



Design Manufacturing and Analysis of Human Organ Hip Implant Using Biodegradable Material Using 3D Printer Technique

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Abstract- In this project work, the advances in digital computer systems and application software for design and development using 3D printing technique is very challenging in biomedical applications. Over the past 30 years, additive manufacturing (AM) has developed rapidly and has demonstrated great potential in biomedical applications. Additive manufacturing is a material it may be metal or polymer-oriented manufacturing technology, since the solidification mechanism, architecture resolution, post-treatment process, and functional application are based on the materials to be printed. Here 3D printing technique is an additive manufacturing procedure for an extensive variety of structures and complex geometries from 3D information or model data. The procedure comprises printing successive layers of material that are fused each other. 3D printing is an additive manufacturing technology that creates a wide range of structures and complex geometries using 3D data or model data. The method entails printing successive layers of material that are distinguished from one another. This approach is based on fusion deposition (FDM). In this work, 3D printing is used to create complex geometries with ease using PLA. Static stress analysis is also done using finite element analysis. However, the use of 3D printable materials in the manufacturing of bio-implants is still limited. This paper examines 3D AM materials for bioimplants. With the advancement of multi-material printing technology, it is now possible to print on a variety of different materials. 3D AM materials will be used to construct bio-implants and soft/rigid hybrid biological structures. In most cases, preparatory technology is employed to create pure plastic. The carbon fibre is reinforced into a polymer resin to make a composite material, which is then extruded into 3D printing filaments. The material is subsequently turned into ASTM standard specimens with the help of 3D printing. The printer is then put through a static stress study for human hip implants using ANSYS.

Key Words: Hip Replacement, CAD software, PLA material, Biomedical implants, 3D Printer, FEA Model.

1. INTRODUCTION

3D printing is an additional additive manufacturing process for manufacturing a wide variety of structures and complex

geometries using three-dimensional information or model data for biological purposes. Printing successive layers of materials that are framed over each other constitutes the method.

Originally known as stereo lithography, the method created by Charles Hull in 1986 was followed by further developments such as fused deposition modelling (FDM). 3D printing, which encompasses a variety of techniques, materials, and hardware, has progressed over time and is now being used in manufacturing and logistics. The use of additive manufacturing has been widely criticized in various building, prototyping, and biomechanical industries, to name a few. "A way of combining materials to produce products from 3D prototype information, usually layer upon layer, differing from subtractive manufacturing technology" according to the definition of additive manufacturing. The pure plastic individual is usually made using preparatory technologies. To make the composite material, carbon fibre is woven into the polymer resin. The extrusion method is then used to transform the produced composite material into 3D printing filaments.

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It is restricted in a variety of applications due to its limited material use and limited material use. Because additive-produced materials are typically only found as a prototype model, AM has highly specific material uses. The multiple printing head technique has been developed in this area, allowing composite materials to be manufactured with precise material combinations and qualities.

2 .*METHODOLOGY*

a. Background.

Given the industry's quick advancement, modifications, and demand increase, the creation of alternate approaches was critical. Despite the fact that "Additive Manufacturing (AM)," often known as "3D printing," is commonly thought of as a new and futuristic technology, its invention dates back over 30 years. In 1983, Charles Hull developed the first AM method, dubbed "stereo lithography". It allowed genuine 3D things to be created from computer data. "A method and apparatus for producing solid things by successively "printing" thin layers of a curable substance, e.g., a UV curable material, one on top of the other," according to Charles Hull's patent (Google Patents, 1996). This patent term was delimited by "printing" with a liquid, but he soon discovered that his breakthrough manufacturing technology was not limited to liquids. As a result, he broadened the definition to include "any material capable of solidification or altering its physical condition".

b. Processing.

Although not all 3D printers employ the same production procedures, the basic concept remains the same. In a nutshell, a 3D printer generates real objects by layering material. FDM (Fused Deposition Modelling) is the most widely used additive manufacturing process, according to Palermo (2013). Plastics are used as a material in FDM printers. The plastic filaments are heated to a point where they melt. After that, they're extruded and layered on top of one other in a semi-liquid form to become a true 3D shape (Palermo, 2013). The production of an object using the FDM process is depicted in the diagram below:

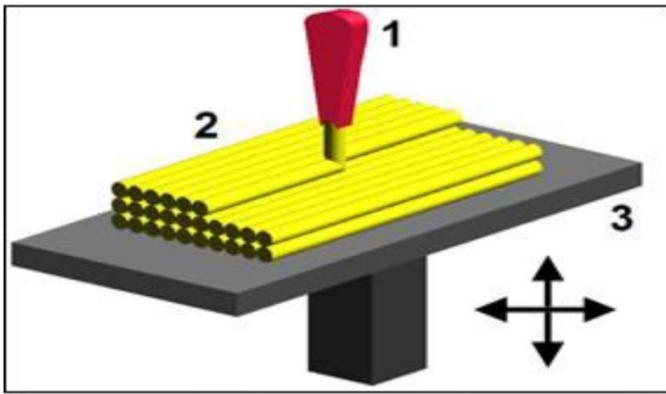


Figure 1. Creation of an object from the FDM method: 1- Nozzle, 2-Part, 3-Movable Table.

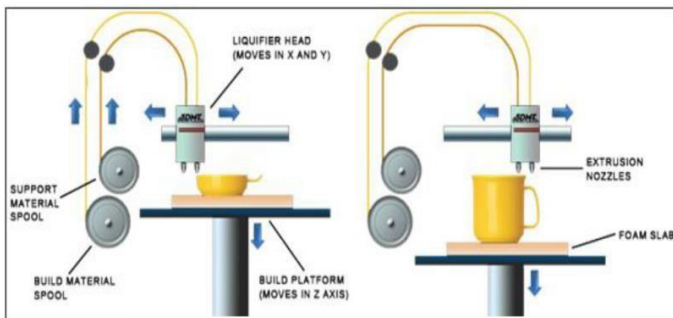


Figure 2. Representation of the how FDM printer works

To be more certain, AM processes are divided into seven categories based on the standards. According to ISO ASTM/DIS 20195, these are categorised as:

- 1- Material jetting
- 2- Material extrusion
- 3- Binder jetting
- 4- Directed energy deposition
- 5- Sheet lamination
- 6- Powder bed fusion
- 7- Vat photopolymerization

Different materials, such as polymers, metals, and ceramics, can be utilised in these procedures depending on the approach. The material for this project will be polylactic acid (PLA), which is a sort of plastic.

C. Hip Replacement in 3D Printing.

The biological functioning of the human body is confounded by the vast variances in biomechanical qualities from bone to bone. The elastic modulus of the critical section of denser bones,

which ranges from 16–20 GPa and is a magnitude greater than the trabecular bone, is one example. As a result, it's understandable that biomechanical mistakes will occur between recently inserted pieces and nearby bones with similar qualities. Furthermore, these biomechanical qualities may differ significantly from one body to the next from a medical standpoint. As a result, there is a reasonable requirement for fabrication processes that can fulfil required geometry for a precise injury/defect. Rapid prototyping (RP) technology, commonly known as additive manufacturing (AM), is a fabrication technique based on the concept of surface development. This approach has sparked research interest in the manufacturing sector since its inception in the 1980s. Unlike traditional implants, 3D printed implants can be customised to treat a variety of ailments. 3D printed implants can solve specific issues where it is difficult to put and repair different conventional implants together due to their great design capabilities.

The capability of bio imitating extracellular matrix (ECM) and the ability to manufacture adaptable scaffolds regardless of shape difficulties for cell distribution to be done homogeneously are two advantages of 3D printing. The availability of acceptable biomaterials with the stability and inherent qualities required for 3D printing of scaffolds is, however, a substantial limitation.

3. MAIN OBJECTIVE OF THE PROJECT

- 1) To collect PLA implant from Raw material
- 2) To design for the development of a Femur model simple to complex shape using CAD modelling software for biomedical hip implants.
- 3) To manufacture hip assembly parts as per design by using advanced manufacturing technique 3D printer.
- 4) To perform FE Analysis for 3D printed specimens for a biomedical Hip implant.
- 5) Results will be validated, from both the obtained results from experiments and FEA
- 6) To improve/produce strong and non-corrosive PLA implant parts at a reasonably less cost.
- 7) To reduce the metals & super alloys by using PLA material in various implants

4. STEPS INVOLVED IN AM

AM entails a set of processes that vary based on the type of manufacturing method utilized, ranging from design development to final product manufacturing. These basic processes are universal and apply to all types of production, whether it's a prototype or a finished product. Figure 3 depicts the phases involved in the AM process.



Figure 3. Steps in AM – Digital Model to 3D Model

The procedures for post-processing differ depending on the material and manufacturing technologies used.

4.1.1 Production of the digital model: -

This method begins with the creation of a digital model of the part using CAD software. To create a digital model, reverse engineering and 3D scanning are also performed.

4.1.2 STL conversion: -

The digital model is then transformed to a Standard Triangle Language (.STL) or Standard Tessellation Language (.STL) file.

The STL file contains data on the model's surface geometry.

4.1.3 Slicing

The STL file is then loaded into the slicer programmer after conversion. The quality of the printed parts is determined by slicing. Based on the information in the STL file, the slicer generates G-codes. The G-code generated is comparable to CNC machine codes, and it specifies the extruder movement and platform direction during printing.

4.1.4 Printing

The 3D printer is ready to print the design after converting the STL file to G-codes. Depending on the type of AM method used, the printing differs. In FDM, the nozzle follows the G-code instructions and moves and deposits the molten filament layer by layer. The G-code controls the movement of the extruding nozzle, the amount of material extruded, and the extrusion time. After the entire model has been printed, some post-processing is required to get the desired product finish.

5. 3D PRINTER AND DESIGN MODEL

a. The 3D printer used.

The printer in this experiment will be "Ultimaker 2 Extended+." The Ultimaker 2 Extended+ is made using the FDM process. The Ultimaker 2 Extended+ 3D printer is shown in the diagram below:



Figure 4. Visualization of the Ultimaker 2 Extended +.

b. Design

Before the 3D printing process, the CAD models of trusses have to be created in the computer environment. Here we are designed an Hip Replacement of each different parts, the dimensions of each part is collected from a previous record. And we are going to assemble each part below figure shows assembled Hip Replacement model.

Solid works 2019 have been used in the modelling process.

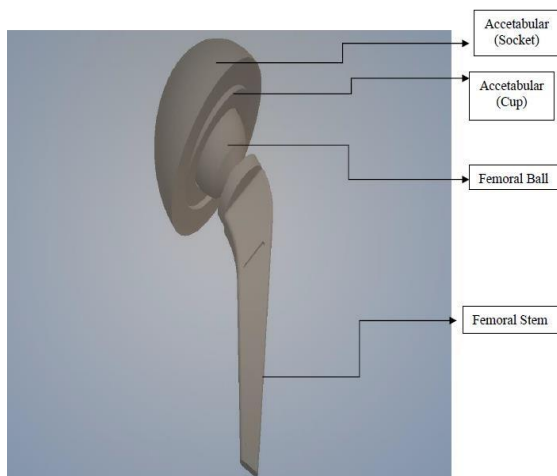


Figure 5. Hip Replacement Model

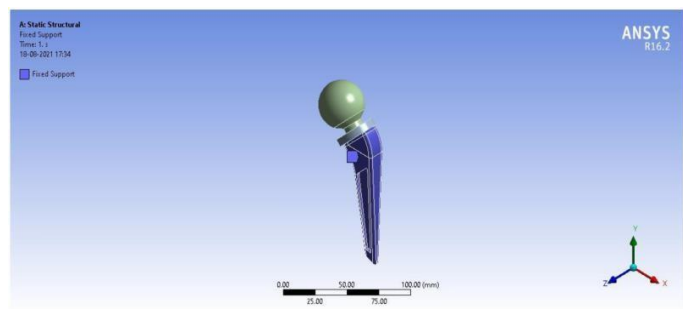


Figure 6. Support Condition

The load must be applied to the specified location. The correct unit and direction of the load should be given close attention.

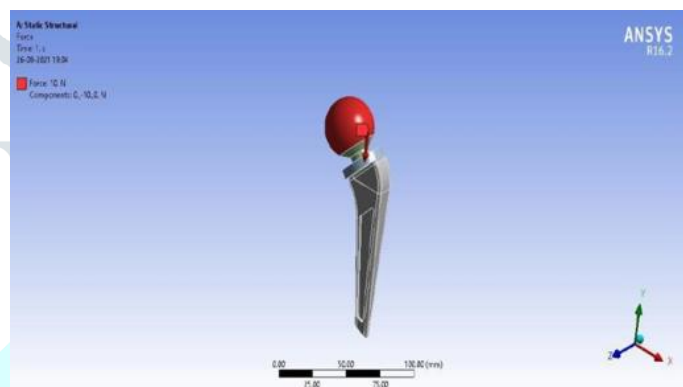


Figure 7. Applying the Load

The Designed body of hip replacement parts of femoral stem, Femoral Ball, and the Acetabular (Cup and Socket) has been finished and the next step is to assign properties of each part for the 3D printing in an **Ultimaker 2 Extended+**. The properties are shown in the below Table 1 and continue with the process So that we can get a model of hip replacement. Then the model was carried out to ANSYS workbench and was assembled and analysed. The core is made of Poly-lactic Acid (PLA). This model thickness is varied and analysed of the design.

6. RESULTS AND DISCUSSION

6.1 Finite Element Method.

Apply the boundary condition and Boundary conditions should be implemented after meshing. The model is positioned where it is required. "Fix support" was chosen as the support type in this circumstance. In fact, the investigation will be carried out for both sorts of contact situations. The model was only fixed on the top of the bottom edge in the first condition. The model, on the other hand, was attached to the backside of the bottom border. The model will be solved for the circumstances in order to comprehend the experimental test findings for each condition. The following Figure 6 Shows the support conditions, respectively

6.2 Finite Element Method.

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7. CONCLUSION

This work has successfully summarised the use of PLA material for human hip implants using a 3D printer technology. In comparison to metals, biomedical implants pose a significant barrier. PLA, a new polymer material, has excellent strength, lightweight, and reliability. It's particularly valuable in the field of biomedical applications, especially for human hip replacements. In terms of gadgets and treatments, society nowadays is clamouring for better or novel medical solutions.

Aspects such as greater life expectancy and changes in lifestyle have increased the frequency of Total Hip Replacements, even if the available solutions still have performance flaws that shorten their lifespan and necessitate prosthesis revision. This gives an opportunity for researchers and industry to improve patient health care while also discovering new business prospects.

From this project work, we can conclude that this synthesized and developed 3D material can be used as an alternative for metals for biomedical applications.

As we compared the results with other materials (Titanium-based alloy) we can conclude that the plastic can also withstand the human body for several months with hygienic. So, by using plastic material in bio-implants we can reduce the waste of plastic materials. Since it is made of recycled PLA it's a biodegradable lightweight material.

8. SCOPE FOR FUTURE WORK

- Poly-lactic-acid (PLA) is one for direct contact of the tissues as a medical device.
- For Poly-lactic-acid (PLA) developments which could be brought in direct contact of the as a support structure.
- PLA implants with 3D printing customization have been found to be both cost-effective and cosmetically pleasing.

Organs with artificial supporting structures termed scaffolds were created using a commercially accessible 3D printer and Polylactic acid

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