Manufacturing Techniques of Aerospace

Chetana K, Ram Kumar, Deva G Naidu, Deepika N, Krishna V

Navi Mumbai, India

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 space is carbon fiber. This has not only increased the strength of the parts manufactured in the space but has also increased fuel efficienc y.

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 space 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]. Ace of the chief recompences of AM is it cannister generate complex geometries simply and thriftily[4]. With the benefit of AM, we can refashion the prevailing fragment and can diminish 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 ended up of fragment 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 take the potential to cut labor costs, lessen material excess, and produce customized compound geometries that were selfsame difficult to accomplish by using outmoded methods [4]. The advent of improver manufacturing (AM) expertise creates an occasion to creation parts on-demand to progress supply hawser dynamics [12].

2. Materials

A change of ingredients are actuality used in the space industry for the manufacturing byusing different processes[13]. Still, research is going on for the betterment of the same. Under is a list on illness that of ingredients nowuse in space industry:

- Spark retardant nylon [14]
- Exotic steel like atomic number 22 [14]
- High command engineering-grade supplies [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 space industry

3.1 Additive Manufacturing

It is the process of assembly ingredients to make matters from 3D prototypical data by by layers upon coat. It is ace of the maximum frequently used trade processes secondhand in the troposphere industry. It has been defined properly above in the primer 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 identified as 3D lithography which fabricates the component in a layer-wise manner unswervingly from a numerary 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 optical maser is cast-off to melt and solidify the material in a precipitate bed giving to slices of a corresponding 3D-CAD model, but the available material range is still limited. Occasionally approval of novel techniques for the similar material anxieties extended while and additional courses [22].

3.5 Fast Prototyping

Currently various corporations 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. (FDM) is a course 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 asset of the actual molded part; this was the main reason because of which this was highly appreciable in the space and aviation industry [14].

3.6 Friction stirs fusing (FSW)

This process is widely accepted in the space business for the production of from top to bottom strength aluminum[23]. This is used in large volume fuel tanks[24]. It has advantages like low distortion, fewer defects, and high powered belongings 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 implement tilt approach, pin measurement, tool turning rate, and wandering speed[26].

4. Composites

Composites are the materials that most preferred in the space business 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 record imperative for satisfying the needs of mechanical and thermal characteristics at very high temperatures and in severe environments[27]. Advanced composite materials (ACM's) also identified as unconventional polymer atmosphere 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 extra than 40 years Complex materials based on glass fiber in thermosetting resins have been widely utilized in industry and advanced composites based on the custom of carbon besides aramid fiber for almost 30 years[30]. High strength, lightweight and corrosion resistance are about of the properties of the composite materials which make them still the ideal choice for the space industry. There is an increasing demand for composites for high-performance components. The

(NCC) has threw its first impartial company – Route Mixtures Inc – to bring martial, defense, and salable 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 regularly used in the aerospace industry.

5. Result

Following 3 graphs had been concluded from my research. We have cross checked the same by usingMATLAB 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.

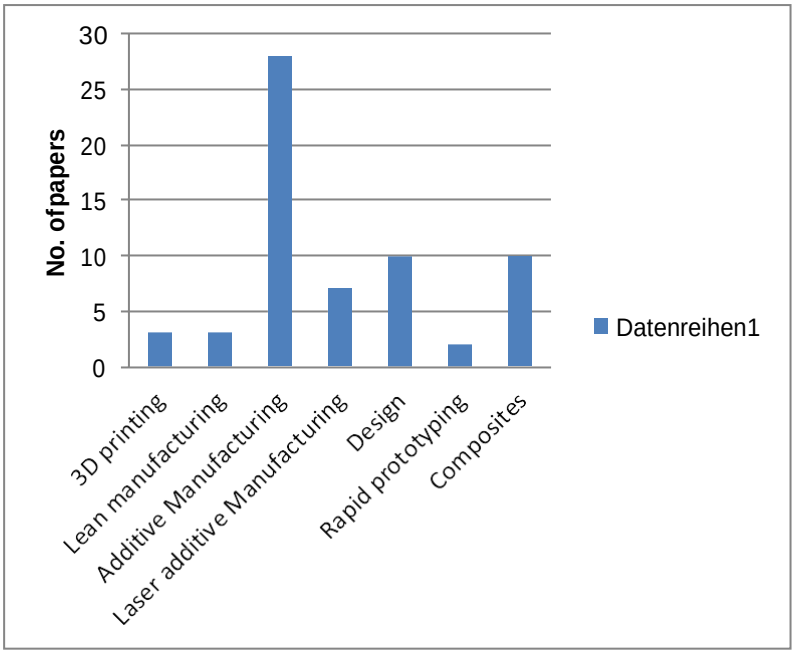

FIG. 1 Process v/s number of papers

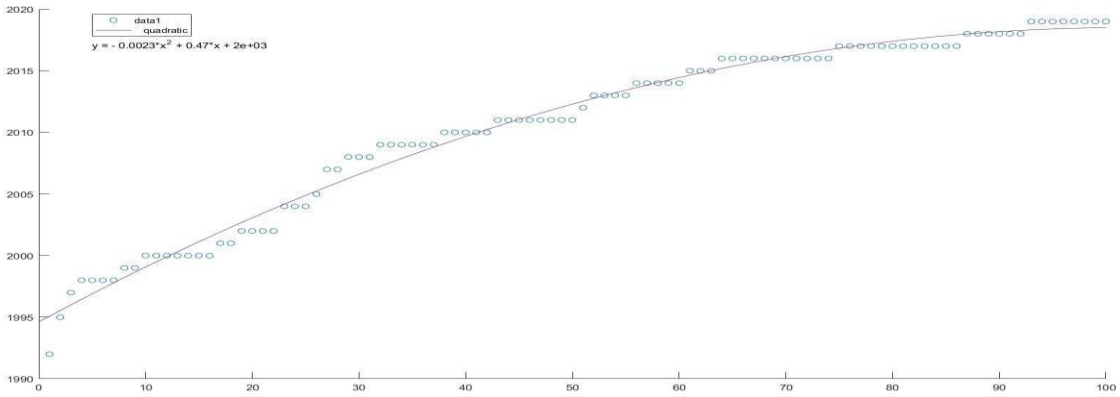

FIG. 2 Paper no. v/s year of publication

It cannister be thought from FIG.1 that additive manufacturing was used in maximum papers. This diagram had been conspired by since 100 papers. Stabilizer manufacturing is still ace of the beloved developments for manufacturers.

The calculation found above shows 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.

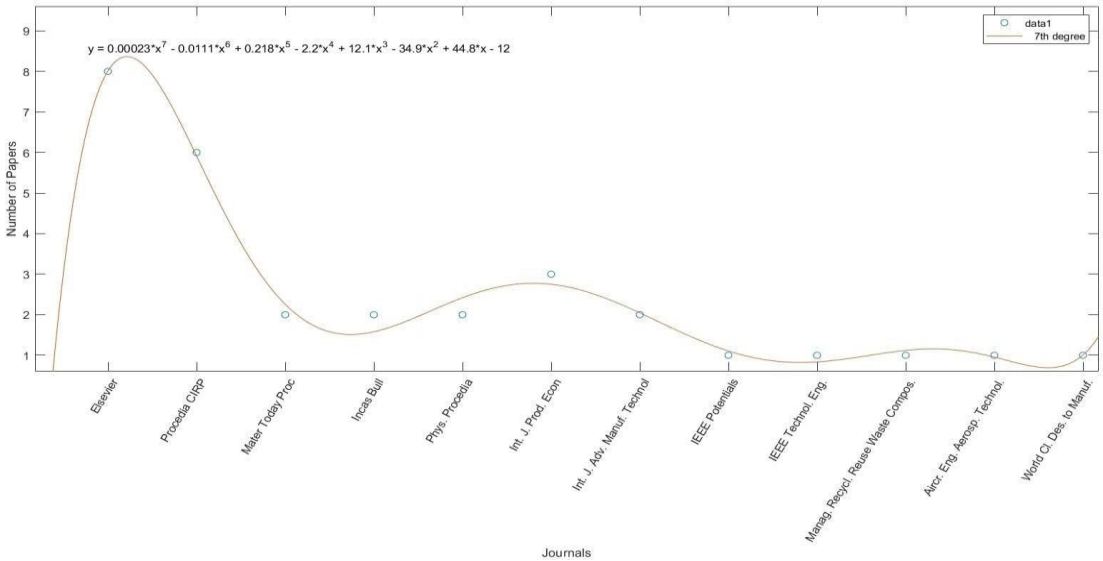

FIG. 3 Journal v/s No. of papers

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.

7. CONCLUSION

It was decided that Stabilizer 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 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 ace of the best techniques developed especially for the space industry. But still today people are unaware of the recent trends and latest technologies developed. The main motive of this weekly is to provide knowledge to people regarding the latest trendsin the manufacturing in aerospace industry. Traditional methods are more complicated and time-consuming as linked 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.

References

[1] S. C. Joshi and A. A. Sheikh, "3D printing in aerospace and its long-term sustainability," *Virtual Phys. Prototyp.*, vol. 10, no. 4, pp. 175–185, 2015, doi: 10.1080/17452759.2015.1111519.

[2] R. Liu, Z. Wang, T. Sparks, F. Liou, and J. Newkirk, *Aerospace applications of laser additive manufacturing*. Elsevier Ltd, 2017.

[3] R. P. Richner, "Research Collection," *Brisk Bin. Robust Invariant Scalable Keypoints*, pp. 12–19, 2011, doi: 10.3929/ethz-a-010782581.

[4] D. Delgado Camacho *et al.*, "Applications of additive manufacturing in the construction industry – A forward-looking review," *Autom. Constr.*, vol. 89, no. August 2017, pp. 110–119, 2018, doi: 10.1016/j.autcon.2017.12.031.

[5] M. Kamal and G. Rizza, *Design for metal stabilizer manufacturing for space applications*. Elsevier Inc., 2019.

[6] R. Cunningham, S. P. Narra, C. Montgomery, J. Beuth, and A. D. Rollett, "Synchrotron-Based X-ray Microtomography Characterization of the Effect of Processing Variables on Porosity Formation in Laser Power-Bed Additive Manufacturing of Ti-6Al-4V," *Jom*, vol. 69, no. 3, pp. 479–484, 2017, doi: 10.1007/s11837-016-2234-1.

[7] P. R. Gradl, C. Protz, and T. Wammen, "Additive Manufacturing Development and Hot-fire Testing Directed Energy Deposition Inconel 625 and JBK-75 Alloys," *55th AIAA/SAE/ASEE Jt. Propuls. Conf.*, vol. 2019, pp. 1–20, 2019.