

Manufacturing of Human Femur Bone by additive manufacturing process (3-D printing)

Pruthviraj Devidas Patil¹, Dr. Deepak Gope², Dr. S. N. Khan³

Research Scholar, Mechanical Engineering Department, Shri Jagdishprasad Jhabarmal Tibrewala University, Rajasthan, India¹

Guide, Mechanical Engineering Department, Shri Jagdishprasad Jhabarmal Tibrewala University, Rajasthan, India²

Co-Guide, Mechanical Engineering Department, JSPM'S Rajarshi shahu College of Engineering, Pune, India²

Abstract: Additive manufacturing is now a days trend process in field of Mechanical Engineering. In an additive process, an item is constructed by laying down consecutive layers of material until the product is complete. Each of these levels may be considered as a gently sliced cross-section of the object. Subtractive manufacturing is the polar opposite of 3D printing and includes cutting or hollowing out a piece of metal or plastic with a milling machine. Current research work is related to conversion of DICOM filed and data obtained in to making 3-D object for further testing. By which the research work get help for further arbitrament

Keywords: ABS, PLA, PVA, PC.

I. INTRODUCTION

Mechanical testing of every component is necessary for finalization of result. This can be now a days easy by taking test on prototype with help of 3-D printed component made by Additive manufacturing, also known as 3-D Printing. By making 3-D printed object and the mechanical testing, its very easy to finalized result. By this some materials like Acrylonitrile butadiene styrene (ABS), Polylactic Acid (PLA), Polyvinyl Alcohol Plastic (PVA), Polycarbonate (PC) etc

II. ADDITIVE MANUFACTURING (3-D PRINTING)

Following are technology used for 3D Printing

1. Stereolithography SLA
2. Multi Jet Fusion MJF
3. Direct Metal Laser Sintering
4. Electron Beam Melting
5. Laser sintering
6. Selective Laser Sintering SLS
7. Digital Light Processing DLP
8. Poly Jet Fusion

There are some basic processes that are involved in 3D printing which are:

- A. PHOTOPOLYMERIZATION
- B. 3D SLICING
- C. STL FILE CONFIGURATION

III. 3D PRINTING MANUFACTURING STEPS

A. Modeling

3D printing begins with the creation of a digital model of the object using software such as AutoCAD, Solid Works, or other appropriate tools.

B. Material selection

Material selection is a key aspect in producing identical prototypes. Similar features from various 3D printing materials on the market should be chosen judiciously. There are several materials available, including PLA, ABS, PETG, Nylon, and Polycarbonate. Material should indeed be finished by matching characteristics.

➡ Structuring a three-dimensional object in its physical configuration from its digital form.

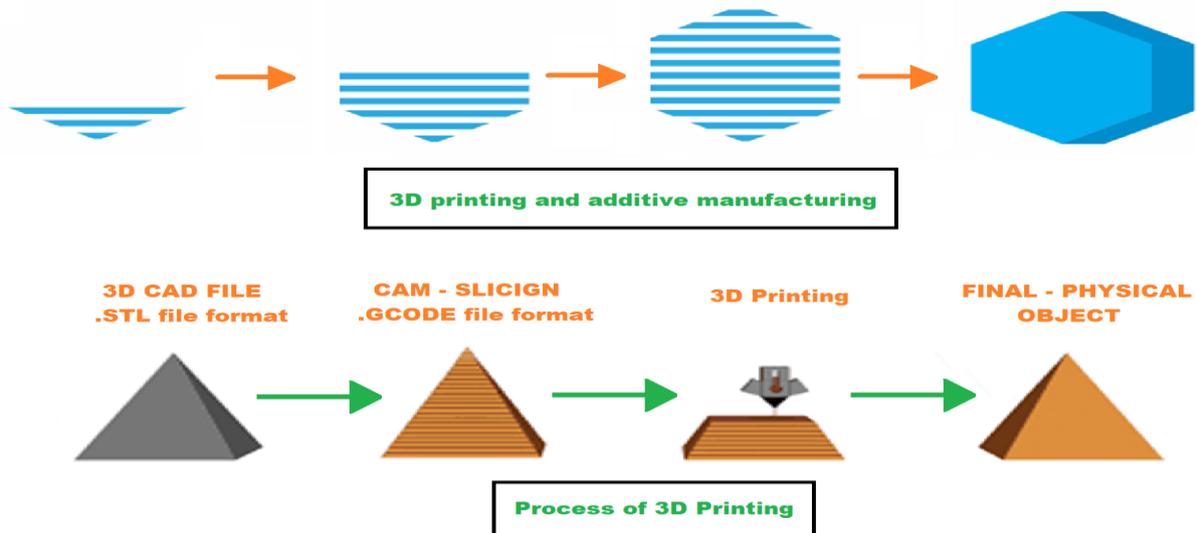


Fig.1- 3D Printing Process [2]

C. Printing

Following approval of the 3D design, the file is fed into a 3D printer, which transforms the digital file to STL format. After converting the digital file to STL format, a 3D Slicer begins configuring the complete operation layer by layer. Depending on the technology utilised by your 3D printer, which might be SLA, SLS, or DLP, each layer is deposited on top of the preceding one. The process is continued until all of the layers are created and our three-dimensional object is finished.

D. Finishing

The final step is to complete the printed portion. As parts of the supporting wall and column must allow for some overhang. As a result, in these last phases, all unneeded elements are eliminated. This results in the end product.

IV. PROCEDURE FOR MANUFACTURING OF HUMAN FEMUR BONE AT NECK BY 3D PRINTING PROCESS

Procedure for manufacturing of human femur bone at neck by 3D Printing process

1. 3D measurement of human femur bone from Mimic or Invivo 5 software
2. Modelling of human femur bone and generation of STL file
3. Material Selection
4. Import the STL file in to the 3D printing suitable software (Slicer)
5. G-Code generation component for final printing
6. Actual printing
7. Finishing

1. 3D measurement of human femur bone from Invivo 5 software

This is the first step of 3D manufacturing in which medical CT Scan data in form of DICOM files are used. This data is measurement of human femur bone. These DICOM files are used for further measurement and to convert these images in to 3D printing readable format like STL files.



Fig.2- Import of DICOM files in to Invivo 5 software

2. Modeling of human femur bone and generation of STL file

With the help of this software, 3D printable files are generated like Standard Triangle Language (STL) files. These are used for modeling of femur bone also. From these files 3D printing processed.

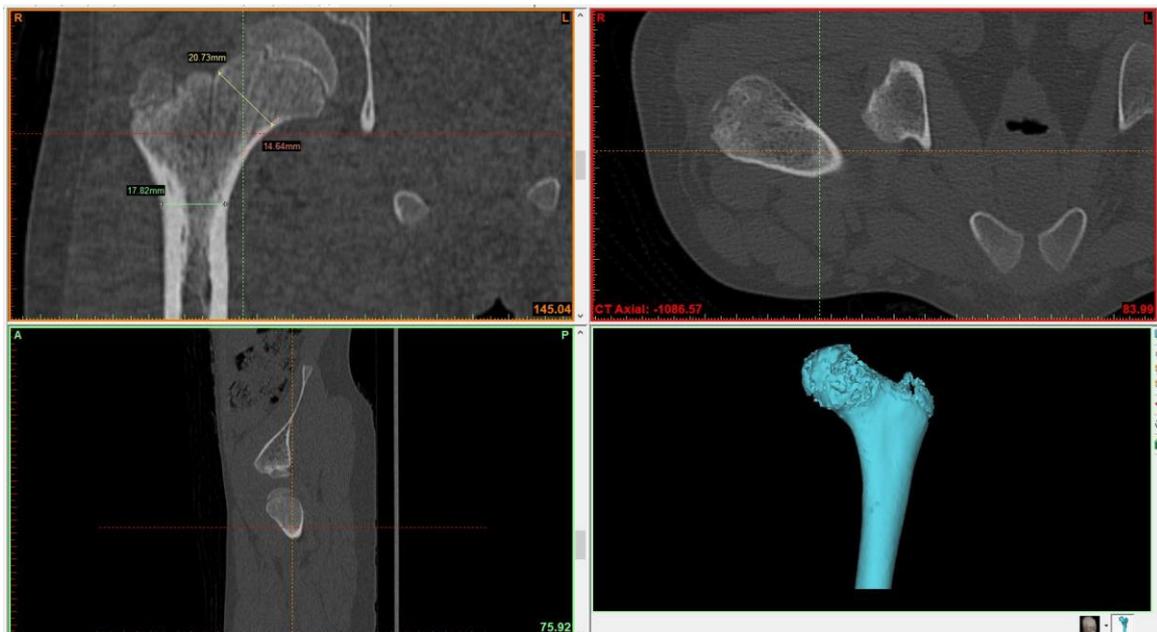


Fig.3- Modeling of Human femur bone

3. Material Selection

As per requirement the material should be used. Most favorite materials are ABS, PLA, PVA

4. Import the STL file in to the 3D printing suitable software (Slicer)

In this step STL file is import for printing

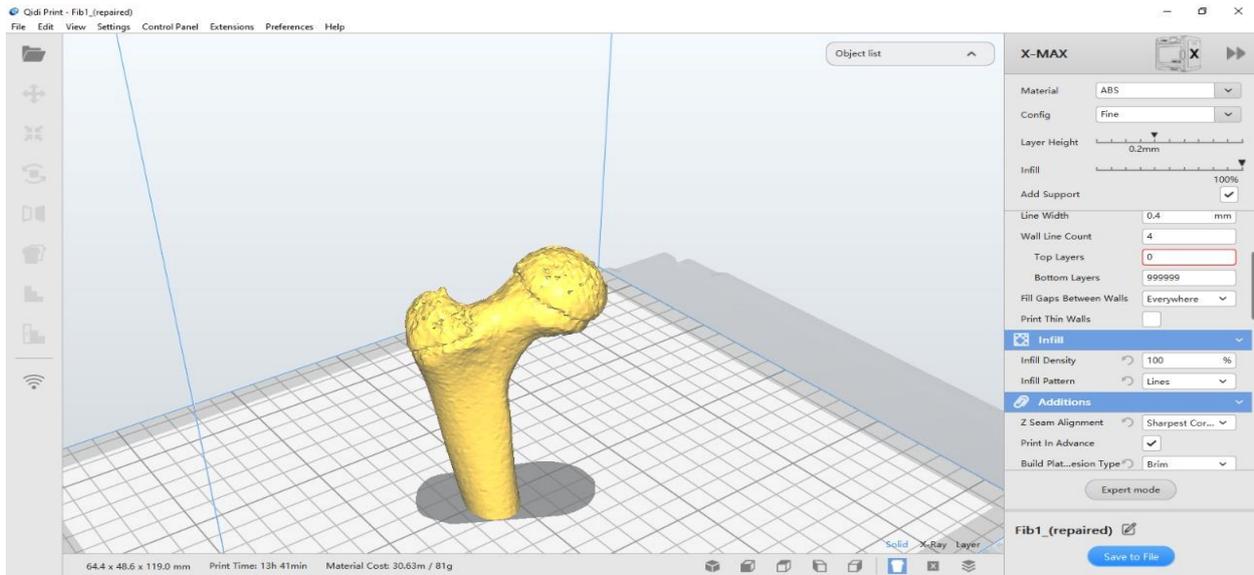


Fig.4- Software image after importing STL image

5. G-Code generation component for final printing

G-Codes are the language of 3-D printers for actual printing. The sliser software make this program language easily.

6. Actual printing

This is the step at which the component going to made at printer platform



Fig.5- 3-D Printer platform

7. Finishing

Extra materials like wall support should be removed. By this final component is ready for testing

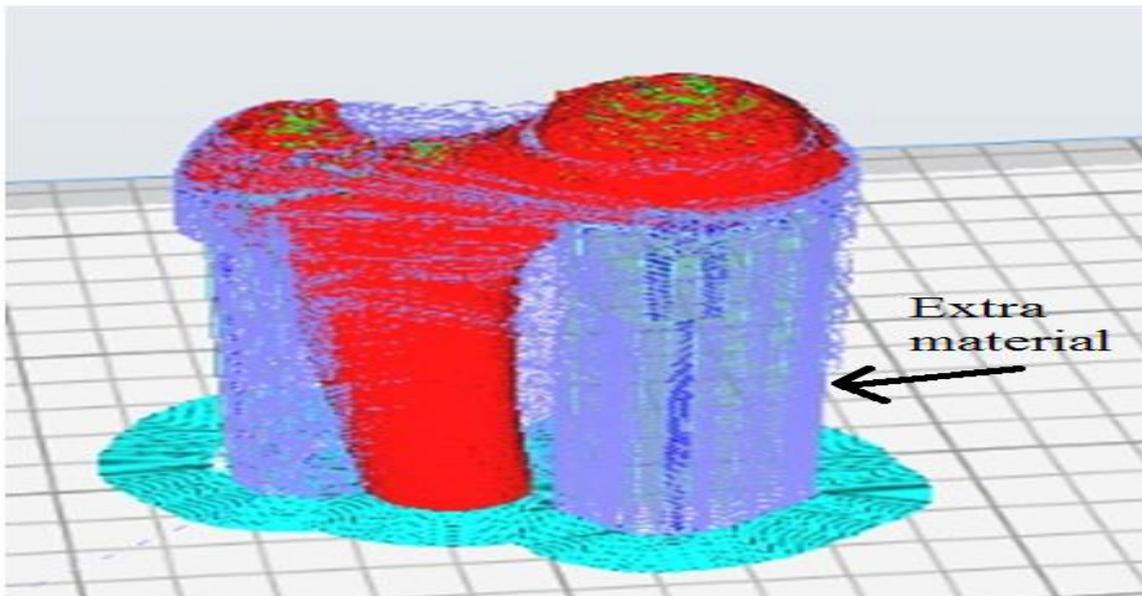


Fig.6- Component with Unwanted extra material

V. CONCLUSION

The 3-D printing technics gives super fastenings process for prototype product creation. This is help for different type of testing. By matching material properties used in 3-D printing, research conclusion can be achieved precisely. This article is ongoing work of research on testing of Human Femur bone. By this 3-D component and testing of it, precise conclusion were made. This helpful for further future research work.

REFERENCES

- [1]. <https://bitfab.io/blog/3d-printing-materials-densities/> (material properties chart)
- [2]. <https://www.theengineeringprojects.com/2021/06/what-is-3d-printing-definition-technology-and-applications.html> (3D manufacturing details)
- [3]. P Doungkom, Analysis of Printing Pattern and Infiltration Percent over the Tensile Properties of PLA Printed Parts by a Fuse Deposition Modelling Printer, 2019
- [4]. D.R .Carter, W.E. Caler, D.M. Spengler, V.H. Frankel, 1981. Uniaxial fatigue of human cortical bone. The influence of tissue physical characteristics. Journal of Biomechanics, vol- 14, 461–470.
- [5]. Carl H. Zetterberg, L. Irstam, G. B. J. Andersson, 1982. Femoral Neck Fractures in Young Adults Vol-53, 427-435.
- [6]. M. B. Schaffler, E.L. Radin, D.B. Burr, 1990. Long term fatigue behavior of compact bone at low strain magnitude and rate. Bone, vol- 11, 321–326.
- [7]. A. C. Courtney, E. F. Wachtel, E. R. Myers, W. C. Hayes, 1994. Effects of loading rate on strength of the proximal femur. Calcif Tissue Int. vol-55, 53–58.
- [8]. AMY C. Courtney, Edward F. Wachtel, 1995. Age-related reductions in the strength of the femur tested in a fall loading configuration. The Journal of Bone Joint Surgery, vol-77 A, 387–395.
- [9]. [K. H. Yang, K. L. Shen, C. K. Demetropoulos, A. I. King, P. Kolodziej, Levine R.S., Fitzgerald R.H., 1996. The Relationship Between Loading Conditions and Fracture Patterns of the Proximal Femur. Journal of Biomechanical Engineering, vol- 118, 575–578.
- [10]. A. Y. Shin, B. L. Gillingham, 1997. Fatigue Fractures of the Femoral Neck in Athletes: Journal of the American Academy of Orthopedic Surgeons vol-5, 293–302