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Role of Additive Manufacturing in Industry 4.0

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ABSTRACT: Industry 4.0, synonymous with smart manufacturing, represents the digital transformation of the industry, enabling real-time decision making, increased productivity and agility. In this new generation the usage of cutting-edge talents of Additive Manufacturing in the context of data generation integration performs a critical function in commercial financial competitiveness. This quick evaluation affords fundamental information of the function of 3DP generation with inside the Industry 4.0.

Due its versatility the Additive Manufacturing performs a key-function with inside the Industry 4.0, saving time and costs, being decisive for system performance and lowering its complexity, making an allowance for fast prototyping and noticeably decentralized manufacturing methods. Currently, an increasing number of commercial segments are adopting AM. The smart factories of the modern era have all methods interconnected via way of means of the Internet of Things, incorporating more flexibility and individualization of producing methods.

I. INTRODUCTION

Additive Manufacturing technology offers the possibility to manufacture customer-specific products by reducing development costs, lead times, manufacturing energy consumption, and material waste.

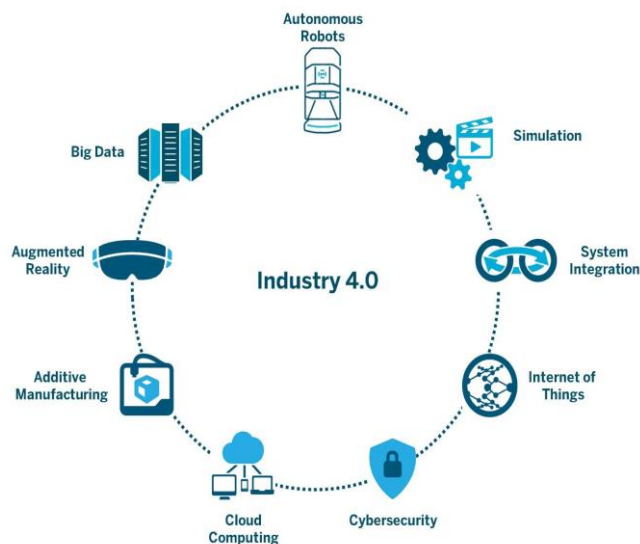


Fig.1.Industry4.0 techniques



Can be used to manufacture complex parts, allowing manufacturers to reduce inventory, manufacture products on demand, create smaller localized manufacturing environments, while reducing cost and time inefficiencies.

Alongside robotics and intelligent systems, additive manufacturing, or 3D printing, may be a key technology driving Industry 4.0. Additive manufacturing works by using digital 3D models to make parts with a 3D printer layer by layer. 3DPrinting is a vital technology that can provide enormous solutions for manufacturing complex products or a new prototype. AM allows that parts can be stored as design STL files and whenever it is requirement rises we can start production.

II. SECTORS USING AM TECHNIQUES

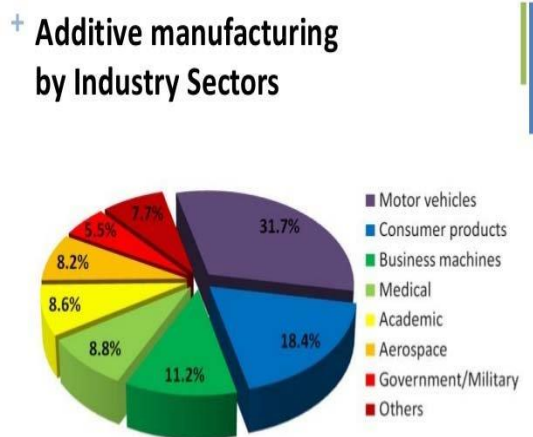


Fig.2.Global industries using Additive Manufacturing

2.1. Electronic product

Electronic products are a large-volume manufacturing industry. Since electronic products manufactured by AM are only suitable for small-batch prototyping, their popularity in electronic products is relatively slow. The demand for 3D printed electronic products comes from many application areas, such as conventional and special circuit boards, high-frequency antennas for satellite communications, anechoic chambers and mobile phones.

2.2. Government/military

The revised FDI regulations now allow 74% of foreign investment to enter the defense sector through automatic channels and 100% through government-approved channels. This will provide an incredible impetus for private companies to obtain advanced 3-D technology from foreign OEMs. The new offset guidelines also extend the technology transfer multiplier to private companies/DPSU/DRDO and OFB to further gain access to niche AM technology.

Strengthen India's defense forces. In addition, the 2020 national defense procurement policy promotes local design capabilities and higher localization

2.3. Automotive sector

The Indian auto sector accounted for 7.5% 40 of GDP in FY19 and has been at the forefront of AM adoption. AM technologies can be used to reduce dependence on imports by increasing the profitability of manufacturing in India. Manufacturing tooling and spare parts on demand significantly reduces inventory costs. Fast set-ups also help reduce the redundancy of the traditional manufacturing process, saving time and money. Indian manufacturer Ashok Leyland saved Rs 74 million in manufacturing costs and 14,138 watch days thanks to Stratasys additive manufacturing technology.



2.4. Medical equipment

This sector can benefit from lower production costs through AM adoption as it allows for shorter supply chains due to lack of tools, reduced inventory, supplier consolidation and less waste. This, in turn, can lead to lower health care costs, making such services cheaper and more accessible.

2.5. Capital Goods

Some products are produced in India by the capital sector such as mining and excavation machinery, textile machinery, heavy electrical equipment, machine tools, construction machinery, machinery. food processing, etc.

2.6. Goods for Consumers

Consumer goods are extremely price sensitive, and they rely heavily on imports to meet rising domestic demand. Furniture, office supplies, toys, figurines, art, jewellery, museum displays, musical instruments, and fashion products are among the commodities sold in this industry.

2.7. Architecture and Construction

Additive Manufacturing technologies have been primarily used in developing housing fabrication, construction components (cladding and structural panels and columns), bridges and civil infrastructure, artificial reefs, follies, and sculptures.

Innovative technology developed by IIT Madras and an Indian startup allows for concrete to set in 3-5 hours as opposed to the traditional timeline of 28-30 days taken for curing. Therefore, AM is a promising technology for reducing time and costs of construction

III. ADAPTING THE AM

The AM cost curve remains flat regardless of production volume, but traditional manufacturing costs for parts start very high and decrease exponentially as production volume increases. At some point, the two lines intersect to break-even. If you are producing less than that number, AM is the best choice. If you are producing more, stick to traditional manufacturing. There are many assumptions and even some errors in such a graph (for example, the AM cost curve is not exactly flat as usually shown), but the cost curve has one simple point. It is intended to explain. A tool used to create parts in AM.

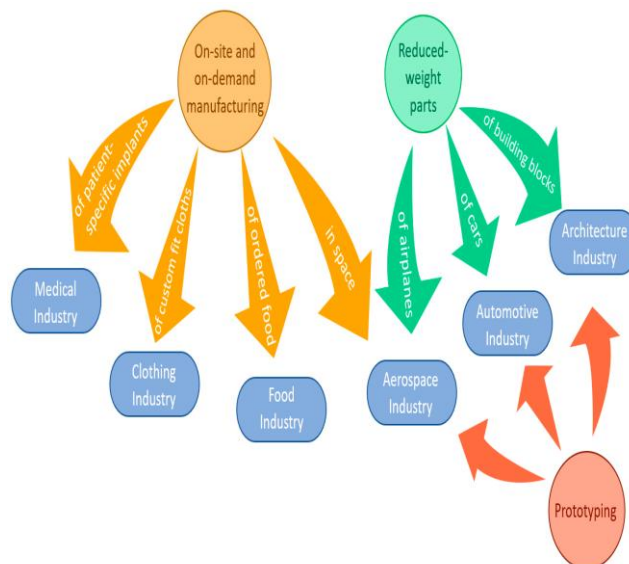


Fig.3..Key impacts of AM in various industries

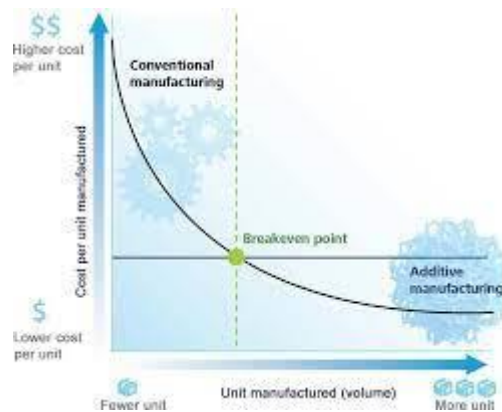


Fig.4.BEP of AM implementation

With AM, you can easily print on demand without the need for expensive manufacturing jigs, fixtures, or tools. However, in traditional manufacturing processes such as injection molding, complex shapes and tools with complex shapes can easily cost hundreds of thousands of dollars. In this case, the production quantity should be in the range of hundreds of thousands or more. If not, the production cost per unit is too high.

The advantage is that you do not need to create tools, special equipment, or equipment for laminating parts. In some cases, the economy changes enough to achieve small lot production or custom production in many situations. For example, Invisalign manufactures approximately 40,000 additional molds per day to create custom aligners for orthodontic patients.

HP claims that the break-even point for the new Multijet fusion printer is 110,000 parts, as it costs 65% less per part than other AM schemes. It is only a matter of time before starting with comparable numbers for AM metal parts, and it is not possible to emphasize how important it is for traditional manufacturers to understand both cost curves and monitor AM.

Low material prices, negligible tooling expenses and quick turnaround times due to little setup are all advantages of additive manufacturing.

The only preparation required for additive manufacturing is to load a 3D model into the machine's software and start printing. The time it takes to set up the machinery is quite short, as is the time it takes to set up the materials. As a result, additive manufacturing saves time and money during the manufacturing setup step, particularly in the case of part changes with no change in setup costs. Furthermore, the capabilities of additive manufacturing are not limited by design constraints. Which factors, in the context of design, are most likely to influence the cost of additive manufacturing?

IV. PROCESSES INVOLVED IN AM.

4.1. Design

The process of Additive Manufacturing starts with a computer programme that creates a digital model for prototyping a real thing, a process known as Computer Aided Design. Reverse engineering with a 3D scanner can also be used to produce a digital model.

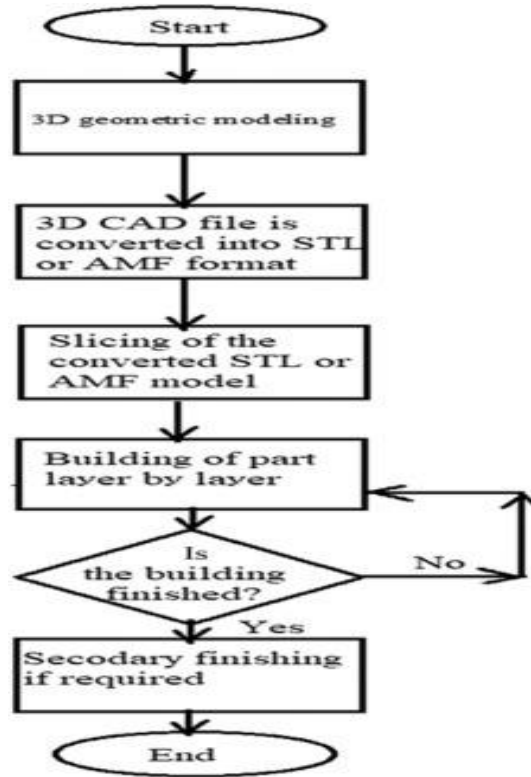


Fig.5...Process flow chart of AM

4.2 Converting design into STL File

The stereo lithography file is created from the digital model (STL). The model is then given to a slicer program/ Computer Aided Manufacturing software, which breaks it down into a set of polygons that represent the object’s surfaces (CAM).

CAM turns the STL file into G Code, a numerical control (NC) computer language that allows it to connect directly with the machine.

4.3. Printing

The ASTM catalogued Additive Manufacturing processes are divided into seven categories, each with its own set of materials and laser-based technologies to enable it.

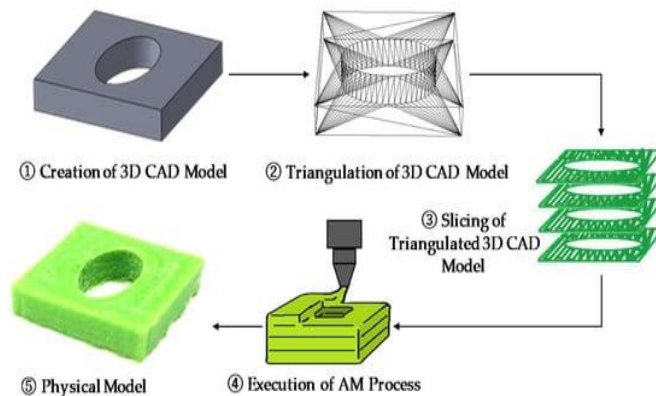


Fig.6.Process flow of AM



The next step in additive manufacturing is that the processing of the part. in comparison to injection molding, additive manufacturing has the disadvantage in time interval . Injection molding has incredibly quick processing times. Comparatively the processing time for AM is more than injection molding Subtractive manufacturing and additive manufacturing both have moderate processing times, but often additive manufacturing gains its advantage over subtractive manufacturing when geometry complexity is in question.

4.4. Post-processing:

Post-processing is the final manufacturing step that an item will go through. Because this procedure might differ from one technology to the next, it's critical to grasp the distinctions between each manufacturing method. Post-processing for injection molding could involve things like flash trimming. Post-processing in subtractive manufacturing could involve operations like grinding and polishing. Post-processing for additive manufacturing varies greatly depending on the type of additive manufacturing employed. In DLP post processing is must to washout the remaining resin. In addition, materials must be cured, either thermally or via UV radiation, to set their final mechanical properties.

V. TYPES OF ADDITIVE MANUFACTURING

1. Binder jetting.
2. Directed Energy Deposition.
3. Powder Bed Fusion.
4. Sheet Lamination.
5. Material Extrusion.
6. Material Jetting.
7. Vat Photo Polymerization.

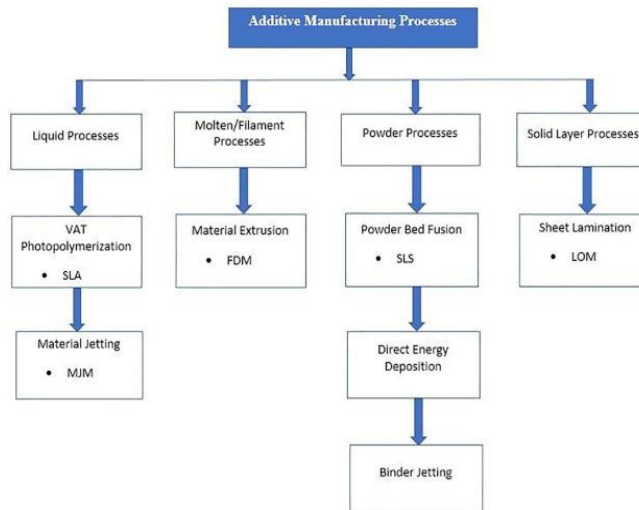


Fig.7..Evolution of Polymer

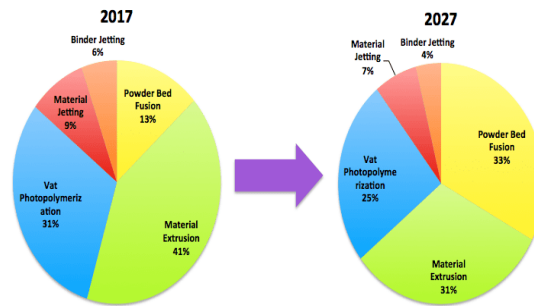


VI. STEPS TAKEN TO DEVELOP ADDITIVE MANUFACTURING IN INDIA

6.1. Government led efforts:

Establishment of 3D printing Manufacturing Lab at National Institute of Electronics & Information Technology, Aurangabad. The Institute also offers a certificate course in 3D Printing.

Evolution of Polymer 3D Printing Hardware Revenues from Use in Professional Environments
2017 vs. 2027, by Polymer Print Technology Group



Source: SmarTech Publishing, Additive Manufacturing with Polymers and Plastics 2018

Fig.8. Various AM processes

6.2. Atal Innovation Mission: Under the aegis of Atal Innovation Mission, Atal Tinkering Labs, 1200-1500 square feet dedicated innovation workspaces have been set up, where do-it-yourself (DIY) kits on latest technologies like 3D Printers, Robotics, Internet of Things (IOT), Miniaturized electronics are installed through government financial support Rs 20 Lakhs so that students from Grade VI to Grade XII can tinker with these technologies and learn to create innovative solutions. As part of the programme, some initiatives such as 3D design challenges were also launched.

7.3. The Gujarat government has signed an MoU with the US Institute of 3D Technology (USI3DT) in California, and OEM 3D systems (a leading global 3D printing companies) for establishing

India’s current potential for additive manufacturing is only 1.3%, close to US\$200 million. We expect a compound annual growth rate of 22% in the next five years. First of all, the idea of additive manufacturing starts at the design stage. AM provides flexibility in designing products and is not limited by traditional manufacturing techniques. This helps manage excessive waste of scarce materials and gives you complete freedom to think and innovate.

AM also acts as an insurance for new conceptual ideas. It accelerates time to market for new products. This is why rapid prototyping with AM is also important. This is not to say that AM will always be more profitable than traditional manufacturing. There should be a Break-Even Point is to be found between innovative design thinking, weight reduction applications, small or mass production, productivity optimization, proof of concept, and more.

VII. AM ROLE IN SME’S

In addition, SMEs should consider investing in AM technology, which will pay off in the long run. This will help them identify design and functional defects of the product earlier in the design cycle and increase product design innovation.

While the initial investment may be a challenge for them, they have access to engineering clusters, 3D printing service providers and offices that can help them realize the benefits of AM.

But in the long run, having their own 3D printer will give them a better ROI if their 3D printing needs increase in the future. In addition, regular seminars and roadshows provide small and medium-sized businesses with a clear understanding of the true potential of AM technology.

Inviting SMEs participate in AM webinars leads to a better understanding of AM and its applications.



VIII. OBSTACLES TO ADOPTION

8.1 Material and Equipment Costs

Because India's AM technology is still in its early stages, equipment and material prices are considerable. When compared to alternative production techniques such as CNC machining and injection moulding, most industrial-grade AM machines and raw ingredients are pricey.

8.2 Absence of formal AM Guidelines Standardization of materials, machines, and procedures would ensure the quality and performance of AM-manufactured components, boosting confidence in the technology and encouraging its adoption.

8.3 Inadequate AM Ecosystem

To deliver comprehensive AM solutions, the AM ecosystem must grow by bringing all service providers together on a single platform.

8.4. Lack of skilled workforce

Lack of qualified and experienced engineers and designers is a key constraint to the adoption and improvement of AM

8.5. Transition to the Domestic Market Because AM adoption reduces physical production footprints, it may free up vast amounts of industrial space and render traditional manufacturing equipment obsolete, raising problems about how to repurpose, recycle, or dispose of this infrastructural product.

8.6. Foreign OEMs have a monopoly on the AM market.

Most of the AM Original Equipment Manufacturers (OEM) are foreign companies. This has created a monopolistic approach towards consumables, which are therefore very expensive and thus hamper the adoption of AM technology, design, and supply chains, which further result those service companies out of business.

These transition issues discourage manufacturers from embracing AM on a larger scale though potential benefits in terms of cost, time and energy savings are known.

IX. CONCLUSION

To position itself as a pioneer in Industry 4.0 India must adopt AM technologies altogether manufacturing segments including defence and public sectors.

The National Strategy on AM should aspire to make a conducive ecosystem for design, development, and deployment of those technologies to grow among other Industry 4.0 techniques.

9.1. National Level Additive Manufacturing & Research centre- Sources said that National centre for additive Manufacturing will be setup in Hyderabad 2021.

9.2. Industry – Institution Collaboration

Industry should be encouraged to open AM centers at academic institutes for proliferation of different AM technologies and development of skilled manpower.

Financial support could also be extended through Government and industrial funding via academic institutions.

9.3. Skilling & Up skilling

Industry driven apprenticeship programmes should aim to inculcate the knowledge, skills and behavior required for specific job roles, to operate in an end to end additive manufacturing production environment.

9.4. Standardizing of Processes

9.5. Materials and software's for AM

9.6. Legal Framework and Certification



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