International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No. (03), January 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

Evaluation of 3D-Printing its Crux role in Bioengineering and chemical Sciences

Pankaj KumarRawat[1], Suneel Kumar Swarnkar[2]

[1,2]Department of Mechanical Engineering,

G.C.R.G Memorial Trust Group of Institution, Sitapur Road Lucknow(India)

ABSTRACT

3D Printers are a new generation of machine that can make revolution in every field of life. It has capacity to form different kind of object of different material from a same machine. 3D printing is a set to make great research and teaching laboratories. This feature covers history of 3D printing or additive manufacturing. This research paper reviews various printing method and present existing current application. The author offer an evaluation of future direction and impact of this technology on laboratory setting as 3D printers becomes more accessible.

Keywords: 3D Printing, 3D Printer, Additive manufacturing.

I. HISTORY& INTRODUCTION

The concept of 3D printing, also Called as additive manufacturing (AM), rapid prototyping (RP), or solid-freeform technology (SFF), was developed by Charles Hull. With a B.S. in engineering physics from the University of Colorado, Hull started work on fabricating plastic devices from photopolymers in the early 1980s at Ultra Violet Products in California.[**1].**

In 1986, he established 3D Systems and developed the**.STL** file format, which would "complete the electronic 'handshake' from computer aided design (CAD) software and transmit files for the printing of 3D objects.**[4].** Hulland3DSystemscontinuedtodevelopthefirst3Dprintertermedthe "Stereo lithography Apparatus"

II.PRINCIPAL OF 3D PRINTING

Additive Manufacturing (AM) technologies build near net shape components one Layer at a time using data from 3D CAD models.AM technologies are the result of evolution of work in 3Dprinting and stereo lithography (the STL files used to convert 3D CAD to layer for building parts come from stereo lithography terminology) and could revolutionize many sectors of U.S. manufacturing by reducing component lead time, cost, material waste, energy usage, and carbon footprint.

The 3D printing concept of custom manufacturing is exciting to nearly everyone. This revolutionary method for creating 3D models with the use of inkjet technology separate model parts. Now, you can create a complete model in a single process using 3D printing. The basic principles include materials cartridges, flexibility of output, and translation of code into a visible pattern.

IJARSE
ISSN: 2319-8354

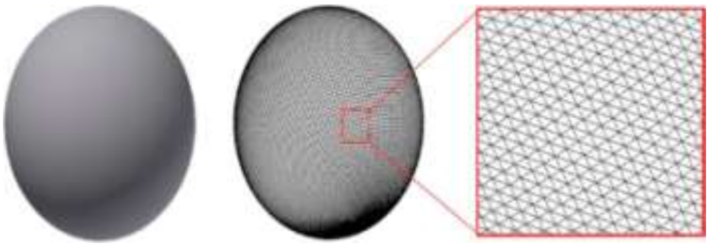


Figure1.Graphic representation of information in an .STL file.

III.3D PRINTING METHODS

3.1 Stereolithography(SLA):Stereo lithography is a form of printing technology used for creating models, prototypes, patterns, and production parts in a layer by layer fashion using photo polymerization, a process by which light causes chains of molecules to link, forming polymers.[2]

Those polymers then make up the body of a three-dimensional solid. Research in the area had been conducted during the 1970s, but the term was coined by Chuck Hull in 1984 when he applied for a patent on the process, which was granted in 1986. Stereo lithography is used to create prototypes for products and in medical modeling, among other uses. While stereo lithography is fast and can produce almost any design, it can be expensive.

Schematic of a layer configuration SLA printer with a projection based curing method. In this configuration of an SLA printer, the stage is submerged a defined distance into the photopolymer reservoir. Next, a laser is guided to the stage to polymerize the material in the reservoir that is between the laser and the stage. In the projection based curing method, the digital mirror device allows for a whole layer to be cured simultaneously. The stage can then be raised again by a defined distance, and another layer can be cured. This procedure repeats until the object is printed.

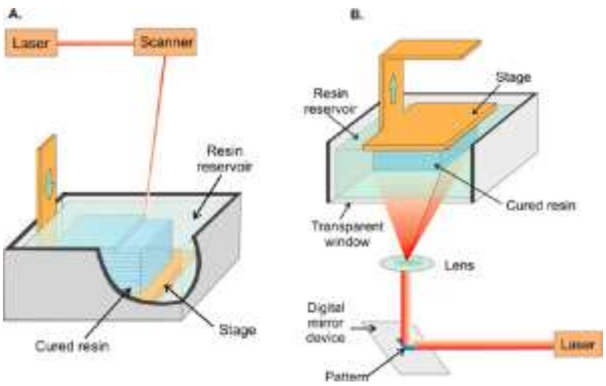


Figure: 2Stereo lithography (SLA) apparatus

3.2Inkjet Printing:

The concept of inkjet printing was initially described in 1878 by Lord Rayleigh,[3] and in 1951;Siemenspatented the first two-dimensional (2D) inkjet type printer called a Rayleigh break-up inkjet device.[4]Inkjet printing has also used for printing structures of sol−gel, conductive polymers, ceramic, metal, and nucleic acid or protein materials.

International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No. (03), January 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

3D inkjet printing is mainly a powder-based method where layers of solid particles, typically 200 µm in height with particle sizes ranging between 50 and 100 µm[5] are bound together by a printed liquid material to generate a 3D model. Specifically, a first layer of powder is distributed evenly on the top of a support stage, e.g., by a roller, after which an inkjet printer head prints droplets of liquid binding material onto the powder layer at desired areas of solidification. After the first layer is completed, the stage drops and a second powder layer is distributed and selectively combined with printed binding material. These steps are repeated until a 3D model is generated, after which the model is usually heat-treated to enhance the binding of the powders at desired regions. Unbound powder serves as support material during the process and is removed after fabrication.

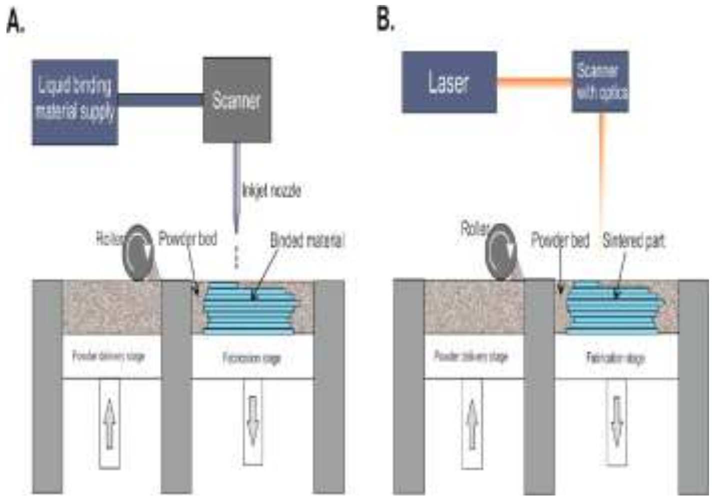


Figure: 3inkjet printing apparatus

3.3 Selective laser Sintering (SLA):

This Process was first developed in 1987 at university of Texas at Austin.

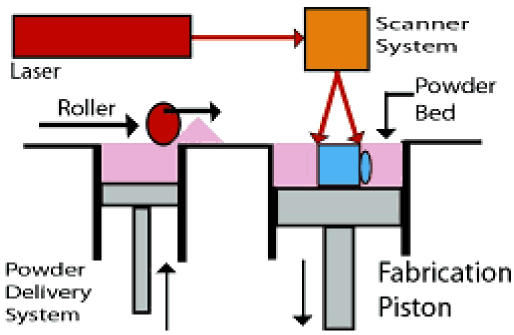


Figure: 4Selective laser Sintering apparatus

In this process, a part is created following a layer-by-layer approach by fusing powdered thermoplastic materials with a high power laser beam. This process of getting powder grains bonded together by localized partial melting is called sintering. In general, sintering occurs when a particle's viscosity drops due to higher temperature and the surface tension effect overpowers the viscosity.SLC uses a high power laser, like CO2 and Nd, to sinter polymer powders to generate a 3D models. In the SLC process, a first layer of powder is spread in to a cylindrical part and is then heated to a temperature just below the powder melting point. A cross-sectional profile designed in the .STL files. A laser beam is scanned over the powder to raise the temperature of the powders melting points to fused powder partials together. After the first layer is completed, the second layer of powder is added, leveled and sintered in the desired areas. These steps are repeated to create 3D model.

3.4Fused deposition modelling (FDM):

This Process was developed by Scott Crump of Stratasys. This is one of the most popular methods for additive manufacturing in this process; 3D objects are produced by depositing a molten thermoplastic material layer by layer.

In this method, plastic filament is directed into a heating block where it is heated to a semi molten state. The molten material can be printed onto an adjustable stage to form a layer of the desired object. The stage is adjusted (lowered) and another semi molten layer is printed.

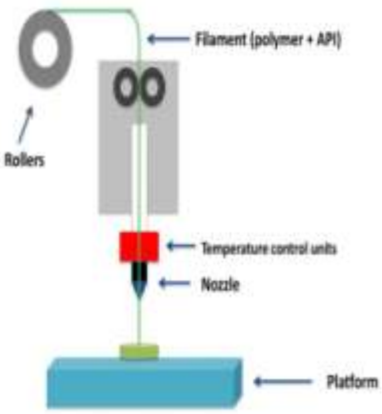


Figure: 4Fused deposition modelingapparatus

3.5Laminated Object Manufacturing (LOM)

This method was developed by Helisys.In this Process, parts are produced by successive bonding of layers of sheet materials and laser cutting of each cross-section. Thin sheets of plastics and composites are also used. The part obtain a wood-like structure and quality.

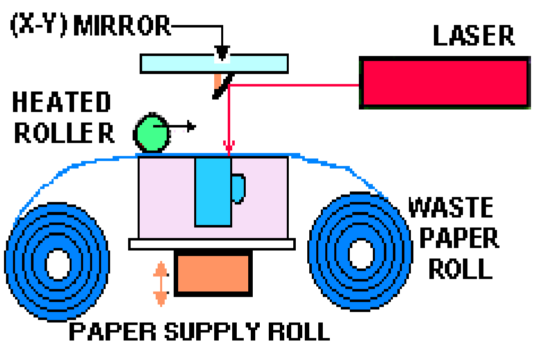


Figure: 5 Laminated Object manufacturing apparatus

International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No. (03), January 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

3.6 Direct Metal Deposition (DMD): This Process was developed by Ann Arbor at University of Michigan. In this Process metal powder is supplied which is melted by a high power laser beam and functional metallic part can be generated. The deposition head is guided by a manipulator.

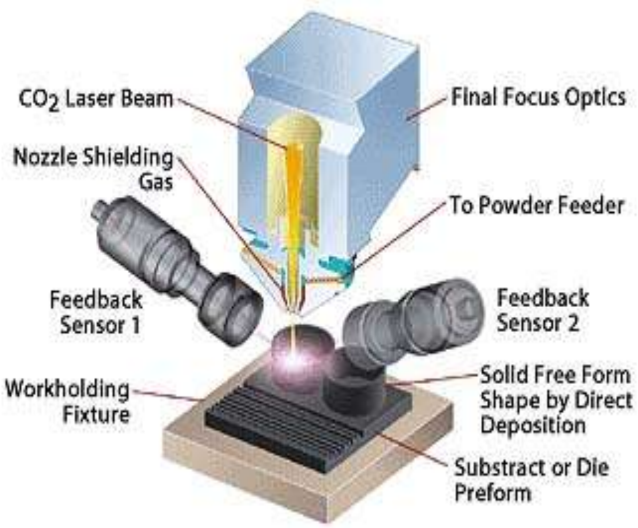


Figure: 6 Direct Metal Deposition (DMD) apparatus

IV. COMPARISON OF 3D PRINTING METHOD

Following method

SNO	Method	Principle	Material Used
1	**SLA**	UV initiated curing of defined photo resin layers	Photopolymer
2	**Inkjet**	Powder-liquid binding or polyjet technology	Photo resin or more commonly, plaster powder particles (50-100μm).
3	**SLS**	Laser Induced heating of powder particles	Thermoplastics, metal powder, ceramics powder
4	**FDM**	Extrusion of molten thermoplastics	Thermoplastics, edible material, Rubber, Modelling Clay
5	**LOM**	Laser/razor cutting of heated, adhesive coated sheet material.	Paper, metal foil, plastic film

Table-1: Comparison of 3D Printing Method

V.RECENT APPLICATION OF 3D PRINTING IN DIFFERENT AREAS

In this Paper, Specifically the topic to be discussed are the application of additive manufacturing and rapid manufacturing in Aerospace, Automobile industry, Biological, Medical and health care Sector, Automobile Industry, forensic science, Dental industry, Chemical and Pharmaceutical.

5.1Biological: 3D Printers are used in widespread applications from guns to models of the buildings, but the medical uses are extremely practical and overtime could really solve ongoing health issues, once it's figured out how to accurately apply them to human health.

Embryonic Stem Cells: These cells can be successfully printed in a lab and could be one-day use to create tissue. This could help test drugs and assist in the growth of new organs.

Printing Skin: There have been many advances in the areas of developing a portion of a skin to help burn victims and skin disease patients.

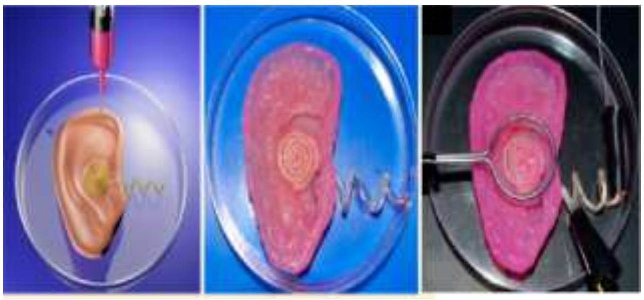


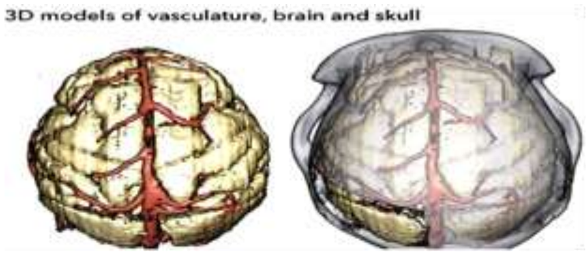
Figure 7:3D printed bionic ear

Blood Vessels & Heart Tissue: Blood vessels and sheets of cardiac tissue can be successfully printed that actually beat along just like a real heart.

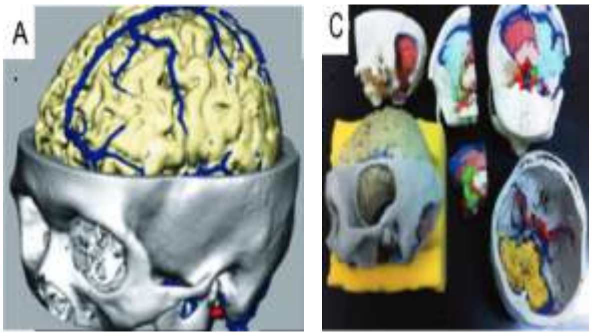
Replacing Cartilage & Bone: 3D printers have also helped scientists and doctors to create stem cells that could eventually develop into both bone and cartilage in the long-term.

Studying Cancer: Printing cancer cells is a way of growing these cells on tissue in a lab to study, test drugs on them and to eventually find a cure for it.

5.2Forensic Science: 3D printing has had a meaningful impact on medical imaging in the field of forensic science, allowing for anatomically correct recreation of bodily injuries from CT and MRI scans. For example, models of both internal and external wounds have been recreated that allow for better explanation of forensic findings, while avoiding the need to present disturbing evidence in the presence of victims' relatives.[6]



Figuer.8.1: Use of 3D printing for presurgical planning. MRI, CT, magnetic resonance angiography (MRA),



Figuer.8.2: Use of 3D printing for presurgical planning. MRI, CT, magnetic resonance angiography (MRA),

5.3Aerospace: NASA engineers drew on ingenuity and advanced technology. About 70 of the parts that make up the rover were built digitally, directly from computer designs, in the heated chamber of a production-grade Stratasys 3D Printer. The process, called Fused Deposition Modeling (FDM) Technology or additive manufacturing, creates complex shapes durable enough for Martian terrain [7].For its 3D-printed parts, NASA uses ABS, PCABS and polycarbonate materials. FDM, patented by Stratasys, is the only 3D-printing method that supports production-grade thermoplastics, which are lightweight but durable enough for rugged end-use parts.[8]Recently, NASA has been testing rocketparts built by 3D printing andmay even use the technology to build habitats in space and on other worlds. NASA has been developing technologies to print wood from the printers using 3D bioprinting technology. The basic theory is that the printer will lay out living cells in a specific manner upon a gel. This gel simulates the cells to start excreting wood. One application could be that astronauts could bring wood to space without having to carry any of it. NASA has also jumped on the printed food bandwagon and are said to be extensively funding research in this area in order to feed astronauts in space.[17]NASA is using a Strat says 3D printer to develop and test a space rover. The rover is about the size of a Hummer with a pressurized cabin to support life on Mars and currently contains over 70 FDM (Fused Deposition Modelling) 3D printed parts. The 3D printed parts on NASA's rover include flame-retardant vents and housing, mounts, pod doors, are part that function as a front bumper and many other customized fixtures' chose Stratsays Ultem 9085 to create the 30 antenna arrays that were vital to the success of this project. NASA and Airbus are just a few examples of how major organizations are turning to 3D printing to solve complex engineering problems and create specialized parts. [18],[19].

5.4 Automobile industry: One of Ducati's key challenges is to reduce time-to-market for new products by reducing the design cycle. To help meet this challenge, the entire design process is validated using FDM prototyping systems from Fortus. FDM (fused deposition modeling) enables Ducati to build both concept models and functional prototypes from ABS, polycarbonate and poly-phenyl sulfone. [9]The first printed bike, made from nylon and as strong as its steel and aluminum counterpart, developed by European Aerospace and Defense group. [21]

Figure 9. The first 3D–printed bike

5.5Medical & Health Care Field: In medical field, surgeons are using 3D printing machines to print body parts for reference before complex surgeries. Other machines are used to construct bone grafts for patients who have suffered traumatic injuries. Looking further in the future, research in underway as scientists are working on-creating replacement organs. [10]

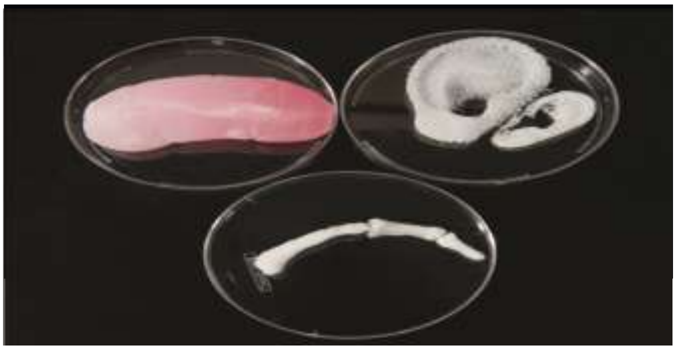


Figure10. These 3D printed structures: kidney (top left), ear (top right) and finger.

The most inspiring use of 3D printing is in the healthcare industry, where 3D printing has the potential to save and improve the lives. The development of 3D printing to create tissue, organs, bones and prosthetic devices, improved the lives. Wake forest institute has developed a 3D printing technique for engineering tissue and organs. Scientist are continuously working on a variety of project like ear, muscles, Jaw, limbs and Kidney. The printer is designed to print organ and tissue structures using data from medical scan, such as a CT and MRI. The basic idea is to print living cells and the biomaterials that hold cells together into a 3D shape. This organ or tissue structures would continue to develop. [12],[13]. In the June 2011 the first 3D printed jaw is made of titanium, was successfully implanted in an 83 years old woman by Dr.Jules Poukens of Hasselt University. This implants perfectly match a patient's body and provide better fixation, which can reduce surgery time and infection. [14],[15].

5.6Education & Research:3D printing and Open Source Rep Rap are latest technology for making goods or articles in classroom.3D printing allows the students to create prototypes of items without the use of expansive tooling required in subtractive material. Student can design actual model easily with help of design. The class room Environment allows students to learn and employ new applications for 3D printing. RepRap, for example, have already been used for an educational mobile robotic platform. [16]

5.7 Construction: In the future, we may live in houses that have been 3D printed. A researcher at University of Southern California claims to have designed a 3D printer that is capable of printing a whole house in 24 hours. This conceptual model uses Concrete as its base element to replicate computer programs of houses. in order to ensure that the house is compatible with plumbing and electrical apparatuses; it uses a layered fabrication tech called "Contour Craft" [17]

5.8 Pharmaceutical: 3D printing has been used in the fabrication of delivery devices, as it allows for more control of the design and fabrication of implants that can be used for direct treatment. The first artificial insect with 3D printed wings that has sustained untethered hovering flight for 85 seconds, by researchers at Cornell University. Drug delivery refers to delivery of a pharmaceutical active ingredient (API) in the body or at the site of action to achieve its desired therapeutic effect. The idea of drug delivery has greatly progressed over the years from conventional dosage forms to novel target drug delivery systems [21]. Therefore, the conventional method like direct tableting are now progressively evolved towards multi-step manufacturing technologies, including granulation, extrusion or coating processes, to allow the development of controlled-release systems. Now-a days novel concepts of formulation have emerged (e.g., nano-scale medicines, biomimetic particles, functionalized liposomes) as well as more sophisticated manufacturing methods [22-24].

Thus, 3D printing process naturally appeared to be an essential tool in research and development area to fit with actual industrial directions of reducing both time and costs in the early stage of a novel manufacturing concept, reducing the inherent risk of new development to fail at later stages [25-27]. 3D printing in pharmaceutical industry represents a well-designed tool for designing simple, accurate, cheap, structured and tailored drug delivery systems [28-30].

Figure 11.first artificial insect with 3D-printed wings.

5.9 Chemical Science: 3D printing, focus on impact on micro fluid and lab on a chip technology. While the possible function of 3D printed micro fluids device are working on bioanalytical research to control cell pattering using soft lithography .The fabrication of a complex microvascular network composed of 100−300 μm cylindrical channels capable of diffusion-based mixing under laminar flow profiles as well as mixing from turbulent flow is one of the earliest examples of 3D printing for microfluidic applications.**[31]**

VI. CONCLUSION

As per Today's scenario, by advancing the current practical uses are endless in the field of 3D printing.

1. Product formation is currently the main use of 3D printing technology. These machines allow designers and engineers to test our ideas for dimensional products cheaply before committing to expansive tooling and manufacturing processes.

2. Creating complete models in a single process using 3D printing has great benefit. This innovative technology has been proven to save companies time, manpower and money. Companies providing 3D printing solution have brought to life an efficient and competent technological product.

3.3D printing exponentially increase the job as

to be read and manufactured by a 3D printer.

5. These hybrid approaches perform 3D printing and well as industries growth and their profit.

4. The creation of any imaginable geometry can be made by CAD software and converted into**. STL** files machining at the same time, eliminating the post-processing.

6. Allows manufacture of more efficient designs: lighter, stronger, less assembly required.

7. Efficient use of raw materials (less waste) & One machine, unlimited product lines.

8. Affordable customization and Manufacturing accessible to allow lower entry barriers.

REFERENCE

[1] SPIE-Professional.Chuck Hull: Pioneering Stereolithography;http://spie.org/x91418.xml(accessed September27,2013).

[2] U.S. Patent 4,575,330 ("Apparatus for Production of Three-Dimensional Objects by Stereo lithography")

[3] Elmqvist, R. Measuring Instrument of the Recording Type. U.S. Patent 2,566,443, September 4, 1951.

[4] Strutt, J. W.; Rayleigh, L. Tr. Mat. O-va 1879, 4−13.

[5] Pfister,A.;Landers,R.;Laib,A.;Hubner,U.; Schmelzeisen,R.; Mulhaupt, R. J. Polym. Sci. Polym. Chem. 2004, 42, 624−638.

[6] Ebert, L. C.;Thali, M. J.; Ross, S. Forensic Sci. Int. 2011, 211, e1−e6.

[7] Wenyong Liu, Ying Li, Jinyu Liu, Xufeng Niu, Yu Wang, and Deyu Li (2013), Application and performance of 3D printing, Journal of Nano materials, pp. 1–7.

[8] Deepa yagnik (2012), Fused Deposition Modeling – A Rapid Prototyping technique for Product Cycle Time Reduction cost effectively in Aerospace Applications, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), pp. 62-68.

[9] http://www.stratasys.com/resources/casestudies/aerospace/nasa-mars-rover

[10] http://net.educause.edu/ir/libarary/pdf/DEC0702.pdf.

[11] http://www.mahalo.com/3d-printers/

[12] Wohler's Report 2011: Additive Manufacturing and 3D Printing State of the Industry, p.164.

[13] (http://wwwwohlerassociates.com/2011contents.htm)

[14] "Transplant jaw made by 3D printer claimed as first," BBC News,6 February 2012.

[15] (http://www.bbc.co.uk/news/technology 16907104.)

[16] Baljinder Singh Shahi, "Advances in Manufacturing Techniques (3D Printing)-An Overview, Journal of Advances in Applied Computational Mechanics &Engineering, August-2016, vol.4, issue-2, pp-1-18.

[17] Siddhartha Bhandari & B Regina, "3D Printing and Its Application", International Journal of Computer Science and InformationTechnology Research(IJCSITR), June-2014, vol.2, issue2, pp-378-380.

[18] http://3dprinting.com/aerospace/nassa-uses-3dprinting-for-their-next-move-on-mars/#.

[19] https://blog.trimech.com

[20] The LEF website (csc.com/3dprinting)

[21] Porter SC (2001) Novel drug delivery: Review of recent trends with oral solid dosage forms. American Pharmaceutical Review 4:28-36.

[22] Sastry SV, Nyshadham JR, Fix JA (2000) Recent technological advances in oral drug delivery-a review. Pharmaceutical science and technology today 3:138-145.

[23] Brannon-Peppas L (1995) Recent advances on the use of biodegradable micro particles and nano-particles in controlled drug delivery. International journal of pharmaceutics 116:1-9.

[24] PoznanskyMJ, Juliano RL (1984) Biological approaches to the controlled delivery of drugs: a critical review. Pharmacological reviews 36:277-336.

[25] Wang X, MÃƒÂ¤kitie AA, Partanen J, Tuomi J, Paloheimo KS, et al. (2013) The integrations of biomaterials and rapid prototyping techniques for intelligent manufacturing of complex organs. INTECH Open Access Publisher.

[26] LeHP(1998) Progress and trends in ink-jet printing technology. Journal of Imaging Science and Technology 42:49-62.

[27] Subramanian V, FrÃ Â©chet JM, Chang PC, Huang DC, Lee JB, et al. (2005) Progress toward development of all-printed RFID tags: materials, processes, and devices. Proceedings of the IEEE 93:1330-1338.

[28] Melchels FP, Feijen J, Grijpma DW(2010) A review on stereolithography and its applications in biomedical engineering. Biomaterials 31:6121-6130.

[29] Kolakovic R, Viitala T, Ihalainen P, Genina N, Peltonen J, et al. (2013) Printing technologies in fabrication of drug delivery systems. Expert opinion on drug delivery 10:1711-1723.

[30] Preis M, Breitkreutz J, Sandler N (2015) Perspective: concepts of printing technologies for oral film formulations. International journal of pharmaceutics 494:578-584.