Kinetic Metallization of Al-MMC Coatings on Mg Alloys for Improved Corrosion and Wear Resistance

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Kevin Spencer and Mingxing Zhang

ARC Centre of Excellence Design in Light Metals

Division of Materials, School of Engineering
The University of Queensland

Introduction

- Most magnesium alloys have relatively poor wear and corrosion resistance
- Solid state coatings such as Cold Spray and Kinetic Metallization enable the coating of heat-sensitive substrates without affecting the microstructure, and little surface preparation is required

Coating Preparation

- Kinetic Metallization (KM) is a subsonic Cold Spray variant that heats the powders well below the melting temperature
- The powder is entrained in a gas stream, accelerated to 500-1000m/s and impacted onto the substrate material, leading to a metallurgical bond both within the coating and at the coating/substrate interface.

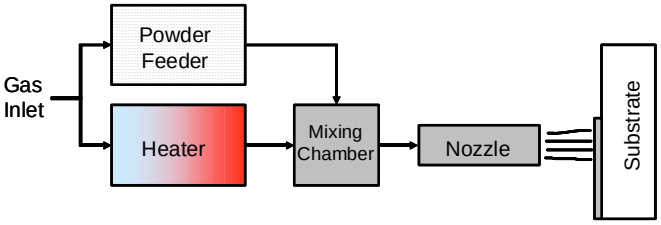


Figure 1: Overview of the Kinetic Metallization process

Coating Properties

Deposition Efficiency

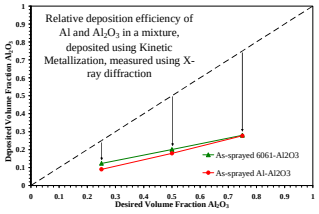


Figure 2: Relative Deposition efficiency of the Al_2O_3 in sprayed coatings of Al/Al_2O_3 mixtures

- Relative deposition efficiency of the Al and Al_2O_3 in cold spray coatings of mixed Al-Al_2O_3 powders (Figure 3) measured using XRD patterns
- Some of the Al_2O_3 is lost during spraying (Figure 2)

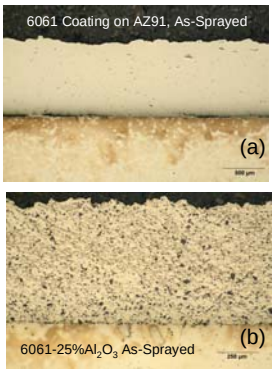
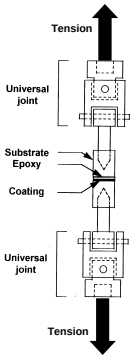


Figure 3: Section of sprayed coatings of Al on AZ91 substrates

Coating Bond Strength



- Coating bond strength ranges from 30 MPa for pure Al coatings, to 40 MPa, for 6061-Al_2O_3 composite coatings
- Failure occurs within the coating, not at the interface

Salt Spray Testing

- AZ91 samples coated with Al (Figure 4a) show minimal surface damage after a 10 day exposure, similar to bulk Al alloys (Figure 4 b and c)
- Uncoated Mg alloy samples are badly attacked (Figure 4 d-f)

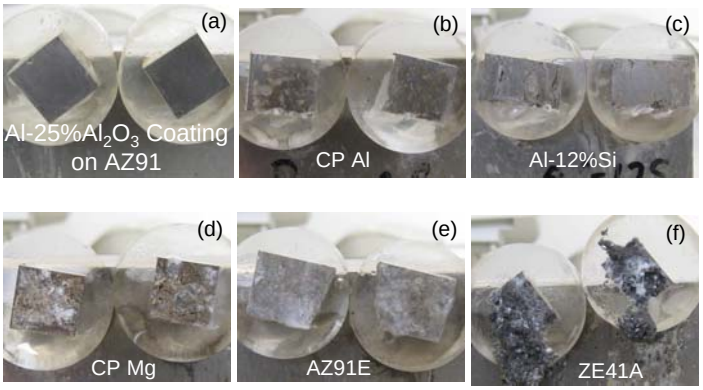


Figure 4: Coated AZ91 samples compared with various uncoated substrates after 10 days of salt spray exposure

Electrochemical Corrosion Tests

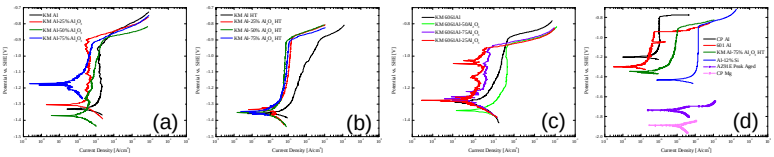


Figure 5: Anodic polarisation data for Al coatings on AZ91 substrates in 5% NaCl, compared with various bulk Al and Mg alloys

- Electrochemical polarisation testing in 5% NaCl shows that the Al coatings have a stable passivation range, Figure 5 a-d
- When the coatings have been heat treated, the passive layer is more stable and the polarisation curves appear like that of a bulk alloy, Figure 5 b
- The corrosion resistance of the Al cold spray coatings is significantly better than AZ91 Mg, and is similar to bulk aluminium alloys

Wear Resistance

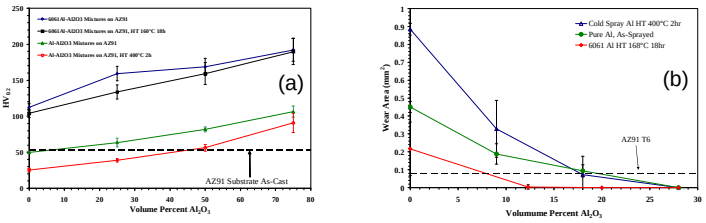


Figure 6: Increase in hardness and wear resistance with the addition of Al_2O_3 to Al cold spray coatings on an AZ91 Mg substrate

- Additions of Al_2O_3 to the Al cold spray coatings increases the hardness substantially over the AZ91 substrate material (Figure 6a)
- Increasing the Al_2O_3 content leads to a more dramatic improvement in hardness than in wear resistance (Figure 6b). The wear rate also becomes more stable and predictable