Additive Manufacturing using Rapid Prototyping Technology

Y. Venkata Sai Rohit
Dept of Mechatronics
Acharya Institute of Technology

Vivek V
Dept of Mechatronics
Acharya Institute of Technology

B.S Manish
Dept of Mechatronics
Acharya Institute of Technology

Prof. Bhagirathi V
Dept of Mechatronics
Acharya Institute of Technology

***Abstract*- We designed a three dimensional portable printer which uses the technology of rapid prototyping[1] for additive manufacturing of different kinds of polymers. The technique used in this technology is fused deposition modelling[2] where a solid polymer spool is converted into a liquid form and laid down layer by layer in order to form a complete three-dimensional object. The device which we developed performs with (i) improved finishing (ii) quick modelling, and (iii) high stability during manufacturing process.**

Keywords - 3D printing, additive manufacturing, fused deposition modelling.

I. INTRODUCTION

Additive Manufacturingis a Rapid Prototyping technology where a three dimensional object is created by laying down successive layers of material. It is a mechanized method where 3D objects are quickly made on a reasonably sized machine connected to a computer containing blueprints for the object.

This revolutionary method for creating 3D models with the use of inkjet technology saves time and cost by eliminating the need to design; print and glue together separate model parts. Creating a complete model in a single process is possible using 3D printing. The basic principles include materials cartridges, flexibility of output, and translation of code into a visible pattern.

3D Printers are machines that produce physical 3D models from digital data by printing layer by layer. It can make physical models of objects either designed with a CAD[3] program or scanned with a 3D Scanner. It is used in a variety of industries.

II. TECHNOLOGY USED

The technology used in building this device is known as Fused Deposition Modelling (FDM). It is an additive manufacturing process in which a polymer is converted into a molten form and passed through an extruder nozzle in three dimensional Cartesian plane, where each layer of polymer is laid one after the other in order to obtain a three dimensional object.This method of layer-by-layer deposition saves time, cost and the raw material used for manufacturing process.

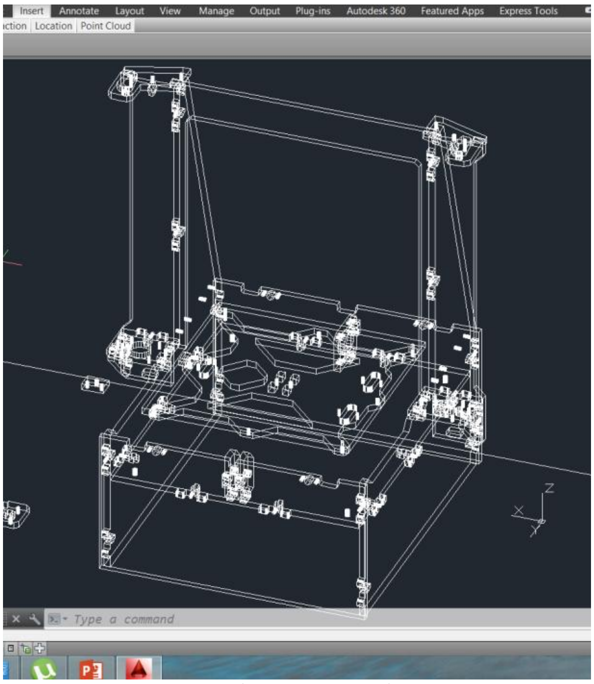

Fig 1. Wireframe structure of design

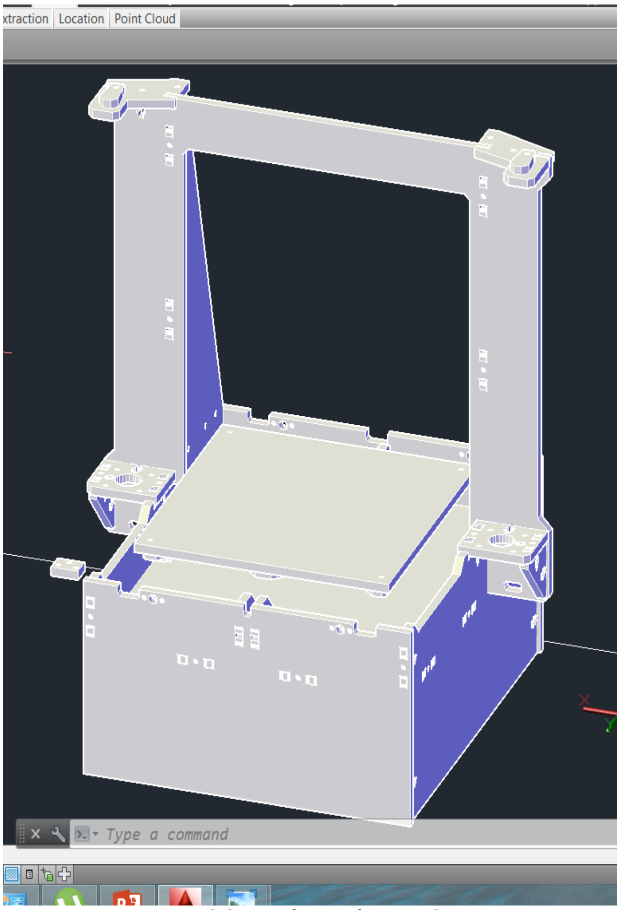

Fig 2. Solid CAD frame of printer design

III. HARDWARE DESIGN

A. Structure of the device

After multiple iterations on deciding the design, we decided on using acrylic sheets made of poly-acrylonitrile[4] which is light weight and strong for structural design. Interlocking mechanism was used to increase stability and nullify vibrations during printing of any model. A MK3 heat bed paired with acrylic was used as base for printing.

B. Electronics

The electronics used are open source components. The microcontroller used isAtmel AT90USB1286[5]integrated with stepper motor drivers. This enables the use of five different NEMA-17[6] stepper motors in a controlled manner. One stepper motor with GT2[7] timing belt for x-axis motion, one stepper motor with GT2 timing belt for y-axis motion, and two stepper motors and two threaded rods paired using helical springs were used for z-axis motion.

C. Extruder

The extruder for our prototype consists of a NEMA 17 stepper motor connected to a worm gear setup. Below the motor assembly lies an all-metal hot end[8], which heats the incoming polymer. The tip of the extruder consists of a conical nozzle through which the molten polymer is printed on the heat bed.

D. Connectivity

The Arduino based printer board requires USB cable to interface with any computer. The inner wiring is simple copper wiring with insulation.

IV. SOFTWARE DESIGN

Arduino programming for the Atmel board. Open source designing software such as Blender[9] can be used to design a three dimensional model virtually. This design must be exported in a specific format - '.stl'. This file consists of all the geometric data of the designed model.

An open source software called Slic3r[10] is used to convert the '.stl' file into completely sliced structure by converting the model into several layers. The file is exported as '.gcode'. A software called Pronterface[11] is used to interface our prototype with the computer. This takes complete command over the printer and controls the motion and extrusion process.

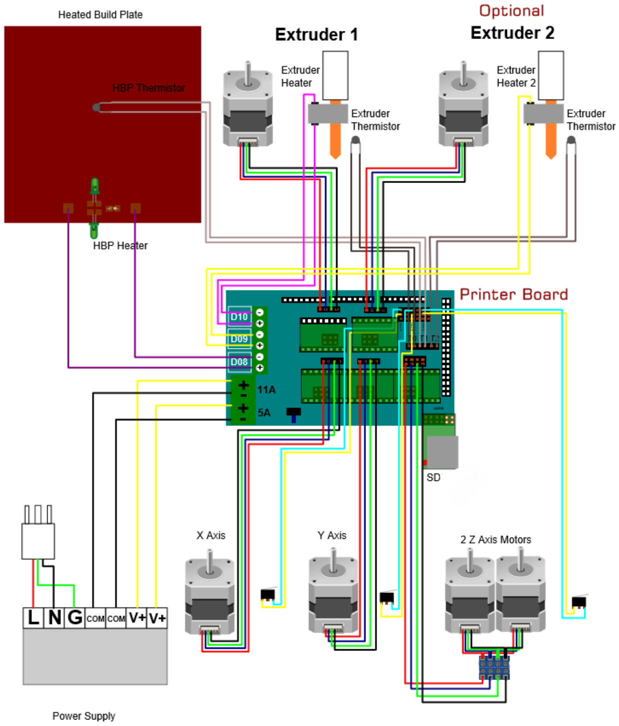

Fig 3. Electronics design plan

V. WORKING PRINCIPLE

A polymer filament such as poly lactic acid is fed into the extruder through the worm gear assembly. The inlet filament is controlled using stepper motor. This filament is directed to the all metal hot end where the polymer is liquefied at its melting point. The liquid polymer is deposited on to the heat bed through the conical nozzle.

The three-axis motion is controlled using NEMA 17 stepper motors, one for x-axis, one for y-axis, two for z-axis and one for extrusion. These motors are coupled with GT2 precision timing belts for smooth and controlled motion.

A three dimensional CAD model is fed into the open source Slic3r software where the model is sliced into several layers. This is converted to g-codes and m-codes. Once these are imported on Pronterface software, they can be redirected to printer board. The printing commands can be controlled directly from the computer software.

VI. ADVANTAGES AND DISADVANTAGES

A. Advantages

- Power saving - due to consumption of 12 volt power supply only.
- Low usage of raw material - only the required amount of material is used and leads to almost zero waste
- Time and tool saving - Instead of multiple processes such as cutting, drilling, boring, this process uses single tool to get a finished product.
- Multiple compatible materials - Due to the all metal hot end's capacity of 800ºC, polymers such as PLA, ABS and nylon can be compatible.
- Low cost of finished product.
- Customizability and complex print capabilities.
- Portable design.

B. Disadvantages

- High installation cost.
- Requires skilled handling.
- Requires continuous power supply

VII. CONCLUSION

The prototype we designed proves to be useful in numerous industries. The resolution of 0.2mm and print area of 15cm^2, makes this a portable design, while the acrylic interlocking mechanism makes the design highly stable. Since softwares used are completely open source, there are no such licensing issues. The device is known for high accuracy and customizability.

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