Additive Manufacturing: Advances in Trends and Technology

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Abstract: The latest process involved in the design, development and delivery of products to the end users has been implemented utilizing additive manufacturing (AM) or three-dimensional (3D) printing. This technology provides a great deal of freedom in the production of complicated parts, highly personalized goods and effective waste reduction. The new technological and Industrial revolution, utilizes the incorporation of intelligent fabrication and CAD processes. Via its various advantages, such as time and material savings, rapid prototyping, has enhanced productivity as well as distributed manufacturing processes, where AM actively participates and plays significant role in the industrial advancements. This paper is intended to conduct an analytical review of the latest developments and technological aspects in the AM innovation. This paper also explores the viability of the additive manufacturing mechanism as well as the advantages of the product in global, social and ecological fields. At last, the paper finishes with an outline of AM's potential in technologies, implementations and products developments, which will generate new concepts for AM discovery in the coming years..

1. Introduction

Product manufacture can easily be characterized as added-value processes by means of which limited usage and desirable raw materials are manufactured in high utility and desired goods in certain specifications, shapes, and finishes with certain functional capacities because of their unacceptable material properties and their limited or irregular shape, structure and build [1]. The absolute number of existing industrial processes is quite difficult to track and is currently in reality because there is a spectacularly high number of activities so far, and even with the increasing demands and exponential advancements in research and technology the number continues to increase. Fortunately, all mechanisms of this type can be commonly grouped into four main classes, i.e. Industrial production and additive manufacture (AM) processes are being formed, joined, subtracted, . The ideal form and scale are obtained from the working material in the subtractive production process by removing items or reduction of the undesirable materials with the required method[2]. Subtractive processing systems are both traditional and non-conventional processes.

In past few years, the industrial utilization of additive manufacturing has considerably increased. AM works in different fields of industry, like automobiles, aircraft manufacturing, machines, electronics including healthcare devices. The technology was developed in the 1980's by stereo lithography that solidifies layers of liquid polymer with the help of lasers [3].
The SLA-1 by 3D Systems was the very first AM system for production and manufacturing of CAD-based products. The desktop computer as well as the emergence of industrialized lasers are innovations that allowed the growth of additive processing. However, the development of specialized and incredibly sophisticated components by added additives is feasible, the slower printing rate of AM processes restricts it to be used for large scale productions.

3D scanning technology has also permitted the reconstruction without costly molds of actual objects. This innovation may transform how customers engage with suppliers with a reduction in the cost of the rapid prototyping AM systems [4],[5]. The product's customization may require the end users to provide more product details. In comparison, a cheap 3D printer makes it possible for the end users to create polymeric materials in his own office and home. A range of polymeric systems actually fall beyond the normalcustomer's budgets [6].
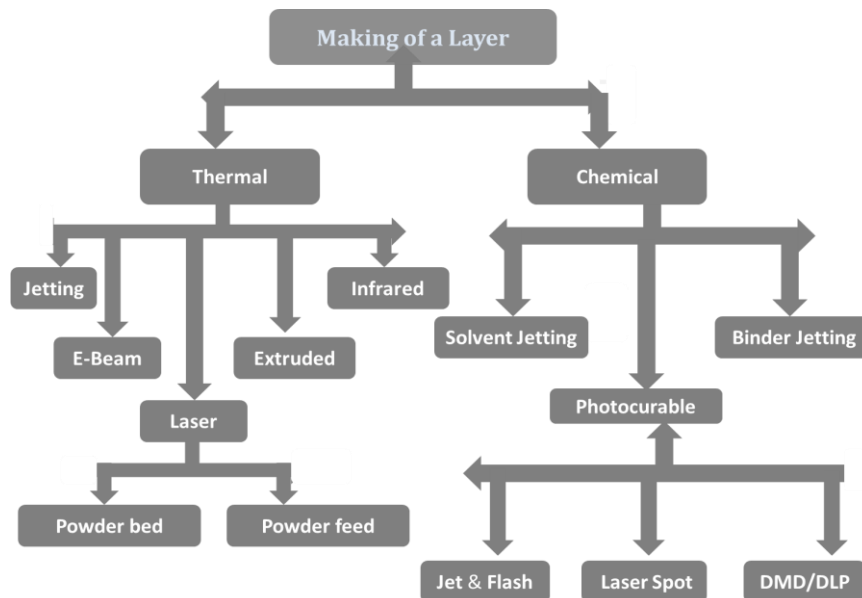
Figure 1: Additive layer bonding mechanism in AM

The ideal structure and scale is extracted from the deposition of layers in the x-y planes of additive manufacturing techniques. The third dimension z occurs in the piling of single layers (Figure 1). The name rapid prototyping (RP), in AM and computer aided CAD productions, signifies to the three-dimensional printing, rapid manufacturing, Solid Freeform Fabrication (SFF) and layered production [7] that are also considered to cover all additive manufacturing production methods. Here, the rapid prototyping is a category of state-of-the-art technology used to create three-dimensional CAD prototypes [8]. RP methods may be used to create instruments in addition to prototypes (also called "rapid tooling") and also for quality components manufacturing (known as "rapid manufacturing") [9],[10].

1.1. Utilization

Additionally, AM technologies for industrial production unlocks new economic and social possibilities(Figure-2). It may make be easier for the aerospace industry to manufacture powerful lightweight products and it makes ideas that were not feasible for previous manufacturing techniques. It is important to revolutionize biomedicine [11]. This technology has the ability to improve the health of the world's people and to make terrestrial and air travel more energy efficient. However, it is not instantaneous to embrace and distribute this new technology. In order to make its use simpler, emerging developments would require new requirements, expertise and infrastructure [6].
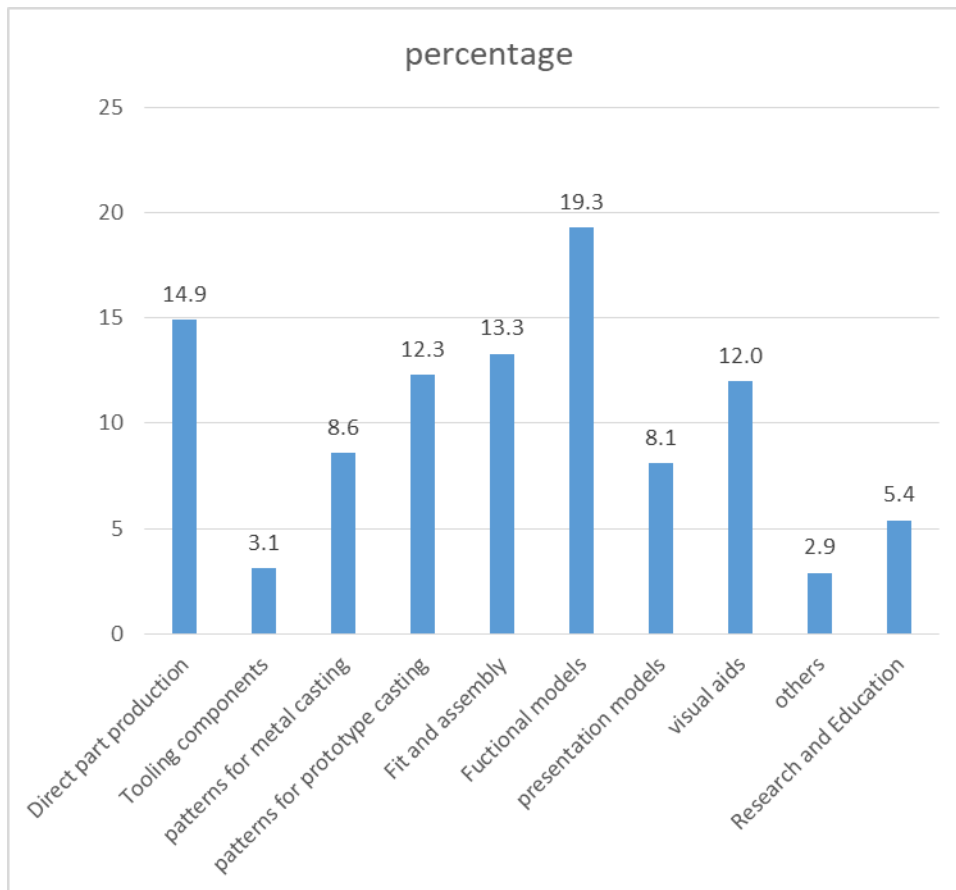
Figure 2: Application of AM technology

The production of these products has even been approved by organizations including the National Institute for Standards and Technology (NIST). Therefore, awareness of the cost effectiveness of the additive manufacturing industries in this context is essential. In that sense, intelligent development and manufacturing of products increases competition in the long run by maximizing jobs, resources and materials in order to manufacture better goods and quickly respond to consumer demands as well as cope with time fluctuations [11]-[14]. This paper also reviews the literature regarding the cost of AM which focuses at areas whereby cost advantages remain preserved and possible cost improvements being defined.

1.2. Opportunities

This phase concept does not simply require the insertion or construction of material. Over the last 20 years additive processing (AM) has developed from a simplistic 3D printing/polymerization system which can be utilized directly to produce components without using any kind of tools, which is used during rapid prototyping in a non-structural resin material. To date, much work has been carried out using plastic materials, and now major efforts are concentrating on utilization of metals [15]. Thus, additive manufacturing has the ability to permit new component designs which cannot be assembled using standard subtractive methods and prolong the operational life of in-service pieces through creative repair processes.

Offshore oil and gas sectors have wide resources to be established, however mixed usability, functionally progressive fabrics, and integrated instruments for sensing and analysing structural performance or other monitoring activities can be considered for utilizing AM technologies.

2.Literature Review

In order to establish a wide variety of technologies of potential relevance to industry, additive manufacturing has implemented various processing techniques such as energy deposition, powder-bed fusion, lamination, binder jetting, material extrusion, curing, etc. [16][17]. In previous work for further explanation, multiple detailed AM technology analyses were documented [18]. Due to the research on low cost machinery growth, greater materiel variability and the difficulty of a vast number of applications, the driving force behind AM technologies' rapid progress is. Latest innovations and techniques put together different materials (including elastomers and hard plastics).

An additive manufacturing study Framework workshop for the next 10-12 years was conducted in 2009 in the U.S. [7]. The workshop was determined to find prospects for growth of architecture, modelling and tracking systems, resources, biomedical uses, energy and recycling, educational programs and development initiatives in the additive manufacturing sector as a whole. The general understanding was that if progresses were made to keep advancing with development of new technology, there will be more possibilities for all of these technological developments. The paper proposed that aNational Test Bed Center (NTBC) to be developed which could utilize resources, equipments as well as human capital in future developmental analysis and better explain the working principle of cyber-enabled automated manufacturing research.

It is assessed that aviation and aerospace will supervise the adoption of AM [19]. A statement given by Wohler Associates industry informed that aerospace production of AM grown up to $1.2 million in 2016 and is expected to expand over $1 billion by 2025 [20].For all the listed industries, AM is the norm for them because the custom of manufacturing its parts is very complex and needed for small run production. Fabricated Parts are commonly taken out from advanced materials like titanium alloys, nickel super alloys, special steels, or ultrahigh temperature ceramics. These materials are difficult to manufacture, expensive and consume time to refine. The way of building parts in an additive manner make an ideal for that, That`s why the producers have managed to use only that material which are needed for parts. Beside that AM minimize the quantity of material used. Which is double savings for the industry .The saving in fuel and material cost result lighter weight in some products. [17].

3. AM and Modern Technology

Previous studies indicates that there can be at least three advantages of AM.

1. It becomes easier to develop Prototype thereby reducing the duration to launch the product into market

2. Results into Innovation

3. Leads to wider applicability by becoming a business case

3.1 Development of Prototype as well as Reduction of Time to Market

➢ The additive manufacturing is regarded as a rapid prototyping based game changer. In only a few hours, AM enables an enterprises to adapt their concepts on the fly in comparison to the conventional techniques of producing metal or wood prototypes in manufacturing plants.

➢ AM can help to achieve market efficiency, since contractors can provide a low-cost rapid prototype framework.

➢ The vast majority of customers are in preference of 3D printing and rapid prototyping.

3.2 Components of AM

The AM process broadly covers two things. The first is the raw material which will be used as the input and second significant thing will be that which source of energy will get used for molding of the parts. In case of AM the technologies that are getting used are like powder bed, free form fabrication (FFF) systems and laser powder injection. In the case of AM, the system of powder bed is getting applied in the bounded chambers. Then it is through the laser and many a time electron beam through which the energy is getting supplied. Once the energy is supplied, it further results into powder bed which easily can be given any shape which we want. When it comes to process of injecting laser powder we are adding materials with help of a powder nozzle which results into the melting down of powder. Next comes free form fabrication which further include electron beam deposition of metal wire, arc deposition of powder and wire, at the same time ultrasonic consolidation of metal layers.

3.3 Traditional Process and Additive Manufacturing

In this method while adopting Conventional processes there is requirement of part fixturing. In the same case occasionally devoted tooling is also needed when we want to configure the different parts. Also, the apparatus' actual geometry may restrict the sorts and sizes of highlights that can be made. A section with inner highlights, for instance, might be troublesome or even difficult to make with customary subtractive cycles. Parts made through additive manufacturing can without much of a stretch acknowledge complex design and inside highlights, since the part is developed each slender layer in turn and isn't restricted by device openness or geometry. [21]. Moreover, additive cycles by and large devour just the measure of info material that is needed for the manufacturing of parts; any overabundance material can typically be reused and utilized in ensuing forms.

When we compare AM based manufacturing with subtractive processes AM based manufacturing is supposed to be better. The reason for it being better is that the unwanted material gets converted to some other form of scrap [22].

	percentage
polymer	51
metal	19.8
metal and polymer	29.2

Figure 4: Current utilization of materials in AM-based manufacturing
In figure 4 we see the current utilization of materials in AM-based manufacturing. This indicate that polymer is 51 percent. Metal is 19.8 percent. Metal and polymer is 29.2%.

3.4 Limitations of AM technology

The general feeling all around us reflects a very optimistic environment for AM technology but the researches still indicate major issues that are yet unanswered. [23]. It is a known fact that AM technology is of recent origin, it is due to this reason it becomes imperative to understand the main reasoning of all the steps involved. To be specific, it is imperative to get clear picture relating to the material microstructure which is a by-product of a specific thermal processing cycle. A number of studies have been done to find the tensile strength as well as the elongation depending on the material compositions [24].

Lack of design knowledge: Product design is a significant concern in case of AM. Mechanical features relating to parts show wide variations subject to processes that are getting used along with other variables like that of individual processes, loading directions, as well as the post-fabrication heat including surface treatments.

High production costs: It is true that AM is avoiding the up-front tooling costs which is getting incurred under any traditional processes. The problem arises when the volume of production goes up. The high cost therefore is a major concern.

4. Conclusion

It is concluded while reviewing the AM that in case of higher volumes, tradition manufacturing methods is cost effective but when the requirement is more of customization as the need of the customers AM proves to be more suitable. Scale of production is an autonomously significant factor, while customization and unpredictability are tradable as far as effect. Nonetheless, instructors should likewise comprehend the ground-breaking idea of these cutting edge innovations and modify educational programs in a way that accentuates the significance of planning for added substance measures as opposed to subtractive cycles. AM permits originators and architects for all intents and purposes limitless opportunity of plan. It will change set up stock chains. Ultimately, it will change the financial aspects of where, how and when things are made. In any case, to exploit these innovations, new and upgraded plan strategies are required.

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