Chapter 9
Improving Surface Integrity Using Laser Metal Deposition Process

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ABSTRACT

Laser Metal Deposition (LMD), an additive manufacturing process (also known as 3-D printing) and a non-traditional fabrication process used for improving the surface integrity of components is presented in this chapter. In LMD, parts are manufactured directly from the 3-D Computer-Aided Design (CAD) model data. Complex parts can be produced in a single step, which is impossible with the traditional manufacturing methods such as casting, cutting, and turning operations. The major steps required in the production of parts using the laser metal deposition process are highlighted. The flexibility offered by the LMD technique makes it an important surface engineering technique. Composite parts or parts whose surfaces are made of composite materials can also be produced in a single step because two or more dissimilar materials can be handled simultaneously in the LMD process to produce parts. This is because the building of parts in LMD is achieved by the LMD machine following the detail described by the CAD model of the part being made. The processing parameters affecting the properties of laser metal deposited parts are described in detail. This chapter establishes the ability of the LMD in the production of complex and one of its kind parts, its ability to improve surface properties, repair high-valued parts, and reduce the buy-to-fly ratio in the production of aerospace parts. It also highlights the use of non-traditional finishing techniques on laser deposited parts to further improve the surface integrity of components. The chapter is concluded by presenting a laser metal deposited Ti6Al4V/TiC composite. The laser metal deposited Ti6Al4V/TiC composite was characterized through the microstructure, microhardness, and wear resistance, and it was found that the resulting deposits were fully dense and of improved surface properties when compared to the parent materials.

DOI: 10.4018/978-1-5225-9624-0.ch009

INTRODUCTION

Laser surface engineering deals with the modification of surface properties of a solid material using laser. The requirement of surface properties in some applications differs from that of the bulk material because of the working environment to which the surface will be subjected. Depending on the type of application, often the properties desired from the surface material are conflicting with what is required from the bulk material and the cost issue may restrict the use of these materials. When a cheaper material is used, there is a need to modify the surface of the material to meet the service requirements such as wear and corrosion resistance. This is because it is this surface of the part that interacts with the working environment and not the bulk material. The interaction between the surface material and the working environment (e.g. working fluid or contacting surfaces) can cause the surface to lose its integrity over time as a result of wear, corrosion and fatigue. Laser surface engineering involves altering the surface properties to reduce the effect of environmental degradation on the surface material over time. This is achieved by modifying the surface such that the surface can withstand the working environment without losing its integrity. Some of the areas where laser surface engineering finds its applications include: automobile, aerospace, biomedical, chemical, petroleum and power. These applications require surfaces that are wear and corrosion resistant amongst other properties. This chapter describes the use of laser metal deposition, an additive manufacturing technique for improvement of surface properties.

BACKGROUND OF LASER SURFACE ENGINEERING

Laser surface engineering, one of the many techniques employed for improving the surface of materials, is achieved by applying laser energy on the surface of the material or melting similar or dissimilar materials (such as metals, ceramic or composites) on the surface of the material in order to improve the properties of the surface of the bulk material. Laser surface engineering processes includes laser alloying (Mabhali et al., 2010; Zhang et al., 2011), laser cladding (Cai et al., 2007; Richter et al., 2004), laser heat treatments (Meng et al., 2012), and laser deposition (Liu & DuPont, 2003; Shukla et al., 2012). These are briefly explained in the following sub sections.

Laser Surface Alloying

Laser surface alloying involves the addition of alloying materials in form of powder or wire, which is melted using laser energy. The molten material mixes with the surface of the bulk material to create a homogeneous surface material with a different chemical composition and phases. An example of laser surface alloying is that of the AISI 316L stainless steel with ruthenium and nickel (Lekala et al., 2012). Another typical example is the laser alloying of aluminum mixed with nickel, titanium and silicon carbide to improve the surface hardness of aluminum (Mabhali et al., 2010).

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