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Short Communication

Influence of heat treatment on microstructure and mechanical properties of iron-based coating

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ABSTRACT

Iron-based alloys were deposited on the low carbon steel by plasma cladding process. Furnace annealing was conducted at 600 °C for 40 min. Resulting microstructure and phases were observed and investigated by scanning electron microscopy (SEM), energy-dispersive spectrometer (EDS) and X-ray diffraction (XRD). Effect of post heat treatment on the mechanical properties of coatings was also studied by instrumented indentation technique. It was found that solid solution γ-(Fe, Ni, Cr) and carbide reinforced phases Cr_7C_3 were the main phases of as-cladding coatings while iron carbide became the main carbide reinforced phase for annealed coatings. For all coatings, hardness and reduced elastic modulus showed obvious load dependence, namely decreased with the indentation load increasing. It was found that calculated values of annealed coatings were generally lower than those of as-cladding coatings as a result of the dissolution of the eutectic structure which decreased the effect of dispersion strengthening.

1. Introduction

Surface wear and corrosion have become the main reasons for equipment failure. The need for improving the qualities of surface leads to the development of surface modification techniques such as spraying [1,2], electroplating [3,4] and laser or plasma cladding [5]. In recent years, plasma cladding technique becomes an active field due to its sufficient rapid cooling rate, good performance and low cost [6–8].

Post heat treatment is now widely used to further improve the required properties of bulk materials, such as furnace heat treatment [9], quenching [10] and laser remelting [11], of which furnace annealing is the most fundamental one. By adjusting the annealing temperature, it can reach the achievement of refining crystal, relieving residual stresses and even changing the microstructure and phases to enhance the mechanical properties [9], such as fracture toughness and wear resistance. However relative to bulk materials, little work have been done to analysis the effect of annealing on materials at small scale, such as films and coatings [7].

In this study, microscopy was used to investigate the effect of furnace annealing on phases and microstructure of iron-based alloy coating produced by plasma cladding process. At the same time, effect on mechanical properties was studied by an almost non-destructive method – instrument indentation test. To avoid the influences of pile-up on the calculating precision of properties, a new method based on the energy of indentation process proposed by Giannakopoulos and Suresh was applied [12,13] instead of the traditional Oliver and Pharr method [14,15].

2. Experimental details

2.1. Material and preparation

Commercial low carbon steel containing 0.1 wt.% carbon was taken as the substrate and degreased in acetone solution. No previous heat treatment was taken. Iron-based alloy powder with particles ranges from 150 to 180 μm was taken as the plasma cladding powder. The compositions of the powder are listed in Table 1.

The experimental equipment adopted in the study was plasma cladding equipment produced by Academy of Armored Forces Engineering (China). Argon was used as the plasma gas. The parameters of plasma cladding process are shown in Table 2.

After plasma cladding, the specimens were divided into two groups. One group remained the original status as cladding, others were annealed at 600 °C for 40 min.

2.2. Characterization

Microstructures of the clad coatings were observed by scanning electron microscopy (SEM) (LEO1530VP) with energy dispersive spectroscopy (EDS) attachment, and phases were characterized by X-ray diffraction (XRD) (D8 ADVANCE, BRUKER/AKS, Germany).

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