e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:04/Issue:06/June-2022 Impact Factor- 6.752 www.irjmets.com

MANUFACTURE OF POLYLACTIC ACID (PLA) FILAMENTS AS RAW MATERIAL FOR 3D PRINTING

Teja Sai Manyapu[*1], Murari Sai Teja[*2], Avidi Chandra Mouli[*3], S. Sreekanth[*4]

[*1,2,3]Student, Department Of Electronics And Communication Engineering, ACE Engineering College, Hyderabad, Telangana, India.

[*4]Assistant Prof., Department Of Electronics And Communication Engineering, ACE Engineering College, Hyderabad, Telangana, India.

ABSTRACT

Rapid prototyping (RP) technology has experienced rapid development during the last few years, one of which is fused deposition modeling (FDM). In its use, often the material used to print the model is wasted when the printing process is complete because of the incompatibility between the product results with the desired initial design. In addition, in complex models some support materials are needed. This spend quite a lot of materials and of course the costs needed. There for a filament extruder machine is needed to be able to recycle and produce filaments such as PLA independently. The object of this study is the process parameters in the Filament Extruder machine made by the Department of Mechanical and Industrial Engineering, Faculty of Engineering, Universities Gadjah Mada. The process parameters that will be the main focus of this research are the heating temperature in the barrel and the rotational speed of the screw. The material used is a red 3 mm polylactic acid (PLA) filament with melting temperatures ranging from 190 - 220 ° C produced by Shenzhen Esun Industrial Co., Ltd. and then crushed to become the size of pellets. From the results obtained that filaments can be made even though in this study no experiments have been carried out in the actual 3D printing applications. The extrusion experiment with 2 variations in temperature settings succeeded in producing filaments namely 170°C and 160°C coupled with 4 variations in screw rotational speed settings of 100, 125, 150, and 175 from the machine monitor which were converted to 12, 14, 16.2, and 18.75 RPM for 170°C settings and 10.5, 16.2, 20, and 26.1 RPM for 160°C settings. The smallest maximum per minimum diameter value obtained is 1.09 or has the most stable profile obtained by the process parameters setting of 160°C and screw speed 100 (10.5 RPM), and the largest output rate 4.67 g/min obtained by temperature setting of 170°C and screw speed 150 (16.2 RPM). Further, filaments are tested out by tensile test processes so that mechanical characteristics can be identified.

Keywords: Filament Extruder, Fused Deposition Modeling, Polylactic Acid.

I. INTRODUCTION

The use of physical models in the world of engineering has passed through history a long one since the last quarter of a century, especially in terms of design and mechanical engineering. Many of these models have now been replaced by computational representation. What the computing model cannot do unfortunately is a form of embodiment and physical handling. Models physical has been commonly used in the world of education and various exhibitions the technology of the early period, and its use has largely been replaced days this is by Computer Aided Design (CAD) models and simulations. But the development of rapid prototyping (RP) technology is now possible to reintroduce physical models as an intuitive way to demonstrates the concepts of mechanics (Lipson et al., 2005). RP Technology very helpful in reducing the time of the product development cycle by creating a physical model for visual evaluation directly from the model 3D computer, which is then passed on to print one of them using 3D printer (Li et al, 2000), or quite known as additive manufacturing (AM) in the world of manufacturing industry and 3D printing in general circles. American Society for Testing and Materials (ASTM) define additive manufacturing as "process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies, such as traditional machining" (Harris, 2012). In other words, additive manufacturing is a process of incorporation material for creating objects from 3D model data, generally layer by layer, as opposed to subtractive manufacturing such as cutting, drilling, and milling which in the process reduces the material from the work piece, until it reaches desired shape.

II. METHODOLOGY

The basic principle of FDM technology is to produce a model directly from three-dimensional CAD data using a material extrusion process in which the fabricated model does not require an advanced machining process. First, three-dimensional CAD models are created and exported in STL data format for specific AM software packages. In this data format, the model is sliced layer by layer or better known as slicing and the tool trajectory rate will be based on the process parameters specified by the operator.

The trajectory of this chisel is illustrated in the renders rendered by the software. After receiving instructions, the FDM machine will drive the thermoplastic filament into a heated liquefier where the plastic reaches a liquid state and can flow then be extruded through holes or orifices of small diameter. Simultaneously, the movement of the chisel is translated in cartesian coordinates X and Y while the material is dispositioned to the top of the workbench to produce layers consisting of contours (borders or fringes that resemble the shape of a 3D CAD model) and raster (patterns of internal contents between contours).

For the fabrication of overhang features, support material is required in the process and can be cleaned or dissolved in a cleaning solution after the model has been completed. After the first layer is finished forming the workbench will go down with a distance of height from the created layer and a new layer is created on top of the previous layer. The subsequent layers are built on the same principle until the whole model is completed. A schematic diagram of the FDM method can be seen in Figure 1.

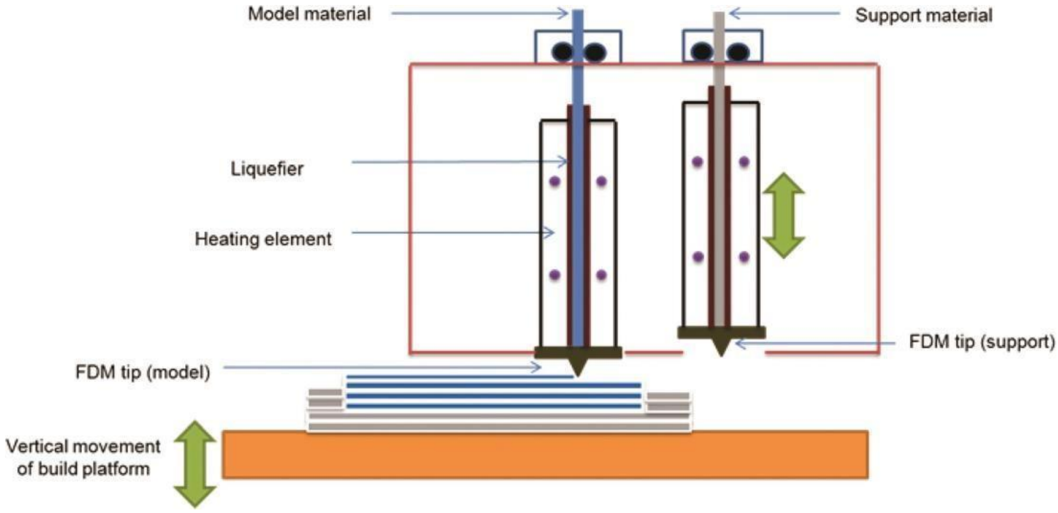

Figure 1: Schematic diagram of the FDM machine

FDM process parameters include development orientation or build orientation, raster angle (RA), contour width (CW), number of contours, raster width (RW), raster to raster air gap (RRAG), layer height or thickness, and seam position.

Polylactic Acid (PLA)

Polylactic acid (PLA) is an aliphatic polyester made from lactic acid (2-hydroxy propionic acid) and can be produced by carbohydrate fermentation or through chemical cystitis. PLA includes thermoplastics that can biodegradable and composted derived from renewable plant sources, such as starch and sugar. Because PLA is biodegradable and derived from renewable materials, it has become a consideration as one of the solutions to address the problem of solid waste disposal and to reduce dependence on petroleum-based plastics as packaging materials. PLA has quite good optical, physical, mechanical, and wall properties when compared to existing petroleum-based polymers. The permeability coefficients of CO2, O2, N2, and H2O of PLA are lower than polystyrene (PS), but higher than polyethylene terephthalate (PET). Mechanically, the PLA is quite brittle, but it has good strength and rigidity. The tensile modulus and elasticity of PLA are higher than high density polyethylene (HDPE), polypropylene (PP) and PS, but have impact strength and elongation at the time of smaller break points.

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:04/Issue:06/June-2022 Impact Factor- 6.752 www.irjmets.com

Hardware Components Used:

- Thermometer XH-B310 - One of thermometers that are able to measure high temperatures (up to 800°C).
- 12V DC Motor (7RPM) - The motor is built into the holder and drives the spool for winding the finished pet filament.
- Heat Block- The heat block is the part heated by the heating element (12V 40W)
- Heater 12V (40 W)- Ceramic heater 12V (40W) is a component that is inserted into the
- heatblock and ensures heating of the nozzle.
- Power Supply 12V- The difference is in the stability of the engine speed and the stability
- Ofthe nozzle temperature.
- PWM Regulator - Adjustable Speed Regulator
- W1209- This is heart of the Petamentor project.
  - 100K Thermistor- This part will replace an original W1209 sensor.

III. MODELING AND ANALYSIS

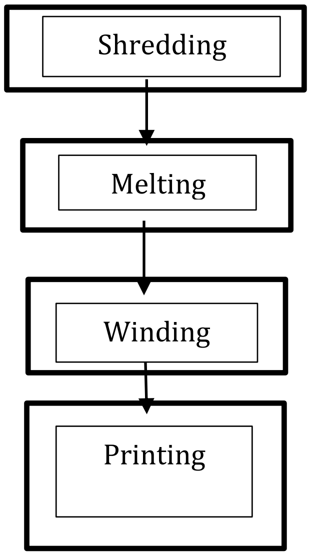

Figure 2: Flow of Process

Shredding:

The recycled fila ment is made of the PET bottles which is made of thoroughly and shred into tiny plastic flakes.

Melting :

These flakes are decontaminated, melted and finally extruded into clean 1.75 or 2.85 mm thick string.

Winding :

This freshly recycled filament is wound on a spool and packed into the boxes.

Printing:

And another batch of fully recycled filament is ready to be printed.

IV. RESULTS AND DISCUSSION

The beginning of the experiment was carried out by setting the heating temperature to 185 °C, which is the melting point temperature of the PLA material. By slowly increasing the rotational speed of the motor, it can be seen that the filaments begin to be extruded at a speed of 100 on the engine monitor or after being converted to about 10 – 12 RPM. With several experiments, the results showed that the PLA filaments extruded from the nozzles were still too liquid and caused the filaments to become shapeless and have many air cavities and wrinkled, some to the point of being reduced in the pigments due to overheating.

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:04/Issue:06/June-2022 Impact Factor- 6.752 www.irjmets.com

Figure 3: Results of extruded filaments with a heating temperature setting of 170°C and screw speed of 100 (12 RPM)

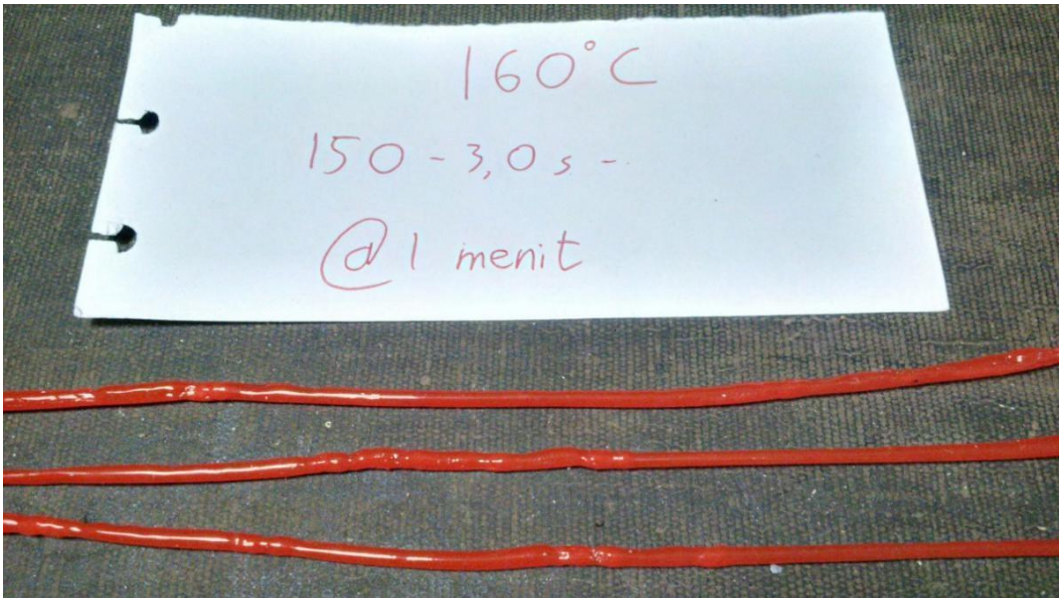

Figure 4: Extruded filament results with a heating temperature setting of 160°C and a screw speed of 150 (20 RPM)

The observed outcome of the project:

- Low cost of production.
- No storage cost.

Advantages:

- Ability to customize products.
- Rapid production of prototypes.
- Quick availability of organs.
- Forluxury and comfortable

Disadvantages:

- Limitations of size.

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:04/Issue:06/June-2022 Impact Factor- 6.752 www.irjmets.com

The observed out come of the project:

Figure 5: Complete Project

V. CONCLUSION

PLA filaments can be made even though in this study there have been no experiments in the actual application of 3D printing;Extrusion experiments with 4 design variations of temperature regulation on the heater namely 185°C, 170°C, 160°C, and 150°C ended with 2 variations successfully producing filaments namely 170°C and 160°C plus 4 variations of screw rotational speed settings of 100, 125, 150, and 175 which were converted to 12, 14, 16.2, and 18.75 RPM for 170°C and 10.5 settings, 16.2, 20, and 26.1 RPM for 160°C settings;Successfully produced filament profiles with a maximum diameter per smallest diameter of 1.09 or having the most stable profile were obtained with a process parameter setting of 160°C temperature and screw speed of 100 (10.5 RPM), and the largest discharge of 4.67 g/min was obtained with a temperature setting of 170°C and a screw speed of 150 (16.2 RPM)

ACKNOWLEDGEMENTS

We are grateful to our guides Assistant Prof. Mr. S. Sreekanthand Prof. B. GIRI RAJU for their continuous support and guidance. Through their guidance, we were able to successfully complete our project. Sincere thanks go to Dr. P. SATISH KUMAR, Head of the Department of Electronics and Communication Engineering at ACE Engineering College, for his support and time. We are very grateful to my family and friends for their constant support and encouragement during the project period.

VI. REFERENCES

[1] Autodesk. (2014). Autodesk 123D. Retrieved January 16, 2014 from http://www.123dapp.com/

[2] Bryce, E. (January 19, 2014). How a 3D printer gave a teenage bomb victim a new arm – and a reason to live. Retrieved January 14, 2014,from http://www.theguardian.com/lifeandstyle/2014/jan/19/3d-printer-bomb-victim-new-arm-prosthetic-limb

[3] Burke. (January 16, 2014). 3D Printing Is The Future, But Safety Comes First. In Information Week. Retrieved February 3, 2014, from http://www.informationweek.com/infrastructure/3d-printing-is-the-future-but-safety-comes-first/d/d-id/1113457

[4] Falconer, J. (September 26th 2013.) Formlabs Creates Blu-ray Based Prosumer 3D Printer. Retreived January 14, 2014, from http://www.gizmag.com/formlabs-blu-ray-prosumer-3d-printer/24300/

[5] McNaney, T. (2014). Filabot. Retrieved January 16, 2014 from http://www.filabot.com/