complex laser reducing. Computer-aided manufacturing is a software tool used in the manufacturing process. It is a controlled machinery. The three components of the system to function are: Software that tells a device a way to make a product by means of generating toolpaths. Equipment that may turn uncooked fabric right into a finished product. Submit processing that converts toolpaths right into a language system can understand.

III. LITERATURE SURVEY

3D printing is technology, the birth of 3D printing was in 1984 at the hands of Chuck Hull who invented a process known as stereolithography, in which layers are added by curing photopolymers with UV lasers, after that, 1990 layer by layer technology used each layer has 0.1mm depth, in 1999 the first use in medicine, in 2000 the first parts of human such as ears, fingers were done, 2005 3D printing technology became open source, in 2006 the first SLS (selective laser sintering) machine become variable, in 2008 the first self-replication printer which made the printer able to print the majority of its own components also at the same year 3D technology developed to do a very hard shapes and artists for designers, in 2009 Atom by atom printing was done which allows for Bio3D printing, in 2011 the first 3D printer Robotic Aircraft at the same year the world's first 3D-printed car and it became commercially available at the next year, at the same year the first gold and silver jewellery were done using 3D printer.

It describes the review, analysis, and classification of 3D printing. Each of the articles was classified by means of 9 categories: study types, affiliation, approach, the origin of the study, geographic scope, unit of analysis, scope, benefits, and negative points. Safety plays a vital role to safeguard many important things, which include money, gold, documents, etc. The most common form of security is the age-old lock and key system. The diversity that exists in the world today among people's professions raises the need for multiple duplicate keys the STL file format, which is used for transferring information from CAD software to the 3D printer, for obtaining the solid model in Rapid prototyping and Computer Aided Manufacturing.

3D Printing Technology is also known as rapid prototyping where a 3- dimensional object is created by lying down the successive layers of material. Application of 3D printing in the education system. It considers two questions: where and how is 3D Printer has been used in the educational system? The review identifies that 3D Printer is being applied across the K-12 3D Printing using Recycled Filament spectrum and in universities, as well as in libraries, makerspace, and special education settings, although adoption is isolated in pockets of excellence and faces integration challenges.

Many commonly found polymers having the potential to be recycled, such as Acrylonitrile Butadiene Styrene (ABS), a prevalent 3D printing material. The advent of new technologies in medical imaging and 3D printing in recent years has made customization of surgical tools and implants more accessible, revolutionizing many surgical fields. In many human diseases, these implants have led to superior surgical outcomes and greatly improved patients' quality of life.

IV. DESIGN AND DEVELOPMENT

A. Block Diagram and It's Description:

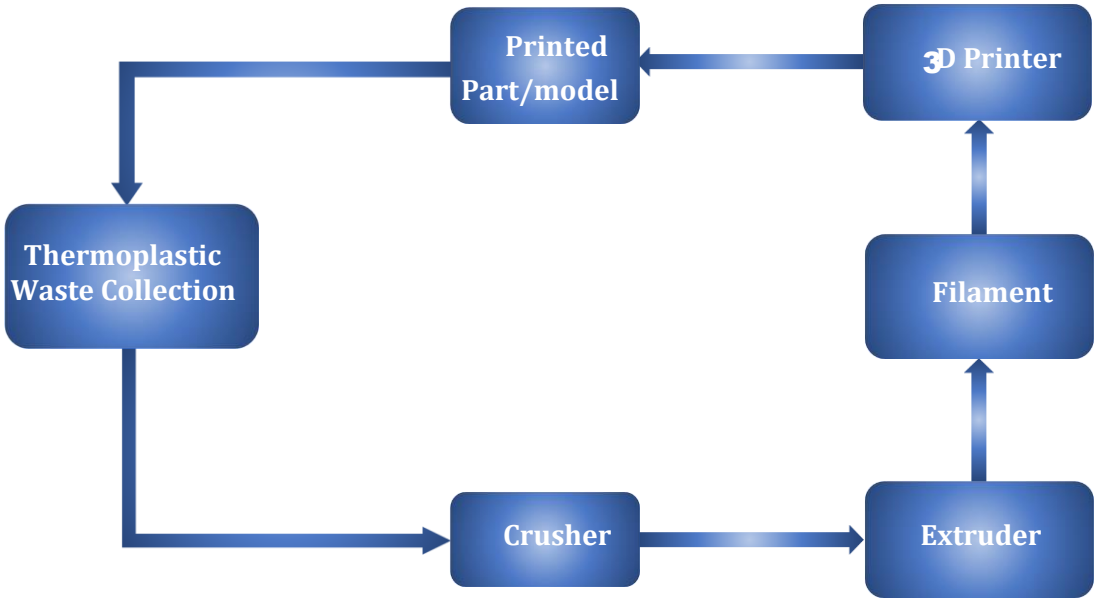


Fig 1: Block Diagram of Recycled 3D Printing Process

- **Thermoplastic Waste Collection:** Thermoplastics are the substance that becomes plastics on heating and hardens on cooling. This is a repeatable process. These plastics are collected from various sources such as waste generated from Industries. When heated these turns to liquid format and further can be structured for any shape or size required.
- The plastics collected belong to a family of Acrylic, ABS, Nylon, PLA, Polycarbonates or Polyethylene. These are generally Lightweight and can withstand up to certain temperatures.

- **Crusher:** Crusher's main objective is to cut or chop down the Thermoplastics waste to equivalent small sized pieces. These mainly consist of multiple rotating blades moving towards each other as a result the plastic is crushed to its powder form.

- **Ecostruder:** It is a system for the extrusion process to occur. Here it consists of a screw inside a hollow cylindrical pipe. The crushed plastic is available at one end of the pipe and on the other, a die of a profile is fixed. The motor drives the screw compressing the plastic forward. Then a required profile of the plastic is obtained.

- **Filament:** The filament is of the thermoplastic material. These are also available in the market but also can be obtained through the recycling process. Here we recycle the plastic using the extrusion process for a profile of 1.25 to 1.75 mm diameter.

- **3D Printer:** It is a machine that allows the creation of a physical object from a three-dimensional software model. The object to be printed is created using a software tool such as AutoCAD or Solid edge software. Then the Printer

prints the model using the recycled filament as the raw material. This is completed by the FDM method i.e. the construction of the model is done by additive manufacturing.

- **Printed model:** It is the output of the Project. A 3D model is obtained from the printer based on the designs fed to the system. The output obtained is additive manufacturing.

B. Extruder:

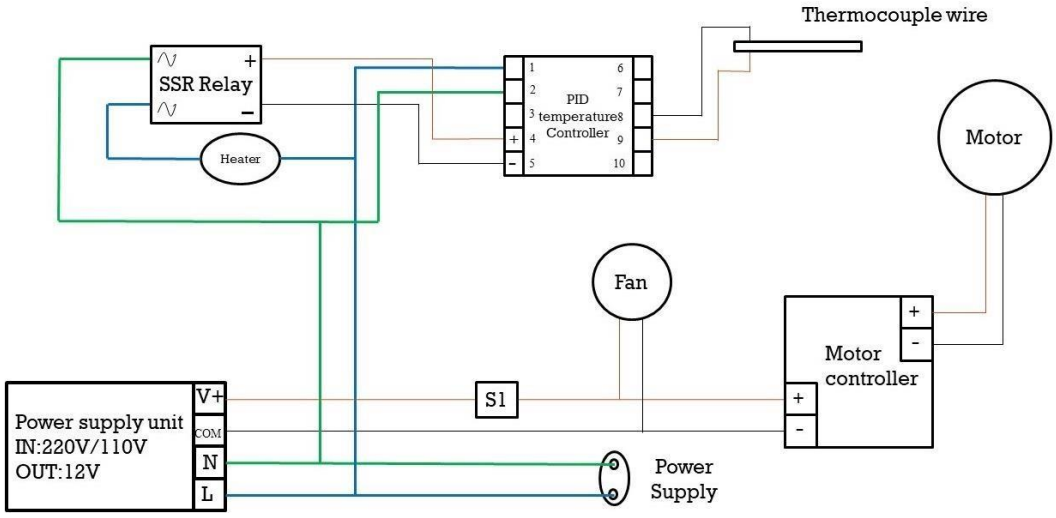


Fig2: Circuit Diagram of Extruder

The Figure represents the circuit diagram of Extrusion process. It comprises of a mica band heater which works on 220 V AC. The main element of the circuit is the PID Temperature controller. The controller has a temperature sensing wire probe which acts as the input to the controller. The output is given to a relay in form of a DC signal between 4 to 30 Volts.

The Melting point of PLA is 180°C but we will set the temperature to 200°C for proper melting and mixing of the material. Once the supply is switched ON the relay is triggered. The relay creates the closed circuit for the heater. Once the heater heats the barrel to 200°C, the PID Temperature controller gives a signal to open the heater circuit. After the temperature drops below 200°C the PID Temperature controller again gives a signal to the relay to close the switch. This process repeats continuously till the supply is cut off. Meanwhile, the plastic granules are put in the Hooper. The DC circuit is switched ON and the motor speed is adjusted to be slow as possible. The motor is shafted with the screw and this screw helps in pushing the plastic granules forward. After it passes through the heater, the material melts and is forced to pass through the die on the other end of the barrel.

C. 3D Printer:

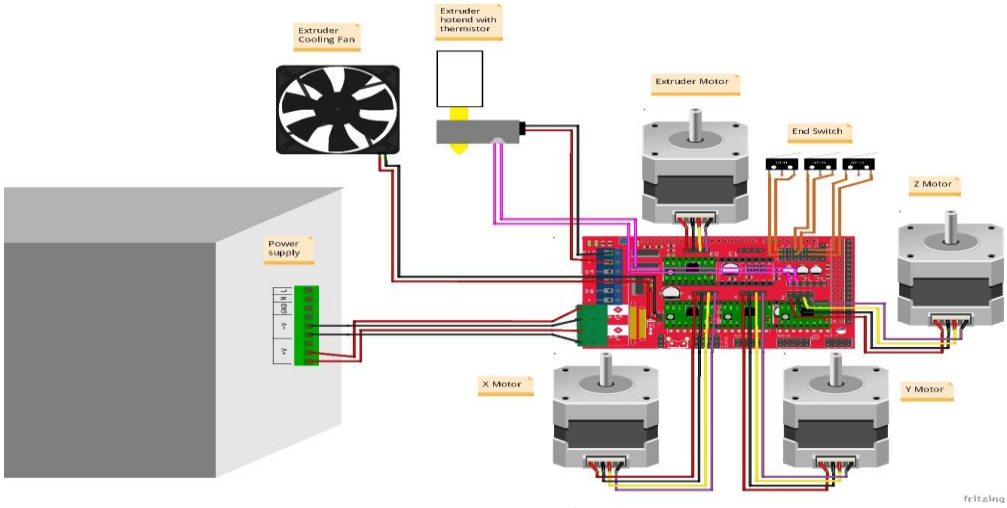


Fig3: Circuit Diagram of 3D Printer

The Figure represents the circuit diagram of 3D Printer. The program is uploaded to the Arduino mega using USB Type A cable connected to the computer. The program sets up the motor to its initial position with the help of the end switches. The G code format file is feed to the board with the help of a SD card or through Print run software. Then the initial setting performs in the model such as heating the extruder. Once the extruder is reached the set temperature the printing process begins.

The axes will be in home position at the beginning, Once the heating temperature is gained the layer formation begins up. The layer is formed with the help of x and y axis, then once the layer is finished up z axis lifts up by 0.5mm. This process repeats till the last layer is completed based on the file provided. Once the model is completely printed the z axis will lift up to a 10 mm height from the last layer. Finally, the model is removed from the base.

D. Flowchart of 3D Printer:

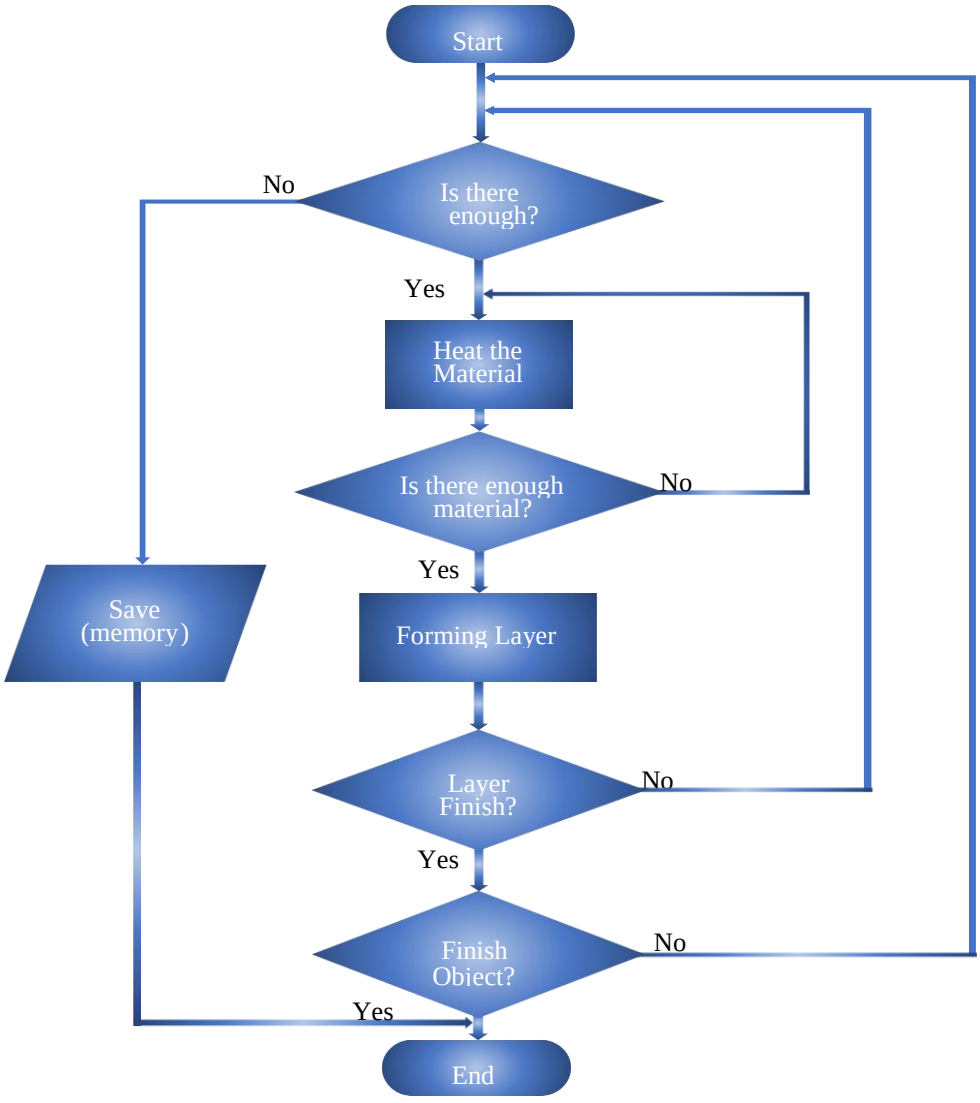


Fig 4: Flowchart of 3D Printer

E. Working Principle of Vending machine and Incinerator:

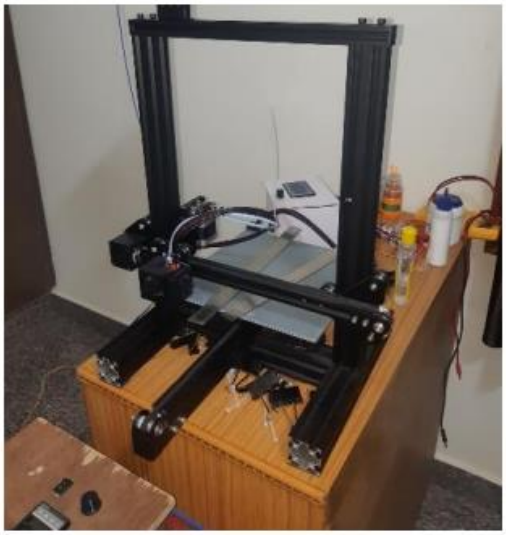


Fig5: 3D Printer

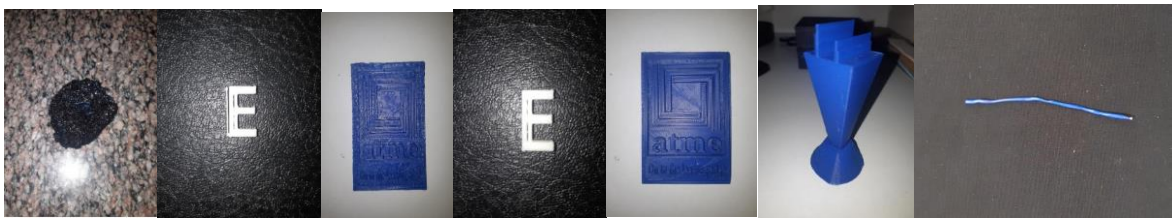
After multiple testing of PID Controller and Relay connections, the circuit is built and sealed in the chamber. The placement of the band heater resulted in melting of the plastic. Hence during first test it was observed that the melting section did not reach the correspondingly. Hence, we moved the position of the band heater at the front. This resulted in a smooth process of melting but the material started burning within due to absence of milky granules**.**

After testing of motors, the Electronics was sealed within a box. The motors could be controlled with the help of the LCD. The file has to be given to a SD card and with the help of the LCD it could be selected. After multiple test the motors were placed at the frame for further testing. The wires had to be suspended freely for proper movement

V. RESULT AND DISCUSSION

The Power supply was switched ON, initially the PID Controller triggers the relay and starts heating the coil. After a certain duration it reaches its defined temperature. Then the plastic is fed from the hopper and melting process begins.

In the printer the file is loaded in G-Code format. Using LCD, the printer is controller. After selecting the file, the bed heating process begins and later the extruder heats up. After heating it begins to print. Initially it was observed that due to improper heating the plastics was never stable enough to stick on the bed hence. But on the latest trials the modification of the code for temperature seems to do the trick for proper building of the model.



(a) (b) (c) (d) (e) (f) (g)

Fig 6: (a) Failed output due to absences of milky granules to avoid burning of the material (b) Output of the letter E during testing (c) Output of the logo during testing (d) Final output 1 (most of the error reduced after modification) (e) Final output 2 (most of the error reduced after modification) (f) Output that could be used as an application based (mobile stand) (g) Output generated from the Extruder

In Fig 6 (d) & (e), After a set of modification most of the errors were reduced and the printing process was smooth. In Fig 6.6 (f), A mobile stand was printed. It took approximately 10 hrs to complete the printing process and Fig 6.6 (g) shows the filament output generated. It was observed that the Filament obtained was of 1mm to 1.25mm and the filament started to stretch due to overheating.

VI. Applications and Advantages

Additive manufacturing in combination with cloud computing technologies allows decentralized and geographically independent distributed production. Companies have created services where consumers can customize objects using simplified web-based customization software and order the resulting items as 3D printed unique objects. By practicing on a tactile model before surgery, surgeons were more prepared, and patients received better care. Virtual planning of surgery and guidance using 3D printed, personalized instruments have been applied to many areas of surgery including total joint replacement and craniomaxillo facial reconstruction with great success.

3D printing is quicker than conventional manufacturing injection moulds and subtractive production. It allows the steps -steps assembly of the objects, which guarantees enhanced designs and eventually better-quality objects. Labour costs play a huge role in determining the amount of money to be spent in developing a prototype. Hence no skilled labour is required for operation. It printing only uses a material that is needed to create a prototype for no more, no less. It creates mesh like structure within the solid hence it also saves the material simultaneously.

VII. CONCLUSION AND FUTURE SCOPE OF DEVELOPMENT

Based on the project constructed and performed it was observed that no skilled person is required for the operation of the 3D printer but however a skilled person is required to construct the design. Direct recycling of Plastic resulted in change is color, durability and other properties. Hence in order to obtain a filament from Extruder it is required to add granules like milky PLA or Polyethylene or Polyvinyl chloride for smooth processing of the material.

Recycling of Plastics: Direct recycling resulted in burning of the material hence Additive compounds could be used. Upgrading to Smart Printer by adding IOT.

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