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Pre-placed WC/Ni clad layers produced with a pulsed Nd:YAG laser via optical fibres

S.W. Huang[a,*], D. Nolan[a], M. Brandt[b]

[a]*Surface Engineering Laboratory, Faculty of Engineering, University of Wollongong, Wollongong, NSW 2522, Australia*
[b]*Industrial Research Institute Swinburne, Swinburne University of Technology, P.O. Box 218, Melbourne, Vic. 3122, Australia*

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Abstract

Laser clad WC/Ni layers were produced on H13 tool steel substrates with a pulsed Nd:YAG laser and optical fibres using the pre-placed powder technique. The effects of parameter variation, such as laser pulse energy, beam profile, traverse speed and volume fraction of the reinforced WC particles, on clad layer formation and its properties were investigated. The microhardness of the clad layers was measured and the microstructure was characterised by optical and scanning electron microscopy and X-ray diffraction. The results show that relatively thick (>0.5 mm), fully dense and crack-free clad layers of WC/Ni can be formed on H13 substrates without any pre-heating. The results further show that the volume fraction of the reinforced WC particles is the dominant factor affecting most clad layer properties such as its porosity, microhardness and wear resistance. The greater the volume fraction of WC particles, the lower the porosity, the higher the microhardness and the higher the wear resistance of the clad layer. Average microhardness values of the matrix were as high as 800 HV and the pin-on-plate (reciprocating) wear tests showed the weight loss of the clad layers is substantially lower than that for the unclad substrate.

Keywords: Laser clad WC/Ni layers; Pulsed Nd:YAG laser; Wear resistance

1. Introduction

Laser cladding is a process which is useful to cover a particular part of the substrate with another material that has superior properties, producing a fusion bond between the two materials with minimal dilution of the clad layer by the substrate [1]. The advantages of laser cladding include low and controllable heat input into the workpiece, a high cooling rate, great processing flexibility and low distortion due to low thermal load on the workpiece. The possibility of selectively cladding small areas is also a great advantage. These advantages not only result in better quality products but also offer significant economic benefits [2]. Laser clad metal matrix composite (MMC) coatings consist of a hard phase (such as carbide or oxide) distributed in a continuous metallic binder phase. This hard phase can be partially dissolved by the metallic binder and subsequently resolidified. The unique microstructure of MMCs allows the coating to withstand high tensile and compressive stresses by the transfer and distribution of the applied load from the ductile matrix to the reinforcing hard phase and result in significant improvement of tribological behaviour [3].

In the present investigation tungsten carbide powder was clad with a nickel matrix on H13 tool steel using a pulsed Nd:YAG laser with optical fibres. The purpose of this study was to determine the optimum process parameters for producing fully dense, low dilution clad layers with high wear resistance and low heat affected zone.

2. Experimental details

The cladding materials used in the experiments were crushed tungsten carbide particles (40–150 μm) mixed with pure nickel powder (40–100 μm). The powders were supplied by Goodfellows and Eutectic of Australia, respectively. The chemical composition of Ni powder

*Corresponding author. Tel.: +61-2-42214502; fax: +61-2-42213428.
E-mail address: shao@uow.edu.au (S.W. Huang).

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