3D – PRINTING

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Abstract

By gradually adding materials, digital fabrication technology—also known as 3D printing or additive manufacturing—creates tangible items from a geometric representation. A rapidly developing technology is 3D printing. The usage of 3D printing is very common these days. In the fields of agriculture, healthcare, the automobile, locomotive, and aviation industries, 3D printing technology is being employed for mass modification and manufacture of all kinds of open-source designs. Layer by layer, material may be deposited to create an item using 3D printing technology and a computer-aided design (CAD) model. The overview of the various 3D printing methods, applications of the technology, and materials utilized in the manufacturing business are all covered in this article.

Keywords: Additive manufacturing, 3D Printing, manufacturing industry

Introduction

Over the past several years, three-dimensional (3D) printing technologies have garnered a lot of media interest. It's possible that some of the attention is the consequence of media hype. However, there are parts of 3D printing - or, more precisely, "additive manufacturing" - technologies that might have a disruptive influence on how things are manufactured, distributed, and consumed generally as well as across a wide range of other industries.

It is crucial to comprehend the history of this technology, how it changed through time, and what sort of innovation ecosystem it generated. Analysis of the interactions between this evolution and the societal and legal institutions whose mission it is to promote innovation is even more crucial for research on innovation policy. Ideally, these findings might contribute to the discussion on how to create innovation policies for technologies like 3D printing and other potentially game-changing innovations. This study examines how 3D printing technologies have evolved over the past few decades, how intellectual property rights have influenced this ground-breaking innovation, and how 3D printing technologies may one day pose a threat to the system of intellectual property rights.

In conclusion, 3D printing technology has become a versatile and effective tool in the advanced manufacturing sector in recent years. Many nations have used this technology widely,

particularly in the industrial sector. As a result, this article provides an overview of the various 3D printing methods, their applications, and finally the materials that are utilized in the manufacturing sector.

Literature review

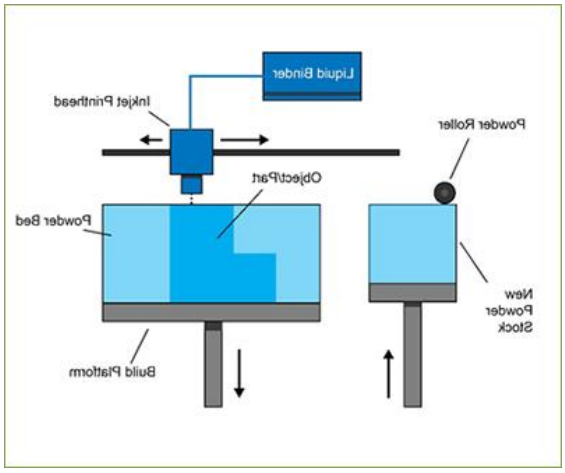
This evaluation covers a wide range of 3D printing applications in the industrial sector. Currently, 3D printing technology is starting to be used in the production sectors; it has numerous advantages for individuals, businesses, and the government. Therefore, research into strategies to accelerate the use of 3D printing technology must continue. The corporation and the government will be able to enhance and develop the infrastructure of 3D printing technology with the aid of additional information about the technology. In order to provide a general overview of the various 3D printing methods, the materials utilized in the manufacturing sector, and finally the applications of 3D printing technology. Future research may be done on the many 3D printing machine types and the ideal materials for each type of machine.

Theory

Types of 3D Printing

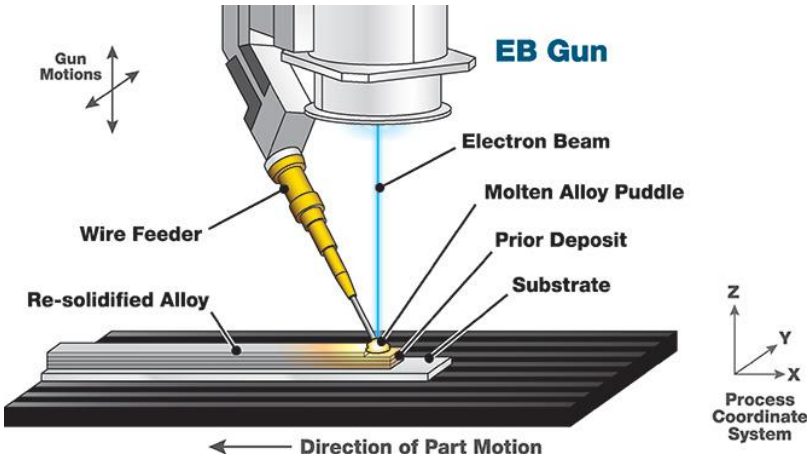
Varieties of 3D printing technologies have been developed with the different function. 3D printing technologies into seven groups, including the binding jetting, directed energy deposition, material extrusion, material jetting, powder bed fusion, sheet lamination and vat photopolymerization. There are no debates about which machine or technology function better because each of them has its targeted applications. Nowadays, 3D printing technologies are no longer limited to prototyping usage but are increasingly also being used for making variety of products.

- **Binder jetting**



Binder jetting is a rapid prototyping and 3D printing process in which a liquid binding agent is selectively deposited to join powder particles. The binder jetting technology uses jet chemical binder onto the spread powder to form the layer. The application of the binder jetting is would be producing the casting patterns, raw sintered products or similar large-volume products from sand. Binder jetting can print a variety of materials including metals, sands, polymers, hybrid and ceramics. Some materials like sand not required additional processing. Moreover, the process of binder jetting is simple, fast and cheap as powder particles are glued together. Lastly, binder jetting also has the ability to print very large products.

- **Directed energy deposition**



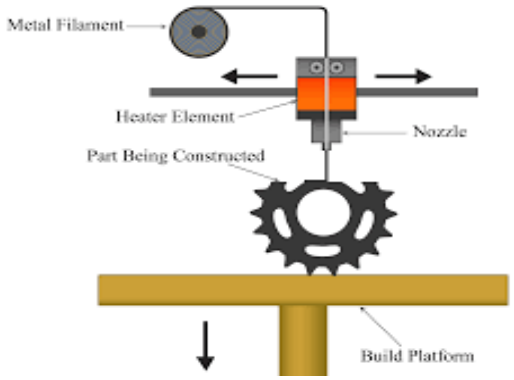
Directed energy deposition is a more complex printing process commonly used to repair or add additional material to existing components. Directed energy deposition has the high degree control of grain structure and can produce the good quality of the object. The process of directed energy deposition is similar in principle to material extrusion, but the nozzle not fixed to a specific axis and can move in multiple directions. Furthermore, the process can be used with ceramics, polymers but is typically used with metals and metal-based hybrids, in the form of either wire or powder. Laser deposition is the emerging technology and can be used to produce or repair parts measured in millimetre to meters. Laser deposition technology is gaining attraction in the tooling, transportation, aerospace, and oil and gas sectors because it can provide scalability and the diverse capabilities in the single system.

- **Bio based 3D printing**

Due to advances in 3D printing, we have developed a technology by which there is a great usage of printing in the bio chemical industry.3D printing has enabled tissue engineering by which organs and body parts are build using inket techniques.

Many parts like some specific organ cells, cell membranes, biocompatible materials are printed into complex 3D functional living tissue to address the need for tissue and organs suitable for transplant.

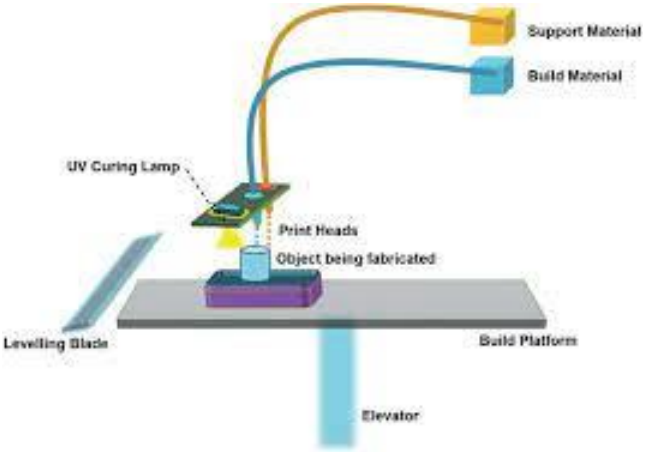
- **Materials extrusion**



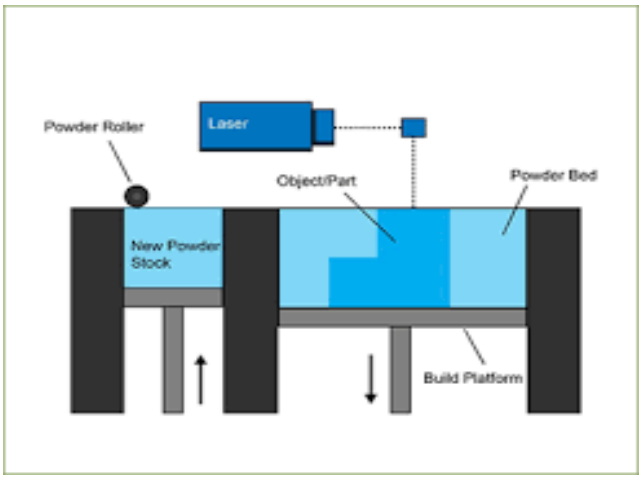
Material extrusion-based 3D printing technology can be used to print multi-materials and multi-colour printing of plastics, food or living cells. This process has been widely used and the costs are very low. Moreover, this process can build fully functional parts of product. Fused deposition modelling builds parts layer-by-layer from the bottom to the top by heating and extruding thermoplastic filament.

- **Materials jetting**

Material jetting is a 3D printing process in which drop by drop of build material are selectively deposited. In material jetting, a printhead dispenses droplets of a photosensitive material that solidifies, building a part layer-by-layer under ultraviolet (UV) light. At the same time, material jetting creates parts with a very smooth surface finish and high dimensional accuracy. Multi-material printing and a wide range of materials such as polymers, ceramics, composite, biologicals and hybrid are available in material jetting.



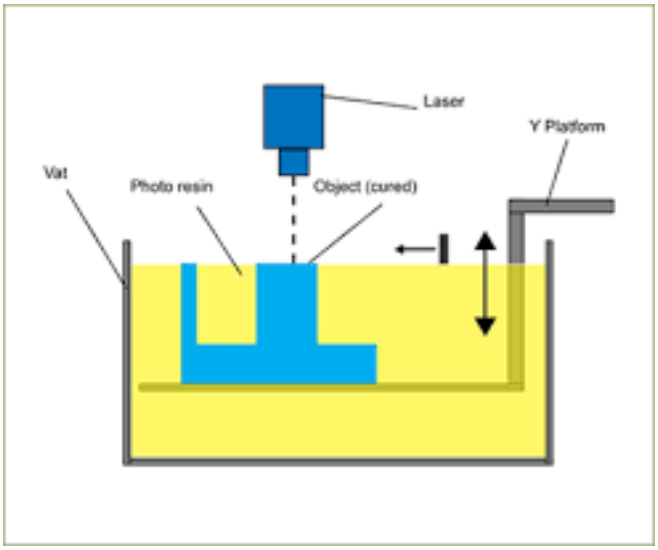
- **Powder bed fusion**



The powder bed fusion process includes the electron beam melting (EBM), selective laser sintering (SLS) and selective heat sintering (SHS) printing technique. This method uses either an electron beam or laser to melt or fuse the material powder together. The example of the materials used in this process are metals, ceramics, polymers, composite and hybrid. Selective laser sintering is 3D printing technology that's functionally in fast speed, has high accuracy, and varies

surface finish. SLS used a high-power laser to sinter polymer powders to generate a 3D product.

- **Vat Photopolymerization**



The main 3D printing technique that frequently used is photopolymerization, which in general refers to the curing of photo-reactive polymers by using a laser, light or ultraviolet (UV). The example of 3D printing technologies by using photopolymerization is stereolithography (SLA) and digital light processing (DLP). In the SLA, it was influenced by the photo initiator and the irradiate exposure particular conditions as well as any dyes, pigments, or other added UV absorbers. Meanwhile, digital light processing is a similar process to Stereolithography that works with photopolymers. Light source is the major difference. Digital Light Process uses a more conventional light source, such as an arc lamp with a liquid crystal display panel. It can apply to the whole surface of the vat of photopolymer resin in a single pass, generally making it faster than Stereolithography. The important parameters of Vat Photopolymerization are the time of exposure, wavelength, and the amount of power supply. The materials used initially are liquid and it will harden when the liquid exposed to ultraviolet light. Photopolymerization is suitable for making a premium product with the good details and a high quality of surface.

Materials Used for 3D Printing Technology in Manufacturing Industry

Like any manufacturing process, 3D printing needs high quality materials that meet consistent specifications to build consistent high-quality devices. To ensure this, procedures, requirements, and agreements of material controls are established between the suppliers, purchasers, and end-users of the material. 3D printing technology is capable to produce fully functional parts in a wide range of materials including ceramic, metallic, polymers and their combinations in form of hybrid, composites or functionally graded materials.

- **Metals**

Metal 3D printing technology gain many attentions in aerospace, automobile, medical application and manufacturing industry because the advantages existing by this process. The

materials of metal have the excellent physical properties and this material can be used to complex manufacturer from printing human organs to aerospace parts. The examples of this materials are aluminium alloys, cobalt-based alloys, nickel-based alloys, stainless steels, and titanium alloys. Cobalt-based alloy is suitable to use in the 3D printed dental application. This is because, it has high specific stiffness, resilience, high recovery capacity, elongation and heat-treated conditions. Furthermore, 3D printing technology has capability to produce aerospace parts by using nickel base alloys. 3D-printed object produces using nickel base alloys can be used in dangerous environments. This is because, it has high corrosion resistance and the heat temperature can resistant up to 1200 ℃. Lastly, 3D printing technology also can print out the object by using titanium alloys. Titanium alloy with have very exclusive properties, such as ductility, good corrosion, oxidation resistance and low density. It is used in high stresses and high operating temperatures and high stresses, for example in aerospace component and biomedical industry.

- **Polymers**

3D printing technologies are widely used for the production of polymer components from prototypes to functional structures with difficult geometries. By using fused deposition modelling, it can form a 3D printed through the deposition of successive layers of extruded thermoplastic filament, such as polylactic acid, acrylonitrile butadiene styrene, polypropylene.3D printing polymer materials in liquid state or with low melting point are widely used in 3D printing industry due to their low cost, low weight and processing flexibility. Mostly, the materials of polymers played important role in biomaterials and medical device products often as inert materials, by contributing to the efficient functioning of the devices as well as providing mechanical support in many orthopaedic implants.

- **Ceramics**

3D printing technology can produce 3D printed object by using ceramics and concrete without large pores or any cracks through optimization of the parameters and setup the good mechanical properties. Ceramic is strong, durable and fire resistant. Due to its fluid state before setting, ceramics can be applied in practically any geometry and shape and very suitable on the creation of future construction and building. Alumina powder for instance has the potential to be processes by 3D Printing technology. Alumina is an excellent ceramic oxide with a very wide range of applications, including catalyst, adsorbents, microelectronics, chemicals, aerospace industry and another high-technology industry.

- **Composites**

Composite materials with the exceptional versatility, low weight, and tailorable properties have been revolutionizing high-performance industries. The examples of composite materials are carbon fibres reinforced polymer composites and glass fibres reinforced polymer composite. Carbon fibre reinforced polymers composite structures are widely used in aerospace industry because of their high specific stiffness, strength, good corrosion resistance

and good fatigue performance. At the same time, glass fibres reinforced polymer composites are widely used for various applications in 3D printing application and has great potential applications due to the cost effectiveness and high-performance. Fiberglass has a high thermal conductivity and relatively low coefficient of thermal expansion. Furthermore, fiberglass cannot burn, and it not affected by curing temperatures used in manufacturing processes, therefore, it is very suitable for use in the 3D printing applicant.

The Applications of 3D Printing in Manufacturing Technology

- **Aerospace industry**

3D printing technology provides unparallel freedom design in component and production. In aerospace industry, 3D printing technology has potential to make lightweight parts, improved and complex geometries, which can reduce energy requirement and resources. At the same time, by using 3D printing technology, it can lead to fuel savings because it can reduce the material used to produce aerospace's parts. Furthermore, 3D printing technology has been widely applied to produce the spare parts of some aerospace components such as engines. The engine's part is easily damaged, which require regular replacement. Therefore, 3D printing technology is a good solution to the procurement of such spare parts. In aerospace industry, nickel-based alloys are more preferred due to the tensile properties, oxidation/corrosion resistance and damage tolerance.

- **Automotive industry**

3D printing technology have rapidly changed our industry to design, develop and manufacture new things. In the automotive industry, 3D Printing technique have made phenomena to bring new shines, allowing for lighter and more complex structures in the fast time. Ford is the leader in the use of 3D printing technology also apply 3D printing technology to produce prototype and engine parts. In addition, BMW uses 3D printing technology to produce hand-tools for automotive testing and assembly.

By using 3D printing technology in automotive industry enable company to try various alternatives and emphasize right in the improvement stages, prompting ideal and effective automotive design. At the same time, 3D printing technology can reduce the wastage and consumption of the materials. Moreover, 3D printing technology can reduce costs and time, therefore, it allows to test new designs in a very fast time.

- **Food industry**

3D printing technology open the doors not only for aerospace industry, but also for food industry. At present, there is a growing demand for the development of customized food for specialized dietary needs, such as athletes, children, pregnant woman, patient and so on which requires a different amount of nutrients by reducing the amount of unnecessary ingredients and enhancing the presence of healthy ingredients. However, the development of customized foods must be conducted in a very detailed and inventive way, which is where the adoption of 3D-food printing appears. Food layer manufacture also known as 3D-food printing fabricated through the deposition of successive layers by layer derived directly from

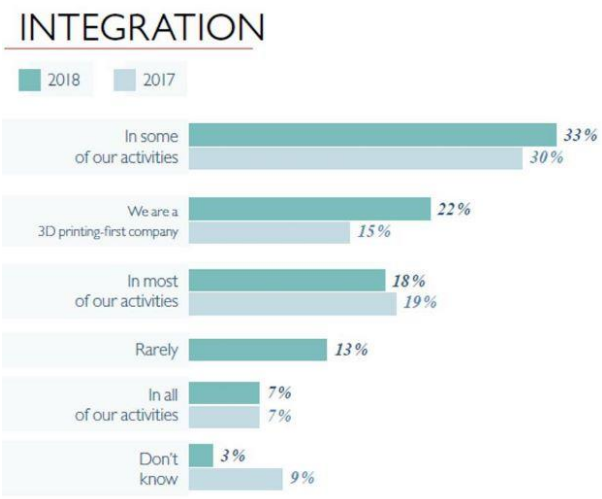
computer-aided design data. By using 3D printing technology, specific materials can be mixed and processes into various complicated structures and shape. Sugar, chocolate, pureed food and flat food such as pasta, pizza and crackers can be used to create new food items with complex and interesting designs and shape.

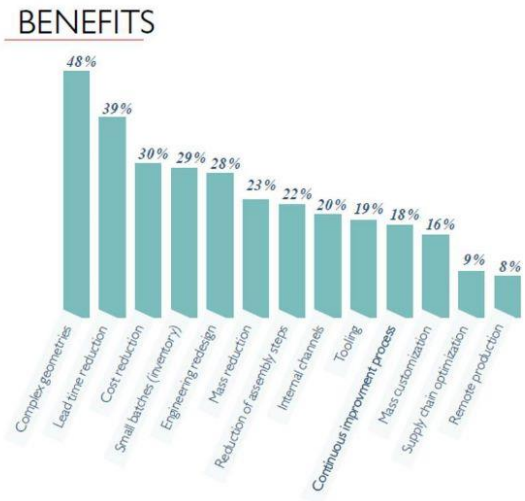
- **Healthcare and medical industry**

3D printing technology can used to print 3D skin, drug and pharmaceutical research, bone and cartilage, replacement tissues, organ, printing for cancer research and lastly models for visualization, education, and communication. There are several advantages of 3D Printing technology for biomedical products.

- **Architecture, building, and construction industry**

3D printing technology can be considered as environmentally friendly derivative and it give unlimited possibilities for geometric complexity realization. In the construction industry, 3D printing technology can be used to print entire building or can create construction components. The emergence of the Building Information Modelling (BIM) will facilitate better use of 3D printing technology.





Conclusion

3D printing technologies have their roots in manufacturing inventions in the 1980s. While it was initially used to accelerate prototyping processes, 3D printing is increasingly being used to print product components or even finished products. While the technological development is still in flux, some stable patterns have emerged. Over the years, the technology has evolved into two distinct directions. In the industrial 3D printing sector, patent protection seems to have played an important role, which is not that different from other manufacturing

industries. In the newly emerging personal 3D printing sector, the intellectual property system faces new challenges. Developers of personal 3D printing systems and services have to cope with large-scale infringement by end consumers. This situation well-known from digital content technologies. At the same time, the expiration of key patents on 3D printing has arguably contributed to a flourishing ecosystem of open-source 3D printer hardware and software. Once the open-source 3D printing community has begun to flourish, it does not rely on intellectual property protection as an appropriation mechanism. Also, knowledge and technology diffusion take place through various channels in the 3D printing industry. Diffusion through the intellectual property system may play a certain role. Diffusion via scientific publications and modern communication technologies are also significant. Studying the progress of 3D printing technologies thereby also informs us about the intricate relationship between intellectual property and innovation in general.

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Biography

Jainam Modi, pursuing B.Tech mechanical engineering from pandit Deendayal energy university. I am a creator, inventor, moral and optimistic person. I have interest in designing, travelling, and reading books.

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