Surface modification of AISI H13 tool steel by laser cladding with NiTi powder

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ABSTRACT

This paper presents laser cladding of NiTi powder on AISI H13 tool steel surface for surface properties enhancement. The cladding process was conducted using Rofin DC-015 diffusion-cooled CO_2 laser system with wavelength of 10.6 µm. NiTi powder was pre-placed on H13 tool steel surface. The laser beam was focused with a spot size of 90 µm on the sample surface. Laser parameters were set to 1515 and 1138 W peak power, 18 and 24 % duty cycle and 2300 to 3500 Hz laser pulse repetition frequency (PRF). Hardness, properties of the modified layer was characterized by Wilson Hardness tester. Metallographic study and chemical composition were conducted using field emission scanning electron microscope (FESEM) and energy dispersive x-ray spectrometer (EDXS) analysis. Results showed that hardness of NiTi clad layer increased three times that of the substrate material. The EDXS analysis detected NiTi phase presence in the modified layer up to 9.8 wt%. The metallographic study shows high metallurgical bonding between substrate and modified layer. These findings are significant to both increase hardness and erosion resistance of high wear resistant components and elongating their lifetime.

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1. Introduction

Laser surface modification is widely used as a remanufacturing process, especially for repairing cracks in mold and dies surface. It produces new properties on the surface of substrate which improves toughness, hardness and corrosion thus reduce wear resistance and thermal stress [1, 2]. One of the laser surface modification technique is laser cladding. Laser cladding offers a good metallurgical bonding with the substrate with wear, corrosion and high-temperature oxidation resistance that guarantees the toughness of the base material [3, 4]. Coating layer between the substrate and the cladding material has a high bonding strength due to a good metallurgical bonding [5]. In laser cladding, parameters like laser power, processing speed and powder feed rate have been optimized to achieve acceptable clad-substrate integrity with maximum clad geometry and dilution, and homogenous structure without any surface porosity and cracks [6-8].

In die casting applications, dies are prone to wear from thermal fatigue and erosion when exposed to high processing temperature. Though hot work tool steels are widely used as die materials, cyclic practice at temperatures of above 600 °C depletes the die lifetime and can easily experience premature failure. Meanwhile, NiTi alloy is among the most desirable materials for aerospace, military, safety, chemical and medical implant fabrication industries because of its good tribocorrosion resistance, high strength to weight ratio and stability of mechanical and chemical properties at high temperatures [9]. Cavitation erosion resistance of laser modified steel surface with NiTi powder was found higher than austenitic stainless steels [10]. Recent cladding process by plasma transferred arc process indicates poor NiTi coating layer on stainless steel was caused by high current densities while failure of bonding in NiTi clad layer was due to different thermal expansion coefficient of NiTi and substrate [11, 12]. In previous study, re-melting of cladding layer of Fe-based alloy mixed with Ti powder on low carbon steel substrate produced a refined and uniform microstructure [13]. This paper investigates the effect of laser parameter on NiTi powder cladding onto AISI H13 tool steel to exhibit high surface hardness and erosion resistance properties. Chemical composition, metallurgical bonding between clad layer and substrate, and hardness of the clad layer are presented.