Microstructure of Ti6Al4V Reinforced by Coating W Particles through Laser Metal Deposition

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***Abstract*— The study of laser power on the deposited of Ti64l4V/W was investigated. The laser metal deposition technique has proven to be a process that is sustainable. The microstructure and microhardness properties of a Tungsten powder strengthened composite coating produced via the laser metal deposition process were investigated in this study. Laser metal deposition was completed utilizing laser power of 800W, 900W, 1100W, 1000Wand 1200W. Scanning electron microscopy (SEM) and microhardness machine were used to characterise the microstructure and hardness of the composite layer formed on the surface of the Ti6Al4V substrate. The microstructures of all the composite layers produced by the laser metal deposition process were enhanced relative to those of the Ti64l4V substrate.**

***Index Terms*— Laser metal deposition, Tungsten, Titanium alloy**

I. Introduction

Titanium Ti6Al4V is used as a part of the aviation, automobile, synthetic, petrochemical, biomedical, and business sports ventures because of their particular high quality and prevalent erosion resistance.

In any case, poor tribological properties, for instance, a high frictiont coefficient and low hardness, restrict their usage in applications that require high surface hardness and wear resistance [1]-[6].

Laser surface modification has been used for the purpose of enhancing the surface of the workpiece since it builds the lifespan of the workpiece and also lessens the cost of assembly cost [7], while ensuring surface hardness [8]. Surface modification by means of lasers appears to be attractive given that they have high coherence and are directional, meaning they offer precision at a particular range without damaging any part of the surface [4]. The cross-section of the microstructure were characterised by using X-ray energy dispersive spectroscopy (EDS).

The effect of the different laser power in LMD processes were compared against the resulting microstructure and micro-hardness of the materials.

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II. Experimental Methods

A. Samples preparation and equipment

The substrate material utilised was 99, 6% Ti6Al4V, and the dimensions of the samples were 103 mm x 103 mm x 7,46 mm^3. The Ti6Al4V substrate was sandblasted to remove unwanted material and was cleaned with ethanol. The laser system equipment with a maximum power of 4400 Watts was employed for laser metal deposition. Different laser power was used for the LMD process at the Council for Scientific and Industrial Research (CSIR) in Pretoria, South Africa. The experimental set-up is available at the CSIR, National laser centre Pretoria, South Africa. LMD was achieved by means of a laser system that uses a Kuka robot (Figure 1). The hopper is filled with powder material, such as pure titanium and the spherical powder W. Cylinders are filled with argon, which is used to anticipate oxygen pollution on the deposited composite, and an argon shield is used to shield the store from oxidation in the midst of the procedure.

A metallographic investigation of the sample was done on cross-segments of the compound layer and the tests were set up according to standard metallographic systems E3-11 ASTM standards [9]. Before the deposition process, all substrates were sandblasted so that all unwanted material on the substrate could be removed to allow good metallographic bonding. Acetone was utilised on the substrate to brush the surface and to enhance the laser power retention.

The standard test method for micro-hardness on metallic material with an indentation weight of 500 g was used, and a spacing time of 10s, spacing between the indentations was 12µm following the ASTM E384-11el standard [10]. All the samples were cleaned so that defects could be avoided. The grinding was done using MD ALLEGRO. After Grinding,

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samples were polished with MD CHEM. Samples were etched in Kroll's reagent for 10-20 s following the ASTM E3-11 ASTM Standard [10].

The procedure parameters utilised as part of this study are shown in Table 1.Fig 1 demonstrates the processing parameters of a Kuka robot that was utilised amid the deposition. The system comprises of the nozzle at its end, hose connector, a controller and another component, for example, the powder feeder, laser components, a chiller and argon gas chambers.

Fig.1. Experimental set up

Table 1. Processing parameters

Specimen names	Power (W)	Scan speed	Powder rate (rpm)		Gas rate	
			Ti	W	Ti	W
N1	800	0.007	9.5	0.5	1.5	3
N2	900	0.007	9.5	0.5	1.5	3
N3	100	0.007	9.5	0.5	1.5	3
N4	1100	0.007	9.5	0.5	1.5	3
N5	1200	0.007	9.5	0.5	1.5	3

III. Results

A. Microstructure

Fig. 2 shows SEM image taken from the etched cross-section of the composite coatings at laser power 0.9 kW, 1.0kW and 1. 2kW. After the laser process at 0.9kW there was no split or pore development, as can be seen in Fig. 2(b). Expanding the laser power to 1 kW brought about no huge modifications in the microstructure of the coating, as presented in Fig. 2(a). Additional extending the laser power to 1.2 kW prompted an expansion in pores as seen in Fig. 2(c). The high porosity may be a direct result of widening solubility of gases in the melting pool with expanding heat input. It can moreover be seen that the W particles were consistently disseminated in the composite coatings accomplished at 0.9kW, 1kW, 1. 2kW. Fig. 2(c) demonstrated that the W particles were equally circulated beside the profundity of the composite coating deposited at 1 200 W. The process might be clarified when the densities of the stages and the solidification process of the melting pool are assessed. Since W has the highest density, the W particles have a tendency to penetrate the composite coating during the hardening process. With the high-temperature contribution of the laser melting deposition procedure at 1 200 W, the solidification procedure is moderate, giving adequate time for the development of the W particles. It can likewise be seen that W particles were consistently circulated in the coatings at 900 W and 1 000 W. The physical appearances of the deposited paths shown in Figure. 3, and the deposition were marked as N1 up to N5

A. Micro-hardness

Hardness testing was conducted in all samples with fifteen indentations on the deposited composites. The coatings were indented from their highest points through the covering and up to the substrate. The composite coatings highlighted W elements circulated in their matrices. A huge increment in hardness was found in all the samples in comparison with the hardness of the substrate material. Be that as it may, the micro-hardness estimates show that the most reduced hardness value was observed in the deposited laser power at 1 100 W (N4). The reduction in the hardness is attributed to the nonattendance of W particles in light of the fact that the advanced laser power contribution amid LMD causes the W to enter the composite coating as shown in Figure 4(1 100 W).The hardness test was done according to the E384-11el ASTM standard (Standard). Figure4 show average hardness in three different zones, that is, the deposit zone, the fusion zone and the HAZ. The hardness values for clads, fusion zones and heat-affected zones are the highest at 1 000 W (N3).

IV. Conclusion

This study reports on the W-reinforced composite coatings. The impact of the diverse laser power values utilised as part of the laser procedure on the microstructural properties of the coatings were analysed. The hardness on the deposited zone of the substrate was determined, and the results of this work can be summarised as follows:

1 The LMD procedure is entirely reasonable for delivering composite coatings on Ti6Al4V alloys.

2. Laser power directly influences the hardness and microstructure properties of the coating.
3. A uniform dispersion of W elements all through the composite coatings framed at N1, N2, N3 and N5 was seen. At N4, W elements were equally circulated along the depth of the composite coatings, which prompted a decline in hardness.
4 After the (LMD) processes at 900 W and 1 000 W, the microstructure demonstrated no breaks or pores. However, it was found that there was an expansion in the porosity of the coating delivered at 1 200 W.

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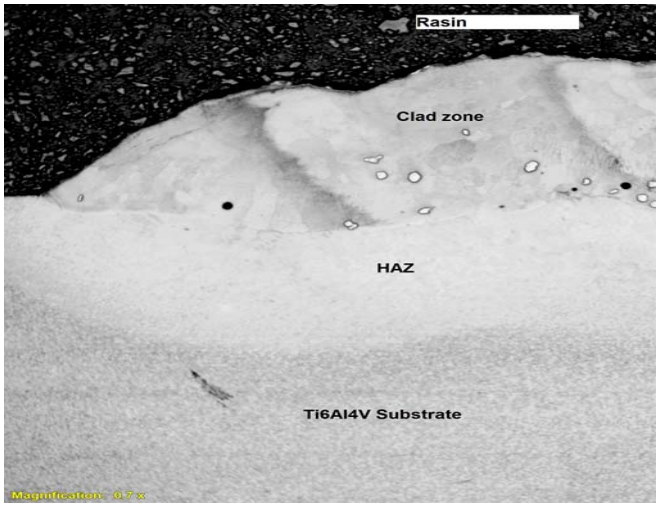
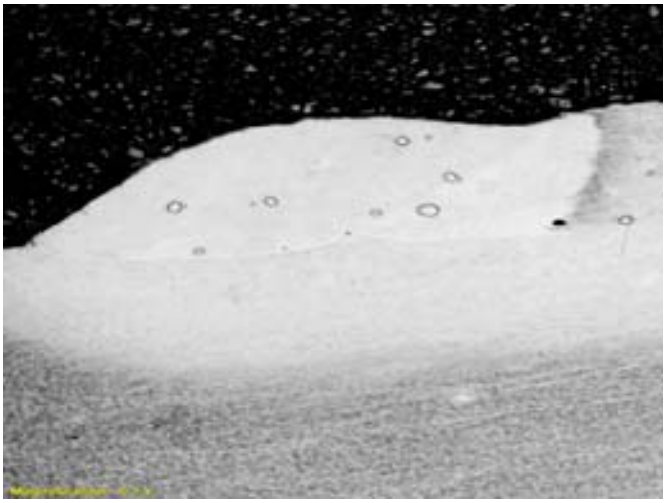


(a)



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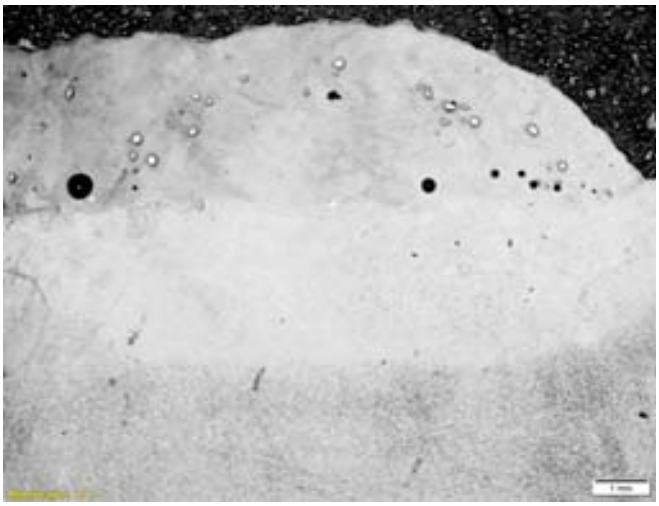

(c)

Figure 2: Cross-sectional SEM micrographs of composites at various powers (a) 1 kW, (b) 0.9 W, (c) 1.2 kW

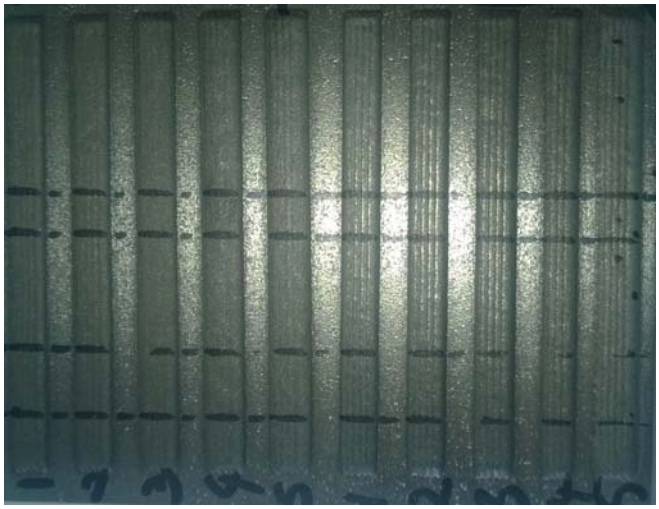

Fig 3: Deposited tracks of samples N1 to N5

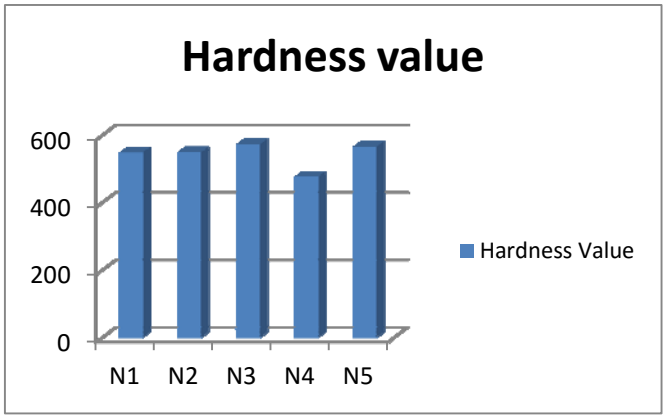

Fig. 4. Hardness profile of the deposited track

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