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Production of phosphor bronze coatings by laser cladding

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Abstract

Laser cladding is a method to deposit a coating to improve the surface properties of a part or to restore the surface of worn components. Phosphor bronze is an alloy with high fatigue resistance, corrosion resistance and low coefficient of friction. So, it is employed in applications like sleeve bearings or cam followers. Laser cladding technique can be employed to generate a bronze coating over steel to improve the surface properties of elements like drive shafts or bearings. In this research work, a High Power Diode Laser was employed to generate a bronze coating on cylindrical AISI 4340 alloy steel (UNS G43400) substrates. The microstructure observed in bronze coatings is dendritic. It is formed by two phases: copper solid solution with tin (α-Cu) and $Cu_{41}Sn_{11}$ (δ-Cu). The hardness of the phosphor bronze coating is 172±12 HV, which is higher than the one reported for cast bronze.

Keywords: Laser Cladding; phosphor bronze; alloy steel; microstructure; hardness

1. Introduction

Laser cladding is a method to deposit a coating to improve the surface properties of a part or to restore the surface of worn components. The interaction of the laser beam with the substrate generates a molten pool, in which the

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precursor material is fed [1]. The relative movement between the beam and the workpiece makes possible to generate a layer with a thickness ranged from microns to millimeters [2,3].

Phosphor bronze is an alloy of copper, tin (3.5%-20%) and phosphorus (<1%). This material presents high fatigue resistance, corrosion resistance and low coefficient of friction [4]. So, it is employed in applications like sleeve bearings or cam followers. Laser cladding technique can be employed to generate a bronze coating over steel to improve the surface properties of elements like drive shafts or bearings.

In this research work, a High Power Diode Laser was employed to generate a bronze coating on cylindrical AISI 4340 alloy steel (UNS G43400) substrates. Microstructure and composition of the coatings have been studied via Scanning Electron Microscopy (SEM), Energy Dispersive X-Ray Spectroscopy (EDS) and X-Ray Diffraction (XRD). The hardness was analyzed by means of Vickers microindentation.

2. Materials and Methods

The laser cladding by powder flow technique was employed to produce phosphor bronze coatings (see Fig. 1). In laser cladding, a laser beam is employed as a heat source to generate a molten pool in a substrate. Precursor material in form of particles is fed in the molten pool. The relative movement between the beam and the workpiece makes possible to deposit single layer or multiple layer coatings.

The experiments were done using a High Power Diode Laser from DILAS with a wavelength between 915 and 976 nm and a maximum output power of 1600 W. Commercial phosphor bronze alloy particles (Cu15Sn0.4P, B15 from Sandvik Osprey Ltd) were selected as precursor material to generate the coatings. The particles are rounded-shaped with a size between 150 µm and 180 µm, as can be seen in Fig. 2. Phosphor bronze powder was carried by argon and laterally injected in the molten pool by a convergent nozzle. The coatings were generated on cylindrical AISI 4340 alloy steel (UNS G43400) substrates with dimensions of 32 mm in diameter and 27 mm in height. A CNC table with a rotatory axis was employed to move the substrate with regard to the laser head.

Laser beam was focused employing a lens with a diameter of 50 mm and a focal length of 250 mm. The laser spot diameter was 3 mm on the surface of the substrate. Single clad tracks were obtained employing a delivered laser power of 1000 W (mean irradiance: 142 W/mm2), a scanning speed of 10 mm/s and a power feeding rate of 24 g/min. Phosphor bronze coatings were generated by depositing consecutive single clad tracks with an overlapping ratio of 66.6%.

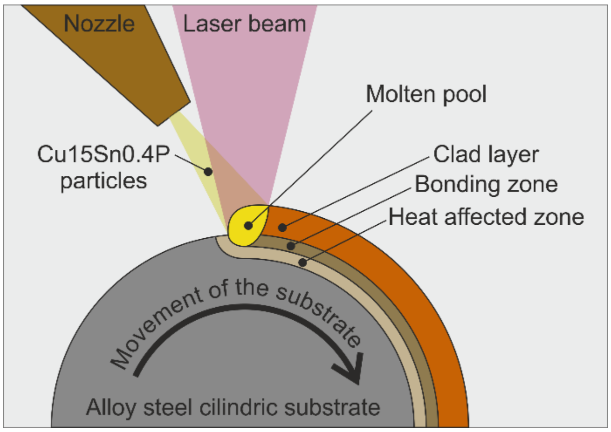

Fig. 1. Sketch of the laser cladding set-up