Emergence of Additive Manufacturing in Automobile Sector

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Abstract— Additive manufacturing is the technology which is bringing a revolution in the manufacturing of any three dimensional object. Additive manufacturing is also known as 3D printing. 3D printing is a method of manufacturing things in which materials like metals and plastic are deposited to form a three dimensional object. Additive manufacturing or 3D printing presents a series of benefits for the manufacture of single automobile component or an entire vehicle while ensuring strong, suitable physical properties. In this paper a large number of research papers on additive manufacturing and automobile had been studied. 3D printing has the potential to enable mass customization of goods on a large scale, which is now a day's visible as many industries are working and producing a lot of goods from the three dimensional printing. Huge companies like Volvo, BMW, and Ford have used 3D printers for product development and rapid prototyping of their new and experimental car parts. It is the technology which is also rapidly emerging in the field of orthopedics, soft bones like cartilages and bone tissues can be obtained from this. In this research paper you will get to know about how additive manufacturing is emerging in the biggest sector of manufacturing such as an automobile industry.

Keywords: Additive Manufacturing (AM), Automotives, 3D Printing

I. Introduction

Additive manufacturing (AM) or 3D printing is the process of joining materials to create objects from a software better known as Computer Aided Design (CAD) model data, usually layer upon layer as opposition subtractive manufacturing methods. This tool-less manufacturing methods can produce fully dense metallic parts briefly time, with high precision. Basically, any material will be produced by one or another AM technique today. These materials are divided into four main categories: metals, plastics, composites, and ceramics. A CAD is formed and exported to stereo lithography (STL) file format that can be read by the AM equipment. There are many techniques available, which may be categorized in keeping with their material. They're powder-based, liquid-based and solid based. Some samples of powder-based techniques include selective laser melting (SLM), selective laser sintering (SLS), and beam melting (EBM). Liquid-based techniques include stereo lithography (SLA) and polyjet while solid-based techniques includes fused deposition modeling (FDM) and laminated object manufacturing (LOM). The foremost commonly used metals in the AM are steel and its alloys because of their availability, reasonable cost, and biocompatibility as bone and dental implants. Titanium and its alloys are very rarely used followed by copper, aluminium, nickel, magnesium, tungsten and cobalt-chrome. When it comes about the work of additive manufacturing in automobile sector all of their prototypes are made with the assistance of AM before manufacturing a component or a totally designed body. The applications of AM systems can also accustomed embed these wireless systems directly into the structure of a vehicle, like embedded sensors. Additive manufacturing within the industry enables the printing of electronics that link vehicle with a wireless network.

II. History

The kick-start of AM began much prior some might think, it was 1981 from now, 39 years back when the news came that a person registered information regarded the manufacturing of a solid printed model and he was Hideo Kodama of the Nagoya Municipal Industrial Research Institute. Some years later, stereo lithography (SLA) was patented by Charles Hull, creating models by curing a liquid photopolymer resin using UV lasers. Hull later commercialized the primary rapid prototyping system, greatly reducing the time for designers and engineers to form 3D concepts and prototypes. It wasn't until 1999 that scientists at the Wake Forest Institute were ready to utilize 3D printing technology for medical applications – printing the synthetic scaffolds needed to grow somebody's bladder. While I'm sure this can be the direction the technology will eventually head in, we aren't quite there yet. Within the current era of 3D printing, most of the printed organs are either non-functioning or they only survive some days the first 2000s,was an amazing time for additive technology, with advancements in printing that brought round the first commercially viable Selective Laser Sintering (SLS) machine, furthermore because the founding of Objet, which developed a machine that might mix multiple materials, allowing parts to be created with different material properties in numerous sections of the build. The decade's other biggest AM event was the launch of MakerBot, bringing desktop FDM printing to the masses and causing a large boom in 3D printing hobbyists. While accuracy and backbone have continued to boost, prices have fallen drastically when put next to the genesis of the technology.

III. Techniques, Process and Technologies

Additive manufacturing technologies provide us various materials with different perks such as flexibility, color, density, durability, texture, and tensile strength. AM technologies can print different prototype models of various parts and can design in any way. Various processes and materials that are used commonly in additive manufacturing technologies with their use in automobile sector are listed in Table 1.

S.no	AM techniques	Process	Materials	Automobile applications
1	Stereolithography (SLA)	It uses the application of ultraviolet laser inside a vat of resin	Acrylate photopolymer Plastic Glass Ceramic	SLA is employed to supply high detail, smooth, scale models of automotive designs.

2	Selective Laser Sintering (SLS)	Sintering is finished by the applying of CO2 laser. A fine thermoplastic powder like nylon or polycarbonate is accustomed form model layer by layer.	Ceramics Powder Plastics Thermoplastics Metal	It is often accustomed make semi-functional bellow pieces where some flexibility is required in assembly or mating.
3	Electron Beam Melting (EBM)	Powerful electron beam wont to built layer by layer metal powder by command of CAD model with exact geometry	Metal powder Titanium	It is commonly used for joining of automotive parts, as they'll perform processing with minimal distortion, contributing to a discount of production costs or a weight reduction of parts.
4	Direct Metal Laser Sintering (DMLS)	This technique is Just like SLS where the application of laser does sintering of metal powder	Titanium Cobalt Aluminum Bronze alloy Steel	It's working is same as SLS therefore it helps in manufacturing of semi-functional pieces.
5	Laminated Object Manufacturing (LOM)	3D model fabricated by adding layers of the defined sheet of materials	Metal Plastic Paper	It is employed to manufacture cable sleeve and it's a typical pressure die casting part employed in the automotive industry.
6	Fused Deposition Modeling (FDM)	The process is similar to extrusion, where a heated thermoplastic material is added layer by layer to fabricate a model.	Polycarbonate Acrylonitrile Butadiene Styrene (ABS) Polypropylene Wax Polyesters	FDM allows for geometric design freedom, while the layup of a material provide the strength and heat-resistivity necessary for this application.
7	Inkjet 3D Printing	Use different fluid fluids like polymer solution provided within the sort of liquid and deposited layer by layer to built a product.	Powder Liquid binder	These are wont to manufacture the logos employed by companies.
8	Polyjet 3D Printing	Production is completed through a UV curable acrylic plastic Uses various types of printing materials, and its post-processing stage is simple.	Photopolymers	Used for the rapid fabrication of structure models.
9	Masked Sterelithography (MSLA)	Masked Stereolithography utilizes an LED array as its source of illumination, shining UV light through an LCD screen displaying one layer slice as a mask.	Thermoplastic Powder	It is employed within the formation of nuts and bolts.
10	Drop On Demand (DOD)	DOD printers use a fly-cutter that skims the build area after each layer is formed, ensuring a superbly flat surface before commencing the following layer.	Sand Full-color sand Silica	It is employed for embedding design within the work piece.
11	Sand Binder Jetting (SBJ)	With Sand Binder Jetting devices, these are low-cost styles of 3D printing technology for producing parts from sand.	Sand Powder	Used within the creation of mould molds for manufacturing.
12	Metal Binder Jetting (MBJ)	Metal powder is bound employing a polymer binding agent. Producing metal objects using Binder Jetting allows for the assembly of complex geometries well beyond the capabilities of conventional manufacturing techniques.	Aluminum Stainless Steel Titanium	It is employed to style the faring and also the body.
13	Digital Light Processing (DLP)	These kind of 3D printing techniques are almost the identical as SLA. The key difference is that DLP uses a digital light projector screen to flash one image of every layer all at once.	Photopolymer Ceramics	It is employed for creating prototype models .
14	Color Jet Printing	Part is constructed by spreading	Gypsum	Used for producing dashboards

	(CJP)	material within the layer, over the build platform employing a roller. Printing head jets layer of binder on the fabric layer	powder Binder	and other internal parts.
15	Multi Jet Printing (MJP)	Nozzles are wont to spray binding of liquid onto metallic powder or ceramic to form a solid thin layer	Powder Plastics	It manufactures plastic parts and various prototypes are made of this.

Table 1: Additive manufacturing technologies techniques, process, materials and applications

IV. Benefits of AM in Automotive Sector

Additive manufacturing enables companies to make complex designs that need fewer parts to provide these components. Consequently, companies are ready to decrease the assembly time and also experience a discount in quality problems.

Various benefits of AM during this sector are as under:

- Differential car parts are developed with the assistance of additive manufacturing.
- A faster achievement of the series maturity is feasible.
- It has more flexibility.
- AM enables designers to develop completely new approaches in terms of design and performance.
- Manufacturer benefits from a shorter production time also as lower costs.
- Easy to provide fully functional prototypes.
- Conservation of resources.
- Faster availability and shorter build times.
- This process is simpler than reworking a factory to form a selected part.
- It could reduce the number of warehouse space needed to manufacture part.
- Lighter cars and better fuel efficiency.
- Fully automated and digitized manufacturing.

V. Present Day Evolution

At this time this industry is growing rapidly as manufacturing and repairing is easy with this. It's often bundled along with robotics, digitization and large data within the 'Industrie 4.0 or 'fourth industrial revolution' vision of the factory of the longer term. Such is that the power of the media's futuristic visions for the 3D printed future, the final public is unaware that 3D printing isn't new. The technology has existed for several decades — the primary commercial systems were on the market within the late 1980s.

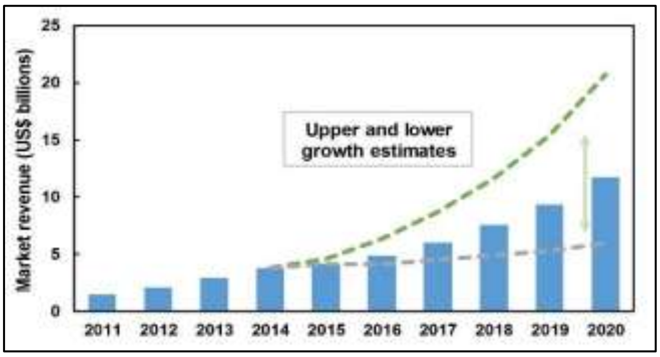

Fig. 1: Additive manufacturing evolution
(Source: researchgate.net)

The AM sector is now within the growth stage. Automotive industry stakeholders worldwide is now moving towards full industrialization, which leads to an era in which the machines going to make the whole process. Beginning with software and materials, passing through the particular AM hardware, and ending with services and a growing number of possible applications. 3D printing is thus well positioned to expand its use because the primary technology for automotive prototyping likewise as tooling, while also establishing a stronger than ever opportunity for serial and mass customized part production. This third dedicated study of automotive additive manufacturing expands coverage to contemplate the greater long run potential for additive manufacturing as a key production technology for the huge global automotive industry, paving the thanks to widespread acceptance of both polymer and metal AM technologies. Additive manufacturing is increasing rapidly not only in automotives rather in other sectors also this technology is usually employed in electronics and for consumer products so in automotives this shows that automotive may be a sector within which Additive Manufacturing is growing rapidly and this system is successful as we are able to see that the changes that additive manufacturing is bringing has no side effects. It's only a drawback that its production isn't up to the mark and as soon as it's production will increase automobile sector will become an industry within which Additive Manufacturing is employed the foremost. We all know that somewhere Aerospace is additionally an element of Automotives which makes automobile sector largest user of this technology. This technology is additionally emerging in orthopaedics by which surgeons can save their time in surgeries and that they may also formation of bones with this technologies.

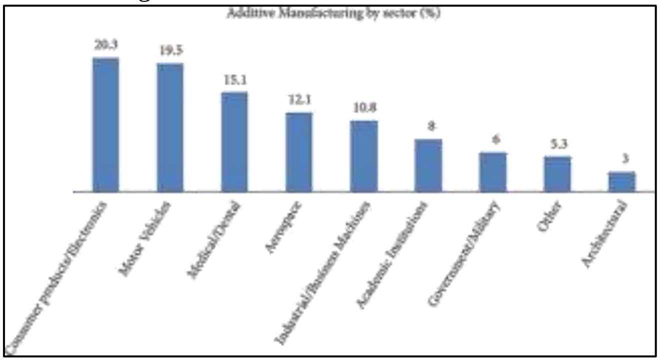

Fig. 2: Additive manufacturing applications in various sector
(Source: ScienceDirect.com)

While the technology remains new and, in many cases, niche, composite 3D printing has the potential to grow into a bigger, more profitable market. It was noted by many experts that there was a small decrease in the sales of metal 3D printer in 2019, due to the slowdown of fragile manufacturing sector and sluggish Asian and European economies.

SOFTWARE	FUNCTION	LEVEL	SYSTEM

VI. WORKING OF A 3D PRINTER

The working is involved in three steps which are under as:
The first step involves the preparation just before printing, after you design a 3D file of anything you would like to print. This 3D file may be created using CAD software, with a 3D scanner or just downloaded from an internet marketplace. Once you have got to check that your 3D file is prepared to be printed, you'll be able to proceed to the second step.

The second step is that the actual writing. First, you wish to settle on which material will best achieve the particular properties required for your object. The variability of materials utilized in 3D printing is extremely broad. It puts in ceramics, resins, plastics, metals, textiles, sand, biomaterials, food, glass and even lunar dust. Most of those materials also allow lots of finishing options that enable you to attain the precise design result you had in mind, and a few others, like glass for instance, are still being developed as 3D printing material and not easily accessible yet.
The third step is that the finishing process. This step requires specific skills and materials. When the article is first printed, often it cannot be directly used or delivered until it's been sanded, lacquered or painted to finish it as intended.

VII. MICROCONTROLLERS IN AM

The use of microcontrollers in 3D Printers has allowed for a large, diverse ecosystem to grow overnight. Here are the five best microcontrollers used in 3D printers.

A. ARDUINOS

ARDUINOS These machines either had Arduino boards like early automakers and also the Mega 1280 and 2560 boards or they used a custom board, with Arduino parts. If a developer knew a way to code for an Arduino, they may work on a 3D printer. This immediately created an enormous pool of developer to fuel the 3D printing fire. It also meant if you wanted to feature support for a replacement feature, it had been just a matter of tweaking the open source firmware and uploading it. after you outgrew that first microcontroller, it absolutely was just a matter of shopping for a much better one.

B. RAMBO

The 3D printer market, emerging rapidly with the introduction of two electronics boards; RAMPS and the Arduino Mega 2560. Rambo, consolidates the 2 boards into one and integrates all of the required components and materials for printing.

C. Smoothieboard from Uberclock

The smoothieboard was among the primary 32 bit controller boards to hit the market. This is often moreover important as 8 bit boards can be operated into trouble maintaining with the most complex computations required for dual extrusion or delta geometries. Just like the Rambo, Smoothieboard has all of the required components onboard including A4982 stepper drivers.

D. AZTEEG X3 and X5

Only two azteeg boards are manufactured by Pancuatt devices, the x3 that needs an 8 bit Atmega processor, and x5 that needs a 32 bit ARM processor. Our main focus is the Azteeg x3, which consists of 4 SureStepr SD8825 onboard and capable of up to 1/128 microstepping, also a beefy heatsink to confirm that the components remain cool.

E. DUET

The Duet is quickly becoming one among the foremost popular boards on the market with a 32 bit processor and also the capacity for a powerful 1/256 microstepping. It evolved from an earlier popular combination of a RDDS board atop an Arduino Due.

VIII. CHALLENGES OF AM IN AUTOMOTIVE SECTOR

AM technologies can print multiple varieties of material and different colors which are helpful for analyzing the defects. This technology reduces development time & the price. AM meet various challenges in this sector that are discussed as under:

- Skilled workers required to control this.
- It takes time to coach people.
- It can't produce large single parts.
- Current AM technology is proscribed.
- AM product design can only be patented not copyrighted.
- The lack of ability during this technology is to supply the nucleon number.
- It is liable to security risks and cyber-attacks.
- Lack of comprehensive set of standards for Additive Manufacturing.
- Different sort of printing is finished different style of products.
- Defect in machine can ruin the full production.

IX. FUTURE ASPECTS

Additive manufacturing has seen rapid development in recent years, and 2020 looks to be no exception. However, while progress is being made to industrialize AM, there's still a way to travel before the technology can viably be used as a producing method for end parts at scale. Costs will must come down, greater focus placed on training and firms will must find the worth of the technology for his or her applications, because the technology and industry mature and these challenges addressed, the speed of AM adoption will only increase. In developed countries where the standard manufacturing sector has experienced decline, the developments in additive manufacturing present potential opportunities for growth. The analysis suggests that while there has been progress, there's scope for improving technologies and reducing costs so as to facilitate wider adoption of and greater business value from 3D printing. While additive manufacturing can save the aerospace industry money and time, it might save lives within the medical field. With an expected growth of $11.528 billion from 2017 to 2028 in line with SmarTech Markets, the medical industry can expect a way forward for nano-scale medicine and even complex printed organs. Producing an element on-demand with 3D printing enables manufacturers to print parts PRN rather than pulling the part of a supply warehouse. On-demand production is going to help companies realizing huge reductions in inventory and storage costs. In fact, having creative freedom without concern about the cost or time penalties is one in all the first advantages of additive manufacturing. In traditional manufacturing, modifying a design during production can result in significant cost increases or time delays as tooling on a assembly line is modified out.

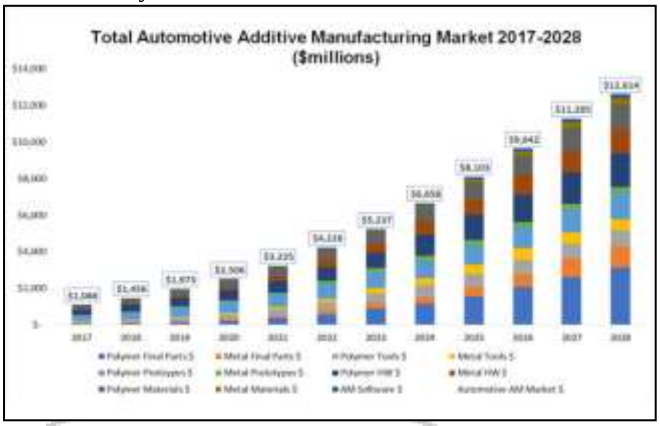

Fig. 3: Additive manufacturing future aspects
(Source: 3Dnatives)

X. Discussion

AM is an evolving technology platform that seems to own extensive applications in various areas of automotive. It can produce complex shape prototype with a large sort of materials and also implants the materials that meet structural requirements. This technology makes industrialist job easier with minimum side effects which meet the various challenges of automotive. 3D printed model gives a higher understanding of complex designs and parts of machines that are suitable for creating prototypes and actual products. Technology has potential to create lightweight, durability, and geometrically complex objects. There's an improvement within the quality of parts and efficiently solve the matter within the manufacturing of spare parts. Thus lowering the manufacturing cost and improving cooperation between engineer and also the machine. In future, additive manufacturing will fulfil more challenges in the automotive sector because the industrie4.0 will bring changes and to AM is required to handle them. This technology creates implants that fit perfectly and quickly accepted by the machines. The engineers always make a prototype before making an actual part. One in all the benefits of AM is it's efficiency within the matter of cost and style plus it's a time saviour too.

XI. Conclusion

Additive manufacturing is employed efficiently in the automobile sector for a duplicate of a component which helps in working of varied machine. The present status shows continuously increasing research work undertaken by additive manufacturing applications and challenges within the field of automobiles. This system is incorporated in making prototypes and workshop practice. This provides a virtual model of a machine that successfully provides planning a few model's manufacturing procedures. AM is employed for providing education about designing and pre-operative progressing in training. For automotive applications, this technology becomes prevalent and creates manufacturing flexibility. Additive manufacturing in automotives will experience a rapid translation in future because thanks to its geometric freedom it fulfils various challenges. It successfully produces unique models for the design of prototypes, fabrication of complex custom parts for education and training. Additive manufacturing technologies create an on-demand production of customized products instruments. Additive manufacturing getting used solely for quick prototypes are gone. The automotive industry is a tremendous example of what is achieved with the technology in the last stages of the assembly process.

XII. Conflict to Interest

I confirm that the submission is original and is not being submitted for publishing elsewhere.

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