3D PRINTING INNOVATIONS: CURRENT AND THE FUTURE

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ABSTRACT

Manufacturing technology that uses three-dimensional materials to create three-dimensional objects such as eyeglasses as well as other 3D artifacts. The difference between this and a traditional ink-based printer is that this one makes a three-dimensional item. 3D printing is used almost exclusively in the design and prototyping of engineering products. The use of new printing materials, however, has now enabled 3D printers to manufacture objects that are on par with products manufactured with traditional methods.

A traditional printer cannot enable mass customization on a large scale, but 3D printing has that ability. 3D printing also has important implications in other fields, including ophthalmology. A lot of medical applications, including the production of eyeglasses, custom- made prosthetic gadgets, and dental implants, have demonstrated the feasibility of 3D printing. The paper aims to give more insight about impact of 3D printing, see this review in which we discuss how 3D printing could revolutionize manufacturing.

Keywords: 3D printing, 3D artifacts manufacturing technology, new printing materials, mass customization

INTRODUCTION

3D printing, also termed additive manufacturing, is a process of producing three-dimensional solid items from a digital file. Additive methods are used to create 3D-printed objects. In an additive process, an object is produced by layering material until the desired shape is achieved. (KENTON, 2020) describes three-dimensional printing is a manufacturing process that takes a computer design and turns it into a physical thing. The procedure begins with gradual continuous addition of light layers of material in the form of liquid or powdered, plastic, metal, or cement, followed by the fusion of the layers.

In a nutshell, it is a new manner of making things that are considerably different from how things have been ‘traditionally' created. It is typically very quick, has low fixed setup costs, and can produce far more complicated geometries than was previously conceivable, with an ever-expanding variety of materials. It has been widely employed in engineering, notably for prototyping and producing lightweight geometries, as well as in medical, education, architecture, and entertainment.

Additive manufacturing is nearly always connected with commercial and industrial applications. Rapid prototyping is another term for 3D printing technologies that are occasionally used interchangeably. When they were first invented in the 1980s, they were referred to as rapid prototyping technologies rather than 3D printing or additive manufacturing, and the relationship stayed because 3D printing was usually only suited for prototypes rather than production parts at the time. In recent years, additive manufacturing has grown into an excellent option for many different types of production parts, while alternative manufacturing technologies have become more affordable and accessible for prototyping.

While some individuals still use the term "rapid prototyping" to refer to 3D printing, the term is changing to encompass all forms of the very fast prototypes as described by (HUBS, 2021) The acceptance of 3D printing has reached a tipping point, and those who have yet to integrate additive manufacturing into their supply chains are becoming scarce. Previously reserved for prototype and one-off manufacturing, 3D printing is increasingly changing into a production process. The majority of 3D printing demand currently is industrial in nature.

As far as 3D printing technology keeps developing, there is a potential to touch virtually every major industry and fundamentally transform our lives, work, as well as influence the future. There is no denying that 3D printing is the wave of the future. 3D printers have a significant impact on our lives, from making little products like clips to full airplane wings. 3D printing is set to change the medical and healthcare fields as well, with prosthetics, dental implants, and accessories, among other things.

3D printers will become easier to use as technology advances, allowing for nearly unlimited customization, design clarity, and faster prototyping, as well as less waste.

HISTORY AND EVOLUTION OF 3D PRINTING

(3D Printing for the Bioscience Classroom, 2019) mentions that the first 3D printing technology became prominent around the later part of 1980s under the name Rapid Prototyping. The reason being methods were originally manufactured as a more rapid and cost- effective technique of prototyping products for industrial development. As an intriguing aside, Dr. Kodama documented the beginning patent request for RP technology in May 1980 in Japan. Unfortunately for Dr. Kodama, the whole patent specification was not filed within the one year following the application, which is particularly unfortunate given that he was a patent lawyer! However, 3D printing dates to 1986, when the initial patent for stereo lithography apparatus was issued (SLA). This patent was originally issued to Charles (Chuck) Hull, who designed the SLA machine in 1983. Hull later co-founded 3D Systems Corporation, one of the largest and most prolific 3D printing companies in the world today.

The SLA-1 system was launched in 1987 and the first of these systems was sold after extensive testing in 1988. The patent was given out in 1989 and SLS was then licensed to 3D System by DTM Inc. EOS R&D focused primarily on lasing sintering (LS), which continued to range from strength to strength, after an interaction with SL processing. The excellence of EOS systems for industrial prototyping and manufacturing applications of 3D printing are today worldwide recognizable. The first stereos system was sold by EOS in 1990.

The DMLS method was the product of an early project with Electrolux Finland, which was subsequently bought by EOS. The project consisted of the company's direct metal laser sintering. Other 3D printing technologies and methods, such as Ballistic Particle Manufacturing (BPM), first invented by William Masters, were also developing during these years. At the beginning of the '90s there was an increasing number of competing businesses on the RP market but three of them were 3D Systems, EOS, and Stratasys which also remain today.

In 2007, 3D Systems saw the first system under 10,000 dollars, although it never really hit the mark. Partly because of the system itself, but also because of other market influences. The holy grail of the time was to get a 3D print that cost under $5000 which was crucial to opening 3D printing technologies for a much wider audience by many industrial insiders, users, and analysts. For many of the year, the highly anticipated Desktop Factory was proclaimed to be the one to watch, a process which many expected would achieve that Holy Grail. The group was no longer able to do anything as the production ran aground. Together with the IP, 3D Systems purchased

Desktop Factory together with its leader Cathy Lewis in 2008, and all were sunken. However, 2007, even when it came to few people realizing it at the time, was, in fact, the year that marks the start of revolution for affordable 3D printers as the phenomenon of RepRap took root.

Dr. Bowyer originated the concept of RepRap is an open-source 3D printer in 2004. In subsequent years, heavy slogs were developed in his team at Bath, especially Vik Oliver and Rhys Jones, who refined the concept using the deposition process through the prototyping of a 3D printer. The year 2007 was when the shots were shown, and this 3D printing movement of the embryonic open source began to get exposure. However, the first commercially accessible 3D printer was not sold until January 2009, in kit-like manner and based on the RepRap concept. It is the 3D printer from BfB RapMan.

The founder, who was strongly into in the development and improvement of RepRap up until they left Open-Source ideology following a major investment, was followed by Makerbot companies in April this same year. Since 2009, many identical filing printers have been produced with, and continue to do, marginally distinct points of sales. Interestingly, though the RepRap phenomena has brought a whole new industry of commercial, entry-level 3D printers, the mentality of the community of RepRap is all about Open-Source 3D press advancements and marketing. 2012 was the year when the market entry level was introduced for alternative 3D printing processes. The first time in June was the B9Creator, followed in December by Form1. Both were established on the Kickstarter funding site and both were very successful. Due to the differences in the market, considerable industrial progress with capabilities and applications, and the dramatic increase in awareness and acceptance across a growing movement of manufacturers, 2012 saw many major media outlets were taking advantage of the technology. 2013 has been an important year of growth and consolidation. Acquiring of Makerbot by Stratasys was by notable steps.

Announced by some as the second, third, and, occasionally even, the fourth industrial revolution, what cannot be denied is. The impact on the industrial sector of 3D printing and the great potential of 3D printing. Proof for the consumers' future. We still have ahead of us what form this potential takes.

TYPES OF 3D PRINTING

The phrase 3D printing is considered as a variety of manufacturing processes that create objects layer by layer. Each method of forming plastic and metal parts is unique, as are the material selection, surface polish, durability and manufacturing speed, and cost as stated by (Ahart, 2019) There are various types of 3D printing, including the following: Photographic stereo lithography (SLA)

- Laser Selective Sintering (SLS)
- Modeling of Fused Deposition (FDM)
- Process of Digital Light (DLP)
- Fusion of several jets (MJF)
- Direct Metal Laser Sintering using PolyJet (DMLS)
- Melting by Electron Beam (EBM)

Selecting the appropriate 3D printing technique for your application demands an understanding of each process's advantages and disadvantages and mapping those characteristics to your product development requirements.

TYPES OF 3D MATERIALS

The materials used for 3D printing are as varied as the finished goods. As such, 3D printing is sufficiently adaptable to allow manufacturers to control a product’s shape, texture, and strength. Best of all, these characteristics can be obtained with many fewer steps than are generally necessary for standard manufacturing processes. Additionally, these products are created using a variety of different types of 3D printing materials.

The 3D printing industry has grown steadily over the years, with innovations being launched regularly. Additionally, new 3D printing machines are being created to print a variety of materials, including plastics, metals, and composites.

There are numerous materials available for industrial 3D printing. Each of these materials has its characteristics, strengths, and shortcomings. Additionally, critical parameters such as material kind, texture, and pricing should be put into consideration to avoid 3d printing errors. It might be challenging to determine the best material for a particular job as stated by (Chen, 2020). Some examples of 3D printing material are.

- Plastic
- Powder
- Resins
- Metals
- Carbon
- Fibers
- Graphite and graphene
- Nitinol Paper

3D MODELLING SOFTWARE

According to (Enfroy, 2021), over the last decade, 3D printing software has improved at a breakneck pace. From construction and manufacturing to technology and healthcare, 3D printing is infant, nonetheless, has an ability to generate lifelike models from software, improve design efficiency, and speed up the manufacture of a vast range of complicated items. However, to produce and print these detailed designs, specialized 3D printing software is required.

3D printing software has flooded the market with new features, incredible new capabilities, and seamless connection with computer hardware in recent years. Some examples of 3D modelling software are.

- Autodesk Fusion 360.
- Autodesk AutoCAD
- Ultimaker
- Cura
- TinkerCAD
- MeshLab
- FreeCAD
- Creo
- Solidworks
- Catia

- OpenSCAD

3D PRINTING PROCESSES

(Design Tech, 2019) states that three-dimensional printing is a combination of software and hardware. Computer-aided design (CAD) files are used to start the 3D printing process. CAD 3D software allows you to quickly create a 3D drawing of an object.

Computer-aided manufacturing (CAM) improves the manufacturing process by combining computer software with machinery. 3D printers use laser or extruder to produce objects in three dimensions by laying down consecutive layers of material in varied forms along an X, Y, and Z-axis. At any given time, these layers can be as thin as a few microns. This is an advantage over the traditional approach, which uses a subtractive approach to cut or drill components from a mold. Layers of components in liquid, solid, or material form are fused using the additive process. To generate a prototype of a product, 3D printers use additive manufacturing or direct digital manufacturing technologies. 3D printers start with a digital blueprint created with CAD software like PTC Creo. After that, the object is created layer by layer. In comparison to traditional prototyping, a manufacturer may create a working prototype in just a few hours with this innovative technology. Companies like Stratasys have come up 3D printers that enable rich visualization with realistic 3D models. In the end, this saves both time and money. Particularly because the additive production process reduces waste.

ADVANTAGES OF 3D PRINTING

3D printing will enable individuals to improve aesthetics, durability, and/or functionality by altering the material composition within a product as printing speeds improve and the selection of raw materials expands. Several developing technologies, sensors, big data, robotics, improved materials, machine learning - are enabling unprecedented levels of precision, productivity, and innovation as the global manufacturing economy changes from mass production of consumer items like shoes or bicycles to complex products like MRI scanners or jet engines. 3D is a natural fit for this new paradigm, known as Industry 4.0 because it sits at the crossroads of materials science, robotics, cloud computing, sensing, and imaging, crowdsourcing, data analytics, and other fields. 3D printing, like its fabrication forerunners, has spawned new manufacturing techniques that promise to transform not only production but also our daily lives in some way. It is nothing less than a revolution. Most manufacturing industries stand to benefit from the earliest incorporation of 3D printing technology. However, automotive, and big manufacturing companies will reap the most tangible benefits, owing to the significant cost savings which relates to digitizing their inventory. Additionally, consumer manufacturing, defense equipment manufacturers, and healthcare companies, particularly those in dental healthcare and prosthetics, are most likely to be of benefit sooner. Due to 3D printing, factories can increase their adaptability, allowing them to meet the demands of an increasingly demanding and unpredictable market.

Additionally, it enables the manufacture of a wide variety of customized objects without the need for expensive molds and manufacturing tools. Similarly, 3D printing is an excellent ally of the environment, which is critical given our current climatic situation and thecritical nature of sustainable manufacturing processes that consume fewer resources and generate less waste. The well-known Gartner curve suggest that, 3D printing has reached maturity very quickly. This curve depicts a technology's maturity, adoption, and commercialization.

Medical implant 3D printing, point-of-sale 3D printing, and supply chain 3D printing are at the forefront. Additionally, we see 3D printing in classrooms and bioprinting for medical research. Industry 4.0 requires the use of 3D printers. 3D printers were introduced around the 1980s, marketable sought-after 3D printing has only been possible in the last decade, owing to earlier on efforts by companies. Globally, leading corporations and consultants are investing heavily in 3D printing knowledge and capabilities to advise and join their clients in the Industry 4.0 revolution, which is reshaping supply chains, product portfolios, and business models.

INDUSTRIES UTILIZING 3D PRINTING.

3D printing is transforming low-volume manufacturing and may eventually change the way we produce everything. While some industries are only considering the benefits of additive manufacturing, others cannot imagine a future without it. Top five industries that are utilizing additive manufacturing and how they can benefit your business. The Space Industry's 3D Printing is among the most expensive, which is why it is critical to incorporate new technologies such as 3D printing.

For instance, Space X was among the first companies to optimize its manufacturing process through additive manufacturing. NASA has also benefited from additive manufacturing by saving millions of dollars and successfully put to test a rocket engine made entirely of 3D printed parts. 3D Printing in the Aviation Industry 3D printing in metal and plastic is frequently used by aircraft makers to cut costs. Boeing, for example, intends to incorporate 3D printed structural titanium parts in their revolutionary 787 Dreamliner.

They might save up to $3 million per plane this way. Another advantage of working with 3D printed parts is that they are lighter, which is important when designing aircraft. 3D printing in the health sector the medical industry is critical and costly 3D printing has lowered the overall cost of existing treatment and rehabilitation methods. Here are two great examples of functional 3D printed prosthetics. Simulators are also used by surgeons prior to a procedure to predict any issues they may experience. 3D-print dentistry rapid prototyping can streamline some manual processes.

3D printing technology shortens treatment time, is more efficient, and less costly. This is a list of additive manufacturing's features: bridges, impression trays, crowns, surgical drill guides, night guards, and more. 3D printing mechanical engineering Manufacturing times have been cut thanks to 3D printing. Accuracy is improving each day. In mechanical engineering, additive manufacturing is used. 3D printing of metal can enable the creation of complex-shaped objects that are "impossible" to make or produce using traditional manufacturing techniques. Construction 3D printing 3D printing is gaining momentum in the construction industry.

Used to construct walls, houses, and bridges. This can be completed in days, not months! This Chinese company printed a five-story house in a few days using 3D printing. FUTURE OF 3D- PRINTING Custom-made products, such as dental and medical gadgets, and low-turnover replacement components, are at the heart of 3-D printings potential. These items are typically ordered in one-of-a-kind configurations and in small quantities. The capacity to supply low- demand components quickly and cost-effectively without risking an unsold finished goods inventory is a big advantage of 3-D printing.

Objects are made only when they are ordered and paid for, because of this reason, designers can take risks they would not have taken otherwise. A bad design in 3-D printing is considered a wasted design time rather than inventory investment as described by Berman (2012). Sherman, (2009) mentions that an advantage of 3-D printing is the ability to decouple product design from production capability.

Alternatively, a customer can quickly download a CAD design for a replacement part online in a same fashion that he or she would digitally download music–and then install it. The part can then be downloaded and printed on the user's 3-D printer. There are numerous concerns involving cost and accuracy, and inherent flaws in 3-D items must be resolved before they can be extensively accepted. For example, thermoplastics suited for 3-D printing can be repeated ten to one hundred times more than typical thermoplastics for injection molding in terms of price, materials, and so on.

In addition, when compared to traditional mass-production procedures, the material options, colors, and surface treatments appropriate for 3-D printing are enlarged. As raw material prices decline and material quality improves, 3-D technology's application will expand beyond its current limitations. Many CAD/CAM designs will soon be made available to end-users and retailers. Customized products can be produced, and replacement parts will be available on ordered basis. Individuals will gain the chance to study the CAD-CAM library for available designs by the general assumption and use of the Internet. CAD-CAM applications, better- quality materials, and lower cost of material result in a higher number of quality 3-D printers.

SERVICES FOR 3D PRINTING

Shapeways is among the most exciting startups in the 3D printing market, especially considering 46.77 percent of consumers are unwilling to pay more than $299 for the technology, and lots of consumer 3D printers now cost around $2000. Perhaps therefore Shapeways' education to consumers through campaigns like #madewithcode, partnerships with firms like Hasbro, and outreach sessions at coworking spaces like Wix is good.

They can use a 3D printing service until consumer 3D printers are at a price that more customers are ready to pay, and the software is easier to use. This is a far more cost-effective solution, and customers will not have to worry about post-processing or 3D printer calibration. Shapeways, like other 3D printing services, have the potential to support a range of 3D printing applications, including tinkering, personal manufacturing, on-demand manufacturing, and small batch production, because 3D printing services are more cost-effective. Shapeways should serve as a model for other 3D printing providers. Shapeways might potentially aid startups like MakerBot by serving as a case study. After the market has been educated and technology has improved, the consumer mass market may adopt the technology as stated by Matias & Rao (2015).

ROLE OF 3D PRINTERS IN INDUSTRY 4.0

(Amelia, 2021) describes 3D printing as a key emerging technology of Industry 4.0. The application and implementation of additive manufacturing, in conjunction with other technologies, is accelerating the industry's evolution toward intelligent production, in which machines (autonomous, automatic, and intelligent), systems, and networks can exchange information and responding to production management systems. Additionally, as a technology capable of directly converting a 3D design into a product, 3D printing plays a critical role.

Additionally, the use of costly tools and fixtures is eliminated, resulting in reduced post- processing, material waste, and human intervention. These are the characteristics that will define the future industry. Industry 4.0 brings to light what has been named 'smart manufacturing,' a process in which cyber-physical systems monitor and make devolved decisions about a factory's physical processes. Physical systems become the Internet of Things (IoT), communicating, and coordinating in real-time through the wireless web with one another and with humans. Digital transformation is at the heart of Industry 4.0, which comprises of the following critical components or frameworks: Big data, model simulation, cloud technology, augmented reality, 3D printers/additive manufacturing, Industrial Internet of Things (IIoT), artificial intelligence, autonomous robots, and cybersecurity as sighted by (DesignTech, 2019).

CONCLUSION

We are on the verge of another industrial revolution, this time dubbed Industry 4.0.

As 3D printers improve in terms of speed, reliability, safety, and quality, and as their cost decreases, they are poised to play a significant role in this industrial digital transformation. As 3D printer performance improves and costs decrease, new opportunities will emerge that will bring 3D printing closer to mass production. As 3D printing technology advances, the range of products that can be manufactured will expand as well. The rapid evolution of unique printing materials, the amalgamation of digital security to protect intellectual property, and regulatory evidence of 3D products will all contribute to the rapid acquisition of 3D printing in Industry 4.0. However, innovative manufacturers to be willing to embrace Industry 4.0's tenets and rapidly digitalize their businesses for their maximum benefit.

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