Laser alloying of Al with Ti and Ni based powders to improve wear resistance and hardness

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Presentation Outline

- Introduction
- Experimental Method
- Results
- Conclusions
Introduction

- Aluminium is extensively used in industry
  - Low cost
  - Light weight
  - Excellent workability
- But has poor wear resistance and low hardness

Objective

- To improve the surface hardness and wear resistance of Al AA1200 by laser alloying with mixed Ni and Ti powders
Laser alloying technique

- Improve the surface properties by modifying the composition and microstructure without affecting the bulk properties of the material
- Involves melting the substrate surface and blowing the powder of the alloying material into the melt pool
  - Fast and accurate
  - Many materials can be alloyed into different substrates
Experimental Method

• Laser alloying was carried out with a 4.4 kW Rofin Sinar Nd:YAG laser
• Beam focus diameter of 4mm on the substrate
• Argon shielding gas
• The flow rate of the shielding gas was set at 2L/min

Figure 1:(A) Nd:YAG laser (B) Experimental setup
Experimental Method

- Aluminium AA 1200 base material
- Ti and Ni powder mixtures
- Powder particle size was between 40 and 100µm
- Different laser scanning speeds (0.01m/s, 0.012m/s, 0.015m/s and 0.020m/s) used
- Single and multiple laser alloyed tracks were created on the surface
- For multiple laser alloyed surface an overlap of 15% between adjacent tracks was used
Hardness

- Polished cross-sections
- The through-thickness hardness measurements
- Load used 100g
- Indentation spacings was 100µm
Wear tests

- The tests were performed on laser alloyed surfaces composed of multiple passes
- The abrasive used was silica sand
- Test specimens were 20mm x 20mm x 5mm in size
- The load used was 10kg force
Results

- A homogeneous microstructure was obtained at 0.010m/s and 0.012m/s scanning speeds.
- There was no sufficient melting and infusion of the powder into the substrate obtained at high laser scanning speed.
- The thickness of the alloyed layer was ~0.52mm.
10wt% Ti and 90wt% Ni at 0.010m/s

Figure 2: SEM micrograph of the surface alloyed with 10wt% Ti and 90wt% Ni at 0.010m/s
Figure 3: XRD pattern of the surface alloyed with 10wt% Ti and 90wt% Ni at 0.010m/s
70wt% Ti and 30wt% Ni at 0.010m/s

Figure 4: SEM micrograph of the surface alloyed with 70wt% Ti and 30wt% Ni at 0.010m/s
XRD Pattern

Figure 5: XRD pattern of the surface alloyed with 70wt% Ti and 30wt% Ni at 0.010m/s
Hardness Results

Figure 6: Hardness versus Ti wt%
Wear Result

Figure 7: Wear rate versus sliding distance
Figure 8: Worn surfaces of Al (A), alloyed with 10wt%Ti and 90wt%Ni (B & C) and alloyed with 20wt%Ti and 80wt%Ni (D)
Conclusions

- Improved hardness and wear resistance was achieved after laser alloying at 0.010m/s and 0.012m/s laser scanning speeds.
- The hardness of the laser alloyed surfaces decreased as the Ti content in the Ni/Ti powder mixture increased.
- The wear resistance decreased as the Ti content increased.
- Grooves, cracks and microfracturing were the dominant wear features for the laser alloyed Al alloys.
Thank you