|| Volume 5 || Issue 5 || May 2020 || ISSN (Online) 2456-0774
INTERNATIONAL JOURNAL OF ADVANCE SCIENTIFIC RESEARCH
AND ENGINEERING TRENDS

3D PRINTING PROCESS USING FUSED DEPOSITION MODELLING (FDM)

Mr. Thakar C. M. [1] Sakshi J[2], Tejaswi Y[3], Sayali K[4] Mayuri G[5], Snehal J[6], Akashta K[7]

Lecturer, Mechanical Department, Government polytechnic karad, Maharashtra [1]
Student, Mechanical Department, Government polytechnic karad, Maharashtra [2 3 4 5 6]

***Abstract*: - Fused Deposition Modeling (FDM) is an Additive Manufacturing technique for printing 3D objects layer by layer. The key purpose of the research is to develop a low cost 3D Printer using easily available parts and conventional methods for manufacture which can be used to print objects confined within 250 x 250 x 250 (in mm) Printing Area. Many Industries uses traditional methods for developing prototype for analysis rather than using technologies like 3D printing because it is expensive. After thorough market survey, we came to a conclusion that 3D Printers available in the Indian market are priced around Rs. 50,000 to 60,000 due to type of supporting material used. Initially we designed our 3D Printer completely in 3D Modelling Software SOLIDWORKS and analyzed each part and selected readily available material appropriately so as to develop a cost effective printer. Main objective of research is to develop a printer which is cost effective and to encourage manufacturers to adopt the method of 3D Printing.**

Keywords: *Additive Manufacturing, Rapid Prototyping, Fused deposition modeling, STL*

I INTRODUCTION

3D printer is an additive manufacturing technique where 3D objects and parts are made by the Addition of multiple layers of material. It can also be called as rapid prototyping as well Desktop fabrication. It is a mechanized method where 3D objects are quickly made as per the required size. Machine connected to a computer containing blueprints of any object. The additive method may differ with subtractive process, where the material is removed from a block by sculpting or drilling. The 3D printing is efficiently utilized various fields Such as aerospace, automobile, medical construction, and in manufacturing of many Household products. It includes many procedures, but FDM is one of the effective and economical process. Three dimensional 3D printing has the ability to impact the transmission of information in ways Similar to the influence of such earlier technologies as prototyping.

1.1 How FDM Works

3D printers that run on FDM Technology build parts layer-by layer from the bottom up by Heating and Extruding thermoplastic filament. The process is simple:

- Pre-processing: Build-preparation software slices and positions a 3D CAD file and calculates a path to extrude thermoplastic and any necessary support material.
- Production: The 3D printer heats the thermoplastic to a semi-liquid state and deposits it in ultra-fine beads along the extrusion path. Where support or buffering is needed, the 3D printer deposits a removable material that acts as scaffolding.
- Post-processing: The user breaks away support material away or dissolves it in detergent and water, and the part is ready to use.

II LITERATURE REVIEW

Thabiso Peter Mpofu, Cephas Mawere, Macdonald Mukosera[1] 3D printing also known as Additive manufacturing technology has been dubbed the next big thing and be as equally wide spread as cellular telephone industry. 3D printers print objects from a digital template to a physical 3-dimensional physical object. The printing is done layer by layer (Additive manufacturing) using plastic, metal, nylon, and over a hundred other materials. 3D printing has been found to be useful in sectors such as manufacturing, industrial design, jewellery, footwear, architecture, engineering and construction, automotive, aerospace, dental and medical industries, education, geographic information systems, civil engineering, and many others. It has been found to be a fast and cost effective solution in whichever field of use. The applications of 3D printing are ever increasing and it's proving to be a very exciting technology to look out for. In this paper we seek to explore how it works and the current and future applications of 3D printing.

Karel Brans [2] it is likely that more articles on 3 D Printing (or Additive Manufacturing) have featured in mainstream media over the past two years than during the entire 25 years that the technology has been around. This paper briefly introduces the 3D Printing technology and explains the unique benefits compared to traditional manufacturing methods. Some of the most important reasons why the technology is currently attracting so much attention are discussed. Significant improvements in equipment, materials and software have enabled high end applications for 3D Printed end use parts. This is illustrated by examples of some of the most successful applications. Moving towards real manufacturing also brings new challenges in quality assurance. This paper presents a software solution for data management and quality assurance in 3D Printing. At the same time, low end variants of the technology are becoming more and more affordable for consumers. The question is raised whether people will be printing their own parts at home in the future.

Hye Won Lim, Tracy Cassidy [3] 3D printing technology, also known as additive manufacturing, is appearing at an amazing rate. It enables the creation of many products in design. This study focused on how 3D printing technology has developed, how it has been adapted from industry, and how it is applied in different areas. In the meantime, it also illustrated how this technology is used in fashion to engage creatively and the exciting potential values inspiring and extending fashion designers' range of work. Nowadays many 3D printing manufacturers are dedicated to developing environmentally friendly products along with more sustainable strategies. It is shown how developers are keen to create with less waste, minimised and ethically manufacturing processes as well as recycling reusable, new eco-friendly materials.

Izabela Hager, Anna Golonka, and Roman Putanowicz[4] The paper presents the state of the art concerning the current achievements in the field of 3D printing of buildings and building components. The 3D printing technologies, comparing to traditional techniques of constructing the buildings, could be considered as environmental friendly derivative giving almost unlimited possibilities for geometric complexity realizations. Numerous advantages of this technology, such as reduction of the costs and time, minimizing the pollution of environment and decrease of injuries and fatalities on construction sites could be cited. Despite many advantages and hopes, some concerns are summarized in the conclusions, as the technology still has many limitations. Creating a model that will be appropriate for 3D printers is possible in many different modeling programs. One of the most popular formats for sharing such models is STL format. In the paper sample models crated in Autodesk Inventor are shown, but also other tools suitable for preparing models for 3D printing are briefly discussed.

Simon Ford, Melanie Despeisse[5] The emergence of advanced manufacturing technologies, coupled with consumer demands for more customized products and services are causing shifts in the scale and distribution of manufacturing. In this paper, consideration is given to the role of one such advanced manufacturing process technology: additive manufacturing. The consequences of adopting this novel production technology on industrial sustainability are not well understood and this exploratory study draws on publically available data to provide insights into the impacts of additive manufacturing on sustainability. Benefits are found to exist cross the product and material life cycles through product and process redesign, improvements to material input processing, make-to-order component and product manufacturing, and closing the loop. As an immature technology, there are substantial challenges to these benefits being realized at each stage of the life cycle. This paper summarizes these advantages and challenges, and discusses the implications of additive manufacturing on sustainability in terms of the sources of innovation, business models, and the configuration of value chains.

Vinod G. Gokhare, Dr. D. N. Raut, Dr. D. K. Shinde[6] This is a research paper on 3D printing and the various materials used in 3D printing and their properties which become a notable topic in technological aspects. First, define what is meant by 3D printing and what is significant of 3D printing. We will go into the history of 3D printing and study about the process of 3D printing and what materials used in the manufacture of 3D printed objects and select the best materials among them which are suitable for our 3D printing machine. Also, see the advantages of 3D printing as compared to additive manufacturing. Introduction part is about the brief history of 3D printing, in the next section we have depicted the 3D-printing and the processes used in 3D-printing and the properties of the 3Dprinter materials. In the third section, we have highlighted the main advantages and limitations of the 3D printing technology. One can conclude that the 3-D printing technology's importance and social impact increase gradually day by day and influence the human's life, the economy, and modern society. 3D printing, on the other hand, can enable fast, reliable, and repeatable means of producing tailor-made products which can still be made inexpensively due to automation of processes and distribution of manufacturing needs.

Ying Zhang and Jyhwen Wang[7] functionally graded porous materials (FGPMs) are porous structures with porosity gradient distributed over volume. They have many potential applications in aerospace, biomedical, and other industries. Despite significant efforts have been made to fabricate FGPMs, the existing manufacturing techniques are either complex, expensive, unable to control exact porosity distribution, or unable to create closed cell structures. This paper presents an additive approach for fabrication of polymer FGPMs with both closed cell and open cell structures using thermal-bonding lamination techniques. Under applied compressive load, controlled heating, and appropriate holding time, it was shown that this thermally induced bonding technique can bond layers of polymer sheets to create porous three-dimensional objects. The effects of various factors on the bonding shear strength were investigated. It was found that the bonding strength can be controlled by properly setting the pressure, temperature, and time in the process

Ze-Xian Low, Yen Thien Chua, Brian Michael Ray, Davide Mattia, Ian Saxley Metcalfe, Darrell Alec Patterson[8] Additive manufacturing, likewise known as 3 dimensional (3D) printing and rapid prototyping, has the ability to create almost any geometrically complex shape or feature in a range of materials across different scales. It has found its applications in various areas, such as medicine (bioprinting), art, manufacturing and engineering. On the other hand, its use in separation membrane engineering is relatively new. The use of additive manufacturing techniques could provide more control towards the design of separation membrane systems and offers novel membrane preparation techniques that are able to produce membranes of different shapes, types and designs which cannot be made using conventional techniques such as phase inversion or sintering. Due to the potential benefits of 3D printing in membrane manufacturing, in particular the unprecedented control over membrane architecture the technique could allow, the use of 3D printing in membrane systems should see significant growth in the near future.

Mehmet Sakin, Yusuf Caner Kiroglu[9] The paper presents the new technology of 3D printing of buildings for the sustainable houses of the future. 3D printing building technology is a new construction technique started with the invention of 3D printer. Latest technologies were described in this paper with pointing to Contour Crafting as a promising technique that may be able to revolutionize construction industry in near future. It has many advantages of this technology, such as reduction of the costs and time, minimizing the pollution of environment and decrease of injuries and fatalities on construction sites could be listed. Integration of Building Information Modeling with the 3D printing building technique is mentioned in comparison with the traditional construction techniques. Moreover, integration of BIM method with 3D printing modeling will be effective for energy efficiency, better design, cost reduction and isolation of structure.

Nadim S. Hmeidat, James W. Kemp, Brett G. Compton[10] Clay-based Nano scale filler materials are commonly used to impart unique and desirable properties to polymer resins. Small volume fractions of Nano clay have disproportionately large effects on stiffness, toughness, strength, and gas barrier properties of polymer matrices due to their high surface-to-volume ratio and platelet morphology. Recent work has suggested that highly loaded epoxy/clay/fiber mixtures possess desirable rheological properties for use as feedstock materials for direct-write 3D printing, but little is known about the effects of the deposition process on the resulting properties of the printed composites. Although the observed anisotropic strength values indicate that the deposition process does impart orientation to the Nano clay, the strength in each direction is significantly greater than values reported for 3D printed thermoplastic composites, suggesting that the epoxy/clay system has high potential for further development as a 3D printing feedstock material.

Uday Kiran Roopavath, Sara Malferrari, Annemieke Van Haver [11] In this study presents materials and design optimization of clinically approved hydroxyapatite (HA) using extrusion based 3D printing process. The effect of various printing parameters including print speed, extrusion pressure, accuracy and infill density to produce defined porous structures is established using various techniques. Tailoring infill density also helps in altering mechanical properties in a predictable manner. Finally, a case study on hydroxyapatite printing of a patient specific bone graft demonstrates the ability of this material and technique to print complex porous structures created on CT-based anatomical bone models and preoperative 3D planning, providing further promise for custom implant development for complex bony designs.

H. Kursad Sezer, Ogulcan Eren[12] This work presents significant mechanical and electrical property enhancement of 3D printed parts through dispersion of multiwall carbon nanotubes (MWCNTs) using twin-screw micro-compounding extruder having a backflow channel facility. The composite structure obtained has been further processed in a single screw extruder to produce 3D printing filaments, 1,7mm in diameter. The mechanical, electrical and melt flow properties of the MWCNT reinforced ABS matrix composite parts, with loading percentages up to 10% has been presented for the first time in this work, using a commercial 3D printer. Moreover effects of raster angle on tensile properties such as tensile strength, ductility and the elastic modulus as well as the electrical conductivity are also studied.

II CONSTRUCTION & WORKING

1) Extruder: The products of extrusion are generally called “extrudates". Drawing metal is the main way to produce wire, sheet, bar, and tube. Extrude molten plastic filament, the "Cold End" forces the raw material.

2) Hot end: The "Hot End" is the active part of the 3D printer that melts the filament. It enables the liquid plastic to exit from the small nozzle to shape a thin and cheap dab of plastic that will stick to the material it is laid on.

Figure 2.1

Figure 2.2

3) Belts and pulley: It is in the form of a loop. It connects mechanically two shafts for transmitting power smoothly from one shaft to another.

4) Pulley: Pulleys are utilized as a part of an assortment of approaches to lifting loads. Apply powers, and to transmit control. The drive component of a pulley framework can be a rope, link, belt, or chain that keeps running over the pulley inside the section.

Figure 2.3

5) Axis of the 3D printers:
X-Axis: It consists of the pulleys, timing belt, carriage, cylindrical rods, and extruder nozzle (used in FDM process) .
Y-Axis: It consists of Carriage, Cylindrical Rods, Pulleys and Timing Belt. The rotary motion of motor is converted into linear sliding motion by timing belt – pulley.
Z –Axis: The rotary motion of the motor is transfer by rotating the lead screws connected to the bed by using flange nut and shaft coupler as shown. The torque produced by the motor is transmitted to the lead screws by using shaft coupler and flange nut.

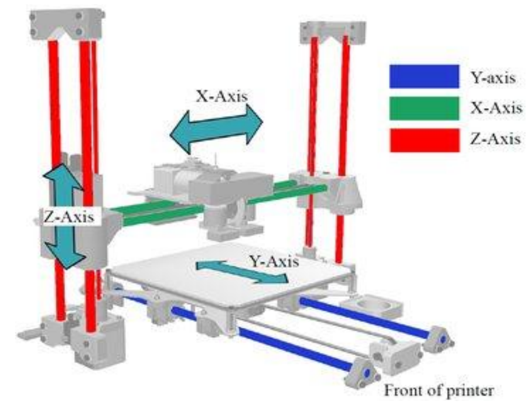

FIGURE 2.4

6) Controller (MKS GEN V 1.4): We used this controller MKS GEN V1.4 in printer. Controller controls the motion of all motors and movements.

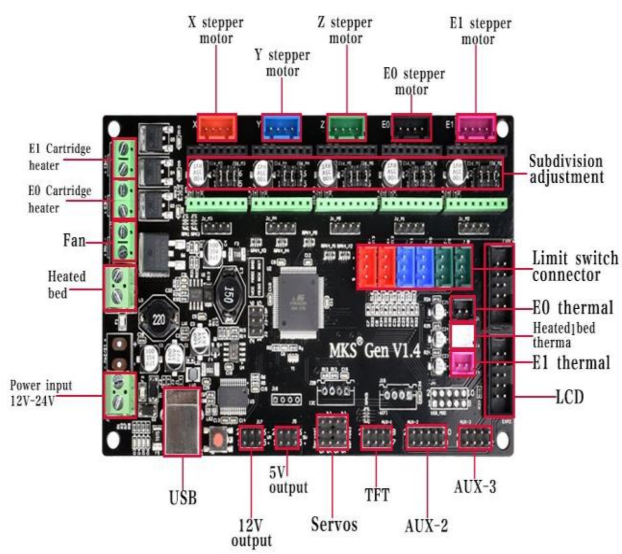

FIGURE2.5

7) Stepper motors: Stepper motors are generally used where precise position control is required, so generally these are used in 3D printing. We used stepper motor named NEMA17. It gives very precise position of X Y and Z axis.

FIGURE 2.6

8) LCD display: The input is given to the display from the MKS board. The display shows all information regarding object being printed like how much percent object is completed, how much time required to compete object etc.

FIGURE 2.7

9) Heated Bed: A heated build platform HBP improves in the printing quality of the 3d model by helping prevent warping. As extruded plastic cools it shrinks slightly. In this process shrinking will not occur throughout the printed part evenly, the result is the warped part. This warping is very commonly seen as corners being lifted off of the build platform.

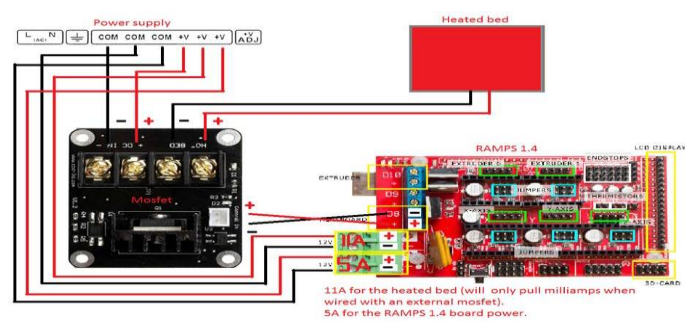

Figure 2.8

2.1 Printing Process

STEP 1: Part Design

The first and foremost step in the process of 3d Printing is to design the part or model to be Printed in any of the 3D Modelling Software's such as Pro-E , Catia , Solidworks…etc.

1. In our case we had used Fusion 360 Modelling Software to design a part. 2. Required dimensions for the part to be printed are decided in the design stage.

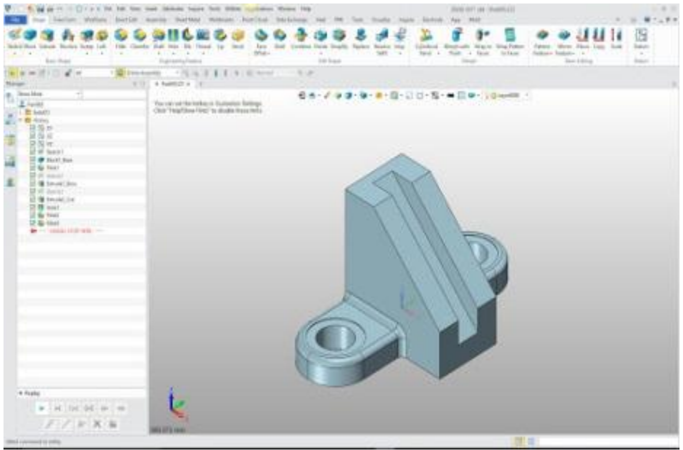

Figure 2.9 Part design in fusion 360

STEP 2: Saving the Design in .STL format

The designed file is saved as .STL format (Stereolithography).This file format is supported by many software packages; it is widely used for rapid prototyping, 3D printing and computer-aided manufacturing.

An STL file describes a raw unstructured triangulated surface by the unit normal and vertices (ordered by the right-hand rule) of the triangles using a three dimensional Cartesian coordinate system.

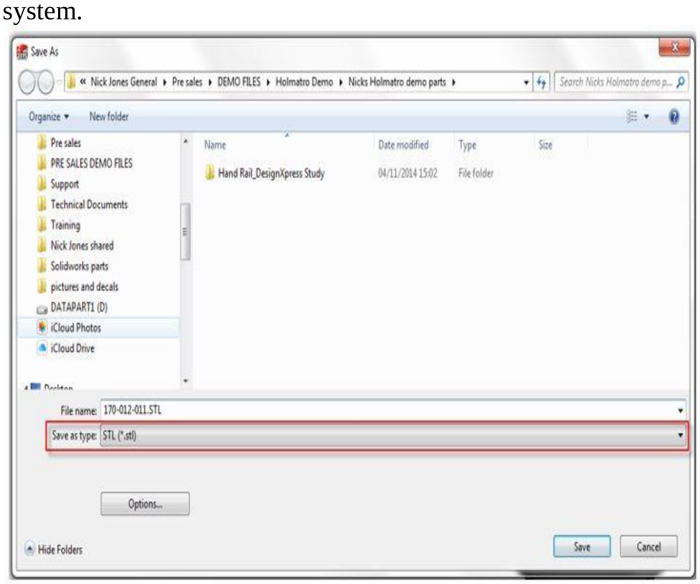

Figure 2.10 saving the file in STL format

STEP 3: Opening file in Slic3r and Export G-code

The .STL file is opened in Slic3r Software where the view of the object or the position in which the object would be printed can be seen.

After checking the view the G-code of the design in this case a Twisted Hexagon can be generated by clicking on the option 'Export G-Code'.

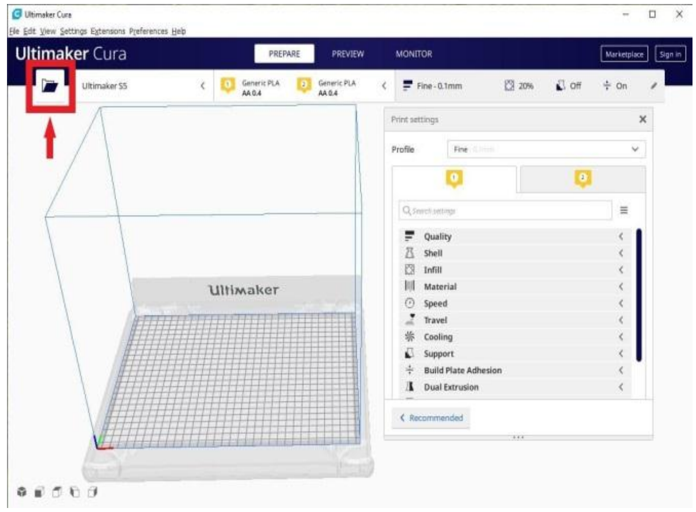

Figure 2.11 Cura Slicer Software

STEP 4: Importing the G-code file and Printing in Pronterface Software

- ➢ The file created is then loaded in the pronterface which connects Arduino with the computer.
- ➢ From the pronterface software we can give print command. The Arduino mega will thus send command to the stepper motor & we get a 3D model.
- ➢ Figure above is a snap shot of pronterface software showing the wagon wheel through which the motions of the 3D printer can controlled.

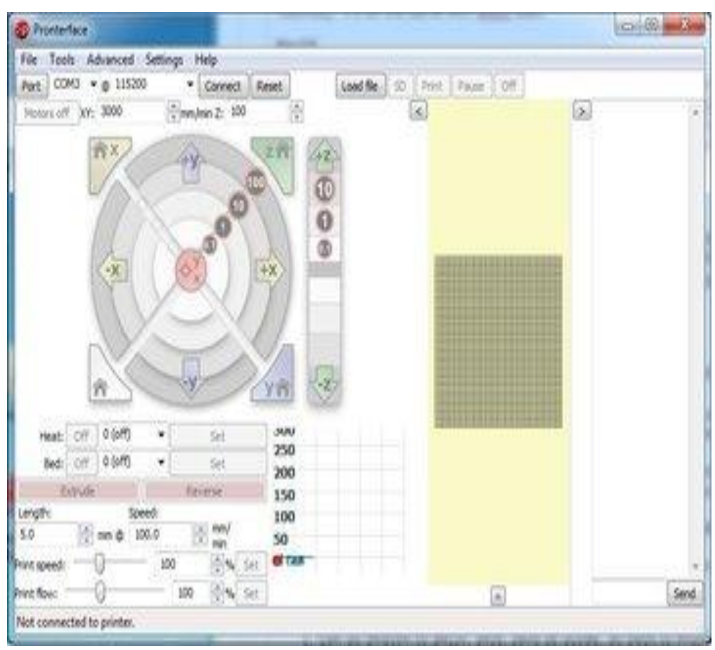

Figure 2.12 Pronterface Software

Printing:

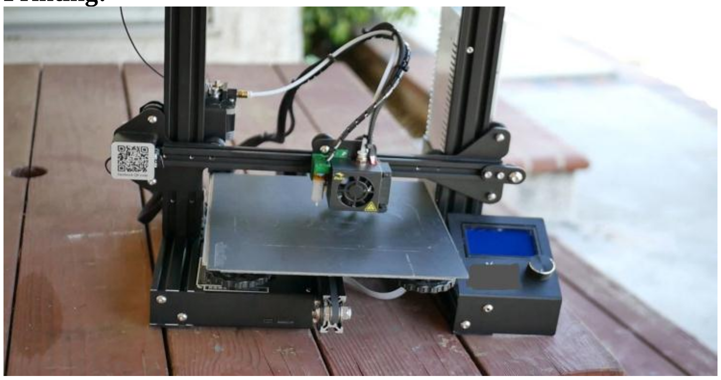

Figure 2.13

III ADVANTAGES OF FDM :

- Scalability: Easily scaled to any size.
- Consistently and accurately creates geometric structures:
- Parts with great stability and durability:
- Wide variety of thermoplastics

IV DISADVANTAGES OF FDM :

- Size of created object is small: It restricts the object size as the printer size is standard.
- Harmful emissions: If material is not eco-friendly to nature then harmful emissions are producing.
- Expensive in some cases.

V APPLICATIONS

1. Education: New learning material: often you must want new teaching materials but may not be able to afford to budget for them. Now their resources can be made using a 3D printer, saving money on your department budget.

2. Apparel: 3D printing technology, also known as additive manufacturing, is appearing at an amazing rate. It enables the creation of many products in design. This study focused on how 3D printing technology has developed, how it has been adapted from industry, and how it is applied in different areas. In the meantime, it also illustrated how this technology is used in fashion to engage creatively and the exciting potential values3D printing technology, also known as additive manufacturing, is appearing at an amazing rate.

3. Construction: With the help of 3D printers, we are able to build civil models like prototype of building or plan structures. So that the customers can easily visualize the models.

4. Dental: With the help of 3D printers, we are able to print jaws it can be a prototype or it can be a jaw bone which can be transplanted as per the needs. An 83-year-old British woman recently underwent the first-ever custom transplant of a lower jaw made by a 3D printer

VI CONCLUSION

The intention behind this research was to develop a low cost 3D Printer by using materials which are easily available and cost effective. We have been successful in reducing the cost to a considerable extent i.e about 10-15 %. The parts made in 3D design software are successfully imported in the printing software and the product obtained has the same dimension given during the design stage of the product i.e an accuracy close to 100%.We were able to successfully fabricate the 3D printer according to its virtual design proposed at reduced cost.

REFERENCES

1. Thabiso Peter Mpofu, Cephas Mawere, Macdonald Mukosera “The Impact and Application of 3D Printing Technolog” International Journal of Science and Research (IJSR), 2012.
2. Karel Brans “3D Printing, a Maturing Technology” 11th IFAC Workshop on Intelligent Manufacturing Systems The International Federation of Automatic Control, 2013.
3. Hye Won Lim, Tracy Cassidy “3D Printing Technology Revolution in Future Sustainable Fashion” 2014 international Textiles & Costume Culture Congress, 25th & 26th October 2014, Chonbuk National University, South Korea.
4. Izabela Hager, Anna Golonka, and Roman Putanowicz” 3D printing of buildings and building components as the future of sustainable construction” International Conference on Ecology and new Building materials and products, ICEBMP 2016
5. Simon Ford, Melanie Despeisse “Additive manufacturing and sustainability: an exploratory study of the advantages and challenges” Journal of Cleaner Production, 2016.

6. Vinod G. Gokhare, Dr. D. N. Raut, Dr. D. K. Shinde "A Review paper on 3D-Printing Aspects and Various Processes Used in the 3D-Printing" International Journal of Engineering Research & Technology (IJERT), 2017.
7. Ying Zhang and Jyhwen Wang "Fabrication of Functionally Graded Porous Polymer Structures Using Thermal Bonding Lamination Techniques" 45th SME North American Manufacturing Research Conference, NAMRC 45, LA, USA, 2017.
8. Ze-Xian Low, Yen Thien Chua, Brian Michael Ray, Davide Mattia, Ian Saxley Metcalfe, Darrell Alec Patterson "Journal of Membrane Science" Journal of Membrane Science 523 (2017) 596–613, 2017.
9. Mehmet Sakin, Yusuf Caner Kiroglu " 3D Printing of Buildings: Construction of the Sustainable Houses of the Future by BIM" 9th International Conference on Sustainability in Energy and Buildings, SEB-17, 5-7 July 2017, Chania, Crete, Greece
10. Nadim S. Hmeidat, James W. Kemp, Brett G. Compton "High-strength epoxy nanocomposites for 3D printing" Composites Science and Technology, 2018.
11. Uday Kiran Roopavath, Sara Malferrari, Annemieke Van Haver, Frederik Verstreken, Subha Narayan Rath, Deepak M. Kalaskar "Optimization of extrusion based ceramic 3D printing process for complexbony designs" U.K. Roopavath et al. / Materials and Design, 2019.
12. H. Kursad Sezer, Ogulcan Eren "FDM 3D printing of MWCNT re-inforced ABS nano-composite parts with enhanced mechanical and electrical properties" Journal of Manufacturing Processes 37 (2019)..