Chapter 10
Enhancement of Surface Integrity of Titanium Alloy With Copper by Means of Laser Metal Deposition Process

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ABSTRACT

The laser metal deposition process possesses the combination of metallic powder and laser beam respectively. However, these combinations create an adhesive bonding that permanently solidifies the laser-enhanced-deposited powders. Titanium alloys (Ti6Al4V) Grade 5 have been regarded as the most used alloys for the aerospace applications, due to their lightweight properties and marine application due to their excellent corrosion resistance. The improvements in the surface integrity of the alloy have been achieved successively with the addition of Cu through the use of Ytterbium laser system powered at maximum of 2000 Watts. The motivation for this research work can be attributed to the dilapidation of the surface of titanium alloy, when exposed to marine or sea water for a longer period of time. This chapter provides the surface modification of titanium alloy with the addition of percentage range of Cu within its lattices; and the results obtained from the characterizations conducted on the laser deposited Ti6Al4V/Cu alloys have been improved.

DOI: 10.4018/978-1-5225-9624-0.ch010

1. INTRODUCTION

So many research works have been conducted on titanium and its alloys both presently and in the past. These works have facilitated the researchers to discover the best method on how to improve on the production of the alloys, in order to enhance their functionality in service. Ti6Al4V alloy is the most applicable among the titanium alloys; since it exhibits a combination of mechanical, physical and corrosion-resistance properties which have made it desirable in the aerospace, chemical industries, energy and automotive industrial services. These alloys are also applied in the developing biomedical applications, due to their excellent biocompatibility among metallic materials (Moiseyev, 2006; Lutjering & Williams, 2007).

The enhancements in the mechanical properties of titanium alloys have mostly been achieved through the addition of alloying compounds (Sen et al., 2010; Gogia et al., 1992; Okazaki et al., 1993; Tian & Nemoto, 1997).

The alloying additions in titanium can be divided into three different classes. The α-stabilizers - an example is Aluminium which impart solid solution strengthening to titanium; the neutral additions, such as tin and zirconium, also contribute to solid solution strengthening; and finally, the β-stabilizers, such as vanadium, molybdenum, niobium, iron, copper, chromium and manganese, serve to introduce the β-phase in an otherwise α-phase microstructure (Leyens & Peters, 2003).

A desired microstructure could also be obtained through thermo-mechanical processing, like the basket weave microstructure achieved from heat treatments in the β-phase field. This is found to offer better creep resistance than an equiaxed α/β phase microstructure (Mishra et al., 2005). The addition of copper to titanium alloys influences the mechanical properties through age- hardening (Lutjering & Weissman, 1970). A beneficial effect of precipitation strengthening has been utilized in Ti-2.5Cu (in weight percent (wt.%)) over commercially pure titanium (Donachie 2000). The work was later extended to titanium alloys containing a variety of other alloying additions with minor composition modification. An experiment was also conducted by substituting vanadium for copper with the same 4 wt.% of vanadium; and this yielded the same results. Copper (Cu), a β-stabilizer, exerts the same influence on the β transus temperature as vanadium; and the direction on the β transus of Ti6Al4V alloy was not affected (Bania et al., 1993). Consequently, an attempt was made by Gollapudi et al., (2011) to improve the compressive strength, as well as the hardness of titanium alloys, by utilizing the precipitation-hardening technique in an experiment that was conducted to ascertain the performance of Ti-6Al-1.5V-2.5Cu in comparison to a standard titanium alloy Ti6Al4V; however the ductility value was decreased marginally. A small amount of less than 2 weight percent of Cu was found to improve the resistance of Ti-48Al-2Cr-2Nb to oxidation. It was also believed that the presence of Cu reduces the concentration of chromium in the scale, thereby enhancing the formation of a more- coherent and protective alumina layer on the surface of the sample (Dang et al., 2001). However, Cu has the tendency to be a useful alloying element for Ti-48Al-2Cr-2Nb.

Titanium and its alloys are very expensive light metals; and recently, there has been a renewed interest in titanium powder metallurgy as a cost-operational way of fabricating components from these expensive metals. The problems faced by these alloys have been the issue of biofouling in the marine industries. Titanium and its alloys have been used as the major components for marine use. There has been the clogging of the sea debris to the marine structures, thereby destroying the surfaces - as a result of the bacterial and virus attacks such as barnacles, fungi, bacteria, and marine debris. Diverse numbers of projects have been carried out to provide solutions to improve and enhance the surface reliability of titanium alloys, and to reduce the problems by increasing the effectiveness and reducing the costs of the device's units or products, and to prolong their service terms.

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