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Exploring the Significant Advancements and Potential Applications of Additive Manufacturing in Industry

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Abstract

The multidisciplinary exploration zone of Additive Manufacturing has recently risen strongly and rapidly, and it is projected to continue. The worldview of personalized things is now beginning to play out as envisaged, thanks to the introduction of new additive manufacturing technology. This is a watershed moment in a new era of precision products, which have become easier to produce and apply as a result. "Industry 4.0," which refers to a current trend in automated intelligent technology, is an example of this. Using Additive Manufacturing's present capabilities in the context of information technology integration is critical in this new era for sustaining industrial economic competitiveness and assuring long-term success. The Fourth Industrial Revolution must allow for improved interaction between humans and robots to achieve more effective and faster solutions. It not only ushers in a new era of customizing, but it also provides a solution to difficult situations. Additive manufacturing is critical in the transition to Industry 4.0 because of its flexibility, ability to save time and money, and ability to be conclusive in gauging efficacy. It also helps to reduce complexity by using quick prototyping and unusually decentralized production processes. The use of additive manufacturing research in a wide range of industrial applications is currently under study.

Keywords:additive manufacturing; Industry 4.0; 3D printing; Internet of Things

1. Introduction

Additive Manufacturing (AM) empowers eco-friendly items, it accommodates end-of-item life cycle answers for taking out waste and scrap, and it considers asset-effective material decisions through reusing. The advantages can even be understood at the same time. Concerning the not-so-distant future, it probably won't have the option to take over different areas in the manufacturing industries, yet in the far future; additive manufacturing will be the greatest thing in this industry-the steadily expanding interest for new products speed up the development of manufacturing technologies.

Because of its ability to print complicated customizable geometry, AM is the most well-known among academics and industry. Before this stage, applications were limited to fast prototyping, limiting their latent capability. The innovation progressions and explorations, on the other hand, assisted in moving the invention to a higher level of tailored functional end-use items. The applications have been widened to include aviation, construction, medical, vehicles, fashion, and the food sector, among other fields [1,2].

AM is an automated layer-based manufacturing technique that produces scaled 3-D physical objects directly from Computer Aided Design data without need for specialized part-dependent equipment. The term "3D Printing" was utilized in the early days, and it is still frequently used now. Rapid prototyping, also known as "Generative Manufacturing," was the first technique presented to the market in 1987, and it served as a forerunner of "Additive Manufacturing." Material jetting, powder bed fusion, material extrusion, vat photo polymerization, directed-energy-deposition, binder jetting and sheet lamination are the seven types of AM technologies. There has been a significant surge in research into 3D printing technology for building components in recent years, with the first construction projects using AM methods completed in the last few years. A vast number of systems for applying AM techniques to small-scale applications and factory production have been created. Because building components are typically huge and manufactured outside of a controlled environment, changes in additive manufacturing technology have resulted in a variety of alternatives [3].

"AM photopolymer fast prototyping systems," invented in the 1980s by Hideo Kodama of NMIRI, Japan, are two additive technologies for making three-dimensional models that are still in use today. Charles Hulls invented stereolithography (SLA) in 1983, and it is a method of making models by curing a liquid photopolymer resin with ultraviolet (UV) lasers. Later, he devised the first fast prototyping system, which enabled designers to build 3D conceptions and rapid operational prototypes in less time than was previously conceivable. He founded 3D Systems after securing a patent for 3D printing technology in 1986. C. Deckard patented for Selective Laser Sintering technology, a process of 3D printing in which powder grains are fused together by laser, while working at the University of Texas in 1988. The SLS technology is currently widely used. Scott Crump, the creator of Stratasys Inc., devised and patented the Fused Deposition Modeling (FDM) technology in 1989. DTM CORP. created a Selective Laser Sintering (SLS) method in 1992. This technology sinters powdered material using a laser as the power source, autonomously directing the laser at points in space represented by a 3D model and binding the material together to produce a solid structure. The three main 3D-Printing techniques were discovered and patented in a decade and the area of 3D printing technology was born [2]. In the present predicament, additive manufacturing has a lot of potential because it can be used in so many different industries. It can be made out of a wide range of materials are metal alloys, ceramic, thermoplastics, composites, and thin metals. The printing of prosthetics, bespoke implants, custom implants, replace missing teeth and dental products in AM is revolutionizing [3].

2. 3D Printing and Materials

The most common 3D printing methods used in additive manufacturing are: Stereolithography; Selective-Laser Sintering; Fused-Deposition Modeling; Multijet / Polyjet Printing; Inkjet Printing; Color-Jet-Printing; Digital-Light Processing; Direct-Metal Laser Sintering; Selective-Deposition

Lamination; Sand-Binding Jetting ; Electron-Beam Melting; Laminated Objects Manufacturing; and Drop-on-Demand [4–6]. When we look at these 3D printing issues in isolation, we can see that they are shared by many industries, including consumer electronics, food processing, fashion, healthcare, heavy equipment, automotive, transportation, and industrial machines. However, when we look at them together, we can see that they share some qualities.

Stereolithography (SLA): Liquid polymer photosensitive resin and ultraviolet (UV) lasers are used in SLA to cure and solidify the various layers of the object, which are then combined into the finished result. The SLA machine is made up of four basic parts: a container carrying photopolymer resin, a heating element, a cooling element, and a cooling fan. To execute this project, a platform that descends into the water tank, an ultraviolet laser, and a computer to control the platform and laser are all required. At the commencement of the procedure, the build platform is exposed to an initial thin layer of photopolymer resin, signaling the start of the process. Reduce the height of the manufacturing platform to expose the next layer of photosensitive polymer resin. Once the laser has placed the second layer, it will remain stuck to the top layer until the object is finished.

*Selective Laser Sintering (SLS):*With this technique, objects can be created using melting techniques. The raw material is sintered in powder form with a CO_2 laser. The heat source is a laser that melts the dust. Then the second layer of powder is re-coated, and the second layer of powder is laser sintered. Repeating this process will completely create the object.

Fused Deposition Modelling (FDM): It is a kind of manufacturing that involves laying layers of material on top of one another to create a product. The material is extruded through the nozzle when it reaches the glass transition temperature (moving in the X-Y-Z directions). FDM technology employs plastic filaments and materials that are placed in layers on the print bed, one on top of the other. The support material is also used in this technology to print complex-shaped products, with the number of layers required to manufacture a part regulated by the support material. Thermoplastics, pastes, metals, chocolates, wood, and a range of other materials are used in FDM. For example, this technology is both low-cost and effective for use in everyday life.

MultiJet / Polyjet 3D Printing (PJP): This technology has two or more jetting heads, of which one is used for part printing and the other is used as support material. It sprayed photopolymer-like materials layer by layer and cured by UV lamp within the printer. This technology uses a gel-like substance as a support material that can be washed away quickly. Model printed by this technology is used in the medical field for better understanding and training.

*Inkjet Printing (IJP):*3D items can be printed using an inkjet printer, which is comparable to 2D inkjet printer. Using a print head, different flows of polymer solution in the form of liquid are deposited on top of one another to make a 3D product. This technology allows for the printing of a wide range of materials while considerably reducing the cost and time involved. This technology is mostly used in the medical field for tissue printing.

*Colour-Jet-Printing (CJP):*This type of additive manufacturing process creates parts by widening powder material in a layer on the build platform with roller, much like a printer does when printing an image. The print head sprays adhesive (binder) onto the powder in the manner indicated by the CAD design to bind it together. This method must be repeated each time the created platform is pushed downward in line with its layer thickness. This technology improves medical, educational, and design applications, as well as the development of a prototype.

Digital-Light Processing (DLP): It is used to flash a single image of each layer using a digital light projector. This image of each layer is formed up of square pixels using a projector and digital screen. It is faster than SLA when compared to SLA because the entire layer is exposed at the same time.

Direct-Metal-Laser Sintering (DMLS): It is an innovative technique that may be used to print metals such as titanium or aluminium. In this innovative technology, metal powder is used in a delicate printing layer. The roller disperses the metal powder and fuses it at particular points with the help of a laser beam, which also serves as a heat source in this process. It is more precise and has greater mechanical strength than the part made using this procedure.

Selective-Deposition Lamination (SDL): It is a paper-based 3D printing process that involves cutting and gluing sheets of paper together to create a 3-dimensional object. As a result, rather than being made of plastic, 3D models are made of paper.

Sand-Binding Jetting (SBJ): It is a low-cost method that is used to construct three-dimensional (3D) things from sand using sand binding jetting equipment. The item is manufactured in full colour and detail using plaster-based powder/silica sand and a liquid binding agent. To print the full-colour model, first bind the agent with jets, and then print the model with colour jets from the print head. The method is repeated layer by layer until the component is done.

Electron-Beam Melting (EBM): Metal powder particles are fused together using a high-energy electron beam, which is employed in electron beam melting. This beam fused and solidified the desired cross-sectional area of metal powder. When compared to other methods, this one yields goods with a relatively high level of strength.

Laminated-Object Manufacturing (LOM): In this technology, 3D models are manufactured with material sheets used as raw material. The first sheet adheres to a heated roller and laser traces the desired dimension of the prototype. A laser is used to remove the material as non-part of the area and the completed layer moves down. Sheets are joined by using adhesive and fresh sheet material is rolled into position. This process is repeated until the completion of the product.

Drop-on-Demand (DOD): This technology is an AM method that employs a pair of inkjets. It uses wax-like material as-built material with dissolvable support material. This printer follows the point wise deposition with a predetermined path of jet material and produces objects layer-by-layer. After the creation of each layer, this printer uses a fly cutter on the built area. The main application of this technology is to create a pattern for investment casting/lost wax casting and other mould-making applications.

In 2000 only polymers were used for 3D printing, which are plastics that can be molded into any desired shape which no one wants with the final product but in early 2010, printers were developed that can work on metals, alloys, polymer composites, ceramics, wood, fibers, and on much more variety of materials which revolutionized 3D printing technology. The 3D printing technology has a wide range of materials that are being used in different areas such as in aerospace, automotive, dental, orthopedics, jewellery etc. The most common material used in additive manufacturing is polymers, ceramics and metals [7].

3. Industry 4.0

Traditional-manufacturing and industrial procedures are continually mechanized in the Fourth-Industrial Revolution through the application of cutting-edge smart technology. Machine to machine and Internet-of-Things are being linked on a global scale to enable higher self-operative, improved communications and self monitoring, and the manufacture of smart-machines that can evaluate and identify issues without the need for human-interaction, among other benefits. The names Industry 4.0 and fourth-industrial revolution are interchangeable when referring to the fourth industrial revolution, which represents a new stage in the organization and control of the industrial value chain. The digital-frameworks are used to structure the premise of Industry 4.0. They utilize existing control frameworks, embedded designing frameworks, and do not require an internet address to communicate or addressed by IoT devices. Industry 4.0 refers to the intelligent networking and processes in the manufacturing industry through the application of information and communication technologies. Industry 4.0 has been defined as the present trend of automation and data exchange in manufacturing technologies including Cybersecurity, IoT, Data Analytics, Cloud-computing as well as the construction of the smart factory is defined as follows [8,9].

The basic purpose of Industry 4.0, which affects fields ranging from order administration to research and development, commissioning, distribution, and product waste and recycling, is to meet the specific needs of customers. There are considerable contrasts between Industry 4.0 and Computer Integration Manufacturing (CIM), the most notable of which is the consideration of people's functions in a manufacturing setting. Because Industry 4.0 is so important in manufacturing, it has been advocated to employ operator-less CIM production. The Industry 4.0 paradigm streamlines the process of linking physical goods, such as sensors, devices, and corporate assets, to one another, as well as to the Internet and other networks. The modern model of an interdisciplinary product development approach must redefine and validate design and development approaches across all disciplines, and it must apply these approaches, among other things, to universally integrated and interdisciplinary information technology approaches, processes, and solutions. Manufacturing processes that are divided into smaller, value-driven units that only share information about the next steps in the process boost flexibility while lowering coordination complexity [2,7]. Applications of nine technologies in Industry 4.0 are as given below:

- *Advanced Robotics:* Autonomous and cooperative industrial robots; there are a plethora of standardized interfaces and integrated sensors accessible [10]
- *Additive Manufacturing:* 3D printing is becoming increasingly common, particularly for spares and prototypes; Decentralized three-dimensional facilities to reduce transit distances and inventory
- *Augmented Reality:*Aerial view of maintenance, coordinating and standard operating procedures of all types; another alternative is to display supporting information, such as through glasses
- *Simulation:*This application simulates value networks; Intelligent systems generate real-time data that can be used to optimize processes
- *Horizontal/Vertical Integration:*Data interoperability across companies based on data transmission standards: As a prerequisite, a fully automated value chain is necessary
- *Internet of Things:*A network connects equipment and goods: Communication between items connected via a network in both directions
- *Cloud Computing:*Large data quantities are difficult to manage in open systems; System communication that takes place in real-time
- *Cyber security:*To operate, networking and open systems are used; Intelligent machines, products, and systems are becoming increasingly interconnected

- *Big Data and Analytics:*An in-depth assessment of all pertinent facts (Enterprise Resource Planning and Supply Chain Management); Real-time decision making assistance and optimization

4. Additive manufacturing in Industry 4.0

We stay in a time when many people are calling the 4.0 Industrial Revolution: 3D printing, greater professionally referred to as additive manufacturing. It has the ability to transport us far from the technology of mass manufacturing and convey us to a brand new truth of customizable, one-off manufacturing. 3D printing or additive manufacturing is the wider time period for tool-much fewer production strategies which allows the production of additives from 3-D version data, generally layer-upon-layer, as adversarial to standard production methodologies. This time period is likewise used generically as a synonym for speedy prototyping. The scope of 3D printing is countless from gadgets and toys to robots and mechanical parts, and there is nearly no restriction to what a 3D printer can create [11].

3D printing is the additive manufacturing (AM) process in which three-dimensional physical object is created "layer by layer" from a digital model created by computer-aided design (CAD). 1980 this printing technology was the process of this technology is in contrast to "subtractive manufacturing processes" like editing. In AM, the material is not removed from the work piece but is added layer by layer as an input CAD file, which has the standard triangular language shape. Format (STL). The technology offers the freedom to manufacture complex-shaped and customer-specific products in less time and at a lower cost. 3D printing technology was formerly known as Rapid Prototype (RP) because it quickly creates any prototype. So far, it has been quite expensive to make a prototype. With the 3D CAD file, a prototype / physical file can now be printed on it. It's a new way of custom manufacturing end products without the need for tools or accessories. The process followed by 3D printing when printing a part. In the current situation, 3D printing is a breakthrough technology or one of the disruptive innovations that can be used to rapidly develop prototypes, new products and equipment, and save time and costs. Due to technological advancements, different types of printing technologies can be used to print parts of different materials. It can also use different materials to make complex objects. In the medical field, 3D printing is an advanced technology for manufacturing 3D implants, prostheses, tools, furniture. The technology is also suitable for printing living tissues, organs and cells [7–9].

5. Future scope of 3D printing in Aerospace & Automobile Industry

Despite the fact that the automobile industry is no stranger to automation, 3D printing has the potential to transform the way commercial and personal vehicles are designed and constructed, making them more affordable and accessible than ever before. Fused filament fabrication is currently one of the most popular and widely utilized 3D printing technologies in the automotive industry. It is conceivable to make bespoke car parts with highly complex geometrical properties at a cheaper cost than is currently attainable with conventional manufacturing technology. It opens up new avenues for mass customization of things in this business. In the automotive sector, AM is utilized to manufacture lightweight components that allow vehicles to be more active while also increasing

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efficiency. Pattern less production is becoming a reality in the aerospace industry thanks to 3D printing.

The incorporation of 3D printing into aircraft manufacturing processes enables the creation of big, complex parts and entirely dense components in less time and with a shorter lead time. The Federal Institute for Materials Research and Testing wants to build new tools utilizing a 3D printer in zero gravity and a novel technique devised by the institute. We have the capability of producing advanced aircraft parts that are both sturdy and low in weight. Many aerospace companies are interested in this technology because it may be used to generate innovative designs and high quality parts. This technology is commonly used to manufacture ornamental airplane interior components as well as components for rocket engines, among other things. This method is used in the design and manufacturing of jet turbines and rocket engines, among other things [12,13]. The most significant advantages of 3D printers are summarized below:

- *Rapid prototyping:* When it comes to vehicle design, one of the most significant benefits of 3D printers is the capacity to undertake rapid prototyping during the pre-manufacturing stage.
- *Lower turnaround time:* The time to market is shortened because of the time saved during the prototyping stage; the turnaround time can be significantly reduced.
- *Low consumption*: The application of 3D printing in car design aids in the reduction of consumption and waste
- *Lower costs:* The amount of time and resources saved at various stages of the manufacturing process contributes to a reduced overall production cost.

The future scope of 3D printing in aero-space and automobile industry can be summarized as: the additive manufacturing landscape will become more competitive; the 3D printing technology is in its initial state, but it has a bright future. In the future, we will make the aircraft and rockets and their components with the help of 3D printing and; to seeing the growing market of 3D printing Indian Government is bringing a policy in which we can increase the production and market by the 3D printing [12,13].

6. Future scope of 3D printing in Food Industry

3D printing has the potential and challenges to revolutionize the food industry through precision; customization; the textures of many foods vary; precision and accuracy are essential in the printing process; productivity is being achieved as a result of the process; food safety is a key cause of worry; production of items with vibrant colours, a variety of flavours, and a variety of structures; reduce the amount of food that is thrown away; reduce the number of pollutants that are emitted; individualized nutrition is nutrition that is personalized to the individual and; it is critical to simplify the supply chain.

3D technology printers aid in the building of the 3D shape, presenting the meal with aesthetic attractiveness and, most importantly, a gratifying taste. You may print with a range of food items, including vegetables, dairy products, cereals, confections, and other culinary elements, using modern printers. Benefits in small-scale food manufacturing of bespoke items for the food service business are exceptional. The four most prevalent types of 3D printers are extrusion base, inkjet base, binder jetting, and SLS. According to BIS Research, the global market for 3D food printing will be worth $525.6 million by 2023, with the United States leading the way [14,15].

Table 1: Applications and benefits of 3D printing in different types of food industries

Industry	Applications	Benefits gained
Military and Space	• Meal preparation on an as-needed basis • It is feasible to prepare meals in outlying places. • Providing food and water to astronauts on long-term space missions	• Allows the Army to provide meals that are tailored to each soldier • It contributes to the extension of food product shelf life. • In zero gravity, food can be printed Bringing food delivery and manufacturing to space to a lower cost
Confectionery & Bakery Markets	• Printing chocolate structures, candies and sugar sculptures	• Chocolate should be dispensed in high-volume, attractive confectionary.
Elderly Market	• Appropriate food preparation is critical in nursing homes • Custom-made medical and nutritional supplements	• Make meals for seniors that are tasty and contain the right ingredients. • To meet dietary requirements, create a one-of-a-kind food formulation. • Digitalization is bringing cooking technologies into the digital age.
Restaurants	• Meals on Demand are produced at the customer's request • Food products' shape, colour, flavors, textures, and nutritional content can all be changed.	• Improves one's ability to think creatively. • Costs are reduced while efficiency is increased.

Food makers will benefit from the ability to produce food on demand, making inventory management easier and more cost-effective. Raw materials will account for a major amount of the entire cost of food production. They will be able to save costs by using 3D printed food, resulting in cheaper and more sustainable meals. 3D printed food has the potential to fundamentally change the way food is produced while also improving resource management and reducing food waste. Furthermore, 3D printing of food provides FMCG food manufacturers with the ability to produce higher-quality, more nutritious food in larger volumes. Furthermore, 3D printing can encourage food innovation and culinary creativity, as proven by the usage of 3D printing by chefs and chefs all over the world to create appealing dishes in a variety of shapes and colours [14,15].

7. Future scope of 3D printing in Fashion industry

The industry of fashion 3D printing is used for prototypes, high-end fashion, and customizable products that offer customers a choice-driven interactive experience. 3D printing is gaining popularity in the fashion industry. Nike worked with SLS to design and build the final lightweight panel that can be connected to the Vapour Laser Talon and Vapour High Agility football footwear. Nike emphasized that his creative collaborator and athlete Michael Johnson posed for a 40-yard dunk competition with him. Talon spotted a little error in each of the first steps after closer inspection. Nike redesigned it to improve the geometry of the studs. A plate holding SLS is also included. Wales uses a combination of engineering tools and creative design software to generate sculptural shapes when constructing complicated seams. To guarantee that the junction is as flexible as feasible during assembly, the accessories were printed on nylon using SLS. Designers can manufacture lightweight and flexible objects by creating permeable, cloth-like fabrics from interlocking structures using recent advances in 3D printing. Everyone who makes one-of-a-kind designer items, including the Belgian company Materialize, has recently developed a lightweight material called TPU-92A-1, which is soft to the touch and highly elastic and has been specifically intended for use in the fashion industry. Some of the important factors are discussed below:

- *Cost:* Some machines will always be more expensive than others since they rely on more expensive technologies, such as lasers; this item is not suitable for mass production; the cost of materials is exorbitant and; the program is prohibitively pricey.
- *Range of materials:* Machines can handle few materials, while others can handle more materials; limited product size because large machines are quite expensive and; involves in limited numbers of unique full colour.
- *Maintenance:* Some machines have different maintenance requirements because they are more complex than others. Companies add value to their machines to provide better support and; not suitable for a mass production system.
- *Speed:* Due to the technology used, machines produce spare-parts quickly; fast print speeds reduce product quality and; high printing speed reduces the product quality.
- *Versatility:* Machines feature complex settings that enable part quality to be adjusted with other dimensions such as assembly speed and; other machines offer fewer customising possibilities, making them simpler to operate but perhaps less flexible.
- *Layer thickness:* Machines have limited layer-thickness due to material process dimension and; thinner layers inevitably reduce build speed.
- *Accuracy:* The resolution of the aircraft, in addition to layer thickness, determines accuracy. This can have a significant influence on the minimum feature size and wall thickness of a component. For example, laser systems have a minimum size feature that is defined by the diameter of the laser beam.

Clothing makers, retailers and architects have been utilizing 3D printers for various capacities to make models for testing, for customization of the items, making of imaginative pieces and extras. Famous is turning out to be 3D-printed swimming outfits, shoes, dresses, where ordinarily utilizing a blend of printing from strong, delicate material and making adaptable constructions are utilized. The primary concern here is the personalization—where the interaction permit is making. Assembling of footwear, its particular parts and adaptable insoles for ordinary use, sports or concentrated assignments is one of 3D printing's quickest developing sections. Enormous attire organizations including Nike and Adidas shoes organizations have effectively incorporated 3D printing into their assembling cycles to print parts like soles and garments [16,17].

8. Healthcare & Medical Industry and the Future Scope of 3D Printing

Additive manufacturing has a lot of applications right now; therefore it has a lot of promise. It is adaptable to a wide range of materials, including metal alloys, composites, ceramics, thermoplastics, and pure thin metals. There is a need for precise fit implants made of various materials, and additive manufacturing (AM) is changing the printing of human bone, prostheses, bespoke implants, and appliances [4,15].

Plastic: This material was utilized in FDM printers in the form of filaments, which were quickly melted and used to build medical parts layer-by-layer. This material is used to make heart valves, intravenous blood bags and disposable syringes.

Silicone: It is used to make a range of medical implants, including tracheal stents. Used in the manufacture of disposable and reusable components as well as diagnostic and surgical equipment.

Carbon fiber: It is widely utilized in 3D-printers for the top coating of plastic materials used in medical applications which is why it is so popular.

Metal: Metal implants, such as metal plates used to support a damaged bone, have been utilized in the medical field to treat patients for more than a century.

Titanium: To mention a few applications, this material is used to make hip-implants, bone brigades, and heart valves. It is not irritant or allergenic to humans. Titanium is lighter, sturdy and more rigid when similar to other materials.

As it is employed in the customization of nutritional goods, organs, and drugs, 3D printing will be required to play a significant role in the movement toward customized medicine. Pharmaceutical companies that produce and distribute medications could be replaced by delivering prescription formulation databases to pharmacies for on-demand pill printing, obviating the necessity for these businesses. The most advanced 3D printing application that is expected in the near future is the bio-printing of complex organs. A patient's tissue may also be produced as a strip that can be used in tests to assess which treatment is best for the patient [10].

9. Need for the Study and Major Findings

Additive manufacturing may decrease material waste, production processes, inventory, and the number of unique parts required for an assembly. Production time is much less in subtractive manufacturing. Additive manufacturing overcomes the constraints of traditional manufacturing techniques, allowing producers to build complex structures with more efficiency and create highly personalized goods. To overcome the technical gap, industries and researchers are embracing additive manufacturing technologies based on materials and working to optimize these processes. Reviewing the different research papers based on additive manufacturing technologies, differences between materials, production time, inventory, advantages and disadvantages. Although additive manufacturing technology has undergone major developments, it has not yet been widely accepted by most industries. It has greatly improved the technology, thereby changing this way of thinking and being recognized in the industry, and expanding, developing, and defining applications. The production of the technology is a new method of smart manufacturing that digitizes an enhanced manufacturing system. This paper’s central motive is to study significant advancements of additive manufacturing using required materials in different areas such as aerospace, automotive, medical, fashion, food industries, etc. The major research objectives of this paper are to study the different types of materials based on additive manufacturing that are used in various applications.

Because of advancements in additive manufacturing methods, 3D printed goods are increasingly being used in the production line rather than just in research and development. Companies that have begun to use 3D printers to meet their rigorous standards and needs, rather than as a replacement for traditional production, are reaping the greatest benefits from additive manufacturing. There are some of the industries that get the most out of additive manufacturing and transformed their production:

- *Aerospace:*The aerospace sector, as a pioneer in additive manufacturing, creates parts that must resist harsh environments and are made of high-performance materials. The aircraft sector was one of the first to adopt 3D printing to create their goods. Overall weight can be lowered due to the high strength of 3D printed pieces and the fact that they use less material.
- *Medical:*When it comes to dealing with complex cases, the medical industry is turning to additive manufacturing, which employs a diverse range of high-strength and biocompatible 3D printing materials. Customization is more crucial than ever in the medical industry. Orthopedic implant devices, dental gadgets, and pre-surgery models built from CT scans are all instances of industry-shaking products. In this facility, a 3D printer is being used to manufacture life-saving items and technologies.
- *Consumer Products:*The time it takes to form an idea and deliver it to market is everything for designers, graphic artists and marketing teams so manufacturers are extensively using 3D printers or additive manufacturing to help iterations and quickly adjust the design. 3D printing is extensively used in producing detailed consumer electronics early in the product development life cycle with realistic aesthetics and functionality. There are many such advancements of additive manufacturing in different industries and the potential of additive manufacturing is way too much for any product-based industry.

10. Conclusion

Without a doubt, 3D printing technologies are laying the groundwork for the next major technological revolution. AM is a vital technology for this fourth revolution, serving as a critical success factor for new development by saving time and money while enhancing process efficiency and lowering complexity, enabling for quick prototyping and highly decentralized production processes. The success of researchers, academia, and businesses are dependent on Industry 4.0. At the moment, AM is being used by a growing number of industrial sectors. AM is a game-changing technology that answers many of Industry 4.0's challenges while also having an impact on its many applications. Smart factories of the future will be able to incorporate greater flexibility and individualization into their manufacturing processes because the Internet of Things will connect all of their activities. AM is now well-positioned to lead the way to Industry 4.0, and organizations are exploring employing these technologies to achieve Industry 4.0 objectives. AM has a wealth of features that are now being used by numerous enterprises to enjoy the benefits of the technology.

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