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Bio-Implant Development: Proposal of Additive Manufacturing FDM Method

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A B S T R A C T

Nowadays, several cases have been discovered in the hospitals where patients are suffering from pain and stiffness at the affected joint in their body. Most of the patients were suffering from severe pain caused due to damage in the hip joint. Hip implants of standard sizes are available in the market which can replace the damaged hip joint in the human body. But it was found that the cost of the hip implant is higher in the market and the patients with this kind of hip implants have to face several post-surgical issues. To address this gap, there is a need to develop a new or modify existing product with better value within affordable cost. The present work deals with reducing cost and manufacturing time for such hip implants in the medical industry. It proposes the manufacturing process using additive manufacturing technology and suitable material without compromising quality and functionality of implants.

Keywords: Bone Implantation, FDM Method, Additive Manufacturing

1. Introduction of Bone Implantation

Bone implantation is a surgical procedure that replaces a missing as well as damaged bone in order to repair bone fractures that are extremely complex, pose a significant health risk to the patient, or fail to heal properly. This process has been practicing since BC 400 and it has tremendously improved as per ages. Hip replacement surgery is a procedure in which a doctor surgically removes a painful hip joint With arthritis and replaces it with an artificial joint often made from metal and plastic components.

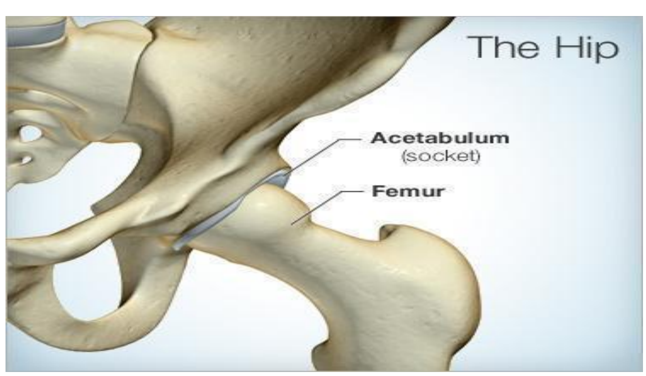

Fig. 1.1 Human hip joint

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2. Summary of Literature

From literature studies and survey, an outcome that AM has accessible for an orthopedic medical segment with all its presently aspects as well as potential automation operation by several machine models available in the market [2][4][10] [12] [13], Especially EBM played an important role to print most complicated structures with accuracy but along with ultimately cost raising of the implant takes place.[2] [10]

Traditionally, hip implant manufactured by Titanium, chromium, cobalt, stainless steel, alloy Ti-Al-Vanadium by conventional molding method but it has proven additive technology can be developed implant by Metal on metal (MoM) Ti-6Al-4V powder and custom made for a patient such method is useful for a patient who has suffered post-surgery of the hip implant. [5][14].

3. Problem Definition

In bio medical industry, orthopedics segment has rapidly grown. Hip implant generally developed by traditional molding process such as sintering, investment wax molding which revealed some issues in patient’s body such as ARMD, particle wear off, blood clogging into blood stream. Besides these, loosening or misalignment of traditional implant among some patients who has some unique health as well as body structure requirements either pre surgery or post-surgery. In such cases surgeons recommends customized implant which either can be developed by traditional molding process or additive technology but presently it is costlier. Hence patient suffers such issues as well as pays high cost with longer painful time. Such issues can be overcome by additive technology process with accessible machine with new material with developed design.

4. Objective

To select the affordable and accessible 3d printing method & material to develop the hip implant.

5. Research Methodology

5.1 Why is Rapid Prototyping Important?

In this fast-moving modern-day consumer market, companies need to develop and introduce new products faster to remain competitive. Since faster product development and technology innovation are key to a company’s success, rapid prototyping becomes the most important element of new product development.

5.2 3D Printing methods

5.2.1 Stereo lithography (SLA)

Stereo lithography is a form of 3-D printing skill used for creating models, prototypes, patterns, and making parts in a layer-by-layer manner using photo-polypropyleneization, a course by which light reasons chains of molecules to link, forming polypropylenes. Those polypropylenes then make up the organization of a 3d solid. Stereo lithography is used to create prototypes for goods and in medical modeling, among other habits. While Stereo lithography is fast and can yield almost any design, it can be luxurious.

5.2.2Fused deposition modeling (FDM)

3D printing machines that use FDM Knowledge build objects layer by layer from the very bottom up by warming and extruding thermoplastic filament. The whole procedure is a bit similar to stereo lithography. Flash-print software, CAD model into layers and calculates the way printer’s extruder would build each layer. Along to thermoplastic, a printer can extrude support resources as well. Then the printer heats thermoplastic till its melting point and extrudes it through nozzle onto base, which can also be called a build platform or a table, along the calculated path. A computer of the 3d printer translates the dimensions of an object into X, Y and Z coordinates and controls that the nozzle and the base follow calculated path through printing. To support upper layer the printer may place below special material that can be melted after printing is finished.

5.2.3 Selective Laser Sintering (SLS)

Selective Laser Sintering (SLS) is a method that uses laser as power basis to form solid 3D objects. The main difference between SLS and SLA is that it uses powdered material in the vat in its place of liquid resin as Stereo lithography does. Unlike some other additive manufacturing procedures, such as Stereo lithography (SLA) and fused deposition modeling (FDM), SLS doesn’t need to use any support constructions as the object being printed is constantly enclosed by un-sintered powder. The material to print with power be anything from nylon, ceramics and glass to some metals like aluminum, steel or silver. Due to wide variety of materials that can be used with this type of 3d printer the skill is very popular for 3D printing tailored goods.

5.2.4 Selective laser melting (SLM)

Selective laser melting (SLM) is a technique that also uses 3D CAD data as a source and forms 3D object by means of a high-power laser beam those passions and melts metallic powders composed. In many sources SLM is measured to be a subcategory of selective laser sintering (SLS). But this is not as true as SLM course fully melts the metal material into solid 3D part unlike selective laser sintering.

5.2.5 Electronic Beam Melting (EBM)

EBM is additional type of additive manufacturing for metal parts. The same as SLM, this 3d printing method is a powder bed fusion method. While SLM uses high-power laser beam as its power source, EBM uses an electron beam in its place, which is the main difference between these two approaches? The rest of the procedures are pretty similar. The material used in EBM is metal powder that melts and forms a 3D part layer by layer by means of a computer, which controls electron beam in height vacuum. Contrary to SLS, EBM goes for complete melting of the metal powder. The process is usually showed under high temperature up to 1000 ℃. Comparing to SLM the process of EBM is pretty slow and luxurious; also, the availability of materials is incomplete. So, the method is not so popular though still used in some of manufacturing procedures.

5.2.6 Laminated Object Manufacturing (LOM)

During the LOM process, layers of adhesive-coated paper, plastic or metal laminates are bonded together using heat and pressure and then cut to shape with a computer-controlled laser or blade. Post-processing of 3D printed parts comprises such steps as machining and drilling. The LOM process includes several steps. Firstly, CAD file is changed to computer format, which are usually STL or 3DS. LOM printers use constant sheet coated with an adhesive, which is laid down across substrate with a heated roller. The heated roller that is delivered over the material sheet on substrate dissolves its adhesive. Then laser or blade traces desired sizes of the part. Also the laser marks hatches of any extra material in order to help to remove it easily after the production is done. The term Additive Manufacturing grips within such technologies like Rapid Prototyping (RP), Direct Digital Manufacturing (DDM), Layered Engineering and 3D Printing. There are different 3d printing approaches that were established to build 3D structures and items. Some of them are very popular currently.

6. Why FDM has been selected?

3D printing machines that use FDM Knowledge build objects layer by layer from the very bottom up by warming and extruding thermoplastic filament. The whole procedure is a bit similar to stereo lithography. Flash-print software, CAD model into layers and calculates the way printer's extruder would build each layer. Along to thermoplastic, a printer can extrude support resources as well.

While comparing the costs among all proposed methods of additive technology, FDM one of the best suitable as well as easily accessible process for assigned problem definition.

Fused deposition modeling (FDM) 3D printing method is selected for the manufacturing of Mould because its products have **high strength**; it is most widely used method for 3D printing. It has huge variety of filaments such as nylon, wood, carbon fiber etc. FDM method is simple doesn't require an expert worker. It is also the cheapest 3D printing method. FDM is used for manufacturing of Mould.

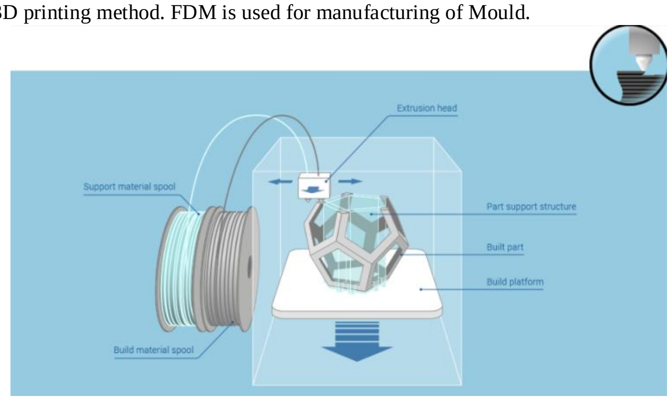

Fig.6.1 Schematic diagram of FDM

In this fast-moving modern-day consumer market, companies need to develop and introduce new products faster to remain competitive. Since faster product development and technology innovation are key to a company's success, rapid prototyping becomes the most important element of new product development.

7. Materials for 3D Printing

Below list shows the range of materials that are used in 3d printing. Newer materials are being launched with increasing frequency.

Current

- Plastics
- Nylon
- Metal Alloys
- Ceramics
- Food
- Paper
- Wood

Emerging

- Silicone
- Graphene
- Biomaterials
- Electrically Conductive

8. Conclusion

It has been concluded that the proposed 3D printing method (i.e., FDM) for manufacturing the hip implant has to be proven beneficial for the patients suffering from the various issues related to damage in hip joints. The usage of 3D printed ABS plus filament has resulted in considerable reduction of weight and cost of the implant when compared to existing products. Taking into account the weight reduction, it is evident that ABS plus filament has the most encouraging properties. FDM is layer by layer material adding process and it has less shrinkage percentage as comparative other additive process, also unlike sintering process, FDM never causes particle wear off phenomenon. Hence such selection of material and 3D printing process can be the very good ultimatum for traditional kinds of implants.

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