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# Design and Fabrication of Low Cost Dual Extruder Fused Deposition Modeling 3D Printer

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**ABSTRACT**

The inspiration for this project comes from the fact that 3D printer is really innovative and revolutionary idea but along with that they are very costly, one cannot afford the 3D printer just for fun or to use at home just to create ideas into reality. One can create an affordable 3D printer by using equipment in their surrounding or probably at home. The technology of 3D printing can be used to create imagination into reality, parts of the machinery of equipment which are not available in the market, prototypes of new ideas and most importantly for fun. Due to higher prices, its access to world is very limited but through this work there will be an increase in the access of 3D printers. Obviously, this isn't going to be fancy but it will show the basics of how the 3D printer works. In the current work the Design and Fabrication of Dual Nozzle Fused Deposition Modelling 3D Printer is developed at low cost.

**Keywords :** 3D Printer, Fused Deposition Modelling, Additive Manufacturing

## I. INTRODUCTION

3D printing is a rapid prototyping process whereby a real object can be created from a 3D design. It uses a CAD model for rapid prototyping process; where by a structure is synthesized from its 3d model.

The 3D design is stored in as a STL format forwarded to the 3D printer. It can use a wide range of materials such as ABS, PLA, PETG and composites as well.3D printing is one kind of rapidly developing and cost optimized form which is used for rapid prototyping. The 3D printer prints the CAD design layer by layer forming a real object. 3D printing process is derived from inkjet desktop printers in which multiple deposit jets and the printing material, layer by layer derived from the CAD 3D data.3D printing is diversifying and accelerating our life, letting various qualities of products to be synthesized easier and faster.[1]

3D printing has the ability to impact the transmission of information in ways similar to the influence of such earlier technologies as photocopying. This identifies sources of information on 3D printing, its technology, required software and applications. Along 3D printing, companies are able to extract and innovate new ideologies and various design replications with no time or tool expense. 3D printing possibly challenges mass production processes in future. 3D printing influences many industries, such as automotive, architecture, education, medical, business and consumer industries.[2–6]

## II. LITERATURE REVIEW

Vedant Daramwar et al. worked on Design and Development Of Multi-Material Extrusion in FDM 3D Printers this research highlights the design, development and choice of the most rugged, accurate, reliable and effective approach towards use of multiple filaments and concluded that the method of printing by using 'Multiple Printing Heads', being a more efficient and accurate technique, has been explained, along with the design of the entire mechanism.

Krisztián Kun worked on Reconstruction and development of a 3D printer using FDM technology to outline the milestones of the reconstruction of the printer, the restoration of the technical documentations (Reverse Engineering), and then the calibrations and the measurement result and concluded that the designed printing unit is a compact, user-friendly jog unit and a head-holder console. And a structure is created, where the extrusion head unit does the X-Y movement at the same time, and to be able to print support material [7].

Andi Dine, Edward Bentley et al. worked on A Dual Nozzle 3D Printing System for Super Soft Composite Hydrogels to design and integrate new subsystems into a conventional extrusion-based 3D printer, to obtain a hardware that encompasses a range of new capabilities and concluded that this printing technique utilises a liquid to solid phase change of the printing solution to ensure structural stability for large scaffold volumes[8].

Roman Polak et al. worked on Determination Of FDM Printer Settings With Regard To Geometrical Accuracy stating that material extrusion is one of the most used additive technologies. The most common application of this technology is in the production of prototypes, preparations and small serial parts. This article deals with relationship between different model geometries and parameters such as temperature, speed of printing and height of layer. Typical features of this technology are ease of printing, but it depends on the type of material used and the particular device. Printers with Fused Deposition Modelling (FDM) technology have no feedback about printed material, such as printing accuracy. This paper aims to easily find ideal parameters for FDM printing technology using Polylactic Acid (PLA) material and concluded that it is hard to find these settings during real production, therefore this experimental analysis was carried out. The collected data shows the dependence of the geometry on the print properties. The main tested parameters were speed, temperature and layer height. The results show the accuracy mainly depends on the temperature and layer height. The best results were obtained using lower temperature and thinner layer. Many articles deal with dimensional accuracy and model post processing with regard to the surface finish. The information contained in this article can be used for verification of these properties and finding the ideal parameters on other FDM devices. This test has many possibilities for continuing and expanding the testing information for ideal FDM printer settings. Further research will continue with testing other print parameters, such as different nozzle sizes, other materials (ABS, Nylon, PETG etc.) and combining them with the parameters tested in this article [9].

Xiuxia Zhang et al. worked on Design and Simulation of Multi-nozzle FDM 3D printer for fabricated Solar thin-film cells in order to widely realize the personalized use of solar thin-film cells in every family, save costs and generate clean energy, our team wants to fabricate a 3D printer of solar thin-film cells. The solar film cells were 3D printed fabrication by FDM3D printer would improve their performance as battery. In this paper, for fabricate P nano-diamond/ZnO solar film cells the hot bed and nozzle of 3D printer were designed to achieve 3D printing of solar cells. A printer for fabricated solar thin-film cells was designed. PID was used to set the temperature of printer nozzle, and a refrigeration device was added to the substrate. And then finally, the printing device was simulated by SW and concluded that For the P nano-diamond/ZnO solar film cells were 3D printed fabrication by FDM3D printer. The nozzle design with temperature control device could realize fully mix slurry, slurry flow more even and more controllable, and avoid the slurry, avoid plug nozzle temperature too low. A slot nozzle was designed and 3D Touch sensor was added to realize automatic leveling of 3D printer. The fuzzy PID adaptive control was introduced to improve the stability of the temperature control system an overcome the uneven temperature can make the product structure was not stable, low precision. Using simulink to make the temperature control simulation, the system could restore stability in a short time [10].

Tim Kuipers et al. worked on presenting a Half toning technique to manufacture 3D objects with the appearance of continuous grayscale imagery for Fused Deposition Modeling (FDM) printers. While droplet-based dithering is a common half toning technique, this is not applicable to FDM printing, since FDM builds up objects by extruding material in semi-continuous paths. The line-based half toning principle called 'hatching' is applied to the line patterns naturally occuring in FDM prints, which are built up in a layer-by-layer fashion. The proposed half toning technique isn't limited by the challenges existing techniques face; existing FDM coloring techniques greatly influence the surface geometry and deteriorate with surface slopes deviating from vertical or greatly influence the basic parameters of the printing process and thereby the structural properties of the resulting product. Furthermore, the proposed technique has little effect on printing time. Experiments on a dual-nozzle FDM printer show promising results. Future work is required to calibrate the perceived tone and concluded that One could adopt a similar technique for FDM printers which have more than two extruders; if it is capable of printing with cyan, magenta, yellow, black and white filament, hatching could be used to produce full color prints. When different less colors are available, a mapping between color spaces should be performed to make the print appear as close to the textured mesh as possible [11].

Fitrian Imaduddin et al. worked on The fused deposition modeling (FDM) 3D printing: Filament processing, materials, and printing parameters to review research the progress on factors that affect the 3D printing results of the fused deposition modeling (FDM) process. The review is carried out by mapping critical parameters and characteristics determining FDM parameters, the effects of each parameter, and their interaction with other parameters. The study started from the filament manufacturing process, filament material types, and printing parameters of FDM techniques. The difference in each section has determined different parameters, and the respective relationships between parameters and other determinants during printing have a significant effect on printing results. This study also identifies several vital areas of previous and future research to optimize and characterize the critical parameters of the FDM printing process and FDM filament manufacturing and concluded that every aspect of factor and input parameters in the FDM engineering process affected the quality and mechanical properties. Aspects that have been stated to influence the results are as follows: filament material composition, extrusion working parameters such as those related to extrusion speed and temperature, FDM machine specifications, extrusion machine specifications, type of filament polymer, and FDM work parameters when printing the filament. This study has identified the additive manufacturing field's scope by using a 3D printing process made from polymer filament for the future research in optimizing and characterizing FDM processes and materials. It has been emphasized that FDM is characterized by a large number of process parameters that determine mechanical properties and the quality of results. Nevertheless, there are still some relationships between factors and parameters that are not yet clear, making future work very important to be determined to give the best results [13][12].

## III. COMPONENTS AND MATERIAL SELECTION

When it comes to the mechanical body, it can be generally broken down into two parts:

- Movement along the x/y/z axes.
- The print bed /Heated bed

There are different configurations and some work better and easier to use for 3D printer when fabricating parts with other tools. Mechanical simplicity at the expense of moving the build platform while others attempt to minimize head inertia by using fixed motors and complex belt actuation.

### A. X/Y/Z Axis Motion

When facing the front of 3D printer, X axis movement is side to side, aka left to right movement, Y axis movement is forwards/backwards movement and Z axis movement is up and down along the vertical plane. Linear movement is generally accomplished using one of 2 different methods:

- Belt/pulley driven motion.
- Threaded rod or lead screw motion.

### B. Belts and Pulleys

When it comes to accuracy, the most important part is belt/pulley combination. Current state of the art is the GT2 belt, along with a machined pulley that matches the exact bore size of your stepper motors (normally this is 5 mm).

### C. Threaded rod

Most Systems use threaded rod for the Z axis. The Z axis doesn't have to move fast (but it is better if it can move quickly) because it generally only goes up tenths of a mm at a time. Threaded rod is ok for accuracy and force. Systems don't require force but some CNC machines, use threaded rod for all 3 axes.

### D. Print Bed

The print bed is what parts get printed on. The print bed may be stationary or it may move along one of the x/y/z axes. Most Systems have the bed move along the Y axis but some will also move along the Z axis.

### E. Extruder

To extrude molten plastic filament, the "Cold End" forces the raw material (usually a 1.75mm or 3mm diameter filament) into the hot end. The feeding filament should then go through the "Hot End" of the extruder with the heater and out of the nozzle at a reasonable speed.

### F. Cooling Fan

The cooling fan plays a really important role in the 3D printing process and it's a must have feature. Not all 3D printing materials require active cooling, but it's truly beneficial for most 3D prints.

### G. Nozzle

The Nozzle is the tip of the Hot End where the plastics comes out. It needs to be exchangeable when needed. The nozzle size is really important. It usually varies from 0.25mm to 2.5mm. The most common size is 0.4mm. The best practice is to change the nozzle sizes depending on your design and desired results.

### G. Controller

The control is done by microcontroller that integrated into the PCB. In addition, to make the communication between the computer and the micro controller, a USB-Serial converter/Memory card/Pen drive is required to send commands to each device.

## IV. DESIGN OF FDM MACHINE

Design of 3D Printer is carried out in Autodesk fusion360 software. The softwares which we have used are Simplify 3D, any cubic, Cura, Repetier, etc and the supported file formats are G codes.

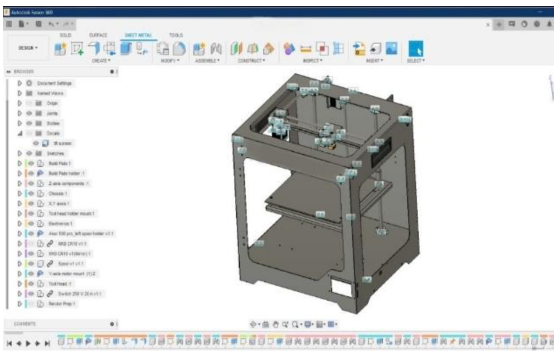

Figure 1: Design of Machine Frame using Fusion 360

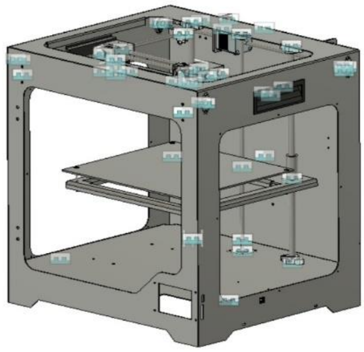

Figure 2 : Design of Machine Frame with stepped motors

## V. Fabrication of 3D Printer

### A. Tools required

Printed parts, M6x.8 Tap, Metric Tape measure or caliper, Set of compatible hex keys, Screw driver

### B. Parts needed

Motors, Smooth rod rails (2 X, 2 Y, 2 Z), Z axis Lead Screws, Heated bed and carriage, Extruder, Hot End, End stops, Bearings, Bearing Houses, Pulley& Idler, Belts (GT2), Controller Board, Power Supply, LCD, Wiring, Miscellaneous M3, M4& M5 screws and nuts

### C. Plastic Parts

This frame uses a number of plastic printed parts. These parts are generally used for alignment, with a secondary goal of adding stability. Each frame joint has at least one metal connective component that will primarily handle the stability of the frame. However, some plastic parts, namely the motor mounts and tensioner, are solely responsible for structural integrity of the connection.

### D. Wiring of Power Supply Unit

As shown in the figure below followed the wiring diagram of power supply. 1, 2, 3 separately represent the line of fire (brown), Zero line (blue), ground wire (yellow). 4, 5, 6 represent negative pole (black) (-); 7, 8, 9 represent the positive pole (red) (+) to avoid danger, please assure the installation is correct.

**E. Firmware**

This controller board is working with Repetier Host 2.0.1 firmware. By downloading and installing the latest versions of firmware, which is a version of Marlin modified to support the Melzi Board.

Figure 3: Welding Process of Machine Frame


Figure 4: Stepped motors used in machine

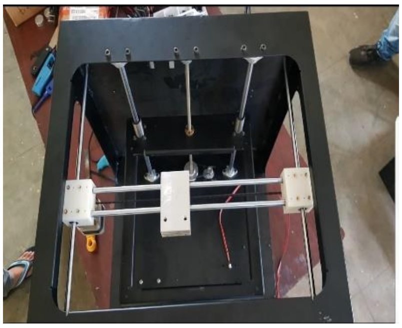

Figure 5: Wiring and Installation of stepped motors

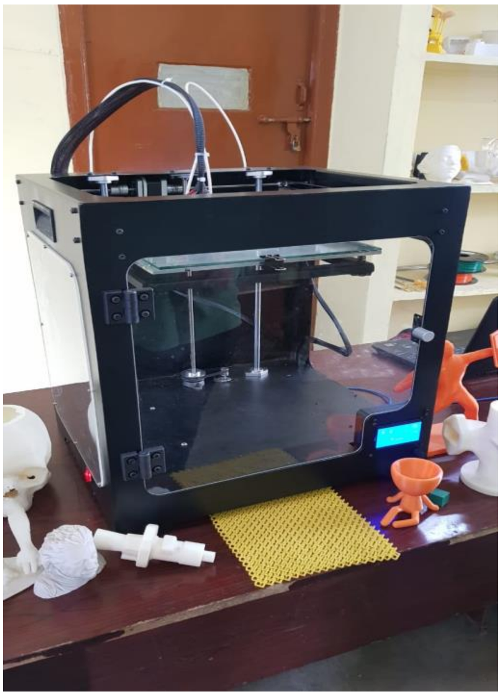

Figure 4: Final Assembled Machine

## VI.CONCLUSION

The outcome of this project is to build an economical 3D Printer which has been successfully completed. The design of the frame is made robust and compact using aluminum sections. Knowing the tensile properties as a design engineer is very crucial. The data in this study can aid the 3D printer user to choose a suitable infill orientation and layer height for the desired application and ultimately make a durable product. PLA printed specimens are tested for finding mechanical properties. Tensile testing of the 3d printed specimens. The higher the layer thickness, the lesser the part weight. If we go above 0.2mm layer height it will reduce the strength of parts. In Z-direction, layer bonding is major drawback. Layer thickness is more than half of the nozzle diameter i.e., for getting strong print using 0.4mm nozzle probably layer height should be ≤0.2mm. This results layers didn't stick better to each other when they all thinner. Besides the layer heights there are many other parameters that will play a role in the strength of your 3D prints especially for layer addition.

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