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Metal Additive Manufacturing and its Scope in Self Reliant India

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Introduction

Additive manufacturing has changed the whole layout of the manufacturing industry with its layer-by-layer approach. With the help of this technique, the fabrication of complex and intricate parts in the different industries was possible in less time and reduced portfolio costs. A lot of research is going on in the scientific community for the fabrication of metal parts using additive manufacturing. Metal Additive Manufacturing (MAM) techniques are coming up with a method to fabricate complex intricate and large-scale metal structures.

Many countries like India are focused on developing this technology. It is believed by many experts that the proper development of AM infrastructure in India is very fruitful for the nation's economic and technological growth. In 2020, the Prime Minister of India, Shri Narendra Modi, launched "Atmanirbhar Bharat," for the country to become self-reliant. Various measures have been proposed in this area to increase efficiency, competitiveness, and resilience. The five obligations of 'Atmanirbhar Bharat' are Economy, Technology-driven systems, Infrastructure and Vibrant Demography. Therefore, AM can be seen as a powerful tool in advancing India towards self-reliance.

This article focuses on Welding based AM techniques in Metal Additive manufacturing. The combination of welding and Additive manufacturing has gained popularity for metal fabrication. It is one of the most researched areas under AM as it has the potential to print larger and sturdier metal components with complex and intricate designs. Many different types of heat sources like wire-arc, laser, electron beam etc. are used to melt the metal which can also be in a powder form. Different Welding based AM techniques includes GTAW, GMAW, LAM, EBAM and FSAW. It also gives a glimpse of the steps taken by the Indian Government to develop AM technology in India.

Metal additive manufacturing

In fabrication of metallic components with additive manufacturing, it is required to heat the metal wire or powder using high concentration heat source and deposit the melted metal in layer-by-layer form. Here laser beam, electron beam and welding-arc is used as heat sources. This process can be classified on the basis of heat source and type of raw material used into mainly two types

a) Powder based additive manufacturing

b) Direct energy deposition techniques

(Figure 1); [1]

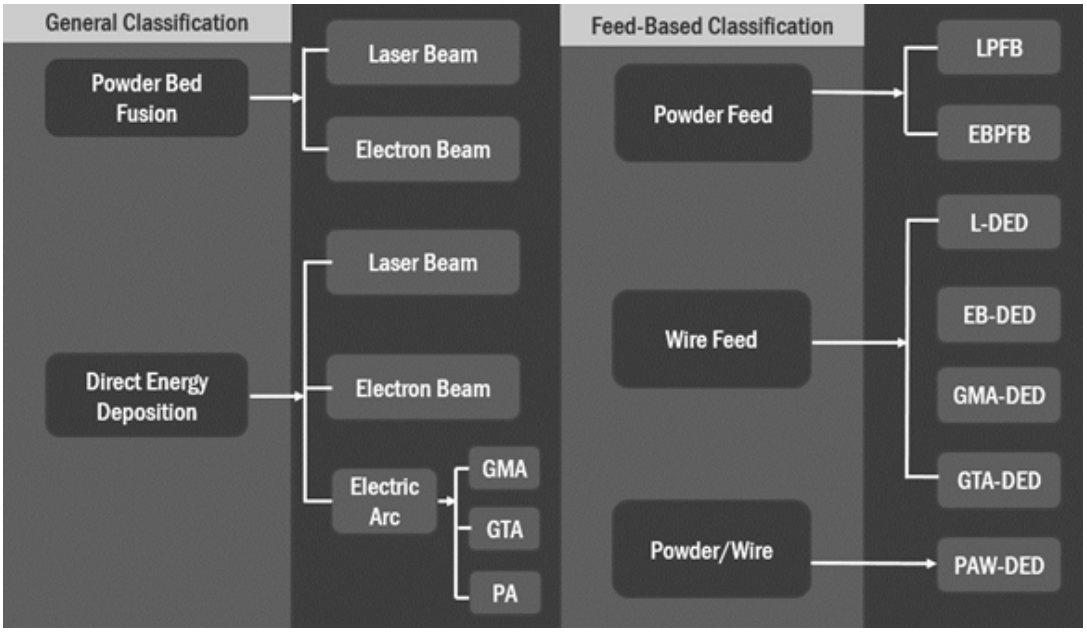

Figure 1: Classification of Welding based AM [1].

Powder based additive manufacturing: The two-powder based metal additive manufacturing techniques are Laser Powder bed Fusion (LPBF) and Electron Beam Powder Bed Fusion (EBPBF). The main difference between these processes is the type of heat source used for melting powder. LPBF is an older process in comparison to EBPBF and many studies have already been carried out and a significant amount of information is available in terms of properties, process parameters etc. The EBPBF is still a new process and studies are going on in this process. It is especially used for difficult to machine metals like titanium, nickel aluminium etc. [2]. Also, the deposition rates are higher in EBPBF in comparison to LPBF [1].

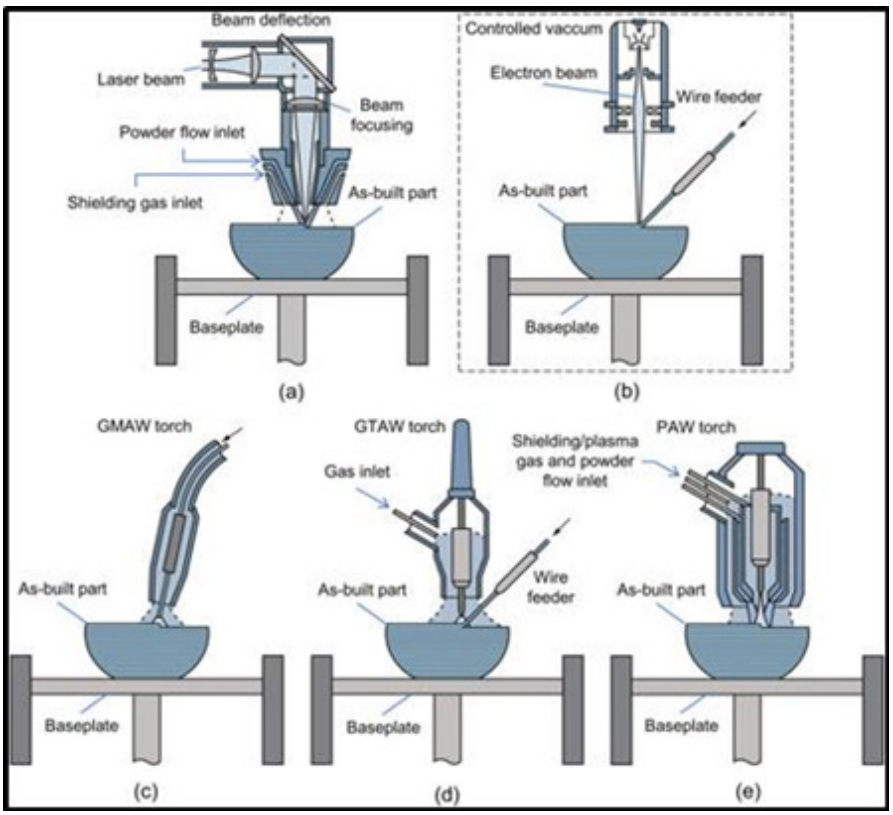

Figure 2: (a) LD-DED (b) EB-DED (c) GMA-DED (d) GTA-DED (e) PA-DED [1].

Direct energy deposition: Figure 2 shows different Direct energy deposition techniques. In Laser direct energy deposition, a laser beam is used as a heat source to melt or sinter the metal. The metal can be in powder or wire form. Shielding gas is required in this process to prevent oxidation. The working principle of Electron beam direct energy deposition is similar to Laser direct energy deposition, the only difference is the heat source used. This process is also carried out in a vacuum so metal wires are used as it is difficult to handle metal powder flow in this environment.

All the process categorized under the Wire Arc Additive Manufacturing process uses an electric arc as the heat source and metal wire as feedstock. Based on the heat source used WAAM process can be divided into three types: Gas Metal Arc Welding (GMAW), Gas Tungsten Arc Welding (GTAW), Plasma Arc Welding (PAW). GMAW process uses a consumable electrode. In this process, the electric arc is formed between the consumable electrode and the workpiece. While in GTAW and PAW non-consumable electrodes are used [3]. WAAM processes are faster and less accurate than laser and electron beam direct energy deposition. Also, WAAM has a higher deposition rate than any other DED technique.

Scope of additive manufacturing under atmanirbhar bharat

Atmanirbhar Bharat, translating to "self-reliant India," is a Hindi slogan popularized by Prime Minister Narendra Modi and the Indian government regarding the country's economic goals and progress. The word is used in this context to refer to making India a larger and more important component of the global economy as well as implementing policies that are efficient, competitive, and robust, as well as being self-sustaining and self-generating.

One of the objectives of the Atmanirbhar Bharat Abhiyan is to establish a sustainable ecosystem for India's Additive Manufacturing industry and to position the country as a global innovation and research powerhouse in that sector. Additive Manufacturing (or 3D Printing) is bringing the world into the Fourth Industrial Revolution, with enormous potential to transform India's manufacturing and industrial production landscape through digital processes, communication, imaging, architecture and engineering that provide digital flexibility and efficiency. In 2017, the industry was worth more than USD 7 billion. By 2023, it is predicted to have grown to USD 35.6 billion [4].

To keep pace with rapid global manufacturing prowess, India needs to adopt an integrated approach to additive manufacturing in all segments including defence and public sectors, especially within the nation's small, medium and large-scale industries. The goal is to create a favourable environment for design, development, and deployment, as well as to remove technical and economic barriers for Global AM leaders to establish operations in India with supporting ancillaries, allowing for the growth of the domestic market and the expansion of global market share.

Initiatives laid out by the Indian government: Establishment of 3D printing Manufacturing Lab at National Institute of Electronics & Information Technology, Aurangabad. The Institute also offers a certificate course in 3D Printing.

The Gujarat government has signed an MoU with the US Institute of 3D Technology (USI3DT) in California, and OEM 3D systems (a leading global 3D printing company) for establishing seven 3D printing Centers of Excellence across seven engineering colleges and technical institutes in the state. A laser metal 3D printing facility has been set up at Pandit Deendayal Energy University to facilitate research and innovation in the energy, healthcare, automotive and aerospace sector.

A. Atal innovation mission: Under the aegis of Atal Innovation Mission, Atal Tinkering Labs, 1200-1500 square feet of dedicated innovation workspaces have been set up, where do-it-yourself (DIY) kits on latest technologies like 3D Printers, Robotics, Internet of Things (IoT), Miniaturized electronics are installed through government financial support Rs. 20 Lakhs so that students from Grade VI to Grade XII can tinker with these technologies and learn to create innovative solutions.

B. The Gujarat government has signed an MoU with the US Institute of 3D Technology (USI3DT) in California, and OEM 3D systems (a leading global 3D printing company) for establishing seven 3D printing Centers of Excellence across seven engineering colleges and technical institutes in the state.

C. Ministry of electronics and information technology is also coming up with an industrial scale policy on 3D printing in observation of its emerging market. Under which it is encouraging market leaders to establish a global base for setting up 3D manufacturing in India, help domestic companies access supportive and ancillary facilities for this technology, issue certification norms and fix standards for 3D printing in India and reducing set-up and associated costs for additive manufacturing units.

D. The Electronics Manufacturing Clusters (EMC 2.0) scheme: To create world-class infrastructure in electronic manufacturing, the government is providing aid for setting up manufacturing clusters. This would include not just new clusters but up-gradation of technological setup in existing clusters. The Government's Grants in Aid would be provided to cover a portion of the project's costs for infrastructure, amenities, and common facilities. Financial assistance would range from 50 to 75 per cent of project costs, with a total cap of 75 crores. The plan also includes funding possibilities for the project's remaining costs.

E. Department of heavy industries" COE at IISc Bengaluru (Additive Manufacturing for High-Performance Metallic Alloys) collaborated with Wipro to build India's first industrial grade 3D printer.

F. Stratasys has announced a collaboration with NTTF (Nettur Technical Training Foundation) to launch India's first additive manufacturing certification course. The training

program aims to help students learn new technologies in 3D printing, plugging-in skill gaps in the industry

Conclusion

The combination of Welding and additive manufacturing has been proven effective for the fabrication of metal components. As the manufacturing industry is moving toward more sustainability additive manufacturing will play an important role in achieving that goal. So these techniques will come in handy as metal fabrication is an important part of the manufacturing industry. Many variants of WAM based process are being developed to decrease the defects produced and to reduce the amount of post-processing required in these components. For the comprehensive market share of Welding based additive manufacturing, it will require a high level of control and standardization to achieve repeatability in component fabrication with consistent properties.

Establishing a manufacturing eco-system in developing countries is always a challenge due to expensive physical infrastructure and production machinery and also lack of skilled manpower and sustainable supply chain. Additive manufacturing technology opens up new opportunities for the economy and society by offering possibilities for a cost-effective and more flexible manufacturing eco-system. Small manufacturers can adapt to demand very quickly, the supply chain can be simplified by the industries by creating in-house AM printed end-use and spare parts. AM technology offers an alternative path for the developing countries to overcome industrial competitiveness without substantial investment in physical infrastructure.

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