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Section Chair Sekcijas vadītāja

Dr. sc. ing. IRĪNA BOIKO, Professor, *Dr. sc. ing. IRĪNA BOIKO, profesore,*
Riga Technical University, Latvia Rīgas Tehniskā universitāte, Latvija

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INVESTIGATION OF LASER PROCESSING OF SPRAYED NICRCOFECBSi/WC COATINGS

UZSMIDZINĀTO NiCrCoFeCBSi/WC PĀRKLĀJUMU
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ŽIVILĒ DECKER, OLEGAS ČERNAŠĒJUS, JELENA ŠKAMAT

Vilnius Gediminas Technical University, Vilnius, Lithuania

e-mail: *olegas.cernasejus@vilniustech.lt*

Introduction

Ni-based coatings are used on engineering components subjected to wear, especially at elevated temperatures. The wear resistance of Ni-based alloy coatings with the addition of hard carbide particles (CrC and WC) has been studied by various researchers [1]. Additionally, other approaches, such as remelting, compaction, and rare earth additions have also been used to improve the wear resistance of thermal sprayed coatings. Remelting and compaction are known to reduce the porosity in various alloy coatings. Literature survey revealed that the performance of the thermal sprayed coatings can be enhanced using a comparatively costlier laser remelting process.

Laser cladding is one of the effective ways to prepare a wear-resistant coating and reduce the surface wear of parts, it can be a useful tool to improve corrosion resistance by forming thin fused layers with refined microstructures with virtually no intermetallic deposits and inclusions. This technology is characterized by high energy density, low workpiece deformation, and strong metallurgical adhesion to the substrate [2]. Increasing the binder content may reduce cracks, but the real-life application of such highbinder parts would be limited [3].

It is difficult to meet the requirements for use of any single-phase coating, so an alloy and WC composite coating is also used in the laser cladding process to effectively enhance the surface microhardness and abrasion properties [4]. However, tests and studies show that there are still many problems, and the quality of coating formation is one of the important factors limiting the development of laser cladding.

Methodology

During the study, nickel-based coatings with tungsten carbides were formed on a structural steel S 235 substrate using a “Rototec 80” flame sprayer and a “Motoman 100” robot. A self-fluxing powder mixture was used for the research: 60 % nickel-based powder and 40 % tungsten carbide powder. Part of the sprayed coatings were remelted in an electric furnace at 1300 °C (heating time 2.5 min). All samples (sprayed only and sprayed with subsequent remelting in an electric furnace) were treated with a single-mode YAG fiber laser (spot diameter 1.0 mm, laser processing speed 500, 750 and 1000 mm/min). Laser treatment of the samples was performed at 20 °C and 200 °C temperatures. The morphology and track geometry of the laser remelted coatings were examined using optical microscopy. A universal hardness tester Zwick/Roell ZHμ with a measurement error of 1 % was used to measure the microhardness of the test samples. The abrasion resistance of the coatings and the values of the coefficient of friction were evaluated in the dry friction test. The tests were performed on a “Microtest” tribometer using a “ball-on-disc” friction pattern.

Results

Morphological studies of the sprayed and variously treated samples showed that additional remelting of the coating in an electric heater at 1300 °C reduced the porosity of the coating from 19.62 % to 3.59 %, which is 5.47 times. Subsequent laser remelting of the coating reduced the porosity of the remelted metal from 2.56 % to 1.40 %. The combined spray remelting technology (electric furnace + laser) has been used to increase the density of the coating and reduce its porosity up to 14 times.

Examining the geometry of the remelted tracks of the sprayed coatings, it was found that increasing the laser processing speed from 500 to 1000 mm/min slightly reduces the track width to 5–10 %, but at the same time, the decrease in the depth of the laser remelting layer is very large (up to 2.4 times). The use of different preheating temperatures for the laser treatment of the samples in the study also influenced the geometry of the remelted tracks of the sprayed coatings. Increasing the preheating temperature of the sample from 20 °C to 200 °C significantly increased the remelting depth. The remelting depth of the sprayed and laser-treated samples increased 1.5 times, and that of the sprayed, furnace-remelted and laser-treated samples 1.75 times. The additional laser remelting of nickel-based tungsten carbide coatings (sprayed and remelted in the heater) significantly increased the microhardness of the coating metal from 856 HV0.2 to 1295 HV0.2 (Fig. 1). This had a significant effect on increasing the abrasion resistance of the coating surface during the wear test.

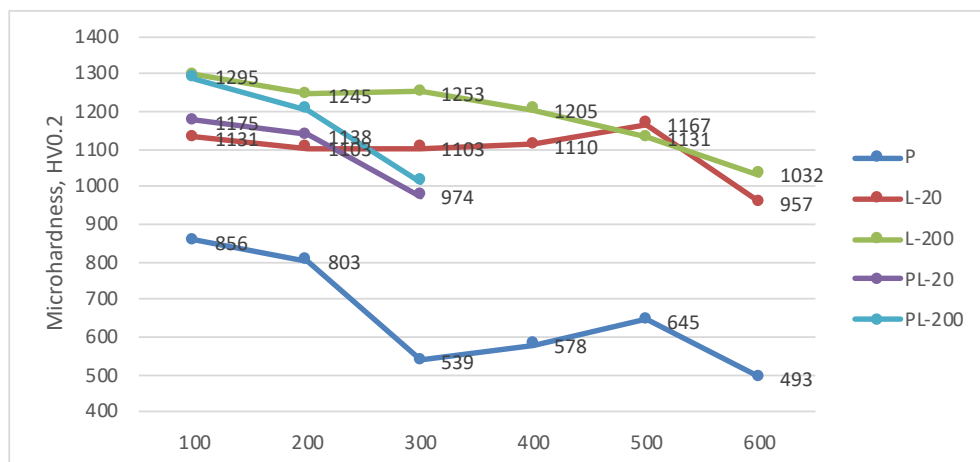


Fig. 1. Microhardness distribution of test samples in the coating remelting zone: P – sprayed sample remelted in the heater; L-20 – sprayed sample treated with laser at 20 °C; L-200 – sprayed sample treated with laser at 200 °C; PL-20 – sprayed sample remelted in the heater and treated with laser at 20 °C; PL-200 – sprayed sample remelted in the heater and treated with laser at 200 °C. The samples were laser treated with 1 mm oscillation and at a speed of 500 mm/min.

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