A REVIEW ON MANUFACTURING IN AEROSPACE

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Abstract:
This paper discusses the research work done in additive manufacturing with majorly focusing on the aerospace industry. All the developments and effect of composites on additive manufacturing is being discussed. Various researchers got curious regarding 3D printing. This manufacturing is really fast and various complex parts mostly used in the aerospace and automobile industry could be easily manufactured with the help of this only. Today's era needs fast and convenient technology which could satisfy the needs of the consumer directly. Despite being the latest technology its initial setup and maintenance are still costly. This technique is also known as layer by layer manufacturing. Then a term known as composites was introduced. These substances are mixtures of more than one type of material to get maximum advantage of properties like heat resistance, strength, wear strength, fatigue failure, and many more. Nowadays various new technologies like Laser additive manufacturing and rapid prototyping are also coming to increase the productivity of the aerospace industry, especially for the manufacturing unit. One of the most used composite materials in the aerospace industry is carbon fiber. This has not only increased the strength of the parts manufactured in the aerospace industry but has also increased fuel efficiency.

Keywords: Additive Manufacturing, Composite; 3D Manufacturing; Manufacturing processes; Comparative analysis and Aerospace Engineering.

1. Introduction

Additive Manufacturing (AM) had created various options for a variety of materials and had increased the rate of production & had reduced the cost of production [1]. AM was first developed at 3D systems in the 1980s [2]. Fabrication is done by AM generally has properties like complex shapes and high-performance parts. The most attractive benefit of 3D printing in the aerospace industry is that it saves the fuel of lighter weighted components [3]. 787 Dreamliner aircraft manufactured by Boeing uses at least four components made up of AM titanium alloy in 2017 [4]. Mostly 2 AM fabrication techniques were used i.e. laser power bed and directed energy deposition system [5],[6],[7]. One of the biggest advantages of AM is it can create complex geometries easily and economically [4]. With the help of AM, we can recreate the existing part and can reduce its weight too [4]. AM is very attractive for low aerospace volumes. Still manufacturing without a traditional factory is an unrealistic concept [8]. AM is also referred to as "the third industrial evolution". The fabrication of internal cooling as a single component without the use of fasteners is possible with the AM method whereas it was difficult with the CNC machine [9]. More than 20% of the market for AM is made up of part production for the automotive and aerospace [2]. There were around 22000 excess parts to be used in 2013. Due to the production of small-volume manufacturing in the aerospace engine production AM industry in the future is expected to increase [10]. With the use of electron and laser beam AM methods, one could easily make complex shapes from spherical powder [11]. It had been seen that using AM technology for construction it have the potential to decrease labor costs, reduce material waste, and create customized complex geometries that were very difficult to achieve by using traditional methods [4]. The emergence of additive manufacturing (AM) technology creates an opportunity to manufacture parts on-demand to improve supply chain dynamics [12].

2. Materials

A variety of materials are being used in the aerospace industry for the manufacturing by using different processes [13]. Still, research is going on for the betterment of the same. Below is a list provided of materials presently being used in the aerospace industry:

- Flame retardant nylon [14]
- Exotic metal like titanium [14]
- High order engineering-grade materials [14]
- Polymer Nanocomposite [15]
- Reinforced with fiberglass, carbon fiber and aramid fiber [15]
- Carbon and glass-fiber-reinforced plastic (CFRP and GFRP respectively) [15]
- Polymer matrix composites reinforced with carbon aramid and boron fibers [16]
- Hoogovens Aluminum [17]
- Abstract Magnesium [18]

3. Common processes used in the aerospace industry

3.1 Additive Manufacturing

It is the process of joining materials to make objects from 3D model data by using layers upon layer. It is one of the most commonly used manufacturing processes used in the aerospace industry. It has been described properly above in the introduction part [9].

3.2 Lean Manufacturing

In 1997 Boeing introduced lean manufacturing. This technique was very helpful in building a 100 seated 717 aircraft in 1999. This was a big achievement indeed. By removing the unnecessary operations the cost was reduced and hence the profit was increased [19]. New ways of having a better weapon system at lower cost were continuously being discovered by the Aeronautical Systems Center (ASC) in Air Force Material Command [20].

3.3 3D printing

AM also known as 3D printing which fabricates the component in a layer-wise fashion directly from a digital file [21] . Various early applications of AM/3D printing are being used in the automobile, aerospace, and healthcare industry [4].

3.4 Laser Additive Manufacturing

It is a repetitive layer-wise process. In this, a beam of the laser is used to melt and solidify the material in a powder bed according to slices of a corresponding 3D-CAD model, but the available material range is still limited. Sometimes approval of new techniques for the same material demands extended time and additional processes [22].

3.5 Rapid Prototyping

Nowadays various companies are focusing on the development of new rapid prototyping processes. Materials such as flame retardant nylon, exotic metal like titanium and high order engineering-grade materials are under simultaneous observation for the betterment of rapid prototyping. Fused deposition modeling (FDM) is a process that consists of a heating chamber having 90 degrees curved elbow-shaped which serves as a melting portion for the whole process. The bestselling rapid prototyping machine was named as FDM in 2006. The machine is capable of fabricating fully functional parts 85% of the strength of the actual molded part; this was the main reason because of which this was highly appreciable in the aerospace and aviation industry [14].

3.6 Friction stir welding (FSW)

This process is widely accepted in the aerospace industry for the fabrication of high strength aluminum [23]. This is used in large volume fuel tanks [24]. It has advantages like low distortion, fewer defects, and high mechanical properties of the joint [25]. Aluminum alloys have high strength and that's why their demand is increasing in welding of large structures. Japan had launched the H2B rocket in September 2009 by adopting the FSW technique. Various process parameters apart from tool geometry are needed to be considered for high mechanical performance. These parameters include the tool tilt angle, pin length, tool rotation rate, and traveling speed [26].

4. Composites

Composites are the materials that most preferred in the aerospace industry which can be defined as "A material made from two or more constituent materials with significantly different physical or chemical properties". With the help of composites integrated structures having lightweight can be easily manufactured [3]. Flexible manufacturing can also be done [19]. Thermo structural composites materials are of the most important for satisfying the needs of mechanical and thermal characteristics at very high temperatures and in severe environments[27]. Advanced composite materials (ACM's) also known as advanced polymer matrix composites [28]. These are excellent structural and functional materials mainly in the aerospace industry. These also represent the future of aerospace materials [29]. ACM's were derived from embryonic efforts of the fiber-reinforced plastics (FRP) industry. For more than 50 years Composite materials based on glass fiber in thermosetting resins have been widely utilized in industry and advanced composites based on the use of carbon and aramid fiber for almost 30 years [30]. High strength, lightweight and corrosion resistance are some of the properties of the composite materials which make them still the ideal choice for the aerospace industry. There is an increasing demand for composites for high-performance components. The National Composite Center (NCC) has launched its first stand-alone company – Vector Composites Inc – to bring military, defense, and commercial aerospace customers the composite parts they need with the low-cost advantages of its signature Rapid Fiber Preform (RFP) and closed molding processes [31].
The table shown below describes the effect of composite materials on the processes which are mostly used in the aerospace industry.

5. Result

Following 3 graphs had been concluded from my research. We have cross checked the same by using MATLAB software.
Link-
https://drive.google.com/drive/folders/1WhKocepLP_1Rtketm6Nr8jUwm_jqhU3q?usp=sharing

One can directly copy and paste this link for generating the graphs with equations. Also a word file is made for the steps.

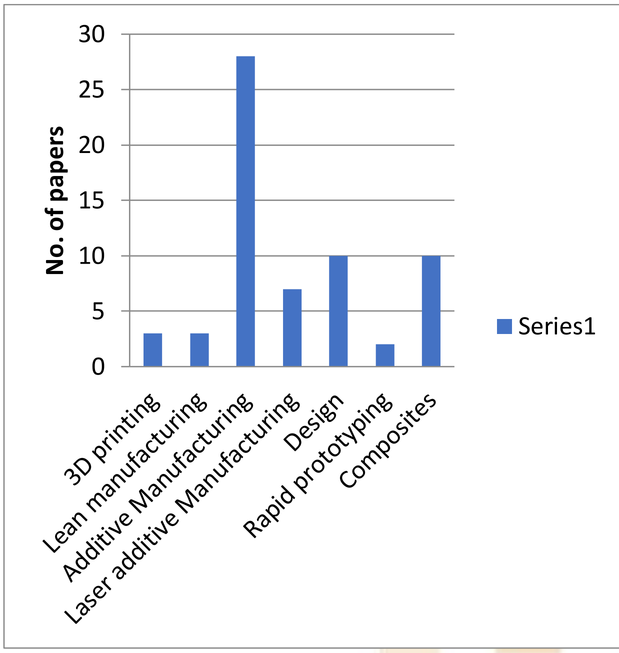

FIG. 1 Process v/s number of papers

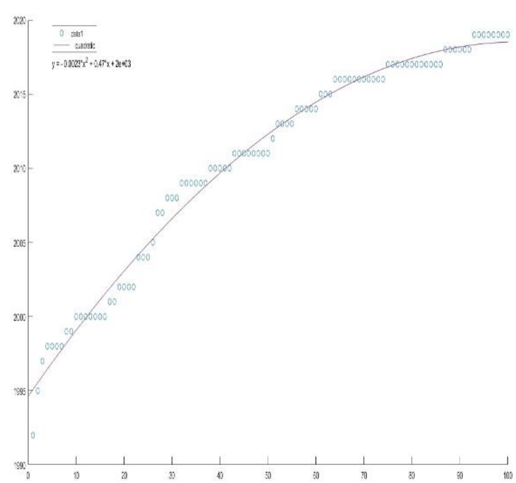

FIG. 2 Paper no. v/s year of publication

It can be said from FIG.1 that additive manufacturing was used in maximum papers.

This graph had been plotted by considering 100 papers. Additive manufacturing is still one of the favorite processes for manufacturers.

The equation obtained above shows that there is a quadratic relationship between the x and y axis's variables.

FIG. 2 describes about the total number of papers published in respective years. It was observed that there was tremendous increase in the papers written on this topic after 2007.

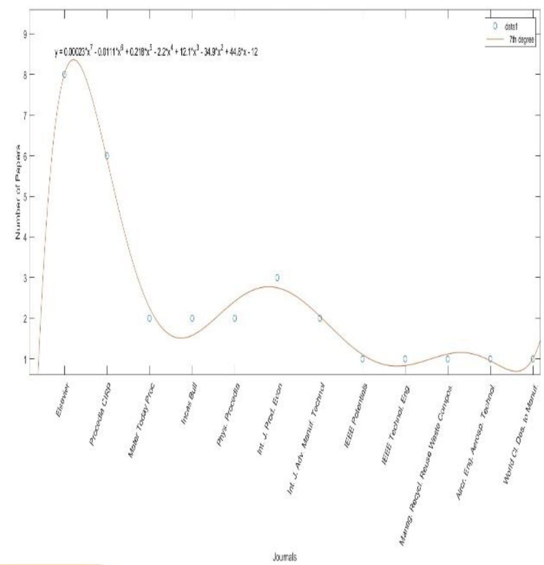

FIG. 3 Journal v/s No. of papers

The equation obtained in Fig. 3 shows a relationship of degree 7 between no. of papers and Journals used in our research.

FIG. 3 describes about the no. of papers taken from different Journals. We have tried to maintain a standard in our paper and hence have taken papers from standard publishers only.

6. IMPORTANCE OF LAW

While India's flying and space exercises have taken off, there has not been sufficient investigation of the issues which are coming up in flying and space, particularly in the non-specialized division. Global Foundation for Aviation, Aviation and Development (India Chapter) has been quick to examine and disperse the information on air and space issues in India including legitimate issues.

In this association, it has been holding workshops and meetings in the course of the last not many a long time. On The event of the third universal meeting of Air and space law National Law University, alongside International Foundation for Aviation, Aviation and Development (India Chapter) and MC Gill University, Canada is satisfied to introduce the papers of the previous two meetings in a book structure. Prior gatherings in 2009 and 2011 were held at National Law University, Delhi. The master gathering was imagined with regards to the remarkable development of Indian aeronautics part just as advancements its space program. Air and space law is a perplexing subject. It must be concentrated as natural entire which requires a shared exertion in information creation by looking at the specifics via security and wellbeing laws, risk issues, condition, air course structures, guideline of air administrations and bi-sidelong air arrangements in the system of sum.

7. RELATION BETWEEN LAW AND AEROSPACE INDUSTRY

The terms Air Law and Space Law are presently utilized; they speak to just periods of the law straightforwardly and during a detour material to man-made flight. To abstain from existing and future disarray, both need to be remembered for a solitary a part of the law. This might be named Aerospace Law. Aviation was characterized during a glossary distributed in 1959 by the Research Studies Institute at Maxwell Air Force Base as follows: "The world's envelope of air and therefore the space above it, the 2 considered as a solitary domain for action within the trip of air vehicles and within the starting, direction, what's more, control of ballistic rockets, earth satellites, zeppelin space vehicles, and the like." The terms aviation design and aviation sciences are presently broadly wont to show the resolute and comprehensive character of building and logical activities and capacities identified with visit any height. The term aviation power was likewise utilized during a similar glossary as chatting with the "intensity of man, gotten from his capacity to fly vehicles within the air and in space." The official diary of the Air Force Association, Air Power and Space Digest, is assigned by its distributers because the Magazine of Aviation Power. My very own perspectives were communicated in an update arranged for the kickoff of The Institute of Global Air Law at McGill University in 1951, quite long while earlier to the starting of Sputnik 1. These perspectives were rehashed and extended in a piece of writing named "Air Law-a Field of International Thinking," distributed in 1951, in Transport and Communications Review (Vol. IV No. 4 p. 1), gave by the Transport and Communications Division, Department of Economic Affairs, United Nations . I at that time encouraged that the term Air Law be utilized during a widened sense.

8. CONCLUSION

It was concluded that Additive Manufacturing is most common process for manufacturing sector of aerospace industry. Still AM is most reliable process but various other opportunities have also emerged in few years. All parameters must be properly considered before making any decision. In this paper, we have tried to cover all the major aspects related to manufacturing in aerospace. Almost all the majorly used manufacturing processes are being discussed here. Additive manufacturing is one of the best techniques developed especially for the aerospace industry. But still today people are unaware of the recent trends and latest technologies developed. The main motive of this paper is to provide knowledge to people regarding the latest trends in the manufacturing in aerospace industry. Traditional methods are more complicated and time-consuming as compared to the latest methods. Also, a comparative analysis of composite materials is provided for the better understanding of correlation between process and material. Apart from the method and material used various other parameters affect the overall efficiency and productivity and those parameters are well explained in this paper. We have concluded from various papers that one should try for a better combination of material and process before finalizing any method.

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