Shape Memory Polymer and its Fabrication Techniques

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Abstract

A drastic change has been observed in medical field which got its new look due to the evaluation in bio-implants for improving human's life from age till now. Not only humans have been benefitted from bio-implants but its conventional techniques have helped in repairing of animals too. Present article discusses the various fabrication techniques of shape memory polymer. It also discusses the requirements and shortcomings of various process.

Keywords: Shape Memory Polymer, 3D Printing, FDM, SLS.

1. Introduction

The beginning of bio-implants was led in early ages where silver and gold were used for replacement of teeth and other body parts. So, from ancient time a tremendous research has been carried out for the improvement of bio-implants which is still expanding its scope further [1]. According to the available data, the people above 40 age are more prone to suffer from osteoarthritis (also called degenerative joint disease), dental issues like periodontitis. So, to resolve these types of problems faced by them, shape memory polymer (mixture of PLA and chitosan) has been introduced. A complex 3D physical objects of body part has been prepared by using this material with the help of 3D printing [2-5].

For a biomaterial to be selected various mechanical as well as chemical properties must be considered. The reciprocal action of implant with the body tissue is also a main selection criterion of biomaterials [6]. Moreover, the process of manufacturing also contributes towards the proper selection as shown in figure 1.

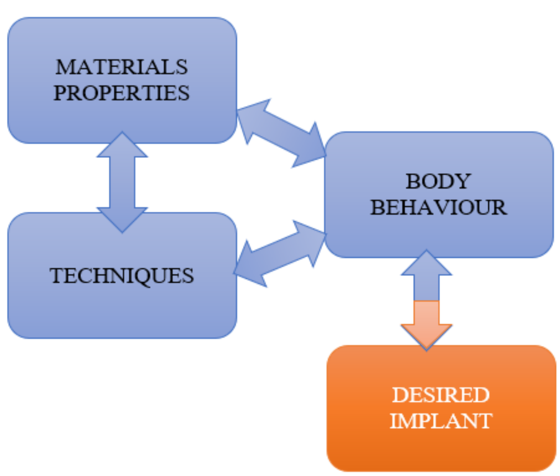

Figure 1. Relationship diagram of fabricating a component

2. 3D Printing

3D printing which is also called additive manufacture (AM) is a procedure for construction of 3D solid objects from digital models over the successive layer-by-layer deposition of materials like metals, plastics, ceramics and even from living cells[9]. The first concept of 3D printing was developed by Charles W. Hull in 1980s in which stereo-lithography technique was used to develop polymer objects.

As of now, there are different kinds of 3D printing innovations which have been as of now formed and separated into different procedure as per ISO/ASTM 52921:2013 standard, which principally incorporate the material extrusion, binder jetting, material jetting, powder bed combination, sheet lamination and direct energy deposition [7-9]. 3D printing is one of the rising advancements that had a progressive effect on manufacture of item for applications in fields like space and aeronautics and space, medicine and healthcare, automotive, textile, food industries, construction and architecture, art which has strained an expanding attention globally.

Ample of additive manufacturing openings exist in the biomedical field in regards to the manufacture of exceptionally molded orthopedic prostheses & implant, medicinal gadgets, organic chips, living constructs, tranquilize screening models, training apparatuses and surgical planning [10].

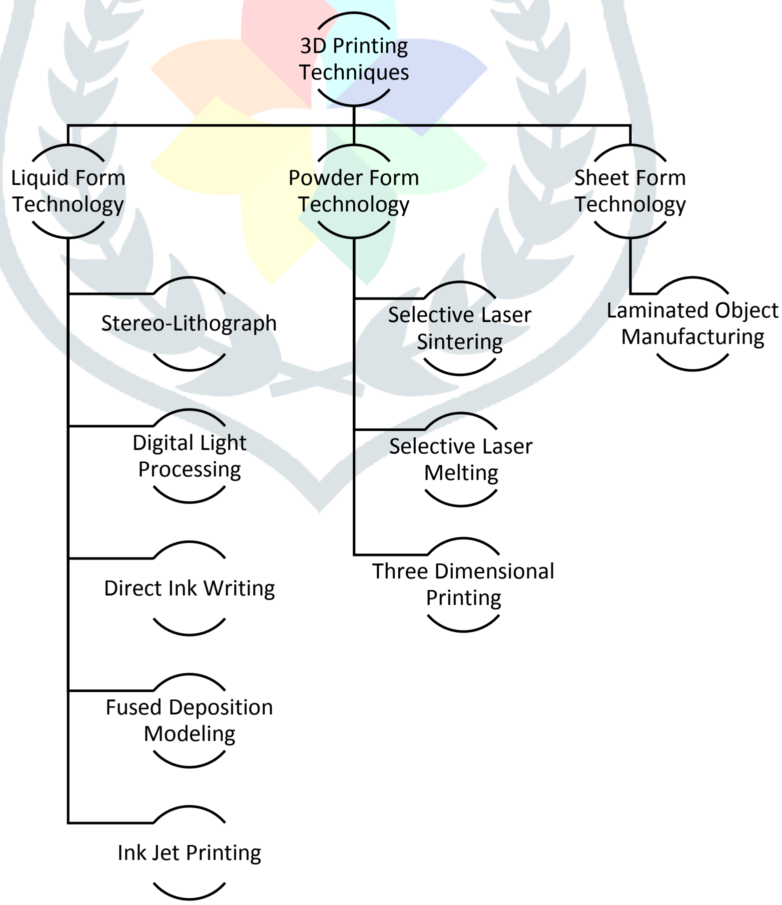

Figure 2. Classification of 3D Printing Technique

2.1. Liquid Form Technique

Liquid form 3D printing techniques mostly contain liquid or semi-liquid arrangement scattered with fine grains polymer as feedstock either as inks or glues, depends upon the solid stacking and viscosity of the framework. The slurry substance could be 3D printed through inkjet printing, extrusion or photopolymerization. In this segment, photo-polymerization based system, like stereolithography (SL), Inkjet Printing, Fused Deposition Modeling, and so forth have been disclosed [11].

2.1.1 Stereo-lithography Technique

Stereo-ithography (SL) technique is widely recognized and famous 3D printing innovation and broadly utilized globally. Hull proposed and developed this technique in 1986 and later it was popularized by 3D Systems Inc. SL is a procedure where a light source of some wavelength (generally in ultraviolet series) is utilized to specifically cure a fluid surface in a compartment containing for the most part photopolymerizable monomer alongside different additives in limited quantities especially photograph initiators.

At the point when polymerization is accomplished for one layer, the stage or base supporting the part being created is lifted or brought down by the layer thickness depending upon whether the structure procedure is being worked in a top-down or base up mode. Occasionally, a wiper blade is necessary to level off the fluid surface before the following layer is printed. SL is equipped for creating portions of good surface quality at fine resolution down to the micrometer scale.

2.1.2 Digital Light Processing

Digital light process or can say digital light projection procedure is mask dependent SL technique in which an indispensable picture is moved to the photo-polymerizable liquid surface by uncovering the light source over a designed pattern mask (cover) once as it were. In 1996, Nakamoto & Yamaguchi were proposed this phenomenon. In 1997, it was additionally established and upgraded by Bertsch with the utilization of a liquid crystal display as the dynamic veil generator.

2.1.3 Inkjet Printing

Ink jet printing process is an outstanding technique for making two-dimensional digital content and pictures by methods for emitting liquid stage materials (for example ink) in type of droplets via print-head spouts onto paper, different substrates and plastics. This method is broadly utilized these days with different kinds of printers available in market running from minimal and modest buyer models to enormous and costly industrial machines. In 1950s, IJP innovation was created during and then commercialization of PC supported IJP occurred by organizations. For example, Epson, Canon & HP.

IJP could be worked in one of two modes which are constant (continuous) mode. Continuous mode is favored in three-dimensional printing inferable from its higher situating precision and lesser size of droplet estimate and can be acknowledged by crushing ink over either warm excitation or the piezoelectric impact. IJP was additionally created as a material deposition procedure for slight layer statement on substrates. The scope of ink materials had reached out to incorporate metals or polymers for electronic designing, cells for fix in tissue engineering and patch glue for microelectronics welding.

2.1.4 Direct ink writing

In 1997, Cesarano was first scientist who recorded and proposed direct ink writing also called robocasting. The procedure was initially produced for handling concentrated materials like polymer slurries and ceramic with minimal organic substance. Also, in some cases robocasting as a wide portrayal of a get together of 3D printing advances that utilization ink (glue or droplet) affidavit to make planned structures.

DIW is fixated on the extrusion strategy utilizing a fiber (filament) of profoundly viscous glue at room temperature consequently adhering to its unique idea. Items are developed by moving spouts to directly compose the predetermined shape layer by layer technique until the part is finished. DIW empowers a less expensive and quicker assembling procedure contrasted and photo-curing 3D printing strategies.

2.1.5 Fused Deposition Modeling Technique (FDM)

Scott Crump developed the Fused Deposition Modeling technique. FDM is divided into three steps which are pre-processing, production and post- processing. FDM innovation assemble parts layer-by-layer by warming thermoplastic material at semi-fluid state and expelling it as indicated by PC controlled paths [10] . FDM utilizes two materials which are support material and modeling material also called displaying material. Displaying material comprises of completed piece and supportive material plays role of scaffolding.

2.2 Powder Form Techniques

In powder form polymer 3D printing, generally use of powder beds typically containing free polymer particles as feedstock is takes place. These particles are reinforced either by scattering of fluid binder or can pe possible with powder combination utilizing thermal energy gave by a laser beam.[11] Now, in this segment, three forms of powder-based 3D printing procedures are examined which are selective laser melting, three-dimensional printing and selective laser melting.

2.2.1 Selective Laser Sintering (SLS)

Deckard and Beaman invented this technique at the University of Texas. Further created by the DTM organization which was procured by 3D Systems in 2001. In a SLS procedure as name suggests, a powerful laser ray is utilized to specifically light the outside of the objective powder bed. The powder at that point warms up and sintered (for example interparticle combination) happens for mass joining. After that another layer of powder is expand onto the past surface for the following run of warming and joining. Along these lines, the procedure is rehashed layer by layer till the structured 3D part is manufactured. No additional help structures must be deliberately arranged for overhanging districts during a SLS procedure as they are encompassed by slack powder in the bed consistently.

2.2.2. Selective laser melting (SLM)

In 1996, the SLM procedure was established at the Fraunhofer Institute for Laser Technology in Germany. It continues in almost a similar path as SLS aside from that it is an efficient and one phase powder bed combination by full softening that utilizes laser source with a lot of higher vitality densities and requires no auxiliary low-dissolving fastener powders. Similarly, SLM can deliver about completely solid homogeneous parts without post treatment process owing on its capacity to completely liquefy the powder into the fluid stage, confirming fast densification rather than warming up the powder to a particular point in which the particles are in part dissolved and combined in the same way in SLS. The innovation was at first created to deliver strong parts from metal powders (for example aluminum, copper and tempered steel) and has now been stretched out to the undeniably utilized progressed composites and alloys especially for the creation of parts having light weight for the airplane business.

2.2.3 Three-dimensional Printing (3DP)

In 1989, Sachs developed this technique at the Massachusetts Institute of Technology. In this process, natural fastener solutions in form of droplet is showered through bunch of print head onto selected areas of a powder bed surface. Solid and thick layers are developed by solidifying (for example sticking) of the penetrating fluid binder which encases the powder. Then, another layer of powder is provided and sprinkled on the past layer to rehash the structure procedure until the part is shaped.

2.3 Sheet Form Technology

2.3.1 Laminated Object Manufacturing

Helysis corporation was the first company, successfully developed this technique in 1986 and by 1991 it gets widely used in industries. It was initially created to deliver paper, metal components and plastics[11]. The procedure for the most part includes laser cutting which is controlled by computer and arranged thinner sheets of material over cross section as per cut computerized CAD models and followed by layer grip of one cut sheet over another and pre-covered with glue specialists to shape 3D parts. Lamination and bonding between nearby layers can be cultivated by ongoing warming and mechanical pressure.

3. Conclusion

The problem with these materials is that when fabricated with FDM process, they possess low mechanical properties which are needed to be enhanced. Hence four ways are possible for property enhancement of the material. 1) Addition of supports to the printed material. 2) Process parameter optimization involving temperature, orientation, raster angle, contour width. 3)Development of new material filament. 4) New printing methods and technology. Hence process parameter optimization and addition of filler materials are common ways to enhance properties.

RP advancements are utilized by different enterprises like aviation, adornments, car, coin making, silverware, saddletrees, biomedical, and so forth. It is utilized to manufacture idea models, practical models, designs for venture and vacuum throwing, restorative models and models for building investigation.

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