ADVANCES IN MATERIALS ENGINEERING

Volume 1

Edited By:
Zahurin Halim
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Chapter 007

Laser Nitriding of Titanium

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Keywords: Surface hardening, Laser melting, Nitrogen environment, Titanium nitride, Dendrite Hardness

Abstract. The modification of titanium surface by the application of a high power CO_2 laser in reactive environments is discussed. This process is commonly identified as laser nitriding when scanning is under nitrogen environments. In this process, the laser beam is scanned to melt a single track on titanium surface under nitrogen environment using different combinations of processing conditions producing a hard structure of titanium nitride. The new surface can have a composition quite different from the base metal. The properties of the treated surface are completely different from the matrix. This laser nitriding can tailor the properties of titanium to suite the service requirements.

Introduction

Titanium and its alloys have good corrosion resistance and high specific strength but poor wear resistance property which limits their use in many dynamic applications. The laser nitriding, a current 'high tech' method for tailoring surface properties of components made of titanium to meet specific requirement is discussed here. The surface modification by laser nitriding process causes compositional change and phase transformation resulting in significant property modification in the titanium material. Since only the surface of the part is affected, the bulk properties of the material remain unaffected. It is no longer a sound theory to heat treat an entire part for one small wear resistance surface or to make an item from superior quality and costly materials if only a small area needs the specific properties. This is the conceptual basis for the laser nitriding of titanium sheet discussed in this work and it represents a cost competitive procedure for generating wear resistance surface compared to conventional bulk processing.

Experimental Procedure

Many series of experiments were performed using a 5 kW CO_2 laser at AEA Culham Laboratory, Abingdon, England. The laser nitriding was applied by scanning the beam on commercial purity titanium substrate surfaces. The laser treatment of the titanium plate under nitrogen environment was limited to the formation of hard titanium nitride phase and some phase changes in the liquid melt zone. The titanium plate samples were in the form of 160 mm by 50 mm with a thickness of 3 mm. The surfaces of the samples were abraded on emery paper down to 220 grit size and subsequently laser treated. The laser treatment was done at different combinations of mixture of nitrogen-helium, nitrogen-argon or pure nitrogen environments, varying gas flow rates, laser scanning speeds, beam power and defocused distances. Effect of spinning was equally investigated by spinning the 1.35 kW beam at 1500 rpm over 4 mm locus under 100% N environment at different energy intensities. The detailed process conditions of the investigation are presented in Table 1. The laser treated samples were subsequently etched for 2 mins in a solution of 10 cm^3 of hydrofluoric acid, 30 cm^3 of nitric acid and 50 cm^3 of water. The microstructure and hardness of the