e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
Volume:03/Issue:03/March-2021 Impact Factor- 5.354 www.irjmets.com

SCOPE OF 3D PRINTING TECHNOLOGY IN VARIOUS SECTORS: A REVIEW

M. Leela Mohan[*1], K. Rakshith Kumar[*2], Mannem Ravi Teja[*3], G. Siva Krishna[*4]

[*1,2,4] Student, Department of Mechanical Engineering, Chennai Institute of Technology, Tamil Nadu, India.

[*3] Student, Department of Electronics and Communication Engineering, Rajalakshmi Institute of Technology, Tamil Nadu, India.

ABSTRACT

One of the fastest-growing technology named 3D printing technology going by the name of Additive Manufacturing (AM). 3D printing creates a design using software and a 3D printer creates a 3-Dimensional physical object by adding layer by layer of material until the shape is formed. In this paper we will discuss the future scope of 3D printing technology in various industries, especially in the space sector, besides we will see how 3D printing plays a key role in the space industry replacing manufacturing cost i.e CubeSats, Rocket Engines, etc also we will see the impact and applications of 3D printing technology.

Keywords: 3D Printing technology, Cube SAT propulsion, Rocket Engine, 3D printer, Additive Manufacturing.

I. INTRODUCTION

In the early 1980s, this 3D printing technique was used only for functional prototypes and process names as Rapid Prototyping. One of the greatest advantages of 3d printing is the ability to create complex shapes which is impossible to create by hand or traditional manufacturing process. (Joshi & Sheikh, 2015). Commercial usage of 3D printers has been increased rapidly in the sectors such as the Automotive industry, space engineering, aerospace industry, etc besides 3D printing has also used in the field of medicine, by making 3d printing as a tool medicine of tomorrow is going to be revolutionized. (Mpofu et al., 2014).

II. THEORETICAL BACKGROUND

The most common three types of 3d printing technology are (i)Fusion Deposition Modelling (FDM), (ii)Stereolithography (SLA), (iii) Selective Laser sintering (SLS). (1)

(i)FDM - Fusion Deposition Modelling

FDM is a type of technology in which the melt extrusion method is used for filament deposition of thermoplastics. This deposition of filament will be done according to the specific pattern. FDM contains a printhead that can able to move along X and Y directions as the object is built layer by layer in a Z-direction. This form of 3D printers is the cost-effective way and can create parts very quickly and effectively and have become a key component for engineering and design departments.

(ii)SLA – Stereolithography

SLA is one of the technologies used for creating models, prototypes, patterns in a layer-by-layer process (one layer at a time) using a photochemical process through which light causes monomers and oligomers to cross-link together to form polymers. The Downfall of the SLA printing technique is the product must be rinsed with solvent after immediate completion of printing.

(iii)SLS - Selective Laser sintering

In this technique, the laser is used as a power source to sinter the powdered material (nylon or polyamide) SLS is a new emerging technology that so far has been used for Rapid prototyping and Low-volume production. One of the major advantages of SLS is it doesn't require any support structure to produce complex designs.

III. 3D PRINTING IN DIFFERENT SECTORS

3D printing Technology in Aerospace Industry

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
Volume:03/Issue:03/March-2021 Impact Factor- 5.354 www.irjmets.com

This section gives an overview of the usage of 3D printing techniques in the Aerospace industry besides case studies and applications of 3D printing Technology Basically, 3D printing is divided into two classes one that is physical state of raw materials i.e liquid, solid, powder-based process and the other the matter which is fused that is thermal, ultraviolet, laser or electron beam. The best example of utilization of Additive Manufacturing in the Aerospace and Defence(A&D) industry the parts which are manufactured using the 3D printing technique are lighter and stronger than the parts made by traditional manufacturing.

Among the different 3D printing technique the one which meets the A&D industry is Selective laser sintering (SLS), Selective laser melting (SLM), Electron beam melting (EBM), and wire and Arc manufacturing (WAAM). (2)

On average a corporate aircraft can travel 75,000 miles per month the part which is designed and manufactured using 3d printing will reduce the drag by 2.1% and also reduces fuel costs by 5.41%. so, These type of small changes will affect the life of an aircraft in a huge way**.**

Selective Materials used for 3D printing.

The materials used in 3D printers are ABS, PLA, PET, PVA, HIPS, NYLON, Carbon, Glass reinforced.

Where,

ABS	-	Acrylonitrile Butadiene Styrene
PLA	-	Polylactic acid
PET	-	Polyethylene terephthalate
PVA	-	Polyvinyl alcohol
HIPS	-	High Impact polystyrene

ABS (Acrylonitrile Butadiene Styrene) is a part of the Thermoplastic polymers family and it is created from acrylonitrile, butadiene, and styrene polymers since it is a petroleum product it can be dissolved in ABS acetone. The temperature range of the product which is 3D printed using ABS material is from 200C to 800C. if the material is exposed to severe UV light there may be a chance of decaying of material. ABS is not preferred for creating large parts since it requires a high temperature besides there is a chance of alter in shape. **(3)**

(i) Advantages of ABS material

- It is frequently preferred due to its high impact resistance.
- ABS material has a good surface quality and is non-inflammable.
- Low melting point of ABS makes it easy to machine using desktop 3D printers.

PLA (Polylactic acid) is a thermoplastic that has the lowest melting due to which it is preferred for 3-Dimensional printers. This polylactic acid is made from corn scratch, tapioca roots, or sugarcane. Since PLA is a non-Newtonian pseudoplastic fluid the more the is stress applied the less is the viscosity. The melting point temperature of PLA is 1800 C lower than ABS.

(ii) Advantages of PLA Material

- Since PLA has low melting it will melt easily.
- Less toxic fumes are released while operation.
- Smoother appearance.
- Due to higher viscosity there may be a chance of clog the print head, if not careful.

Table-1: Commonly used 3D printers (1)

S. No	Material	Extruded temp	Bed Temp	properties
1	ABS (Acrylo-nitrile-Butadiene styrene)	$215^0C - 250^0C$	$80 - 110^0C$	Durable strong, Sightly flexible heat resistant

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
Volume:03/Issue:03/March-2021 Impact Factor- 5.354 www.irjmets.com

2	PLA (Poly lactic acid)	170 – 220^{0}C	20 – 55^{0}C	Tough Strong
3	PVA (Poly vinyl Acetate)	160 – 170 ^{0}C	45^{0}C	Used to print support material
4	TPE (Thermoplastic Elastomers)	180 – 230^{0}C	20 – 25^{0}C	Properties of soft rubber even makes more flexible and elastic than soft PLA filament.

Advantages of 3D printing in Aerospace industry

- Efficiently Manufacture high-tech parts and satisfy the standard safety requirements.
- Successfully produce a lightweight structure with 40-60 % less weight.
- Increases production efficiency and improves supply chain lead times.
- Simplifies assembly and quality assurance process.

Fig-1: Sample products made with 3D printing technology (3)

Conclusion

The products which are manufactured with the traditional manufacturing process will take much time to get finish rather than 3D printing. The surface quality and the material used for printing a model are far better than other manufacturing processes. Whatever the prototype products are prepared with 3D printing will increase the productivity rate as well as the strength of the product. The weight of the product that is 3D printed is very less nearly (40 to 60%) and even complex structures are also printed very easily the traditional manufacturing process.

IV. 3D PRINTING TECHNOLOGY IN SPACE SECTOR

A new era has begun for space exploration in which Additive manufacturing plays a major role in future human space travel as well as interplanetary colonization. 3D printing has already enabled the production of low-cost satellites and efficient rocket engines to take cargo into orbit. The feedstock of a 3D printer cannot be a powder form since it would float everywhere, to come up this problem NASA's Langley research center says using the EBF3 technique we can print in space, which uses an electron gun to melt two strands of wire that too one layer at a time to print a 3D shape. (4)

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
Volume:03/Issue:03/March-2021 Impact Factor- 5.354 www.irjmets.com

4.1 Additive manufacturing in rocket engines

Additive Manufacturing Technology can reduce the cost and lead times with the development of liquid rocket engines. NASA uses 3D printing technology to make products like rocket engines, injectors, turbopumps, spark igniters, and valves.

Fig.-2: 3D printed Liquid hydrogen Turbo pump, spark Igniter. (5)

4.2 3D printing in Zero-G ISS

NASA's In space Manufacturing has begun the project which leads the development of 3D printing technology and its capability to explore the moon, Mars, and beyond. This 3D printing Zero-G will be the first machine to perform the AM technology in space. This Zero-G 3D printing technique helps to repair or replacement of tools in space which means that it doesn't require sending the cargo from the ground station all the time. (6)

(i) Areas Applying 3D printing in Space

There are many cases where 3D printing plays a key role in space in which some are included in the following but they are not limited:

- Well known and foretell Repairs.
- Untold Repair and Replacements.
- Known production and Assembly.

(ii)Future goals of Zero-G 3D printing Technology

- ABS material is used to perform extrusion-based Additive Manufacturing.
- Using Computer Aided Drawing (CAD) file and to perform "On Demand" printing capability.
- To perform Capacity-building Activities in science, Technology, Engineering, and Mathematics.
- In future technology developments this is used to reduce the design as well as functional risks.
- Since there will be a limited supply of material from earth to space they are planning to have a reusable system which makes to reuse the material which is already printed part.

4.3. 3D printing Technology in Medical Industry

3D printing technology plays a crucial role in the medical industry. Many new treatments and most advanced technology, methods have been developed in 3d printing technology. The most commonly used technology was the powder bed fusion for printing the medical devices, based on identical copies of the same device or matched unique patients anatomy. i.e, (patients specific- Device which specifically made based on the patients special features. (7)

Power Bed Fusion is the most commonly used technology in 3d printing Because it works over the specified materials like Titanium and Nylon.

Devices That Produced Using 3d-Printing Technology:

- 3D-Skin
- Organ (Ear, Teeth, Bionic Eye. etc)

- Bones and cartilages
- Clinically validated stethoscope. etc.

There are several advantages of using 3d-printing technology in biomedical products. (8)

4.4 Bionic Eye

The discovery of the "bionic eye", could help someday to the people who are blind and the sighted people can see better. The bionic eye process makes 25% of the efficiency of light in converting it into electricity, with fully 3d-printed semiconductors on a hemisphere. This total process takes an hour. (9)

4.5 3D printed skin

The 3d printing skin can be used to test chemical products, cosmetics. Therefore, researchers can reduce the animal skins to perform these tests. As this 3d printing technology skin gives an accurate result using the replicate of the skin.

4.6 Clinically Validated Stethoscope

The 3d printed stethoscope is one of the best stethoscopes on the market at present. A team of researchers had developed the 3d-printed clinically validated stethoscope using open-source software, with ABS material. The stethoscope is made using the open-access template for all called Glia template.

Using this template anyone using this technology can easily access the code. The main theme of this idea is to serve these stethoscopes where the medical services are limited. With the glia template and the 3d printer, we can do it at a low cost and even for less time. We can use recycled plastic for this stethoscope.

4.7 Advantages of 3D printing in Medical Field

- 3D printer can able to print even more complex parts very effectively and easily.
- Customization of prosthetics and make it available at low cost

  (Prosthetics – it's an artificial device which replaces the missing part in human body which functions as a real one.). (10)

4.8 3D printing Technology in Automobile Industry

In this competitive world, the usage of automobiles increasing rapidly. To meet these demands, our traditional methods like subtractive manufacturing including cutting, forming, casting, welding, etc. won't be preferred. As it requires more time for manufacturing and production, replacing this 3d printing is a suitable alternative. It is also known as "additive manufacturing". As the phrase itself refers that, a 3-dimensional object is going to be manufactured by adding successive layers using desired materials. By incorporating this method, we can form complex objects which cannot be able to form using traditional methods (subtractive method) with ease. So, applying 3d printing techniques in the automotive industry can make a drastic difference in the production time as well as cost. Perhaps, it may double the output and efficiency. Not only in the automotive industry but, it is also emerging in various fields like medical, food, architecture, etc. (11)

4.9 Application of 3d printing on automobile industry:

As we all know that, demands for the automotive increasing day by day. So that, rate of production should also equal the demand. To produce complex structures of automotive components with properties like strength, toughness, being robust, etc. will take more time and manpower. To reduce the cycle time along with weight and cost, additive manufacturing is so apt and preferable. A lot of reputed companies like Audi, BMW, etc., were already incorporated these techniques in their manufacturing processes.

At present, additive manufacturing helps in manufacturing the following components for the automobile industry:

- Exhaust and emissions
- fluid handling system
- 3, exterior body

In the future, 3d printing may also be included in the manufacturing of the following components:

- interior body
- engine components
- frameworks
- tires, wheels, and suspension

With these, we can say that additive manufacturing is going to be a new revolution in the automobile industry in the coming years. The shadow of 3d printing is not only on automotive but also on aerospace, medical, food, etc.

4.10 Advantages of 3d printing in automotive:

- Life cycle time for a component will decrease.
- Low consumption and wastage.
- Reduction in costs.
- Rapid prototyping_(12)

V. CONCLUSION

In short, Additive manufacturing can make a lot of difference in manufacturing processes in the coming years. As of now, Manufacturing is done by the subtractive method which consumes more time and money. But, by making use of 3d printing technology, automotive industries, Aerospace Industries and Medical Sector can become more productive with less time and manpower. In conclusion, Hopefully, I can say that additive manufacturing is going to be our future almost in every field.

VI. REFERENCES

[1] A Comprehensive Study on 3D Printing Technology. Saxena, Abhishek,Kamran, Medhavi. 2, 2016, Vol. 6. ISSN 2230-7680.

[2] 3D printing in aerospace and its long-term sustainability. Joshi, Sunil C.Sheikh, Abdullah A. 4, 2015, Vol. 10. ISSN: 1745-2759 (Print).

[3] Additiv3e manufacturing and 3D printer technology in aerospace industry. Kalender, MurathanKilic, Sefa EnesErsoy, SegainBozkurt, YahyaSalman, Serdar. 2019.

[4] 3D printing in aerospace and its long-term sustainability. Sheikh, Abdullah A.Sheikh, Abdullah A. 4, 2015, Vol. 10. ISSN: 1745-2759.

[5] Additive Manufacturing for Affordable Rocket Engines Description. Marshall Space Flight Center, 2020.

[6] 3D printing in zero-G ISS technology demonstration. Johnston, Mallory M.Werkheiser, Mary J.Snyder, Michael P.Edmunson, Jennifer E. s.l. : AIAA, 2014. AIAA 2014-4470.

[7] FDA. [Online] 12 04 2017. https://www.fda.gov/medical-devices/3d-printing-medical-devices/medical-applications-3d-printing.

[8] RtoZ.org. [Online] https://www.rtoz.org/2018/09/26/3d-printing-in-the-medical-field/.

[9] University of minnesota. [Online] 08 28, 2018. https://twin-cities.umn.edu/news-events/researchers-3d-print-prototype-bionic-eye.

[10] Leapfrog 3d printers. [Online] https://www.lpfrg.com/blog/3d-printing-in-the-medical-industry/.

[11] 3D Technology in the Automotive Industry. Elakkad, A. S. 11, 2019, Vol. v8. ISSN: 2278-0181.

[12] Divide by Zero. [Online] https://www.google.com/url?sa=t&source=web&rct=j&url=https://www.divbyz.com/industries/automotive&ved=2ahUKEwiy0_furc_vAhVIyzgGHcJYCOsQFjANegQICBAC&usg=AOvVaw17jEBY0nSD3_NJrrvFQAyR&cshid=1616809814941.

[13] Joshi SC, Sheikh AA. 3D printing in aerospace and its long-term sustainability. Virtual Phys Prototyp. 2015;10(4):175–85.