Chapter 2
Additive Manufacturing (AM): Processing Technique for Lightweight Alloys and Composite Material

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ABSTRACT

The need for less weight and high-performance materials in manufacturing industries has continuously led to the development of lightweight materials through the use of advanced additive manufacturing (AM). The race of lightweight and high-performance metals continue to evolve as this continuously provides better understanding about connection existing between material processing, microstructural development, and material properties. AM technique is an interesting manufacturing process that is employed in production of engineering components with improved properties. The choice of titanium and its alloys in structural applications are attributed to their superior strength-to-weight ratio and high corrosion resistance. This chapter looked at different additive manufacturing (AM) techniques developed for the processing of lightweight metals, their strengths, and limitations. The chapter also looked at the role and contribution of AM to the 4th industrial revolution, processing, and application of titanium aluminide for high temperature applications.

INTRODUCTION

In this present economic time, cost reduction, time management and geometric complexity are major market demands in the development of new products. These are posing serious issues to the tooling processes that are already expensive and time consuming. Additive manufacturing (AM) and modern operational

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structures are effective tools that can assist to reduce time and cost (Ludovico et al., 2010). The quest for lightweight high performance structural metals by major industrial sectors such as the automobile, aerospace, energy and chemical have made researchers, engineers and other major stakeholders in the manufacturing sector to continuously develop different manufacturing techniques.

Three-dimensional (3D) printing has progressed into AM process with the ability of fabricating parts directly via layer-by-layer build-up process (Abdulrahman et al., 2018). Several companies have embraced Additive manufacturing technology because of its unique capabilities such as customization, multifunctionality, improvement in product reliability, high performance rate and overall production cost reduction. These companies include Siemens and other hearing aid manufacturers that use Stereolithography and sintering machines to produce hearing aid shells, Align Technology apply stereolithography to produce molds for production of dental braces, Boeing and its suppliers employed the selective laser sintering in the production of ducts and other similar components for fighter jet F-18 (Gibson et al., 2010a). AM technique is a progress made from rapid prototyping which is now employed in the production of end-use products that now find applications in different areas such as the automobile and aerospace industries (Wholer's Report, 2016). AM processing technique produces components using 3D model data.

The main objective of the use of AM technique is to enhance the quality and performance of produced parts through cost of production, material usage and lead time (Kobryn et al., 2006). Some AM processes are undertaken with the use of lasers as the main source of energy to provide fast heating in melting the metal material thereby creating a melt pool with the capacity of enhancing diffusion rate of introduced metal powder to properly mix (Tlotleng et al., 2016).

History

Additive technology sometimes referred to as 3D printing has recently spread into new areas including medicine, energy, electronics, automobile and aerospace. The application of printing technology is becoming a highly promising manufacturing practice as it is greatly studied and its usage is fast growing (Gibson et al., 2010b). The first commercially successful 3D printing technology, the ModelMaker by Solidscape (formerly Sanders Prototype) was introduced in 1994. The ModelMaker was able to print using basic wax material as raw material. By 1996, 3D Systems joined the race of 3D printing technology with the birth of the Actua 2100 which is also based on the printing of wax material. Thermojet, an improvement on Actua 2100 was marketed in 1999 (Gornet & Wohlers, 2014). The build materials of the first set of rapid prototype machines are based on melted waxy thermoplastics which made them very useful for concept modeling and investment casting patterns (Gibson et al., 2010b).

Additive Manufacturing Techniques

Additive manufacturing (AM) is an advanced layer-upon-layer manufacturing technology that applies the use of 3D model data in the fabrication of near-net-shape components (Abdulrahman et al., 2018). AM technology helps in the fabrication of functionally graded components with specific material properties that cannot be easily manufactured using casting and other conventional manufacturing techniques (Gasper et al., 2017). The technology is fast growing because of its capability of producing complex components that seems difficult to be manufactured using the traditional production techniques such as casting and machining (Herderick, 2011). The robust capability of AM has made it popular in different areas of applications especially in aerospace, automobile, defense, energy generation, medicine and