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Short Communication

Effects of surface alloying on microstructure and wear behavior of ductile iron surface-modified with a nickel-based alloy using shielded metal arc welding

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ABSTRACT

In this study, the effect of surface alloying on the microstructure and wear behavior of ductile iron was studied. In this regard, ductile iron samples were coated by single and double pass welds of a nickel-based electrode (ENiCrFe3) using shielded metal arc welding. The effects of number of passes on microstructure, hardness and wear resistance of cladded layers were investigated. Optical microscopy and X-ray diffractometry were used to identify the microstructure and phase composition of cladded layers and interfaces. The results revealed that cladded layers consist of austenite (Fe, C), γ(Fe, Ni) and small quantities of carbides such as Cr_7C_3. It was also found that the hardness of the cladded layers was higher than that of substrate. In samples processed with a single and double passes, hardness reached up to 500 and 450 HV, respectively. Pin-on-plate wear tests showed that the wear mechanism is predominantly delamination in the cladded layers and substrate.

1. Introduction

Ductile iron (DI) is a ferrous alloy widely used in the manufacturing of machine tool beds, cams, pistons, cylinders, etc., because of low cost, good fluidity and castability, excellent machinability, good mechanical strength and good wear resistance [1,2]. However, under severe service conditions the performance and reliability of DI can be limited by various forms of wear, including erosion [3].

Hardfacing can be used when a casting requires an unusually hard and wear/corrosion resistant surface. Conventional hardfacing materials, also referred to as weld overlays, are normally classified as steels or low-alloy ferrous materials, high-chromium white irons or high-alloy ferrous materials, carbides, nickel-base alloys, or cobalt-base alloys [4].

Nickel alloys are used in high temperature conditions and corrosive environments. Their hardness is obtained with chromium borides, chromium carbides or nickel silicates [5].

Several welding techniques such as oxyacetylene gas welding (OAW), gas metal arc welding (GMAW), shielded metal arc welding (SMAW) and submerged arc welding (SAW) can be used for hardfacing. The most important differences among these techniques lie in the welding efficiency, the weld plate dilution and materials costs. For example, SMAW is commonly used in industry because it uses low cost electrodes and can be easily performed in comparison to other welding techniques [6].

Several investigators have studied the effect of laser surface modification on wear and erosion of cast irons [2,7]. For example, Benyounis et al. [2] carried out surface melting of nodular cast iron by Nd–YAG laser and found that a laser beam of maximum power 100 W led to dissolve most of the graphite nodules. The resolidification resulted in a fine dendritic structure comprising of retained austenite as well as some martensite and cementite (Fe_3C). The maximum hardness was found to be between 500 and 600 HV [2]. In addition, the uses of welding techniques to deposit hardfacing alloys on cast irons have been reported in the literature [8,9]. However, surface modification of DI using hardfacing alloys has been subject of fewer studies in literature. In this regard, Shamanian et al. [8] studied the effect of clad thickness on microstructure and surface properties of austenitic stainless steel cladding on DI using SMAW. They found that thin cladded layer have higher hardness and represent better wear resistance in comparison to thick cladded layers and substrate due to presence of more carbides and a finer distribution of phases in their microstructure.

The surface modification of DI with Ni-based electrodes using SMAW has not been reported in the literature. In the present work, the microstructure, hardness and wear behavior of clad layers of NiCrFe3 electrodes deposited on ductile iron plates have been investigated.

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