"Design and Fabrication of 3D Printer to Enhance Productivity"

Kalpesh Dapurkar[1], Rahul Singh[1], Sitaram Gawas[1], Rahul Ugale[1], Dipak Shelar[2]

[1]Student, Dr. D Y Patil Institute of Technology, Pimpri, Pune-411018, India
[2]Professor, Dr. D Y Patil Institute of Technology, Pimpri, Pune-411018, India

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Abstract – *The main objective of the paper is to analyze the design and fabrication of 3D printer with respect to the parameters of speed and accuracy. The 3D printing is basically based upon the process of Fused Deposition Modeling with the view of increasing the speed of the 3D printer as compared to that of the traditional 3D printer with the view of what is being delivered by them. Critically operated speeds of the 3D printer tend to decrease with time being exposed to high temperatures due to slow cooling of the deposited polymer stock on the heat bed. Decrease in the time of cooling of the polymer can subsequently decrease operational time to a great extent. It is further observed that this problem addresses the gap through a comparison of 3D printed objects, providing a detailed quantitative evaluation of energy and costs for this manufacturing approach.*

Key Words*: *Pronterface, Arduino, Slicer, Heat bed.

1. INTRODUCTION

3D printing majorly dealing with the process of Rapid Prototyping & Additive Manufacturing process plays vital role in it. But major obstacle in to this is speed of rapid prototyping machine. It takes few hours to days to print the part. So, the main goal of this experiment is enhancing the speed of rapid prototyping machine. The difference is in the use and scalability, not in the technology itself: Rapid Prototyping: used to generate non-structural and non-functional demo pieces or batch-of-one components for proof of concept. Additive Manufacturing: used as a real, scalable manufacturing process, to generate fully functional final components in high-tech materials for low-batch, high-value manufacturing.

Stereo lithography (STL) is the most common file types that 3D printers can read. Thus, unlike material removed from a stock in the conventional machining process, 3D printing or Additive Manufacturing builds a 3D object from computer-aided design (CAD) model by successively adding material layer by layer.

3D printing, also known as additive manufacturing (AM), refers to processes used to create a three-dimensional object in which layers of material are formed under computer control to create an object. Objects can be of almost any shape or geometry and typically are produced using digital model data from a 3D model or another electronic data source such as an Additive Manufacturing File (AMF) file.

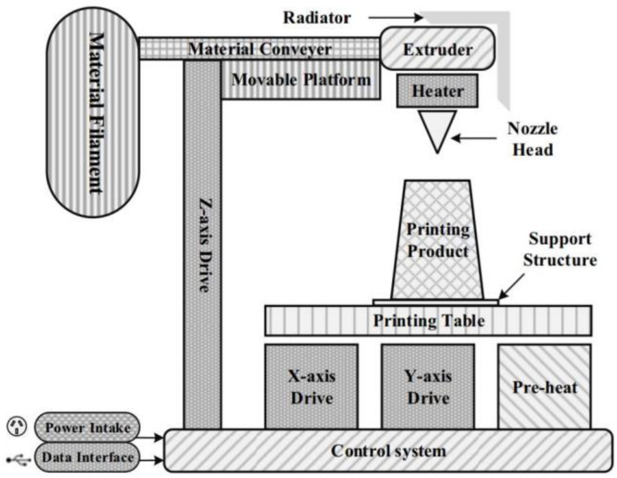

Fig-1 Schematic Daigram of 3D printer.

2. Working Criteria

3D printing ensures usage of operational relationships between software and hardware components for better and smooth processing. The working cycle can be defined as follows:

- Design of CAD CAM model in designing software like CATIA.
- Transfer of the CAD file to SLICER software to be divided and broken down in form of G codes which can be compatible for further operational processes.
- Syncing the G codes in Pronterface which will decide and direct the stepper motors used in the model of 3D printer.
- G codes defining the direction of stepper motor will direct the motors in X, Y and Z direction for the specifically assigned stepper motor for each directional axis.
- Movement of the stepper thus ensures movement of heat bed and extruder in the stated direction as the motors. This transfer of motion takes place through threaded rods.
- Extruder containing polymer base will deposit the polymer on the heat bed in the shape and direction prescribed with respect to the G codes.
- Fan for additional cooling effect of the polymer ensures reduction in the operational time of the process of 3D printing.

4. Methodology of Modeling

3D printable models may be created with a computer-aided design (CAD) package, via a 3D scanner, or by a plain digital camera software. CATIA version of CAD designing can be used to design conventional 3D printed models created with CAD result in lower errors and higher flexibility that can be adjusted before printing, allowing verification in the design of the object before it is printed. The manual modeling process of preparing geometric data for 3D computer graphics is based of primary designing with respect to different axis. 3D scanning is a process of collecting digital data on the shape and appearance of a real object, creating a digital model based on it.

CAD models can be saved in the stereolithography file format (STL), a de facto CAD file format for additive manufacturing that stores data based on triangulations of the surface of CAD models. This STL file sent to the slicer software for formation of G codes. STL is not adapted for additive manufacturing because it generates large file sizes of geometric G Codes, optimized parts and lattice structures due to the large number of axis and surface involved. A new CAD file format, the Additive Manufacturing File format (AMF) was introduced in 2011 to solve this problem of large size data capturing. It stores information using curved designing of the CAD model designed.

4.1 Printing of the 3D Model.

Before the actual printing a 3D model from an STL file, it must first be checked for errors. Most CAD applications produce errors in output STL files, of the following types:

1. Holes
2. Faces Normal
3. Self-Intersections
4. Noise Shells
5. Manifold Errors

An error caused in the modeling can decrease the accuracy of the model. STL feature of "repair" fixes such problems in the original model. These problems can differ to model to model with respect to what is being designed. Generally, STLs that have been produced from a model obtained through 3D scanning and operating, most of the times have more of these errors. This is due to how 3D scanning and developing works-as it is often by point to point acquisition, 3D reconstruction will include errors in most cases depending upon the model.

Once completed, the STL file needs to be processed by a piece of software called a "slicer," which converts the model into a series of thin layers and produces a G-code file containing instructions tailored to a specific type of 3D printer (FDM printers). This G-code file can then be printed with 3D printing client software (which loads the G-code, and uses it to instruct the 3D printer during the 3D printing process).

4.2 Finishing

Though the produced higher resolution is sufficient for many applications, better accuracy can be done by printing a bit oversized version of the model in standard resolution and then removing material using a higher-resolution subtractive process.

The structure comprising of part and layers inside and outside the part surfaces which are curved with respect to platform. The effect of this mainly depend on the orientation and design of a part surface with respect to different axis inside the model building process.

Some printable polymers such as ABS and poly-propylene allow the surface finish to be considerably smoothed, and improved using vapor processes based on the chemical polymer distribution of molecules.

Some additive printing and manufacturing process are capable of using variety of materials with respect to requirements in the course of constructing parts. These methods are able to process in multiple colors and combinations simultaneously. Some techniques require internal strengths and supports to be manufactured for overhanging works during construction. These supports may be removed or dissolved upon completion of the model.

After the completion, the base of the polymer tends to stick to the surface if not cooled or operated properly while taking the final product on the heat bed. This final product is handled with care if it is still hot as this can damage the product by disturbing the shape of the model, thus making it a waste. High grade heat beds are not stick materials which handles the model and prevents sticking but this in turn increase the cost of the printer with high cost heat bed.

The finished product has applications in the modeling industry as this is the specimen with the view of rapid prototyping. Industry such as Medicine, Engineering, Manufacturing tend to rely on these prototypes for research and application in these fields.

5. Illustrations

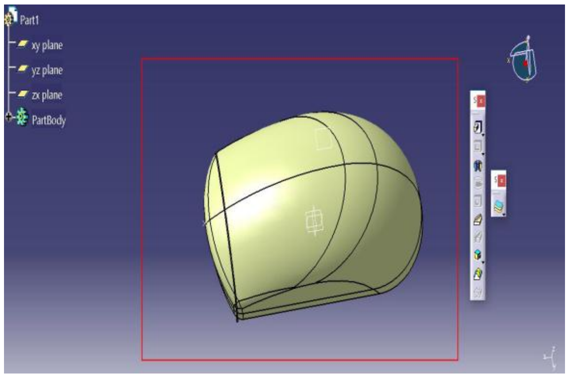

Fig. CAD modeling of the specimen.

This includes all the designing processes required in the CATIA software with which the model is being designed with the surface parameters and alignments in the axis resolution.

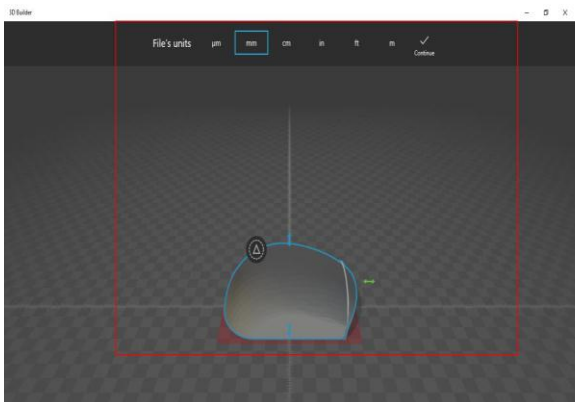

Fig. Addition of extra thickness for slicer software.

This is done to increase the error gaps with extra material and dimensions which helps in better designing and dimensions in case an internal error in the machine occurs. This is the pre-step for the slicer to cut the CAD model in layers and generate the G Codes accordingly.

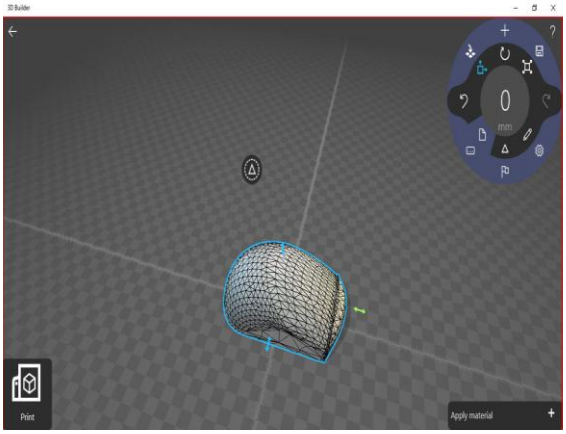

Fig. Orientation of the model and conversion in STL format.

This format in essential for the 3d printer to read the commands accordingly. Differentiation of the object in form slices is what acts as the basic modeling format in FDM.

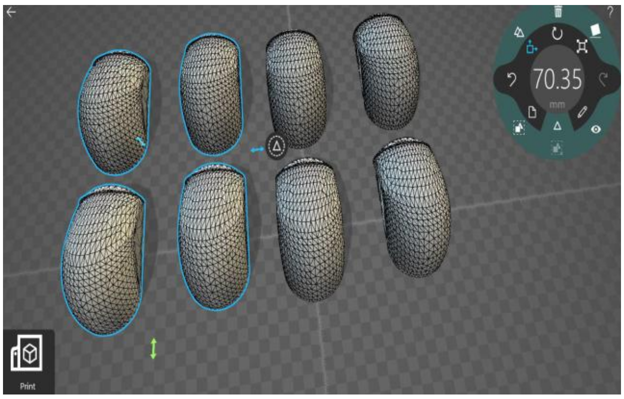

Fig. Final machine operations in the printer.

Layer to layer deposition of the polymer as per the G codes and software instruction takes places while formation of the model on the heat bed.

6. Problems Incurred

- Time incurred for the overall printing operation was more, which wasn't feasible.

- Speed of the heat bed was operationally less due to it's heavy weight design.

Traditional polymer was sticky and troublesome due to the heating effect applied on it.

All the above mentioned problems were based of the fields of speed and accuracy which was critically acclaimed with the working of a basic 3D printer. Improvement of these problematic factors will not only ensure more accuracy but also improve the compatibility and feasibility of the 3D printer based on the working of Fused Deposition Modeling. Fused Deposition based on the principle of additive manufacturing basically requires more accuracy for a better usage in the field of Rapid Prototyping .

Heat bed having more weight tend to move slow with the force compensated by the stepper motor. This increases the over all operational time in the 3D printing process. Increasing the capacity of stepper motor can hamper and increase the vibration observed on the basic alluminium frame of the printer making it difficult to operate.

Polymer content can be sticky and less viscous when heated which tends to stick on the heat bed, hereby decreasing the operational accuracy of the 3D model.

Cooling of the polymer also contributes to the increase in overall time of operation of the 3D printer.

7. Improvements

- Installation of fan on the extruder ensured faster cooling of the polymer filament on the heat bed. This ensured decrease in the operational time by upto 20% with respect to the end to end process of 3D modelling.

- Light weighted heat bed with inclussion of alluminium plate not only ensured rapid movement of the bed but also ensured the elimination of stickyness of the polymer filament. This ensured reduction in operational time by faster moving of the heat bed. This also tends to decrease the load capacity observed on the stepper motors of the apparatus. Load reduction decrease the vibration observed on the apparatus thus eliminating the noise factor.
- Usage of Polylactic Acid (PLA) increased the accuracy due to lower moleculer weight. This tends to allow the polymer to adapt critical shapes and avoid stickyness of the product once the printing is finished. Moreover, PLA being biodegradable also reduce enviornmental wastage.
- All these improvements not only increased the speed of the process and thereby decreasing the operational time but also increased the overall accuracy in the designed models.

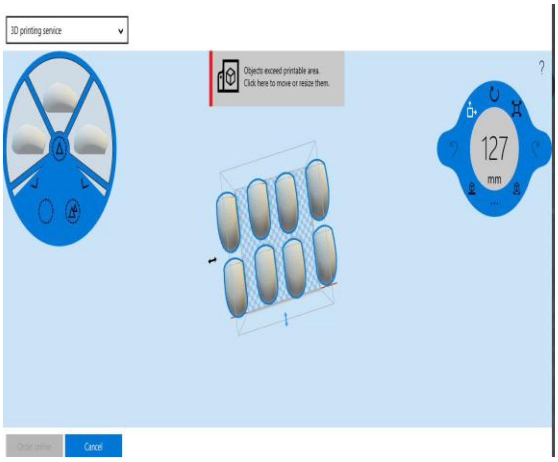

Fig. Final design after implying all the improvements

8. CONCLUSIONS

1. Usage of external devices like fan and cooling devices for the polymer to be cooled before the final representation can help in time saving up to 20%.
2. Usage of high molecular intensity polymer can help in increasing the accuracy of the model which helps it to be bend and turned around sharp corners.
3. Usage of PLA tends to develop the social responsibility of the printer as PLA being bio degradable helps to reduce environment waste related to 3D printing process.
4. Aluminum plate heat bed reduce the weight of the printer which significantly and results in swift movements of the heat bed.

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