Effect of Various Coating Materials on Wear Properties of Electrodeposited Composite Coating

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ABSTRACT – The pure nickel, nickel-phosphorus (Ni–P) coating and nickel-phosphorus-quarry dust (Ni–P-QD) composite coatings were deposited on zincated aluminium alloy 7075 (AA7075) substrate by using electrodeposition technique. The electrodeposition process was carried out for 1 hour at 40ºC under the current density of 3 A/dm^2 in a modified nickel Watt's bath containing QD particles at 50 g/L. The produced composite coatings and QD were characterized and tested using scanning electron microscopy(SEM), particle size analyser(PSA), X-Ray Fluorescence(XRF) and wear test. As the present of QD in the coatings, the wear resistance will also increase from COF 0.35 to 0.30, due to the presence of high silica and alumina content in the quarry dust particles and heat treatment process.

INTRODUCTION

Today, Ni-P coatings are considered important engineering alloys due to their interesting combination of properties such good wear resistance and corrosion, high electrical conductivity, good solderability, uniform and smooth surface morphology, low friction coefficient, paramagnetic characteristics, and electrocatalytic activity; they can be gained through simple electrochemical methods[1–4].The physical characteristics of the Ni-P coatings can generally be enhanced with a suitable heat treatment [5-8], which can be attributed to precipitation of fine Ni crystallites and hard intermetallic Ni_3P particles during the crystallization of the amorphous phase [9]. The aim of this study was to review the consequences of varied coating materials on the wear of composite coatings.

METHODOLOGY

The AA7075 substrate with dimension 40 mm x 30 mm x 3 mm were grind using silicon carbide papers of 180, 600, 800 and 1200 grit. Then, the substrates followed by immersion in 10 wt. % of sodium hydroxide (NaOH) solution for 10 seconds and immersion in 30 vol. % of nitric acid (HNO_3) for 20 seconds. The double zincating process was carried out by dipping the pre- cleaned substrate vertically in a small glass beaker containing a zincating solution at room temperature. The chemical composition and operating condition for electrodeposition of Ni-P-QD composite coating on AA7075 substrate were summarized in Table 1. The schematic diagram of electrodeposition of composite coating is shown in Figure 1. The surface morphology of the Ni-P-QD composite coatings was characterized using scanning electron microscopy (SEM). The wear properties of the Ni-P-QD composite s were evaluated using reciprotary friction and wear monitor (TR-281-M8). The coefficients friction was obtained by sliding coatings against 6mm steel ball at room temperature under non-lubricated condition. QD characterization using XRF, PSA and SEM were analysed.

Table 1 Composition of modified nickel Watt's bath and electrodeposition operating condition

Modified Nickel Watt's bath				Electrodeposition process	
Chemical	Concentration (g/l)			Parameter	Condition
	Pure Nickel	Ni-P	Ni-P QD		
Nickel sulphate hexahydrate	200	200	200	Temperature (°C)	40
Nickel chloride	20	20	20	Deposition Time (min)	60
Sodium citrate	30	30	30	Current Density (A/Dm^2)	3
Sodium hypophosphite	-	0.3	0.3		
Quarry dust	-	-	50		

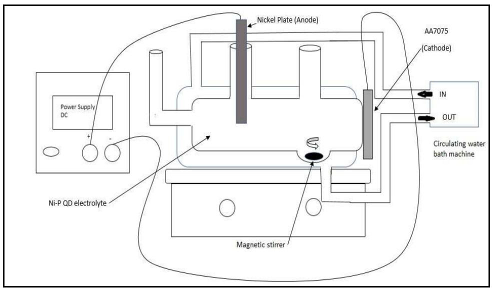

Figure 1 Schematic diagrams of electrodeposition process

RESULTS AND DISCUSSION

3.1 Characterization of Quarry Dust

The elemental composition for quarry dust particles are found by XRF technique and shown in Table 2.

Table 2 Composition of quarry dust particles, as found by XRF technique

Element	SiO_2	Al_2O_3	CaO	Fe_2O_3	MgO	Na_2O	K_2O	SO_3	TiO_2	P_2O_5
Concentration (Wt%)	72.6	15.1	1.1	1.9	0.8	3.0	4.9	0.2	0.3	0.1

Figure 2 shows the particle size distribution of quarry dust particles. It is found that the particles are having a size distribution less than 600 µm. It has been shows that the quarry dusts used in this study have an average size of 300µm as shown in the Figure 2.

The morphology of quarry dust was studied by SEM. It can be seen clearly from Figure 3 that the quarry dust particles are in irregular shape with various sizes.

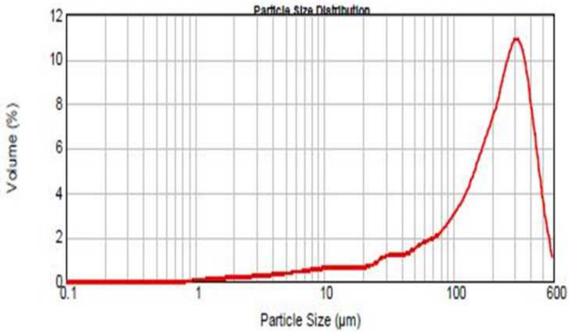

Figure 2 Particle size distribution of quarry dust

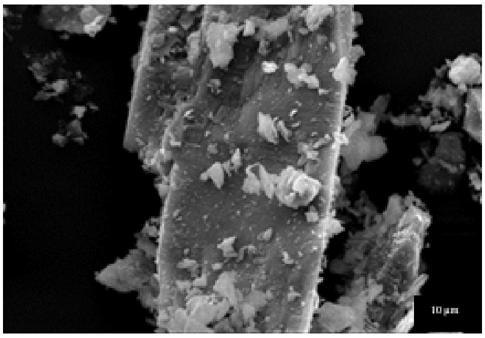

Figure 3 SEM image of quarry dust particles

3.2 Effect of Various Coating Materials on the Wear Scar of Composite Coatings

Figure 4 shows the typical behaviour for the coefficients friction of the various coating materials including heat treatment. Ni-P-QD (50 g/l) composite coating at 400°C heat treatment has the lowest COF value compared to other composite coatings. This result is consistent with the wear tracks obtained, as shown in Figure 5. Ni-P-QD 50 g/l coatings, heat treated at 400°C exhibited the narrowest wear width and shallowest plough lines compared to other coating materials. These findings indicated that Ni- P co-deposited with 50 g/l of QD and heat treated at 400 °C has improved the wear resistance of bare AA7075, pure Ni, Ni-P and Ni-P-QD 50 g/l (deposited at room temperature). According to Chang et al. [10], the improvement in wear resistance of the composite coating is due to the phase transformation from Ni to Ni_3P after the heat treatment process.

CONCLUSION

In summary, the Ni-P-QD 50 g/l with heat treatment at 400°C is successfully improved the wear resistance of bare AA7075, pure Ni and Ni-P composite coating. This is due to the presence of high silica and alumina content in the quarry dust particles co-deposited in the nickel matrix. Furthermore, it is also due to the phase transformation from Ni to Ni_3P after the heat treatment process.

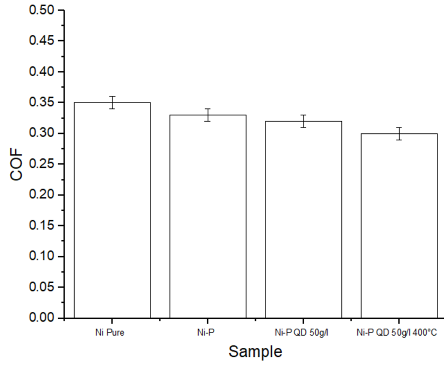

Figure 4 COF values of various coating materials

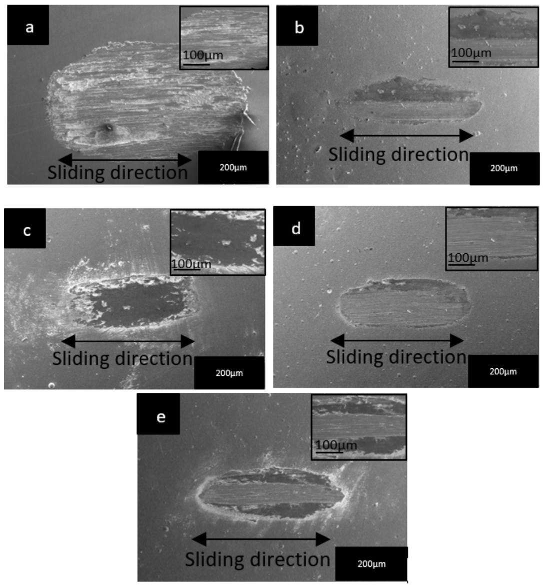

Figure 5 SEM image of wear scar:a) Bare AA7075, b) Pure nickel, c) Ni-P, d) Ni-P-QD 50 g/l, e) Ni-P-QD 50 g/l (400°C)

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