Recent Trends in 3D Printing

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***Abstract* — 3D Printing is the technique of building up of materials layer by layer with the help of an inkjet printer which uses an AMF file made by CAD systems for its execution. SLA is most widely used method among its various types. Nowadays 3D printing finds its application in aerospace, electronic, food and automobile industries. The main advantage of 3D printing is significant decrease in weight with increase in strength, toughness and other mechanical properties. Unlike other methods, the material wastage is very minimial and alloys or ceramics which are easily available in powders can also be 3D printed.**

Keywords : AMF,SLA,CAD.

I. INTRODUCTION

3 D printing refers to an additive manufacturing process that creates a physical object from a digital design. This method involves cutting and joining of materials together, the materials are added together usually layer by layer. It builds a three-dimensional object from computer-aided design (CAD) model or additive manufacturing file [AMF].The process usually involves melting of a metal powder with the help of laser as heat source, an inkjet printer is used to print the object layer by layer with the help of object design data file or AMF. Apart from metals, materials such as plastic, sandstone, alloys, rubber can also be 3-D printed. Binder materials are used to bind the different layers of the object together.

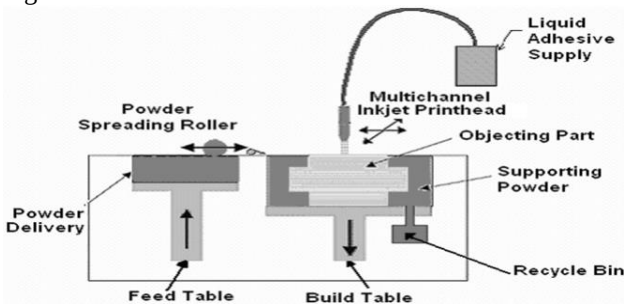

Fig 1. Principle of 3D Printing

The objects 3-D printed are known to have high strength, light weight, inert to atmospheric conditions and have excellent mechanical properties, thus making their field of applications wide.

II. PRINCIPLE

An AMF file is created with the help of CAD software and this file is given as input to the inkjet printer, the printer slices the object data file into various layers and adds layer by layer of metal powder or melted plastic, the layers are then fused together with the help of binding materials to give the final 3-D object.

III. TYPES

1. Stereolithography [SLA]
2. Material Jetting
3. Binder Jetting
4. Fused Deposition Modelling [FDM]
5. Selective Laser Sintering [SLS]
6. Laminated Object Manufacturing [LOM]

1. Stereolithography [SLA]

In SLA process [Fig 2], an ultra-violet sensitive resin is kept inside a translucent tank and a build platform is submerged inside the tank filled with liquid resin, a laser source builds the object to be printed layer by layer from bottom of the tank and solidifies the material.

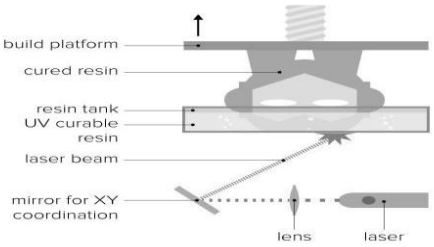

Fig 2. Stereolithography [SLA].

After the layer has been mapped and solidified by the light source, the platform lifts up and lets a new layer of resin flow beneath the layer of the object printed.

This process is repeated layer by layer until the desired object has been completed. Another method very similar to Stereolithography is Digital light processing [DLP], it differs from SLA only in the aspect that DLP uses traditional light sources such as arc lamps or projectors to solidify the resin.

2. Material Jetting

In this process [Fig 3], material is applied in droplets through nozzle layer-by-layer to a build platform making a 3D object and then hardened by UV light. The printer jets the liquid material into the build tray. The jets are followed by UV light, which instantly cures the tiny droplets of liquid photopolymer. As the process is repeated, these thin layers accumulate on the build tray to create a precise object. Where complex shapes require support, the printer jets a removable gel-like support material which can be removed after the printing is completed. Opaque plastic, wax, acrylics are the materials used in material jetting process.

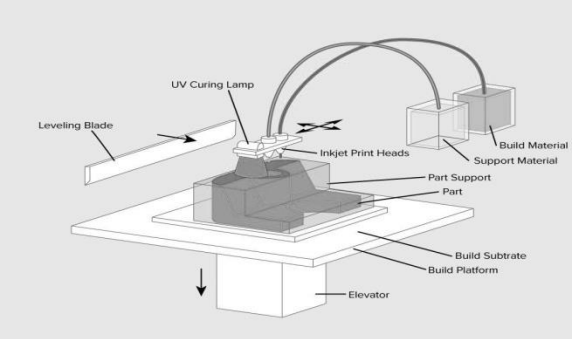

Fig 3. Material Jetting

3. Binder Jetting

In this method [Fig 4], the powder material is spread on the build platform with the help of a roller, the print-head of the printer deposits the adhesive or the binding material on the powdered built platform,

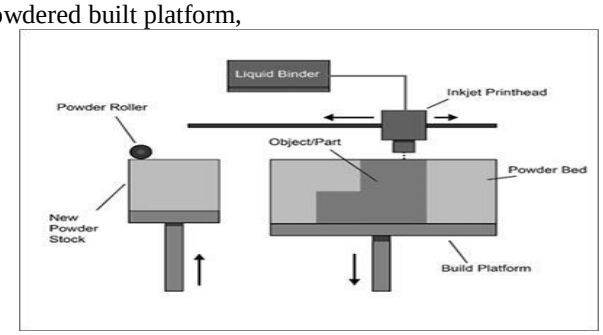

Fig 4 Binder Jetting [BJ]

then the build platform is lowered and another layer of binding material is applied on the build platform, the object is formed where the powder is bounded by the liquid.

Stainless steel, ABS, PA, PC, glass are the common materials used with binder jetting process

The binder jetting process uses two materials; a powder material and a binder. The binder acts as an adhesive between powdered layers. The binder is in liquid form and the build material in powder form. A print head moves in both X and Y direction and deposits alternating layers of the build material and the binding material. After each layer, the object being printed is lowered on its build platform.

4. Fused Deposition Modelling [FDM]:-

A fused deposition modelling machine [Fig 5] melts a plastic wire or filament and extrudes it through a nozzle. The melted material is laid down on the build platform, where it cools and solidifies. By laying down layer on layer the part is built.

Fused deposition modelling requires support structure which supports the parts on the build platform and overhanging structures. Through the use of a second nozzle, the support structure can be built in a different material. Standard plastics such as ABS, PLA, PC are commonly used materials for FDM.

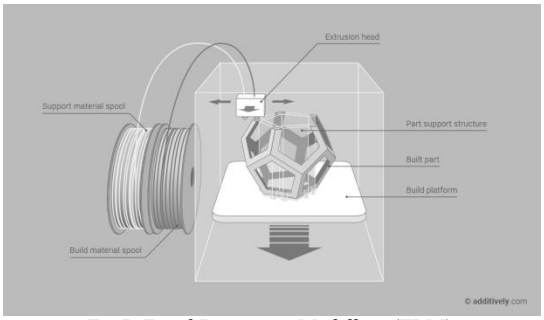

Fig 5. Fused Deposition Modelling (FDM)

5. Selective Laser Sintering [SLS]

In laser sintering process [fig 6], a layer of plastic powder is placed on a build platform, which is melted by a laser. The build platform will then be lowered and the next layer of plastic powder will be laid out on top. By repeating the process of laying out powder and melting where needed, the parts are built up in the powder bed.

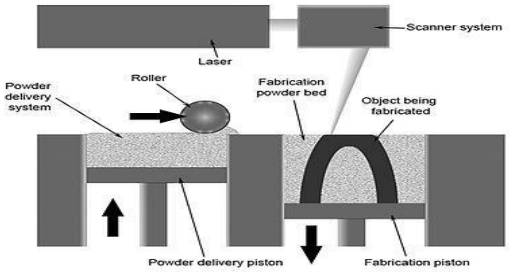

Fig 6 Selective Laser Sintering (SLS).

Laser Sintering does not require any support structures. The built parts are sustained by the loose plastic powder. The process chamber is preheated and under a protective gas environment. Composite, plastics, sand and metal powders are the commonly used materials for SLS process.

6. Laminated object manufacturing:-

An LOM apparatus [Fig 7] uses a continuous sheet of material such as plastic, paper or metal which is drawn across a build platform by a system of feed rollers. The build materials are coated with an adhesive. A heated roller is passed over the sheet of material on the build platform, melting its adhesive and pressing it onto the platform. A computer-controlled laser cuts the material into the desired pattern. The build platform is lowered once a layer is finished with printing. New material is then pulled across the platform and the heated roller again passes over the material, binding the new layer to the one beneath it. This process is repeated until the entire object has been formed. Once an object is done "printing," it is removed from the build platform, and any excess material is cut away.

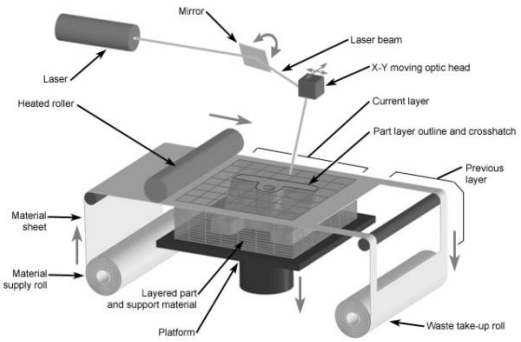

Fig 7 Laminated Object Manufacturing [LOM].

V. ADVANTAGES

3 D printing involves use of materials as powder and building them layer by layer to form a 3 D object, this process have many advantages over traditional processes which involves CNC manufacturing, use of lathes and shaping machines to build objects

The advantages of 3 D printing over conventional methods are:-

1. Rapid Prototyping: Products can more quickly go from just a design to an actual prototype.

2. Manufacturing Speed: The manufacturing speed for products is very fast.

3. Complexity and design freedom: Complex shapes can be easily printed and any kind of design can be realised practically with the use of 3 D printing technology.

4. Storage: Traditional methods requires large storage spaces for parts produced but with 3 D printing method, the products are much more compact and requires less storage space.

5. Improved flexibility and strengths: parts produced possess higher strengths and good mechanical properties than the parts manufactured by traditional methods.

6. Reduced cost of rebuilding of objects with erroneous designs:-

The designs of objects to be printed are given by a STL file and any changes in the design can be rectified at the initial stages.

There is no material removal process involved in 3 D printing and thus there is no wastage of material as such in traditional methods.

There is no kind of material distortion or stresses in the products which occurs in case of conventional methods due to finishing and machining of the part.

VI. DISADVANTAGES

1. The cost of the equipments is very high.
2. Only limited materials can be 3D printed.
3. The concept cannot be extended for printing of large volume objects.
4. The material should be available in powdered form to 3 D print the object.
5. It requires the need for design knowledge to design the STL file before the object is 3D printed.
6. Efficient heat control of lasers is required or else the products are distorted due to over-heating.

VII. COMMERCIAL ANALYSIS

3 D printing method is a boon in areas which requires weight reduction of materials with same strength, as a result it finds application in manufacture of various components in aerospace, medical and automobile industry. The commonly used materials for 3 D printing are mainly synthetic resins and thus the material cost is low. It allows to exact replica or prototype of objects so that they serve the same purpose with same properties. The major advantage of 3 D printing is it's adaptability to print various objects with different materials and least material wastage. Time required for building up of materials is also less and as the whole process is guided with the help of as AMF file which serves as input to the printer, there is least chance of any errors and material clogging in the printed object. One of the disadvantages of 3 D printing is its high equipment cost, the whole setup makes use of sophisticated equipments, the range of materials which can be used for printing materials is also limited. Apart from resins, plastics, wax, silicones are some of the other materials which can be 3 D printed. The use of AMF file requires skilled operators to create the data file.

VIII INDUSTRIAL APPLICATIONS

1. Aerospace industries use 3 D printing build jigs, fixtures, check gauges & end-use parts as the parts printed have good temperature, chemical, UV, and environmental resistance and they don't absorb moisture.

2. Architectural models can be printed to help better visibility of the concept design and reduce time spent building models by other methods.
3. In automobile sector we can conduct tests more thoroughly on the model prototypes and move confidently into production without the use of costly CNC methods.
4. Commercial products manufacturers have the flexibility to make great products in small, medium or large volumes and test the design problems.
5. Dental labs can accurately and rapidly produce crowns, bridges, stone models and a range of orthodontic appliances with reduction in fabrication times and increase output per technician.
6. 3D printing gives government, military and defence manufacturers the freedom to design quickly low-volume tooling, or build complex, precise prototypes which within short time span.
7. Compact sizes of the electronic components are now possible by 3D printing them.
8. Moulds used for casting processes can be easily 3 D printed with higher accuracy and precision.

IX POTENTIAL AREAS OF IMPROVEMENT

1. 3D printing can be used in consumer electronics industry for fabrication of smartphones, which comprise about 35% of total consumer electronics sales. Smartphone manufacturers

are slowly moving beyond prototyping applications for 3D printing with more growth projected in the near future after advancements in materials and equipment.
2. The average 3D printer production speed is expected to increase by 88% by 2023 with the use of effective print heads and as printer speed increases, volume capabilities would also increase.
3. New combinations of 3D printing materials as well as improvements to existing materials, will not only enable unlimited 3D printing applications, but also will help reduce prices.
4. The Zortrax M200 to print elements of a vein winch for facilitating of removing varicose veins in legs.
5. 3D printing is also assistance for doctors and scientists in their research of the artificial heart.
6. Printing of a 3D object in space was conducted in the International Space Station. This is one of the most amazing applications of 3D printing technology and it has huge potential. In the future it will relieve space stations of having to wait until new elements are delivered. Some of them will be printed on site. 3D printing will thus facilitate space flight.
7. Food can be 3 D printed on demand.
8. 3D printing can be used as a source of understanding of mechanics schools and colleges.
9. Metal parts can be made stronger by striking them repeatedly using ultrasonic tool as each layer gets printed. This relieves the stresses from the part, thereby paving the way to print large objects such as aircraft wings.
10. Use of 3D printing is also expected to be useful in developing testing prototypes in the manufacture of IC engines to check clearances, angles and tolerances without investing in CNC machining.

X. CONCLUSION

Thus the paper covers the basics of 3D printing to its various aspects including it's types, advantages, disadvantages, commercial and technical viability, applications and it's futuristic scope in industries.
3D printing is definitely the future of product manufacturing, the robustness and many factors which have been discussed in the paper suggest that the share of 3D printing in the global market will increase in next 30-40 years.

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