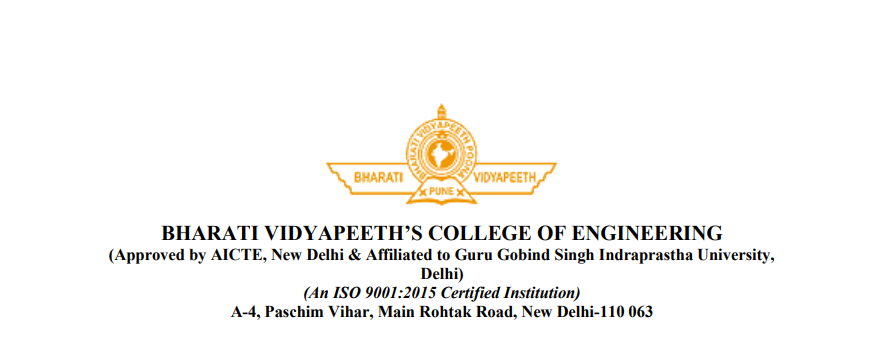
horizontal line



**CASE STUDY**

**Branch: CSE-1**

**Year: 1st**

**Subject: Applied Mathematics-I**

**Submitted To: Dr. Saurabh Agrawal**

**(GROUP - 1)**

**Team Members -**

1. **AARYAN AGGARWAL - (02611502722)**
2. **ALEX VARGHESE - (03711502722)**
3. **AKSHAY KUMAR - (08311502722)**
4. **ANSH SHARMA - (09011502722)**
5. **ABHINEET GAUTAM - (04111502722)**

CASE STUDY

**ADDITIVE MANUFACTURING**

MANUFACTURING PROCESS

horizontal line

# Placeholder image

***“Additive manufacturing is fundamentally changing what we can do.******It's not 10 years away.******It's here.”—Ryan Hooley***

# Introduction

Additive manufacturing is a latest technology that could improve manufacturing processes by building up thin layers of materials from three - dimensional designs virtually constructed using the advanced CAD software. This technique affords the creation of new types of objects with unique material properties.But while AM is widely billed as the next industrial revolution. In reality , there are still significant hurdles for successful commercialisation of the technology. This paper aims to provide the comprehensive review of the literature , technologies and manufacturing practices on modern ADDITIVE MANUFACTURING.

AM refers to a group of technologies that build physical objects directly from three dimensional CAD data. AM

adds liquid, sheet, wire or powdered materials, layer-by layer, to form component parts with little or no subsequent

processing requirements. This approach provides a number of advantages including near 100% material utilisation, short

lead time sandun-rivalled geometric freedom of design.

The ASTM has defined ‘additive manufacturing’ as a (ASTM international, 2012) : “ process of joining materials

to make objects from 3D models data, usually layer upon layer, as opposed to subtractive methodologies, such as

traditional machining.”

## Definition of Additive Manufacturing

AM refers to a group of technologies that build physical objects directly from three dimensional CAD data. AMadds liquid, sheet, wire or powdered materials, layer-by layer, to form component parts with little or no subsequent processing requirements. This approach provides a number of advantages including near 100% material utilisation, short lead time sandun-rivalled geometric freedom of design.

The ASTM has defined ‘additive manufacturing’ as a (ASTM international, 2012) : “ process of joining materials to make objects from 3D models data, usually layer upon layer, as opposed to subtractive methodologies, such as

traditional machining.”

The ASTM has defined ‘additive manufacturing’ as a (ASTM international, 2012) : “ process of joining materials to make objects from 3D models data, usually layer upon layer, as opposed to subtractive methodologies, such as traditional machining.”

**Past uses of Additive Manufacturing**

Historically, AM technology was used to build conceptual prototypes referring to that process as Rapid Prototyping (RP), a term which is still often used as a synonym to AM. Those prototypes were meant only to accelerate the development phase of a product and under no circumstance are comparable to the end product with respect to material, durability and quality (Feenstra, 2002). Rapid Manufacturing (RM) has evolved through RP due to technological advancements defined by Rudgley (2001) as “the manufacture of end-use products using additive manufacturing techniques (solid imaging)”.RM was responsible for approximately 20% of overall AM revenues in 2010, as per 2011 Wohlers Report.

**Present uses of additive manufacturing**

A sub-category of RM is Rapid Tooling (RT) whose aim is to create consistent tools which serve traditional manufacturing procedures (Dimov, 2001). RT has been mostly used to create injection moulds but recent developments enable RT technology to be used for other tooling processes like casting and forging (Levy et al., 2003). RT further portioned into direct tooling and indirect tooling. In direct tooling moulds are layer manufactured for use, and indirect tooling, a master model is created and furthermore used to produce a casted mould. According to 2009 Wohlers Report,

16% of AM processes were used for direct part production (RM), 21% for functional prototypes (RP) and 23% for tooling and metal casting patterns (RT) from which approximately 56% and 9% of process preferences were direct metal and direct polymer tooling respectively (Levy et al., 2003). In AM, object representation is stored in a STL file (stereolithography), generated by conventional CAD software or obtained from Magnetic Resonance Imaging, laser scanning, Computer Tomography (CT) and mathematical modelling software (Reeves, 2009). Afterwards, the STL file is imported into slicing software in which the three dimensional digital object is sliced into layers and oriented appropriately in order to define the best possible tool path for the printer which then creates the object via selective placement of material

(Campbell et al., 2011). Furthermore, it is essential to choose the appropriate building direction as it can change specifications of the object such as lead time, cost and quality. Choosing a direction other than the optimum would lead to more layers required resulting in increased lead time needed to manufacture the product (Reeves, 2009).

**Impact Of Coronavirus Outbreak**

**Positive Impact**

The additive manufacturing (AM) sector has been significantly impacted by the COVID-19 epidemic. The epidemic has brought attention to the need for supply chains that are more adaptable and resilient, which has increased demand for AM. This is due to the fact that AM makes it possible to produce parts quickly and effectively when needed, which can be advantageous when traditional supply channels are hampered during emergencies.

**Additive Manufacturing a Serendipity**

For instance, AM has been utilised to make parts for face shields, ventilators, and other medical devices during the epidemic. Aside from that, additive manufacturing (AM) has been utilised to create components for PPE like masks, gloves, and gowns.

**Negative Impact**

The pandemic, on the other hand, has also caused a reduction in manufacturing operations across several industries, which has had an impact on the demand for AM. Due to this, fewer AM projects are being undertaken, which has resulted in a reduction in the sales of AM equipment and supplies.

In conclusion, the pandemic's effects on the additive manufacturing sector have been inconsistent. While there has been a gain in some markets for AM, there has also been a fall in others, having a mixed effect on the industry as a whole.

**From Prototype To Production**

In additive manufacturing (AM), the process of going from prototype to production often entails multiple steps:

* **Design:** The first stage is to use computer-aided design (CAD) software to produce a digital design of the intended product. The AM machine may then read the file created using this approach.
* **Prototyping:** After the design is finalised, AM can be used to create a product prototype. This enables the design to be tested and assessed before going into production.
* **Material selection:** Choosing the right material for the finished product is the next stage. AM is applicable to a wide range of materials, including composites, metals, ceramics, and polymers.
* **Process improvement:** The AM process needs to be improved for production once the design, prototype, and material are completed. The machine settings may need to be adjusted, the design may need to be changed for better construction quality, and the process may need to be tested to make sure it is repeatable and consistent.
* **Production:** Using additive manufacturing, the product can be produced in huge quantities when the process has been optimised. To maximise productivity, this can include using many machines or even automating the procedure.
* **Quality Control:** The last stage is to confirm that the finished product satisfies the necessary requirements for quality. To make sure the product is free of flaws and satisfies the relevant criteria, inspection and testing may be necessary.

Design, prototyping, material selection, process optimization, production, and quality control are all steps in the AM process that go from prototype to production.

**FUTURE OF 3D PRINTING**

“What can be done with 3D printing isn’t theoretical anymore. It’s now a manufacturing imperative."

Just a few years ago, the benefits of additive manufacturing remained speculative. We were debating whether there was a financial or technological case to convert from traditional, high-volume processes to additive processes. Now, the demonstrable time-savings in design and manufacturing along with higher efficacy products are leading to a rapidly growing number of use-cases, positioning 3D printing as a mainstream manufacturing technology. [Additive manufacturing](https://www.jabil.com/capabilities/additive-manufacturing.html) has found its stride, and as an increasingly important pillar in the manufacturing renaissance, **“the future of 3D printing is bright”**.

‘Rapid Prototyping’ seems to be the earliest describer and trends to be deemed ‘layer based processing for creating 3D components in its infancy’. However, considerable progress in the field has taken the technology far beyond that of ‘prototyping’. 3D printing, a term brought about in the 90s, has been widely used since and has become a wider spread term for creating layered 3D components, more generally known for low- cost 3D home printing and some of the larger commercial 3D printing systems. The term ‘Additive Manufacturing’ was later introduced and seems to have taken the position for describing the technology overall, and more specifically for industrial applications and professional high end equipment and applications.

Now more than six in 10 use 3D printing for production parts. But as additive manufacturing technology adoption grows, how will it shape other industries and aspects of manufacturing? What does the future of 3D printing hold?.Here are some predictions about it :-

## Scalability from Rapid Prototyping to Production:

3D printing use for jigs, fixtures and tooling, bridge production and production parts have grown remarkably over the last few years. In that time, the heavy equipment and machines industries ,jigs, fixtures and tooling; healthcare and the orthopaedics have seen the highest adoption rate .

Additive manufacturing benefits every step of the product development process, enabling easy scalability in rapid prototyping to full-scale manufacturing. After all, prototyping without an eye for full-scale production misses a key tenant of what additive stands to deliver: more efficient lifecycle management.

Additive manufacturing benefits every step of the product development process, enabling easy scalability in rapid prototyping to full-scale manufacturing. After all, prototyping without an eye for full-scale production misses a key tenant of what additive stands to deliver: more efficient lifecycle management.

When volumes are still relatively low – if a brand is looking to print 100 parts for testing or regional-market testing – additive manufacturing enables a team to iterate on designs and features free of charge. Even quadrupling that number can be done with no added retooling costs using 3D printing.

Additive remains the perfect fit for low- to mid-volume production where high tooling costs and high fixed costs can deter market entry. With the right level of planning, engineering and material development, 3D-printed parts can seamlessly transition into rate production equipment, such as injection moulding.

Producing a part on-demand enables manufacturers to produce 3D printed parts as needed instead of pulling the part from a supply warehouse. On-demand production leads to measurable reductions in inventory and storage costs. In the [automotive industry](https://www.jabil.com/industries/automotive-electronics-components.html), spare parts inventory can be reduced by 90% with 3D printing.

## Making the Supply Chain More Resilient Through Digitization :

If the global pandemic has taught us anything, it’s that global supply chains can be unpredictable. Historically, supply chain management has focused on cost and efficiencies at the expense of resiliency. It’s no wonder that many supply chains failed when faced with a disruption as big as the pandemic—[COVID-19's supply chain impact](https://www.jabil.com/blog/covid-19-supply-chain-impact.html) was felt across every industry, but especially in healthcare and medical devices. Now, building [supply chain resilience](https://www.jabil.com/blog/successful-supply-chain-resilience-strategy.html) is a key objective across industries.

When a shortage of personal protective equipment (PPE) and ventilator parts was crippling the healthcare supply chain, additive manufacturing was a big part of the solution. Faced with pandemic-related obstacles, Superfeet, an insole manufacturer, dedicated available capacity to [producing face shields](https://www.superfeet.com/en-us/blog/superfeet-to-produce-vital-medical-supplies-for-covid19-response). With 3D printing serving as their main manufacturing method, converting their lines to produce shields was done quickly with little switching cost.

It’s no surprise that additive manufacturing is a leading factor in digital transformation. It’s one of the purest digital technologies because it doesn’t require tooling and fixturing, thereby reducing or eliminating switching costs in moving production between different printers and locations. That’s a radical departure from labour-intensive methods employed by the manufacturing industry over the last 150 years where aggregation of high volume at a single site was required to achieve cost targets, especially in the highly price-sensitive consumer product markets.

Rather than stocking a warehouse full of components that might become obsolete and mass quantities of spare parts that may or may not be in demand, additive manufacturing condenses the piles of boxes eating up physical space into digital files that can be stored in the Cloud and easily accessed when needed.

With 3D printing, manufacturers can better connect the physical [supply chain](https://www.jabil.com/capabilities/supply-chain.html) with a digital thread and manage products more efficiently from concept to end-of-life. Manufacturing can be distributed to any location that has digital manufacturing systems in place simply by putting a file on the wire.

## Offering Greater Flexibility and More Customised Designs:

A prevailing consumer trend transforming numerous industries is the desire for [customised products](https://www.jabil.com/blog/meeting-mass-customization-demands-with-3d-printing.html). Rather than purchasing an item that was made through mass production, customers are more frequently wanting a product that is created for them specifically, gratifying their personal tastes and preferences.

Personalization and customization can be easily enabled with the low-volume production capabilities offered by additive manufacturing. 3D printing gives brands more flexibility in responsive design, specifically through [design for additive manufacturing](https://www.jabil.com/blog/design-for-additive-manufacturing.html). Instead of making advanced market predictions and then spraying large quantities of identical objects into the market, manufacturers can afford to produce smaller batches, allowing designers and engineers to adjust product designs and innovate in a cost-effective manner as inspiration strikes, consumer sentiment is known, or customer feedback trickles in.

The accessibility of 3D printing is starting to reach the point where you wonder, “what can’t we print?” And when we start to dissect everything down to the molecular level, it’s just a matter of time before individual consumers can print food or frames for their glasses or… well, anything. In the future, 3D printing and future permutations of digital production will more fully empower consumers.

## The Future of Digital is all about Materials:

While increasing investments in the additive manufacturing ecosystem are fueling growth, I don’t think you can overstate the significance of the materials. Outside of the high cost of the equipment, the next big barrier is materials and closed additive manufacturing ecosystems, which have stymied the 3D printing industry’s growth. Numerous types of [3D printing materials are on the market](https://www.jabil.com/capabilities/additive-manufacturing/jabil-engineered-materials/filaments-listing.html) today, but few are advanced enough to meet the quality or regulatory requirements of industries.

With current challenges surrounding volumes in most industries, suppliers and manufacturers aren’t incentivized to create the different materials necessary for new applications. However, the future of 3D printing is in materials—specifically [engineered and application specific materials](https://www.jabil.com/blog/filling-the-additive-materials-gap-to-broaden-adoption-of-additive-manufacturing.html). The different needs of diverse industries all require custom solutions to their problems. Integrating new engineered materials will transform a new generation of applications, including heavily regulated industries.

The markets will reward companies that compress the process and timeline associated with introducing [3D printing materials](https://www.jabil.com/blog/3d-printing-materials.html) tailored to specific manufacturing and engineering requirements. By establishing the processes to accelerate the development and release of materials into the additive markets in a cost-effective manner, a greater number of [3D printing applications](https://www.jabil.com/blog/3d-printing-applications.html) will be served and the overall digital manufacturing flywheel will begin to spin.

Creating a More Sustainable Future with 3D Printing:

Finally, two of the key tenets to additive manufacturing are sustainability and conservation. One of the intrinsic benefits is that scrap material is reduced, if not eliminated. “[Additive Manufacturing and Sustainability: An Exploratory Study of the Advantages and Challenges](https://www.sciencedirect.com/science/article/pii/S0959652616304395),” additive manufacturing mimics biological processes by creating objects layer by layer, rather than produce a hulking item that must be whittled and chunks carved out to achieve the desired shape. “It is inherently less wasteful than traditional subtractive methods of production and holds the potential to decouple social and economic value creation from the environmental impact of business activities,” they write.

Aside from reducing waste, 3D printing also conserves energy. The [Metal Powder Industries Federation](https://www.pickpm.com/wp-content/uploads/2017/04/PM-Intrinsically-Sustainable.pdf) did a study that listed 17 steps required to produce a truck gear using subtractive manufacturing versus the six steps to manufacture the same product with additive manufacturing. With 3D printing, the same product took less than half the energy. Additionally, by bringing products closer to the customer, 3D printing reduces the need for transporting products and materials, thereby positively affecting the quantity of carbon poured into the atmosphere. Therefore, we can already see that digital and additive strategies are already leading to a more sustainable future.

This is a pivotal time for the manufacturing industry. We’re standing at an epicentre where our ideas, designs and products can be nearly fully represented in the digital space and we can increasingly convert those representations into physical products using sound production methods cost-effectively with appropriate quantities using additive. As the first truly digital production technology, additive manufacturing is demonstrating its transformative nature and has already been reshaping businesses and industries with remarkable efficiencies.

**ADDITIVE MANUFACTURING TECHNOLOGY PROCESS**

1. **Powder Bed Fusion (PBF)**

Powder bed fusion (PBF) methods use either a electron beam or laser source to melt and fuse material powder together. Electron beam melting (EBM), methods require a vacuum but can be used with metals and alloys in the creation of parts. All PBF processes involve the spreading of the powder material over previous layers. There are different mechanisms to enable this, including a roller or a blade. A hopper or a reservoir provides fresh material supply. Direct metal laser sintering (DMLS) is the same as Selective Laser Sintering (SLS), but with the use of metals and not plastics. This process sinters the powder, layer by layer. Selective Heat Sintering differs from other processes by way of using a heated thermal print head to fuse powder material and, layers are added with a roller in between fusion of layers as before (Gibson et al., 2010). Figure 2 bellow shows Powder bed fusion methods.

1. **Directed Energy Deposition (DED)**

Directed Energy Deposition (DED) is a more complex printing process commonly used to repair or add additional material to existing components (Gibson et al., 2010), also called as Laser engineered net shaping, directed light fabrication, direct metal deposition, 3D laser cladding.

A typical DED machine consists of a nozzle mounted on a multi axis arm, which deposits melted material onto the specified surface, where it solidifies. The process is similar in principle to material extrusion, but the nozzle can move in multiple directions and is not fixed to a specific axis. The material, which can be deposited from any angle because of 4 and 5 axis machines, is melted upon deposition with electron or laser beam. The process can be used with polymers,ceramics but is typically used with metals, in the form of either powder or wire. Typical applications include repairing and maintaining structural parts.

1. **Material Extrusion**

Fused deposition modelling (FDM) is a common material extrusion process in which material is drawn through a nozzle, where it is heated and is then deposited layer by layer. The nozzle can move horizontally and platform moves up and down vertically after each new layer is deposited. FDM is a commonly used technique used by many inexpensive, domestic and hobby 3D printers. The process has many factors that influence the quality of final model but has great potential and viability when these factors are properly controlled. Whilst FDM is similar to all other 3D printing processes, as it builds layer by layer, it varies in the fact that material is added through a nozzle under constant pressure and in a continuous stream. This pressure must be kept steady and at a constant speed to enable accurate results (Gibson et al., 2010). Material layers can be bonded by the use of chemical agents or temperature control. Material is often added to the machine in spool form. Advantages of the material extrusion process include use of readily available ABS plastic, which can produce models with good structural properties, close to final production model. In low volume cases, this can be a more economical method than using injection moulding. However, the process requires many factors to control in order to achieve a high quality finish. The nozzle size and shape will affect the final quality of the printed object because nozzle which deposits material will always have a radius, as it is not possible to make a perfectly square nozzle and this (Chua et al., 2010). Accuracy and speed of FDM are low when compared to other processes and the quality of the final model is limited to material nozzle thickness (Krar et al., 2003).

1. **Vat Polymerization**

Vat polymerisation uses a vat of liquid photopolymer resin, out of which the model is constructed layer by layer. An ultraviolet (UV) light is used to cure or harden the resin where required, whilst a platform moves the object being made downwards after each new layer is cured. As the process uses liquid to form objects, there is no structural support from the material during the build phase. Unlike powder based methods, where support is given from the unbound material. In this case, support structures will often need to be added. Resins are cured using a process of photo polymerisation (Gibson et al., 2010) or UV light, where the light is directed across the surface of the resin with the use of motor controlled mirrors (Grenda, 2009). Where the resin comes in contact with the light, it cures or hardens.

**MATERIAL USED IN ADDITIVE MANUFACTURING**

Polymers are the most widely used material in AM. Most notably, nylon is the most widely used polymer because it melts and bonds better than other polymers (Guo, N. & Leu, M.C, 2013).

Metal products can be formed in a “direct” way – by melting metal particles together or an “indirect” way – by bonding the metal with post-processing. There are many ways and AM methods to form metals through the indirect or direct way (Ibid) .

Ceramics are used in AM processing because of their chemical structures and resistance to high temperatures. Unfortunately, these materials can be brittle making them difficult to manufacture especially if complex geometries are involved. Examples of ceramics include alumina, silica and zirconia. Ceramics can be produced through indirect or direct process (Guo, N. & Leu, M.C, 2013).

Composites are, as their name suggests, materials that are combinations of two or more materials, either naturally (in nature) or engineered. Composites can be mixed uniformly or no uniformly to make different compounds (Ibid).

Functionally graded materials can be created through AM processing. Guo & Leu (2013) show that, “One example is a pulley that contains more carbide near the hub and rim to make it harder and more wear resistant and less carbide in other areas to increase compliance.” (Ibid).

**ADDITIVE MANUFACTURING INDUSTRIAL DEVELOPMENT**

AM technologies started more than twenty years ago but public attention has only focused on it in the latest years, mainly owing to the publicity around developments in 3D printing (Hype Cycle for 3D Printing, 2014) This is illustrated by the Gartner Hype Cycle (Hype Cycle for 3D Printing, 2014) (Figure 8) which demonstrates what the expectations are for technologies to be close to adoption. For instance, up to 2009, AM is not even referenced. Only in 2010, AM appears for the first time with an estimation of 5-10 years to maturity (Figure 8). In 2013, nevertheless we already see that

industrial applications appear, such as Enterprise 3D Printing already situated on the ‘slope of enlightenment’, almost near real production. There are also concepts emerging for 3D scanners and consumer 3D printing, estimated to reach in 5-10 year the ‘plateau of productivity’, close to mainstream adoption.

Another information matrix that was released by Tuan Tranpham, from Objet Inc., helps to compare the various role-players in the AM industry (Materials KTN., 2012). The horizontal axis, from left to right follows the stages of development from obtaining 3D content to producing the physical part. The vertical axis, from the bottom up shows the different categories of user-groups for each of the various technologies presented.

# Market growth and Market approach

The additive manufacturing market is concerned with the design, production and distribution of yarn, cloth, clothing and garments. The raw material may be metal, plastics, alloys and ceramic. The additive manufacturing industries contribute significantly to the national economy of many countries. Growing demand for lightweight components from the automotive and aerospace categories and advancement in 3D metal printing technologies has highly increased the demand in the global additive manufacturing market.

The global additive manufacturing market report provides details of market share, new developments, and the impact of domestic and localized market players, analyses opportunities in terms of emerging revenue pockets, changes in market regulations, products approvals, strategic decisions, product launches, geographic expansions, and technological innovations in the market. To understand the analysis and the market scenario, contact us for an Analyst Brief. Our team will help you create a revenue-impact solution to achieve your desired goal.

The global additive manufacturing market is expected to gain significant growth in the forecast period of 2023 to 2030. Data Bridge Market Research analyses that the market is growing with a CAGR of 20.9% in the forecast period of 2023 to 2030 and is expected to reach USD 91,853.88 million by 2030. The major factor driving the growth of the additive manufacturing market is the increasing demand for lightweight components from the automotive and aerospace industries.

**Manufacturing in Pharmaceutical Industry**

Global Additive Manufacturing Market, By Material Type (Metal, Plastic, Alloys, and Ceramics), Technology (Stereolithography (SLA), Fused Disposition Modelling (FDM), Laser Sintering (LS), Binder Jetting Printing, Polyjet Printing, Electron Beam Melting (EBM), Laminated Object Manufacturing (LOM), and Others), Application (Automotive, Healthcare, Aerospace, Consumer Goods, Industrial, Defence, Architecture, and Others), Market Trends and Forecast to 2030.

The additive manufacturing market is concerned with the design, production and distribution of yarn, cloth, clothing and garments. The raw material may be metal, plastics, alloys and ceramic. The additive manufacturing industries contribute significantly to the national economy of many countries. Growing demand for lightweight components from the automotive and aerospace categories and advancement in 3D metal printing technologies has highly increased the demand in the global additive manufacturing market.

The global additive manufacturing market report provides details of market share, new developments, and the impact of domestic and localized market players, analyses opportunities in terms of emerging revenue pockets, changes in market regulations, products approvals, strategic decisions, product launches, geographic expansions, and technological innovations in the market. To understand the analysis and the market scenario, contact us for an Analyst Brief. Our team will help you create a revenue-impact solution to achieve your desired goal.

The global additive manufacturing market is expected to gain significant growth in the forecast period of 2023 to 2030. Data Bridge Market Research analyses that the market is growing with a CAGR of 20.9% in the forecast period of 2023 to 2030 and is expected to reach USD 91,853.88 million by 2030. The major factor driving the growth of the additive manufacturing market is the increasing demand for lightweight components from the automotive and aerospace industries.

**Countries Covered**

U.S., Canada, Mexico, U.K., Russia, France, Spain, Italy, Germany, Turkey, Netherlands, Switzerland, Belgium, Rest of Europe, Japan, China, South Korea, India, Singapore, Thailand, Indonesia, Malaysia, Philippines, Australia & New Zealand, and the Rest of Asia-Pacific, Brazil, Argentina, Rest of South America, Egypt, Saudi Arabia, United Arab Emirates, South Africa, Israel, and Rest of the Middle East & Africa.

**Market Definition**

Additive manufacturing (AM) is different from the subtractive method of production, which envisages grinding out unnecessary material from a block of material. The use of additive manufacturing in industrial applications usually refers to 3D printing. Additive manufacturing involves a layer-by-layer addition of material to form an object while referring to a three-dimensional file with the help of a 3D printer and 3D printer software. A suitable additive manufacturing technology is selected from the available set of technologies depending upon the application.

**Global Additive Manufacturing Market Dynamics**

This section deals with understanding the market drivers, advantages, opportunities, restraints, and challenges.

**Drivers**

Increasing demand for lightweight components from the automotive and aerospace industries

The automotive and aerospace sector requires numerous interacting technical and economic objectives of functional performance, lead time reduction, lightweight, cost management and delivery of safety-critical components. To meet the demand and to compensate for the fuel consumption and cost management to enhance the technical performance and allowable to make a lighter structure which directly related to enhancing economic and technical performance and which will help the airlines industry to carry more payload, which will directly improve their revenue. Additive manufacturing technologies, unlike conventional traditional manufacturing, use layer-by-layer manufacturing based on typical powder or wire and materials like plastic polymer, which is light in weight.

**Advantages offered by additive manufacturing in various end-user industries**

Industries like aerospace were some of the industries that used additive manufacturing products for their performance, and aeroplane parts are used by additive manufacturing products that are lightweight and can withstand harsh environmental conditions, due to less material required and by the process of forming materials layers by layers, aerospace industries utilize it as the advantage for weight reduction and waste reduction, which are very important for the manufacturing of aerospace parts for major companies.

In rapidly innovating medical industries, the utilization of additive manufacturing products is of great advantage for doctors, patients and research institutions. Through functional prototype design provided by additive manufacturing technologies, it has been of great advantage to create a flexible design of various design lifesaving tools needed for surgical and study purposes, tools used in the dental procedure, pre-surgery models for CT scans, custom saw and drill guides, enclosure and specialized instrumentation.

Easy customization and bulk production using additive manufacturing

Additive manufacturing customization, unlike traditional manufacturing, doesn’t add additional cost for customization and doesn’t require any certain mold or tools for the design it just needs a prototype 3D design and can be created by the customer itself because of the easy customization and fast production there is high demand, and we can mass produce any unique design without hampering the cost and time when making use of the 3D printers. Not only does it provide mass customized production, but it also gives the consumer a unique buyer and consumer experience where it gives them the feeling of belongingness and consumer satisfaction compared to the counterpart who doesn’t provide personalized design. It also allows the consumer to buy the design of their choice. For example, NIKE, a shoe manufacturer, sells shoes on their website with a 3D design where the consumer can add their colour choice on their own without much hesitation. This will add an advantage to market competition since, through this system, it lets the manufacturer know their client.

Rise in industrialization and advancement in 3D metal printing technology

With the rise in industrialization, there is a huge demand for 3D metal printing products in industries like aerospace, automotive, health care and others industries. With the demand from various fields for parts in aerospace for their jets engine and other structural parts to customize parts in automotive industries to customize the design of shoes and other electronic gadgets, there is a demand for the rigorous development of 3D printing technologies, which will perform more efficiently and can produce the product at a much faster rate with more precision. So the demand for the advancement and convenience of additive manufacturing technologies lead to an increase in the demand for 3D metal printing technologies.

**Additive Manufacturing Market Analysis and Size**

The additive manufacturing market is concerned with the design, production and distribution of yarn, cloth, clothing and garments. The raw material may be metal, plastics, alloys and ceramic. The additive manufacturing industries contribute significantly to the national economy of many countries. Growing demand for lightweight components from the automotive and aerospace categories and advancement in 3D metal printing technologies has highly increased the demand in the global additive manufacturing market.

The global additive manufacturing market report provides details of market share, new developments, and the impact of domestic and localized market players, analyses opportunities in terms of emerging revenue pockets, changes in market regulations, products approvals, strategic decisions, product launches, geographic expansions, and technological innovations in the market. To understand the analysis and the market scenario, contact us for an Analyst Brief. Our team will help you create a revenue-impact solution to achieve your desired goal.

The global additive manufacturing market is expected to gain significant growth in the forecast period of 2023 to 2030. Data Bridge Market Research analyses that the market is growing with a CAGR of 20.9% in the forecast period of 2023 to 2030 and is expected to reach USD 91,853.88 million by 2030. The major factor driving the growth of the additive manufacturing market is the increasing demand for lightweight components from the automotive and aerospace industries.

By Material Type (Metal, Plastic, Alloys, and Ceramics), Technology (Stereolithography (SLA), Fused Disposition Modelling (FDM), Laser Sintering (LS), Binder Jetting Printing, Polyjet Printing, Electron Beam Melting (EBM), Laminated Object Manufacturing (LOM), and Others), Application (Automotive, Healthcare, Aerospace, Consumer Goods, Industrial, Defence, Architecture, and Others).

**Countries Covered**

U.S., Canada, Mexico, U.K., Russia, France, Spain, Italy, Germany, Turkey, Netherlands, Switzerland, Belgium, Rest of Europe, Japan, China, South Korea, India, Singapore, Thailand, Indonesia, Malaysia, Philippines, Australia & New Zealand, and the Rest of Asia-Pacific, Brazil, Argentina, Rest of South America, Egypt, Saudi Arabia, United Arab Emirates, South Africa, Israel, and Rest of the Middle East & Africa.

**Advantages offered by additive manufacturing in various end-user industries**

Industries like aerospace were some of the industries that used additive manufacturing products for their performance, and aeroplane parts are used by additive manufacturing products that are lightweight and can withstand harsh environmental conditions, due to less material required and by the process of forming materials layers by layers, aerospace industries utilize it as the advantage for weight reduction and waste reduction, which are very important for the manufacturing of aerospace parts for major companies.

In rapidly innovating medical industries, the utilization of additive manufacturing products is of great advantage for doctors, patients and research institutions. Through functional prototype design provided by additive manufacturing technologies, it has been of great advantage to create a flexible design of various design lifesaving tools needed for surgical and study purposes, tools used in the dental procedure, pre-surgery models for CT scans, custom saw and drill guides, enclosure and specialized instrumentation.

**Easy customization and bulk production using additive manufacturing**

Additive manufacturing customization, unlike traditional manufacturing, doesn’t add additional cost for customization and doesn’t require any certain mold or tools for the design it just needs a prototype 3D design and can be created by the customer itself because of the easy customization and fast production there is high demand, and we can mass produce any unique design without hampering the cost and time when making use of the 3D printers. Not only does it provide mass customized production, but it also gives the consumer a unique buyer and consumer experience where it gives them the feeling of belongingness and consumer satisfaction compared to the counterpart who doesn’t provide personalized design. It also allows the consumer to buy the design of their choice. For example, NIKE, a shoe manufacturer, sells shoes on their website with a 3D design where the consumer can add their colour choice on their own without much hesitation. This will add an advantage to market competition since, through this system, it lets the manufacturer know their client.

**Rise in industrialization and advancement in 3D metal printing technology**

With the rise in industrialization, there is a huge demand for 3D metal printing products in industries like aerospace, automotive, health care and others industries. With the demand from various fields for parts in aerospace for their jets engine and other structural parts to customize parts in automotive industries to customize the design of shoes and other electronic gadgets, there is a demand for the rigorous development of 3D printing technologies, which will perform more efficiently and can produce the product at a much faster rate with more precision. So the demand for the advancement and convenience of additive manufacturing technologies lead to an increase in the demand for 3D metal printing technologies.

**Opportunities**

**Advancement in the healthcare sector**

In the medical field, every patient is unique, and therefore additive manufacturing has a high potential to be utilized for personalized and customized medical applications. The most common medical clinical used are personalized implants and medical model saws guides. In dental fields, additive manufacturing products are used in splints, orthodontic appliances, dental models and drill guides. However, additive manufacturing products are also used to make artificial tissues and organs, which can be used for study purposes in a research institute or in between doctor and patients consultation. The development of digitalizing medical imaging that digitalization allows for the reconstruction of 3D models from patients' anatomy. The typical workflow of the personalized medical device starts with imaging or capturing the patient’s geometry of the anatomy using computed 3D scanning methods. Such data can be utilized to print 3D models of a patient’s anatomy or can be used to create personalized devices or implants.

**Increasing government funding to promote additive manufacturing**

Additive manufacturing has immense potential to revolutionize the manufacturing and industrial production landscape through digital processes, communication and imaging. Additive manufacturing is a trending business that has high demand from various industries like aerospace, automotive, medical sector, electronics, fashion etc. seeing the potential possibility of this sector's contribution to the nation's economy, governments of different countries are coming up with a different strategy to support and promote this industry.

**Restraints/Challenges**

High costs of the equipment, machinery and lack of skilled professional

The benefits that additive manufacturing provides have opened wide horizons for creating absolutely any 3D shapes and components. But not every business does not have the capacity to affordably integrate this type of activity into their business processes. Some of the most common causes that hinder the future of additive manufacturing are the high cost of equipment and the lack of professionals in this industry.

The average price for additive manufacturing equipment is between USD 300,000 to USD 1.5 million. The industrial consumables cost varies from USD 100 to USD 150 per piece. Although, the final price depends on the chosen material, such as plastic, which is considered the most budget-friendly option among all other materials available. The time required is also quite high as it takes more than an hour to print a 40cm object.

**Lack of software efficiency**

Additive manufacturing using the laser powder-bed fusion (PBF) process has the ability to build complex and intricate shapes along with organic structures which were previously too expensive or complex to make using traditional manufacturing operations. For example, the design freedoms achieved by laser PBF could be exploited for lightweight components to build the most intricate lattice structures for more efficient material usage. But, laser PBF has its disadvantages. It includes thin-walled/high-aspect-ratio parts that might fail during a build, difficult-to-remove support structures, layering effects on surface roughness and different process parameter settings such as laser settings for up-skin versus down-skin surfaces.

**Additive Manufacturing Market Analysis and Size**

The additive manufacturing market is concerned with the design, production and distribution of yarn, cloth, clothing and garments. The raw material may be metal, plastics, alloys and ceramic. The additive manufacturing industries contribute significantly to the national economy of many countries. Growing demand for lightweight components from the automotive and aerospace categories and advancement in 3D metal printing technologies has highly increased the demand in the global additive manufacturing market.

The global additive manufacturing market report provides details of market share, new developments, and the impact of domestic and localized market players, analyses opportunities in terms of emerging revenue pockets, changes in market regulations, products approvals, strategic decisions, product launches, geographic expansions, and technological innovations in the market. To understand the analysis and the market scenario, contact us for an Analyst Brief. Our team will help you create a revenue-impact solution to achieve your desired goal.

The global additive manufacturing market is expected to gain significant growth in the forecast period of 2023 to 2030. Data Bridge Market Research analyses that the market is growing with a CAGR of 20.9% in the forecast period of 2023 to 2030 and is expected to reach USD 91,853.88 million by 2030. The major factor driving the growth of the additive manufacturing market is the increasing demand for lightweight components from the automotive and aerospace industries.

**Advantages offered by additive manufacturing in various end-user industries**

Industries like aerospace were some of the industries that used additive manufacturing products for their performance, and aeroplane parts are used by additive manufacturing products that are lightweight and can withstand harsh environmental conditions, due to less material required and by the process of forming materials layers by layers, aerospace industries utilize it as the advantage for weight reduction and waste reduction, which are very important for the manufacturing of aerospace parts for major companies.

In rapidly innovating medical industries, the utilization of additive manufacturing products is of great advantage for doctors, patients and research institutions. Through functional prototype design provided by additive manufacturing technologies, it has been of great advantage to create a flexible design of various design lifesaving tools needed for surgical and study purposes, tools used in the dental procedure, pre-surgery models for CT scans, custom saw and drill guides, enclosure and specialized instrumentation.

Easy customization and bulk production using additive manufacturing

Additive manufacturing customization, unlike traditional manufacturing, doesn’t add additional cost for customization and doesn’t require any certain mold or tools for the design it just needs a prototype 3D design and can be created by the customer itself because of the easy customization and fast production there is high demand, and we can mass produce any unique design without hampering the cost and time when making use of the 3D printers. Not only does it provide mass customized production, but it also gives the consumer a unique buyer and consumer experience where it gives them the feeling of belongingness and consumer satisfaction compared to the counterpart who doesn’t provide personalized design. It also allows the consumer to buy the design of their choice. For example, NIKE, a shoe manufacturer, sells shoes on their website with a 3D design where the consumer can add their colour choice on their own without much hesitation. This will add an advantage to market competition since, through this system, it lets the manufacturer know their client.

**Rise in industrialization and advancement in 3D metal printing technology**

With the rise in industrialization, there is a huge demand for 3D metal printing products in industries like aerospace, automotive, health care and others industries. With the demand from various fields for parts in aerospace for their jets engine and other structural parts to customize parts in automotive industries to customize the design of shoes and other electronic gadgets, there is a demand for the rigorous development of 3D printing technologies, which will perform more efficiently and can produce the product at a much faster rate with more precision. So the demand for the advancement and convenience of additive manufacturing technologies lead to an increase in the demand for 3D metal printing technologies.

**Advancement in the healthcare sector**

In the medical field, every patient is unique, and therefore additive manufacturing has a high potential to be utilized for personalized and customized medical applications. The most common medical clinical used are personalized implants and medical model saws guides. In dental fields, additive manufacturing products are used in splints, orthodontic appliances, dental models and drill guides. However, additive manufacturing products are also used to make artificial tissues and organs, which can be used for study purposes in a research institute or in between doctor and patients consultation. The development of digitalizing medical imaging that digitalization allows for the reconstruction of 3D models from patients' anatomy. The typical workflow of the personalized medical device starts with imaging or capturing the patient’s geometry of the anatomy using computed 3D scanning methods. Such data can be utilized to print 3D models of a patient’s anatomy or can be used to create personalized devices or implants.

**Increasing government funding to promote additive manufacturing**

Additive manufacturing has immense potential to revolutionize the manufacturing and industrial production landscape through digital processes, communication and imaging. Additive manufacturing is a trending business that has high demand from various industries like aerospace, automotive, medical sector, electronics, fashion etc. seeing the potential possibility of this sector's contribution to the nation's economy, governments of different countries are coming up with a different strategy to support and promote this industry.

**Restraints/Challenges**

High costs of the equipment, machinery and lack of skilled professional

The benefits that additive manufacturing provides have opened wide horizons for creating absolutely any 3D shapes and components. But not every business does not have the capacity to affordably integrate this type of activity into their business processes. Some of the most common causes that hinder the future of additive manufacturing are the high cost of equipment and the lack of professionals in this industry.

* Conclusion:

Three-dimensional printing transforms 3D manufacturing into simple 2D superposition, which greatly reduces the complexity of design and manufacturing; however, simultaneously, there will be many defects that affect the performance of products. First, the layer-by-layer superposition principle leads to anisotropy, which leads to different mechanical properties in different directions and restricts the long-term use of intraoral instruments such as occlusal splints. Second, the existence of layer thickness affects the consistency from the digital model to the entity, which makes the surface of the equipment with high surface smoothness requirements, such as ceramic restoration, non ideal. Future research should focus on reducing the negative impact of the 3D printing principle. It is also important to note that 3D printing requires a combination of digital file acquisition equipment and CAD software. The high cost of the equipment makes the popularisation of 3D printing a challenge. In contrast, although current 3D printers can print out models in a relatively short period, acquiring digital files takes longer; therefore, 3D printing is not currently applicable to emergency cases. In addition, the accuracy of the printed models is somewhat reduced compared to that of digital files. Additionally, there are some challenges, such as high process, material cost, and time-consuming postprocessing. The lack of well-trained operators may also hinder the application of 3D printing in medical treatment. Moreover, 3D printing technology is suitable for many fields, and most of the machines currently used are not customised for dentistry, which causes some functions to be unsuitable to medical staff. Owing to these drawbacks, 3D printing is still at a competitive disadvantage compared to traditional methods for manufacturing products in bulk. Therefore, 3D printing technology in dentistry should aim to reduce the cost and production time, optimise the surface quality, and improve the process reliability and performance gradient in materials. We anticipate that the use of 3D printers in dentistry will become more specialised and sophisticated in the future. In the future, new materials and technologies that fulfil dental requirements should be further developed and applied. For example, the Co-Cr alloy material used in the restoration is one of the application materials for DMLS; however, its properties should be further studied to ensure the safety and applicability of the restoration . In addition, in clinical applications, 3D scanners, CBCT, and CT will be better integrated with 3D printing technologies based on their advantages, which will further promote the development of the digital process, not only simplifying the traditional modelling and production process, but can also make the products more accurate, streamlining the production process and lowering the labour cost . In recent years, 3D printing has progressed toward the cellular level, and 3D bioprinting provides unlimited possibilities for the creation of various tissues. The application of 3D printing in oral soft tissue biomaterials has been reflected from experimental to clinical . For example, Nesic et al. described the potential of stem cells, 3D bioprinting, gene therapy, and layered bionic technology, which can be used to regenerate periodontal tissue . To improve the whole CAD/CAM process, machine learning (ML) has been applied to all aspects of the technology . The application of ML algorithms covers all the main aspects that directly affect the quality of the final 3D printed parts, including 3D printing design and other aspects related to the efficiency of the design and manufacturing process . In the near future, ML will be more widely used in the field of 3D printing. Additionally, virtual reality design can interact with 3D printing technologies in the field of dentistry. For example, individuals can directly perform the 3D design of the restoration in the virtual world and observe the 3D restoration products to better estimate the feasibility of the products and reduce the wastage of time and resources. In summary, we anticipate that 3D printing technology will have a bright future.