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Design and Development of Thermal Rapid Prototyping Machine and Its Application

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Abstract – Rapid prototyping technology is an additive manufacturing technique and green technology which transform digital design model into three dimensional physical solid model without using jig and fixtures. In this paper a single jet thermal energy based rapid prototyping machine is design and developed. In this paper machine assembly, process steps and its application and limitations are discussed.

Index Terms – CAD Component design and development, Assembly, Additive Manufacturing Processes.

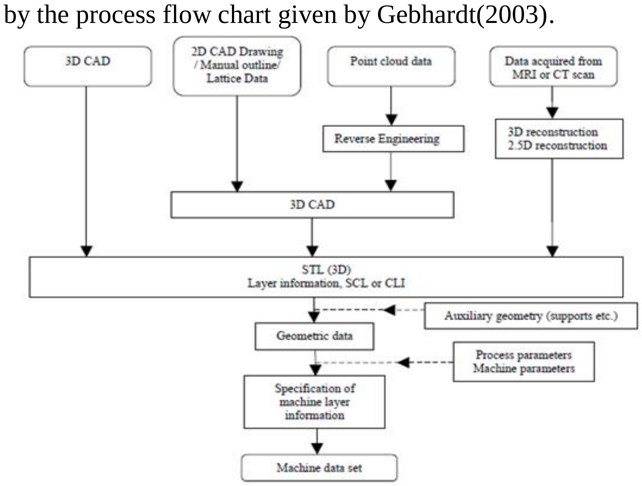
1. INTRODUCTION

Rapid prototyping is the additive manufacturing processes. In this paper a small model component design, developed and assembled on the basis of thermal energy. In this machine Fused Deposition modeling concept is used. In the process first of all the thermoplastics are heated past their glass transition temperature. Then the thermoplastics are deposited by an extrusion head, which follows a tool-path according to GM coding, and the part is built from the bottom to the up, layer by layer & one layer at a time. A plastic filament or metal wire is unwound from the coil and it supplies the material to an extrusion nozzle which can turn the flow on and off. The nozzle is heated to melt the material and can be moved in both horizontal and vertical directions by a numerically controlled mechanism. The model or part is produced by extruding small beads of thermoplastic material to form layers as the material hardens immediately after extrusion from the nozzle. Stepper motors or servo motors are typically employed to move the extrusion head.

The basic concept can be understood by following points to print any part.

- First of all CAD model developed and then covert it STL format.
- The RP machines then processes the .STL file by taking it as input and create sliced layers of the model as output.
- The first layer of the physical model is created and then the model is lowered by the thickness of the next layer, and the process is repeated until completion of the model.
- Finally the model and any other supports are removed and the surface of the model is then finished and cleaned.

Generally the data flow and process of RP can be understood by the process flow chart given by Gebhardt(2003).



Generalized illustration of data flow in RP

Figure 1 Stepper Motor

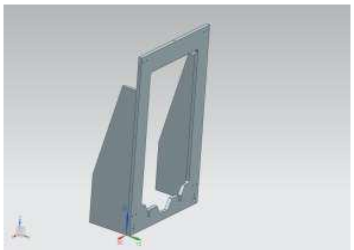


Figure 2 Frame

Figure 3 Base Assembly

Figure4 Rod

Figure 5 NUT

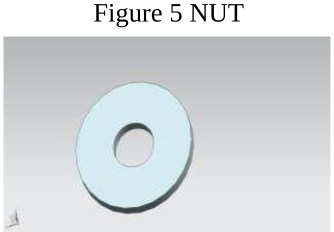


Figure 6 Washer

Isometric View in assembled state of the 3D printing device

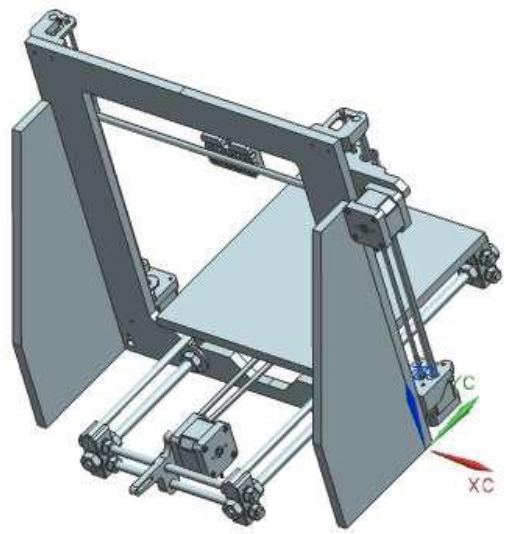


Figure 6 Front Isometric View in assembled state of the 3D printing Device

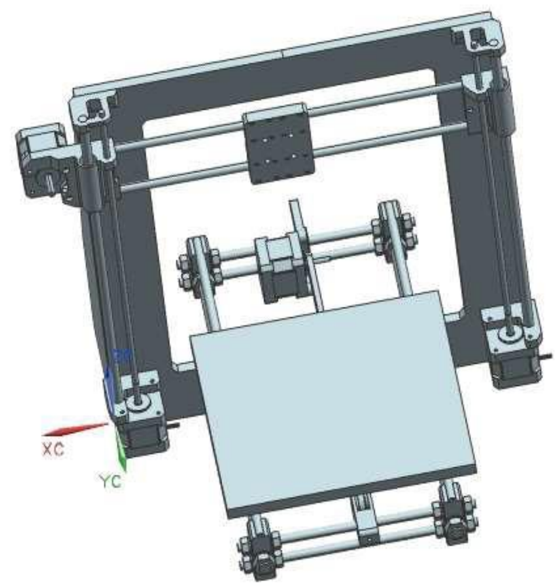
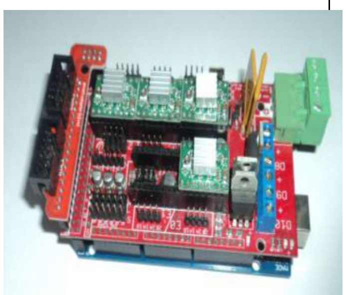
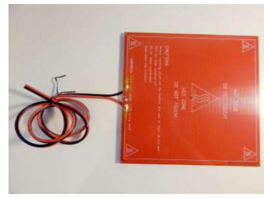
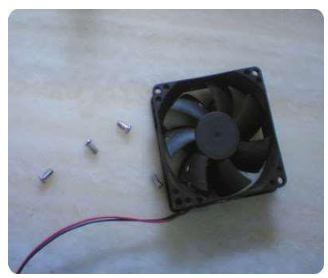


Figure 6 Front Isometric View in assembled state of the 3D printing Device

Table 1

Electrical and Mechanical Components			
Electrical Components			
	Parts	**Quantit y**	**Remarks**

01	SMPS, (12V/30A) 	**01**	Converts power supply from AC to DC
02	RAMPS Controller Board 	**01**	Controls the printer parts.
03	Stepper Motor  NEMA 17	**05**	Controlling movement and filament Supply
04	End Stops 	**03**	03 sets for each axis

05	Heated Bed 	**01**	
06	Heated Extrusion Nozzle 	**01**	
07	Cooling Fan 	**01**	
	Mechanical Components		
		Remarks	
01	Frame	For Support	
02	Rods (Smooth) 	On which the printer head is driven and for stability	
03	Rods (Threaded)	For driving the printer head	
04	Nuts, Bolts, Washers, Bearings, Clips etc.	For binding together	

05	Pulley Belts	For Driving the Print head

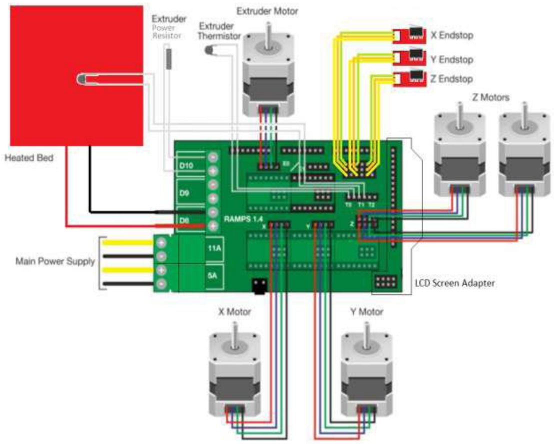


Figure 7 Connections for RAMPS

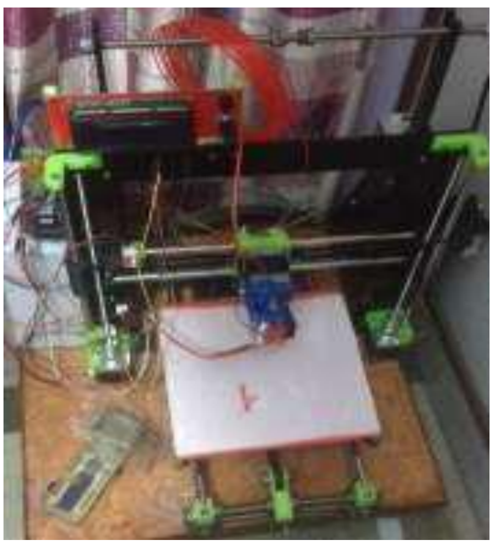


Figure 8 Assembled 3-D Thermal Printer

1. Create a 3d model and export its STL file.

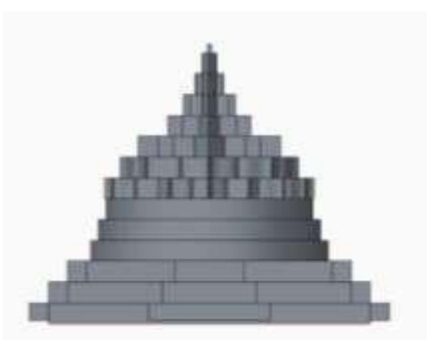


Figure 9 Sri Yantra Model

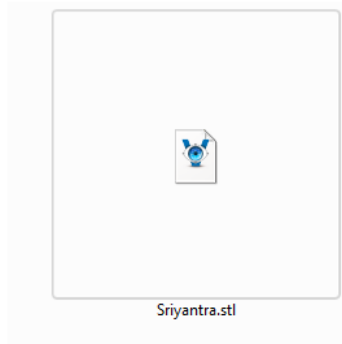


Figure 10

3. Import the STL file in the Printer Software.

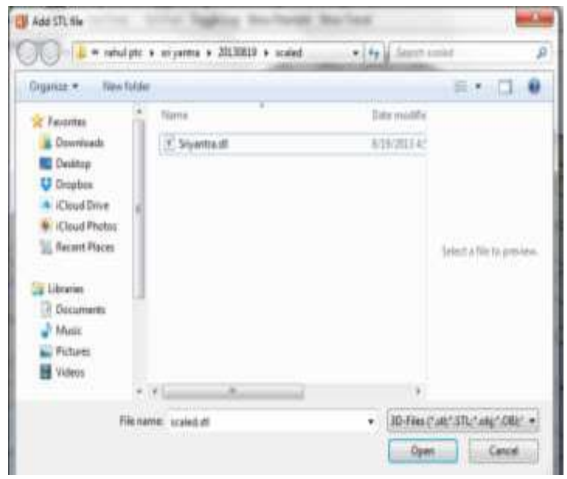


Figure 11

4. Arrange one or more models on a virtual print plate.

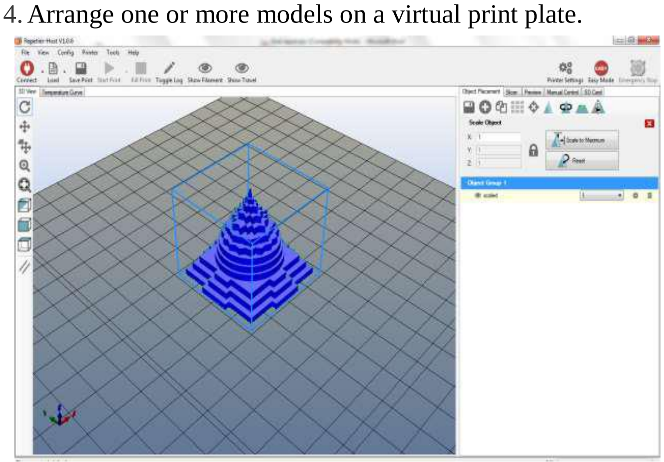


Figure 12

5. Slice the models into thin slices and compute a path for printer head. This is done by slicing software, which converts the model into g-code, the language your printer speaks.

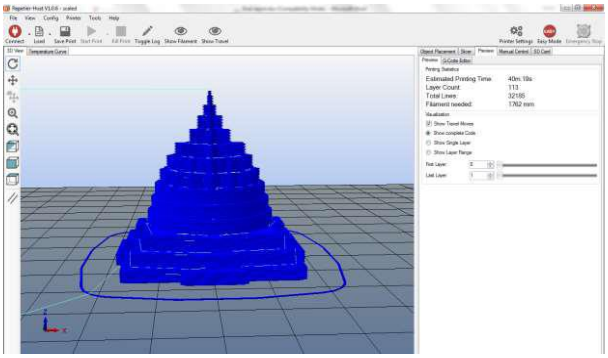


Figure 13

6. Check the created g-code for errors and printability.

```
G21 ; set units to millimeters
M107
M190 S70 ; wait for bed temperature to be reached
M104 S215 ; set temperature
G28 ; home all axes
G1 Z5 F5000 ; lift nozzle

M109 S215 ; wait for temperature to be reached
G90 ; use absolute coordinates
G92 E0
M82 ; use absolute distances for extrusion
G1 F1800.000 E-1.00000
G92 E0
G1 Z0.400 F7800.000
G1 X78.734 Y77.980 F7800.000
G1 E1.00000 F1800.000
G1 X80.723 Y76.807 E1.27422 F1080.000
G1 X81.930 Y76.477 E1.42282
G1 X92.760 Y74.577 E2.72869
G1 X93.920 Y74.476 E2.86700
G1 X106.080 Y74.476 E4.31119
G1 X107.240 Y74.577 E4.44950
G1 X118.070 Y76.477 E5.75537 F1080.000
G1 X120.242 Y77.261 E6.02960
G1 X122.020 Y78.734 E6.30382
G1 X123.193 Y80.723 E6.57805
G1 X123.523 Y81.930 E6.72664
G1 X125.423 Y92.760 E8.03251
G1 X125.524 Y93.920 E8.17082
G1 X125.524 Y106.080 E9.61501
G1 X125.423 Y107.240 E9.75332
G1 X123.523 Y118.070 E11.05919
G1 X122.739 Y120.242 E11.33342
G1 X121.266 Y122.020 E11.60764
G1 X119.277 Y123.193 E11.88187
G1 X118.070 Y123.523 E12.03046
G1 X107.240 Y125.423 E13.33633
G1 X106.080 Y125.524 E13.47464
G1 X93.920 Y125.524 E14.91883
G1 X92.760 Y125.423 E15.05714
G1 X81.930 Y123.523 E16.36301
G1 X79.758 Y122.739 E16.63724
G1 X77.980 Y121.266 E16.91146
G1 X76.807 Y119.277 E17.18569
G1 X76.477 Y118.070 E17.33428
G1 X74.577 Y107.240 E18.64015
G1 X74.476 Y106.080 E18.77846
G1 X74.476 Y93.920 E20.22265
G1 X74.577 Y92.760 E20.36096
G1 X76.477 Y81.930 E21.66683
G1 X77.261 Y79.758 E21.94106
G1 X78.696 Y78.027 E22.20816
G1 F1800.000 E21.20816
G92 E0
G1 X81.922 Y94.652 F7800.000
G1 E1.00000 F1800.000
G1 X82.440 Y94.545 E1.06280 F378.000
G1 X83.090 Y94.545 E1.13999
G1 X83.608 Y94.438 E1.20279
G1 X83.715 Y93.920 E1.26559
```

7. Send the g-code to your printer by clicking start print or copy the code to a SD card, which you can insert into your printer.

Monitor your printer.

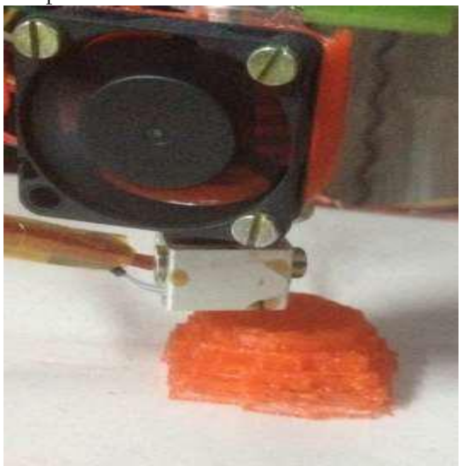


Figure 14

3-D printed Sri Yantra

Figure 15

2. APPLICATION OF RP

Rapid Prototyping play an important role in Product Design and Development, Reverse Engineering applications, Short Production Runs and Rapid Tooling, E-manufacturing Processes, Medical Field etc.

3. CONCLUSION

This paper demonstrates about machine components design and development, assembly and gives fundamental concept about processes of rapid prototyping. Part which has

Geometrical constraints in subtractive marching processes that can be print without any constrains in single processing time. This technology is free from geometry .This is green technology with respect to environmental perspectives. This machine has some limitations.

1. Power supply must be continuing without any interrupt.
2. Raw Materials can be used only PLA, and ABS due to working temperature limiting conditions.
3. Parts surface finish is not excellent
4. Parts required post processing operations.
5. Machine can run continuously for limited hours.
6. Waste Materials after post processing cannot be reused.
7. Post processing is difficult and takes more time to finish or to remove support materials in case of hollow, shell, and blind hollow spiral type object.

This is the future based technology. In future research work is going on to remove its limitations. In future this technology plays more roles with respect to Customer Perspective, Market competitiveness, Financial Perspectives and Environmental Perspectives and e-manufacturing for solving supply chain management issues.

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