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3D Printing: The Dawn of a New Era in Manufacturing

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Abstract--Printing is a process for reproducing text and images, typically with ink on paper using a print press.3D printing is method of converting a virtual 3D model into a physical object from a digital file. It is achieved using Additive Process, where an object is created by laying down successive layers of material until the entire object is created.3D printing could revolutionize and reshape the world. Advances in 3D printing technology can significantly change and improve the manufacturing world with effects on energy use, waste reduction, customization, product availability, medicine, art, construction and science. By using this technology it becomes easier to transmit designs for new objects around the world.

Keywords--*Stereo lithography, Fused Deposition Modelling, Selective laser sintering, Laminated Object Manufacturing.*

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I. INTRODUCTION

Since the 1980's, the large-scale inkjet printer was widely used in a variety of flat printing tasks with full colour, and established its unshakable status in the printing industry. With the improvement of the printing technology and the development of the computer 3D simulation, more and more 3D printing requirement become burst. However, the existing ink-jet printing equipment could only print on the plane material, the printing technology for the three-dimensional model is currently only at the exploratory stage, which is far behind 3D technology in computer. Furthermore, there are few reports for the theoretical issues in research three-dimensional printing. Flat printer can print on different flat materials, such as PVC, marble, glass. Also Gazeau Jean-Pierre and his partner invent a 5-axis robot for printing high resolution pictures from media on vertical wide surfaces. In 3d printing, the mechanical design and printing control will face many complex challenges because the printed must be very close to the material. At present, there are very few devices commercially available, capable to printing on 3D surfaces of objects.

II. DEFINITION

Printing is a process for reproducing text and images, typically with ink on paper using a print press.
3D Printing is a phrase used to describe the process of creating three objects from digital file using a materials printer, in a manner similar to printing images on paper.

III. HISTORY

In 1984 Charles(Chuck) developed the first 3D printer and named the technique as Stereo Lithography. Later in 1993 MIT used 2D ink jet printing technology to 3D printers named it as 3 Dimensional Printing techniques. Z Corporation obtained license from MIT in 1995 and started to develop 3D Printers for general market. In 2005 Z Corporation launched first high definition colour 3D printer. It follows the achievement of RERAP the first open source 3D printer introduced by Cornell University in 2006. The first 3D printer that could produce functional prototype parts was introduced, which made a great achievement Urbee, the first car ever with three wheels and two seats to have its entire body printed out on a giant 3D printer. Recently in August 2014, Organovo the pioneer in biological 3D printing company demonstrated that its 3D human liver system can detect the toxicity of a drug.

IV. METHODS OF 3D PRINTING

a) Stereo lithography:

Stereo lithography allows you to create a solid , plastic, three dimensional objects from CAD drawings in a matter of hours. It is an Additive manufacturing process which uses a vat of liquid UV curable photopolymer resin and a UV laser to build parts a layer at a time. On each layer, the laser beam traces a part cross-section pattern on the surface of the liquid resin. Most SLA machines can produce parts with a maximum size of 20" x 20" x 24". Prototypes made by SLA can be very beneficial as they are strong enough to be machined and can be used as master patterns for injection moulding, thermoforming, blow moulding, and also in various metal casting processes. Although there are no limitations when it comes to the shape of the parts that it can be created, the process is expensive. An SLA machine can cost up to $100,100 to $400,000.

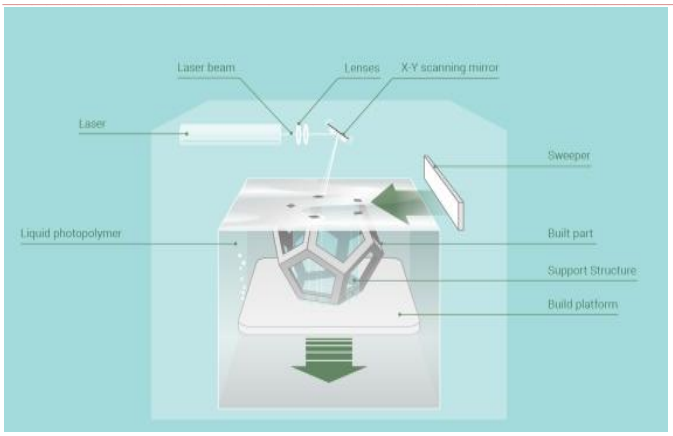

Figure 1: Stereo lithography

b) Fused deposition modelling (FDM):

Fused deposition modelling (FDM) is a solid-based rapid prototyping method that extrudes material, layer-by-layer, to build a model. In this method, a thread of plastic is fed into an extrusion head , where it is heated into a semi-liquid state and extruded through a very small hole onto the previous layer of the material. Support material is also laid down in a similar manner. It builds parts with a size of 10" x 10" x 10", by using materials like ABS, Casting Wax. Advantages of this method are High Strength, Water Proof, Cost effective, Multiple material colours.

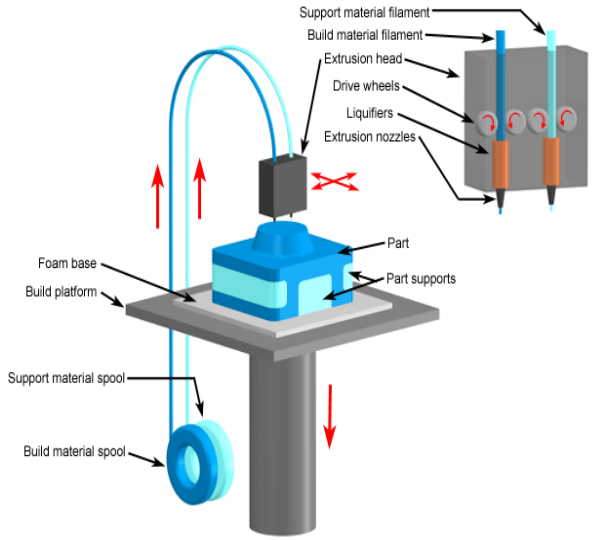

Figure 2 : Fused deposition modelling

c) Selective laser sintering (SLS):

Selective laser sintering is an additive rapid prototyping technique that uses a high power laser to fuse small particles of thermoplastic, metal, polyamide(nylon), ceramic, or glass filled nylon. SLS offers the key advantage of making functional parts in essentially final materials, depending on use of the part. Size of SLS single made parts are generally 13.3" x 13.3" x 12". The thickness of an individual SLS layer is 0.15 to 0.2 mm layer thickness, depending upon the material used. The process of SLS is quite simple. The entire internal system is heated to below the melting point of whatever substance is being used. So that when heat is applied by the high energy CO_2 laser melts and sinters the substance.To do this two piston-like platforms, a roller, an optical sensor, and whatever material is being used to form a part are used in co-ordination with the laser. The first piston contains most of the substance. When this piston is raised it makes the substance available to the roller. The roller moves the material over the second position to cover the part being constructed. The material which has been moved to the second piston will then be sintered by the laser, to form an additional layer on the part.

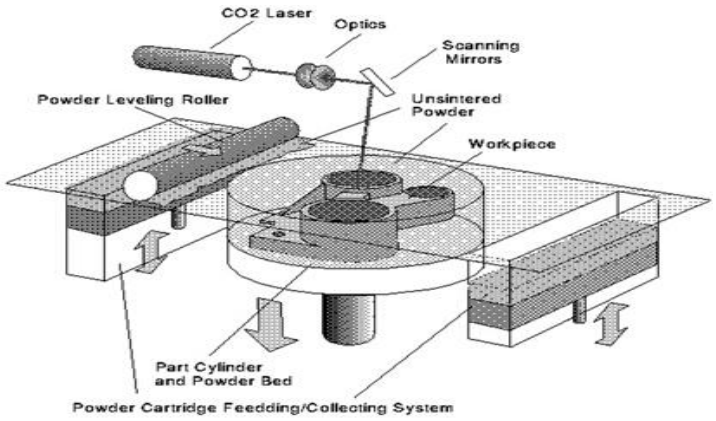

Figure 3 : Selective laser sintering

d) **Laminated object manufacturing (LOM):**

As the name implies the process laminates thin sheets of film. The laser has only to cut the periphery of each layer. In this process the build material is stretched from a supply roller across a platform to a take-up roller on the other side. A heated roller passes over the paper bonding it to the platform. A laser, focused to penetrate through one thickness of paper cuts the profile of that layer. The excess around and inside the model is etched into small squares to facilitate its removal. The objects created using LOM technique are durable, multilayered structures which can be machined, sanded, polished, coated and painted. It is used as visual models and for limiting testing

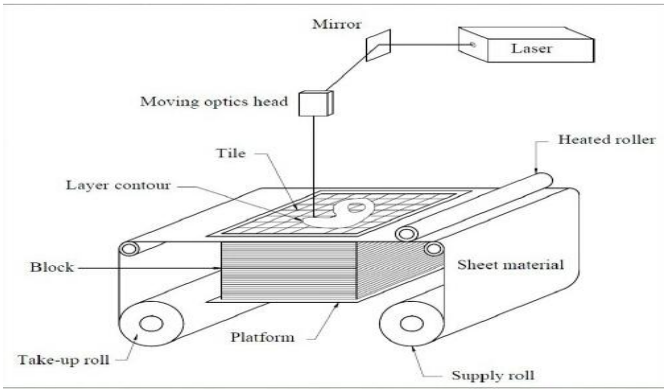

Figure 4 : Laminated object manufacturing

V. 3D PRINTING WORKING

The working of 3D printing involves three stages. They are:

a) Preparation :
Once you click "3D print" from Z-print, the printer initiates the pre build routine. First it warms the air inside the printer and creates optimum operating environment. At the same time, it fills the Build Chamber with 1/8th inch layer powder.

b) Printing :
Once the pre build is complete, the printer begins printing the layers created in the Z-print software. The machine deposits 0.1mm thick layer of powder from the Hopper. The Print Carriage then moves across this layer depositing the binder.

The binder solidifies the powder in that cross section of the model. The piston below the Build Carriage lowers the powdered bed by 0.1mm, preparing the next layer. The process repeats until the model is complete.

c) Recycling :
When finished the model, it is suspended in the powder to cure. At the end of curing time, the machine then automatically removes most of the powder around the model by vacuum pressure. The loose powder is pneumatically conveyed through the system for reuse.

VI. ADVANTAGES

1. Rapid Prototyping :
Since 3D printing can manufacture anything at instant, it facilitates rapid prototyping, which means, it takes really very low time for designs to get converted into respective prototype.

2. Creation of Employment Opportunities :

The increase in the use of this technology would create the requirement for highly-skilled designers who are proficient at using 3D printers, and technicians who are skilled at trouble shooting.

3. Manufacture of Customized Products :
With 3D printing technology now anyone can manufacture any product they want. This has paved the way for customized products as it allows you to create your own designs and get them printed.

4. Boon for Organ Donation :
One of the biggest breakthrough of this technology would be in the field of Medicine and Organ replacement to be specific, where thousands of people die every year for the want of donor organs. This technology of creating human organs using 3D printing is called as Bio printing and very sooner we shall be able to create complex human organs, such as the heart and the brain, using tissue from the organ recipient.

VII. APPLICATIONS

As anticipated, this modern technology has smoothed the path for numerous new possibilities in various fields. The list below details the applications of 3D printing in certain fields.

1. Product formation is currently the main use of 3D printing technology. These machines allow designers and engineers to test out ideas for dimensional products cheaply before committing to expensive tooling and manufacturing processes.
2. 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 is underway as scientists are working on creating replacement organs.
3. Architects need to create mock ups of their designs. 3D printing allows them to come up with these mock ups in a short period of time and with a higher degree of accuracy.
4. 3D printing allows artists to create objects that would be incredibly difficult, costly, or time intensive using traditional processes.
5. This new technological concept is exciting to nearly everyone including artists. 3D printing allows artists to create objects that would be incredibly difficult, costly, or time intensive using traditional processes.

VIII. DEFECTS

1. Counterfeiting :
This technology makes a manufacturer out of anyone who owns a 3D printer and gets hold the blue print. Thus, it would be very difficult to trace the source of fake items and copy right holders would face many problems.

2. Manufacture of Dangerous Items :
With everything being created in one click, this technology can be used to create guns and other dangerous weapons in field of Atomic and Nuclear science. Also the technology can be used by small children to print out stuff that might prove hazardous.

3. Size Limitations :

At present 3D printers have limitations regarding the size of the objects created. In the near future, we shall have printers that can even print the famous architectural structures.

4. Production of Unnecessary Stuff :

People would even print stuff on a surf, and this would result in a huge number of unnecessary stuff being produced. We already facing lot of difficulties in recycling stuff and this might be a serious problem.

IX. SUCCESS STORIES

i) Space Exploration:

Recently, NASA tested 3D-printed rocket engine injectors in hot fire tests, exposing them to extreme temperatures and pressures. They passed with flying colours.

ii) Medical Field:

A bionic ear was printed from a concoction of calf cells and hydro gel and antennae made from nano particles**.** Last year an 83 year old Belgian woman received the first 3D printed jaw bone, a transplant that was tailored specifically for her facial structure.

iii) High Fashion:

MIT researchers have used 6,500 silkworms to 3D print the ethereal silk dome-shaped pavilion covering in the cheapest way.

iv) Defence:

Defence distributed founder Cody Wilson created and shot the first 3D printed hand gun in may 2013.

X. CONCLUSION

3D Printing technology could revolutionize and re-shape the world. Advances in 3D printing technology can significantly change and improve the way we manufacture products and produce goods worldwide. It has a lot of possible benefits to the society and there will be a significant decrease in the product development cycle and costs. The digital 3D printing revolution could bring mass manufacturing back a full circle to an era of mass personalization, and a return to individual craftsmanship.

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