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Additive Manufacturing in the Automotive Industry

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Abstract –*In this paper, discussion executed on Additive Manufacturing which seen as being one of the important revolutionary industrial processes of the subsequent few years especially in Automotive sector. Additive Manufacturing (AM) also regarded as 3D printing, is a rising technological know-how which has a potential to limit environmental impacts in the manufacturing industry. Additive manufacturing is the solution which enables the flexible production of customized products without significant impact on costs and lead time and fabricating complex lightweight structures which at the same time possess good rigidity. In This Paper mainly the rise of additive manufacturing in the automotive sector is discuss. This paper list the procedure of additive manufacturing in automotive sector which follows the industries to produce various parts. This paper focuses on the current and the future scenario of 3D printing in Automobiles Industry. AM Materials suited for automotive applications also discussed in this paper. Leading automotive manufacturers are already undergoing in expanding prototyping and test part production with 3D printing .At last, Challenges faced by automotive sector in Additive Manufacturing is elaborated.*

Keywords: Additive manufacturing, 3D printing, Automotive industry, Rapid Prototyping, AM Materials, CAD.

1. INTRODUCTION

Additive Manufacturing gives a new strategy to the modern challenges going through the automobile industry. It gives design freedom while permitting the advent of complex yet light-weight components. Additive manufacturing is a disruptive and rapidly-growing technological that permits designers to put together or rapid prototypes as nicely as complicated designs, which in any other case would not have been possible through legacy subtractive manufacturing processes. This technology is additionally used for testing, manufacturing, and assembling automotive components and factors with greater efficiency, optimization, and cost-efficiency.

For instance, 3D printing in the car area has helped producers in minimize the price of product enhancement however in the aerospace industry, it allowed air airplane makers to assemble lighter planes.The automobile industry has experienced an unprecedented, enterprise broad adoption of 3D printing as a manufacturing method on the grounds that it's early days. It is no shock that automobile producers are among one of the most engaged to discover new features and beautify the technological know-how further. With additive, automobile producers can expand the effectivity of their look up and development, enabling them to get their vehicles to market quickly. Using the Rapid Prototyping gadget nearly any form can be produced. Time and money savings vary from 50–90% compared to traditional systems (1). AM presents most design freedom while permitting the introduction of complex but mild elements with excessive tiers of rigidity. Additive Manufacturing permits the production of components with integrated functionality - except the want for tools, thereby reducing improvement and production costs.(2)

1.1 What is Additive Manufacturing?

Additive manufacturing, additionally regarded as 3D printing, is a transformative method to industrial production that lets in the introduction of lighter, most effective parts and systems. AM refers to a system by way of which digital 3D design information is used to build up a aspect in layers through depositing material. For example: as an alternative of milling a work piece from a solid block, AM builds up aspects layer via layer the use of materials which are on hand in fine powder form. A broad vary of unique metals, plastics and composite substances may be used (2). 3D printing can be used in a variety of methods to enhance product innovation. Primarily, additive manufacturing is used in prototyping in the car industry, referred to as rapid prototyping. (3). Currently, Additive manufacturing is at a peak that in reality appears to proceed growing. The kick-start of AM commenced a whole lot earlier, nearly forty years in the past in 1981, when Hideo Kodama of the Nagoya Municipal Industrial Research Institute, regarding the manufacturing of a stable printed model. (4). With its trending and unique high-quality it is now fascinating challenge subject for academician and scholars to research, explore and prolong the challenge of this non-conventional technological know-how of prototyping turning manufacturing tool.(5) .AM can produce aspects with fewer layout restrictions that often constrain greater normal manufacturing processes. This flexibility is extraordinarily beneficial while manufacturing products with customized features, making it feasible to add elevated functionalities such as built-in electrical wiring (through hole structures), decrease weight (through lattice structures), and complicated geometries that are no longer feasible via standard processes.(6)

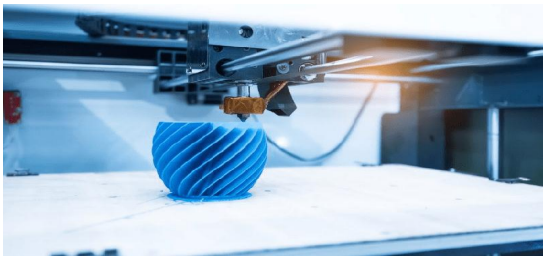

Fig -1: Additive Manufacturing

1.2. Rise of Automotive Additive Manufacturing

GLOBAL automobile manufacturing has excessive boundaries to entry, mainly at the top where the four biggest OEMs accounted for a 1/3 of the international enterprise income of over $2 trillion in 2013. On the different hand, the $1.5 trillion components and add-ons manufacturing area is characterized through excessive competition among a giant variety of smaller players.(6)

AM has the potential to revolutionize the automotive enterprise and the producers are presently exploring AM as part of their manufacturing procedure in two ways

1. **As a product innovation driver :**3-D printing allows automotive companies to experiment with prototypes at much quicker rate and produce a vast variety of prototypes, some of which are not entirely viable via the traditional manufacturing procedures. According to a research report by Deloitte, "Components that are produced by additive manufacturing has lesser design restrictions that frequently constrain more traditional manufacturing processes. This flexibility is extraordinarily beneficial while manufacturing products with custom features, making it viable to add some multiplied functionalities such as built-in electrical wiring, complicated geometries and lower weight. These products cannot be manufactured via traditional processes."(7)

2. **As a supply chain transformation driver:** Manufacturershave a possibility to produce some of the closing aspects used for its vehicles the use of additive manufacturing processes. This will enable the employer to limit typical time to market for its products. Furthermore, AM-manufactured light-weight elements can decrease handling costs, while on-demand and on-location manufacturing can decrease stock costs. For example, with additive manufacturing, Ford changed the normal system for creating a prototype of an engine manifold that would have fee $500k and 4 months to being in a position to advance multiple iterations of the component in just for days for a price of $3k .(2)Additive manufacturing enabled mass-customization and manageable to grow to be a key differentiator for predominant players in the automotive enterprise.(7).

Together, Supply chain transformation and Product Innovation have the capability to change the business models of Automobile companies.

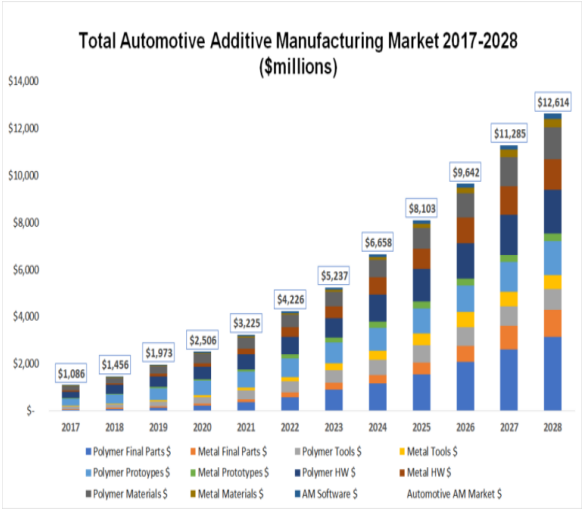

Fig -2: Rise ofAdditive Manufacturing

2. Procedure of Additive Manufacturing

1. **Computer Aided Design (CAD)** – Making a model i.e. digital is the initial step in the AM process. The mostly used method for producing a digital manufacturing is computer aided sketch (CAD). There are a giant vary of free and professional CAD programs i.e. AutoCAD, Solid works, Fusion360, that are well matched with additive manufacture. Reverse engineering can also be used to generate a digital model with the aid of 3D scanning and advance tools.

2. **STL conversion and file manipulation**: A most important stage in the AM is the requirement to convert a CAD model to STLwhich takes use of triangles (polygons) which indicates the object surface. Information on conversion of CAD model to an STL file can be seeing here. Once a STL file has been created then the file is taken into a slicer program, and finally STL file a converts it into G-code through this program. G-code is NC programming language.

3. **Printing**: 3D printing machines regularly comprise of many small and complex components therefore, proper maintenance and calibration is necessary to producing correct prints. At this stage, the print materials are also loaded into the printer. The raw materials used in additive manufacturing often have a restrained shelf lifestyles and require cautious handling. While some strategies offer the capacity to recycle extra construct material, repeated reuse can result in a

reduction in fabric properties if now not changed regularly.

4. **Removal of prints:** Print removal for some additive manufacturing technologies is as easy as isolating the printed parts from the construct platform. For other extra industrial 3D printing strategies the elimination of a print is an exceptionally technical system involving precise extraction of the print while it is still encased in the material or connected to the build plate.

5. **Post processing**: Post processing strategies again differ through printer technology. SLA requires a component to treatment under UV earlier than handling, metal parts frequently need to be stress relieved in an oven whilst FDM components can be handled right away. For technologies that make use of support, this is also eliminated at the post-processing stage. Most 3D printing materials are in a position to be sanded and different post-processing strategies consisting of tumbling, high-pressure air cleaning, polishing, and coloring are implemented to prepare a print for end use.(8)

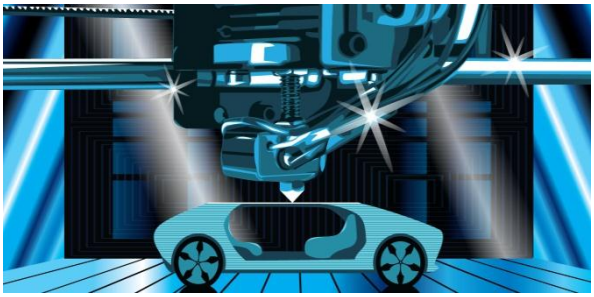

Fig -3: 3D Printing

3. Future Of AM In Automobiles

Although the automobile enterprise has been rapid to undertake AM and to use it in a range of applications, automobile industry future depends mainly on additive manufacturing .Here's some of the new ways that additive manufacturing is anticipated to be used in the very near future.

1. **Interior and seating** - Using polymers and the methods of selective laser sintering and stereo-lithography dashboards and seat frames should be manufactured.

2. **Tires, wheels and suspension** - Aluminium alloys and polymers can be manipulate with the resource of selective laser sintering, inkjet technology , selective laser melting to create suspension springs and tires .

3. **Electronics** - Selective laser sintering can used on polymers to producevary of refined elements together with components which have to be embedded, example single part manipulate panels and sensors.

4. **Framework and doors** - Selective laser melting used on metallic compounds such as aluminium alloys to produce physique panels, such as framework and doors and many other products.

5. **Engine components** - Various useful parts of the engine can be made from metals and its alloys such titanium and aluminium etc. , approves when strategies such as electron beam melting and selective laser melting are used.(1)

6. **Exterior**: Using selective laser sintering and polymers are presently used to produce wind breakers and bumpers.

Figure 2. Illustrative applications of AM in an automobile[35]

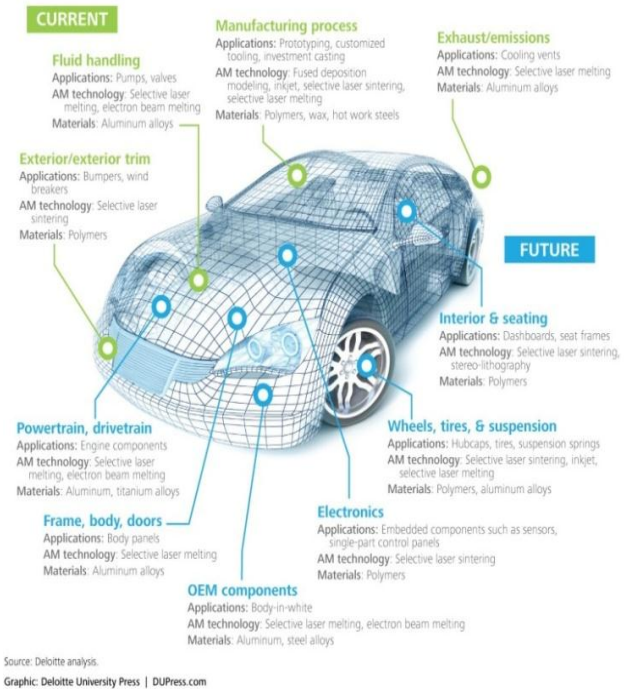

Fig -4: Applications of AM in Automobile Industry

3.1AM Materials Used In Automotive Applications

The table below presents a range of materials that are used in the automotive industry along with the associated application.(9)

Table -1: AM Materials used in Automotive

Application	Process	Material	Material
Interior accessories	SLA	Resin	Customized cosmetic components
Air ducts	SLS	Nylon	Flexible ducting and bellows
Full scale panels	Industrial SLA	Resin	Large parts with a surface finish comparable to injection molding that allow for sanding and painting
Under the hood	SLS	Nylon	Heat resistant functional parts
Bezels	Material jetting	Photopolymer	End use custom screen bezels
Complex metal components	DMLS	Metal	Consolidated, lightweight, functional metal parts

3.2 Current status of additive manufacturing in different industries

The most frequent uses of additive manufacturing in the automotive industry are nevertheless prototyping, jigs & fixtures and tools. However, the last two decades delivered a huge progress, and additive manufacturing in automobiles is increasing beyond these applications. Few examples from automobiles companies using additive manufacturing are:-

1. **Ford Motor Company:** It used to be returned in 1988; however a lot of growth has been made seeing that then. Ford had invested $45 million in its Advanced Manufacturing Center, devoted for developing and incorporating 3D printing and unique applied sciences to their manufacturing lines. Earlier this year, Ford Performance, which is the excessive basic performance division at Ford Motor Company, has printed what claimed to be the greatest 3D printed metallic auto section in history.(10)

2. **BMW:** BMW is one of the early adopters of additive manufacturing that has been experimenting with this science for a number of years. Since 2010, it had already crossed the one million 3D printed components mark. As for mass production, BMW is aiming for manufacturing of 50,000 aspects per year and 10,000 spare parts. BMW has proven various success memories in imposing printed metal parts to their vehicles. As for example, BMW chose to utilize 3D printing in the manufacturing of two parts of its i8 Roadster(10).

Fig -5: Additive Manufacturing in BMW

3. **Volkswagen:** It has been using in-house 3D printing for a number of years, putting in almost a hundred 3D printers in its factories to date. At Volkswagen, additive manufacturing main utility is for application like tooling, jigs & fixtures and prototyping. Almost all of its tooling manufacturing has been switched and is based totally nowadays on 3D Printing, saving the company hundreds of 1000$ each year since.(10)

4. **McLaren:** McLaren Racing and Stratasys team up to carry additive manufacturing to Formula 1. McLaren Racing will be receiving Stratasys latest Fused Deposition Modeling(FDM)- and Poly Jet-based 3D printing solutions and contemporary substances for visual and functional prototyping, personalized production parts and production tooling together with composite tooling, This will allow accelerated transport whilst increasing

performance and productiveness in McLaren's design and manufacturing operations.(11)

Fig -6: McLaren Racing Car made via AM

4. Advantages Of Additive Manufacturing

1. **Quicker And Proximity to Market:** The longer the product stays in design cycle, the lesser is the profit to the company. Hence fast production units are required which also produce tools with precise measurement. Thus 3D printers can supply such a fast rate of production to the companies.

2. **Cost Saving efficient and Economical**. In 3D printers, mostly ABS plastic is used as a working material which reduces the cost of production to an amazing extent and also saves the raw materials which would be used in traditional method.

3. **Increased Data Security**. Having a 3D printer at home eliminates any worry about the misuse of the confidential STL archives which can then be safely sent to the vendor.

4. **More Rigorous Product Testing**. Basically 3D printers were used only for printing models of the real objects which were much stronger and do not contract or absorb moisture.

5. **Early Feedback identifies design flaws, defects and Discontinuities**. As the output generated by using the CAD software is very quick therefore it gives sufficient time to the user to identify any flaw if observed in the design.

6. **Early Changes Saves Money**. The cost of production increases if the changes are made in the later phase of the process. Thus it is necessary to communicate and collaborate with each other to reduce the cost of production.(12)

Fig -7: Advantages of Additive Manufacturing

5. Challenges of AM in Automotive Industry

1. Lack of human capital: It takes time to teach humans in unique areas of layout and manufacturing required for this surprisingly new and swiftly evolving manufacturing method. For additive manufacturing to come to be a dependable and efficient method requires an navy of professional humans behind it skilled in CAD (Computer-aided design) skills, AM computing device making, maintenance, quality assurance, supply chain administration and fabric preparation. It is not just the lack of human capital on hand in this place that is challenging; what coaching there is accessible at this factor is not standardized, that means it is challenging to create a stable and capable workforce, according to a Deloitte University press study. Most training is unofficial and on the job; this will want to be formalized with committed talent development programmers if AM is to evolve into a stand alone profession

2. The gradual production times involved in additive manufacturing are hampering massive uptake of the manner in the car enterprise as traditional, mechanized methods proceed to outperform on pace and efficiency**.** Moreover, to spotlight the price of manufacturing globally, round three cars were made each and every second in 2013**.** Additive manufacturing, even if it's solely used for small components, in its current guise is potentially a full-size bottleneck in the manufacturing process**.** Robust funding in high-speed AM is a referred to location of research for academics, material scientists and business interests**.** Despite being a key focal point for lookup in latest years there has been limited growth on this front to date**.** For an industry pushed through volumes, the low-level manufacturing AM presently gives is no longer possible for usual business applications**.**(13)

3. Even if additive manufacturing considerably extended production velocity and upped its quantity output, it nevertheless cannot produce large single parts. This is some other key task going through AM researchers as they are looking for new methods to take advantage of

3D printing technology for car applications. The construct envelope for present day AM technologies is limited, that means even large elements that can be printed should nonetheless be assembled through mechanical joining or welding. Academia, government and industry are placing vast assets into overcoming this hurdle, with Department of Energy's Oak Ridge National Laboratory (ORNL) main lookup in conjunction with businesses along with Lockheed Martin and Cincinnati Inc. – on Big Area Additive Manufacturing (BAAM). Last year improvement work commenced on a machine that should print polymer aspects up to 10 times larger than modern structures are successful of and at speeds up to five hundred times quicker than current AM machines.

4. One of the biggest challenges with AM comes not from the capabilities of the manufacturing process, but from legal site. Product designs of AM can only be patented not copyrighted. The lack of clarity on patent protection and the limited ability to enforce it means the potential for producing components is sizable. One of the Research firm, has quantified the market for counter3D printed products in the car industry, indicate that it could be worth as much as $15 billion in 2016 due to intellectual property theft.

5. To produce single complex components -One of the key future objectives for additive manufacturing in the automobile industry is to include and consolidate many components. 3D printing will require the printers and printing processes to improve considerably. The increase in demand is already in growth although, a market lookup firm, forecasting the market for 3-D printers and services to develop globally from $2.5 billion in 2013 to $16.2 billion in 2018.

6. Printing in distinctive materials at the same time is one of the most interesting possible advantages of additive manufacturing; actually growing that capability will be one of the most substantial challenges. Multi-material printing abilities would open up new plan chances and assist create progressive cease products. Likewise the mission of embedding sensors, batteries, electronics and micro electromechanical systems (MEMS) at once into elements and components could revolutionize the manufacturing process. (13)

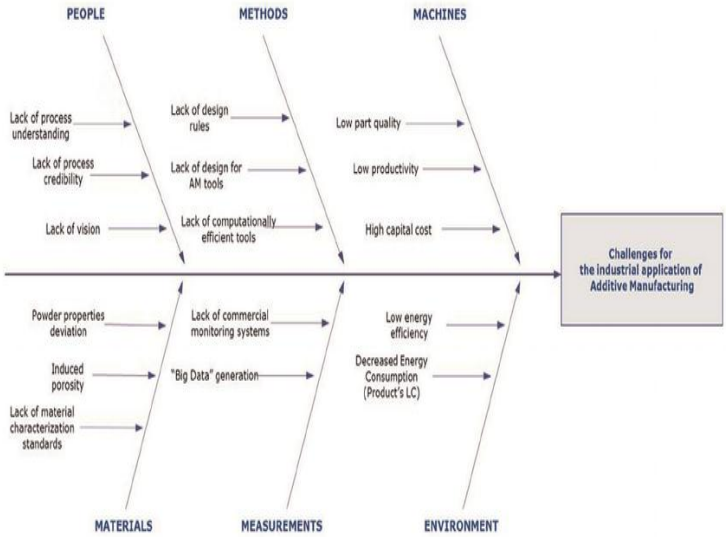

Fig -8: Challenges of Additive Manufacturing

6. CONCLUSIONS

This paper aimed to discuss the scenario of additive manufacturing in automobile industry. Additive Manufacturing is the future of Automobile Industry, as some of the examples are discuss in this paper. In AM, CAD software's can be used for optimizing the manufacturing process of automobiles in the automotive industry. Through the use of 3D technology, certain parts of vehicles such as the Framework and doors, engine components, exterior, dashboard components, among others, can be created with ease. Owing to its very few challenges when compared to the numerous advantages it offers, Additive Manufacturing can be considered a very effective technology.

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BIOGRAPHIES

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Born on 19 November 1998, he is a Third year student of Btech in Mechanical Engineering. He did his internship at Nrl Hyundai where he acquired knowledge about automotive parts and its manufacturing. He acquired the knowledge of 3D printing in Summer Camp (June, 2019) at Dayalbagh Educational Institute. His interest areas include Machine design, Manufacturing Process and Thermal Engineering.