Chapter 9
Laser Metal Deposition Process

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ABSTRACT

Laser metal deposition process belongs to the directed energy deposition class of additive manufacturing process that is capable of producing highly complex part directly from the three dimensional (3D) computer aided design file of the component by adding materials layer after layers. Laser metal deposition process is a very important additive manufacturing process and it is the only class of additive manufacturing process that can be used to repair valued component parts which were not repairable in the past. Also because this additive manufacturing process can handle multiple materials simultaneously, it is used to produce part with functionally graded material. Some of the features of the laser metal deposition process are described in this chapter. Some experimental studies on the laser metal deposition of Titanium alloy- composite are also presented.

1. INTRODUCTION

Laser Metal Deposition (LMD) is an additive manufacturing process that uses laser beam to create a melt pool on the surface of a metallic substrate and powder particle or wire is fed into the melt pool created. The powder or wire melts in the process to form a deposit that is metallurgically bonded to the substrate. The required shape is built up layer after layer according to the geometry of the two dimensional (2D) cross section of the part from the three dimensional computer aided design (CAD) model of the part (Scott et al., 2012). Laser metal deposition process is an important additive manufacturing process that was grouped into the class of Directed Energy Deposition by the F42 committee on additive manufacturing standards (Scott et al., 2012). Laser metal deposition process has a unique characteristics such as reduction in material wastage during the manufacturing process, repair of high valued parts which were in the past costly to replace or difficult to repair, and deposition of functionally graded material (Zang et al., 2008). Difficult to machine engineering materials such as titanium and its alloys are easily formed using the laser metal deposition process.

Titanium alloy Ti6Al4V is an important aerospace alloy and it is the most widely used titanium alloy that is referred to as the workhorse of the industry (Ramesh et al., 2008; Cui et al., 2012). Ti6Al4V pos-

DOI: 10.4018/978-1-5225-1677-4.ch009

sess some exciting properties such as high strength to weight ratio, good corrosion resistance, retaining of properties even at elevated temperature and bio-compatibility which makes them to be more favoured in most field of human endeavor (Ribeiro et al., 2003; Lütjering and Williams, 2003). Despite all these exciting properties, titanium and its alloys are difficult to machine because they chemically react with the cutting tool material thereby causing high temperature and galling of the cutting tool (Arrazola et al., 2009). In the aerospace industry, manufacturing of complex part is material wasting when produce through the traditional manufacturing process which results in the typical high buy-to-fly ratio of the aerospace parts (Brandl et al. 2011). All of these challenges can be overcome if the complex aerospace parts are manufactured through the laser metal deposition process. The development of the part using the laser metal deposition process is achieved by adding materials layer by layer directly from the CAD model of the part no matter the complexity resulting in improvement of the buy-to-fly ratio. Also producing part made of titanium and its alloy through laser metal deposition process will overcome the problem of tool reacting with the workpiece since the LMD process is a tool-less process. The features of the laser metal deposition process are described in this chapter and how the processing parameters influence the properties of the deposited part. Also some experimental studies on the laser metal deposition of titanium alloy composite are presented in this chapter. The laser metal deposition process is described in the following sub-section.

2. THE LASER METAL DEPOSITION PROCESS

Typical laser metal deposition process equipment consists of a laser system with optical laser beam for focusing, a powder feeding system (nozzles) and a control system. The Laser engineering net shaping (LENS) is an example of machine that is based on the laser metal deposition process. There are five (5) basic steps involved in the laser metal deposition process like any additive manufacturing process; the steps are explained as follows:

Firstly, the component to be made must be drawn using 3D software such as AutoCAD, solid work, Uni-graphics and Pro Engineer. This CAD model is sent into the LENS. The CAD model file received is converted into a standard triangulation language (STL) which has now been termed as an Additive Manufacturing File (AMF) according to the F42 committee on additive manufacturing standards (Scott et al., 2012). The old file format –STL is not capable of defining some characteristics that are now present in the new AMF format. The AMF is based on an open standard Extension Mark-up Language (XML) (Scott et al., 2012). The AMF format is capable of describing in detail, the texture, the colour, the curve triangles, and the lattice structure, as well as the functionally graded materials. The AMF format represents the 3-D surface assembly of planar and curved triangles containing the co-ordinates of the vertices of these triangles. The third step after the conversion process is the slicing of the AMF into two dimensional (2-D) profile sections that is defined by the geometry of the CAD model and the chosen build orientation. The building orientation will affect the way the AMF file is sliced. The building orientation is the direction with which the building process will follow, for example, from the bottom to the top, from one side to another side etc. The software may choose the building orientation, or the operator may choose the building orientation. Support structures may are also generated automatically if necessary (Boboulus, 2010). The slicing process is a very critical part of the whole process because it determines the dimensional accuracy of the product. After the slicing is completed, the fourth step is the building of the part. The building process in LMD is achieved by creating a melt pool on the surface