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The Dispersion of Nanometer SIC on Electro Less Ni-P-Nano SIC Composite Plating

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Abstract: In this study, we study the effects of the concentration of Sic using the orthogonal test method, the speed of mixing, the temperature and the surfactants on depositing rate and micro-hardness and obtain the optimized technological scheme and fine Ni-P-SIC composite coating. The results showed that using citric acid-acetic acid as complexing agents can obtain high speed of depositing and homogeneous coating with Sic well-distributed. Among the technological parameters, the effects of temperature on depositing rate are biggest and the surfactants are next; the effects of the concentration of Sic particles on micro-hardness are biggest and the surfactants are next. Give consideration to depositing rate and stability of the liquid, the temperature should be controlled at 82±2°C, the concentration of Sic particles and surfactants should be controlled in 4 g/L and 60 mg/L. The influence to micro-hardness value of coating with ultrasonic disperser craft also is studied.

Keywords: Depositing rate, disperser, electro less composite plating, micro-hardness, microstructure, nanometer sic, speed of mixing ultrasonic, surfactant

INTRODUCTION

With the rapid development of aviation, aerospace, electronic, mechanical, chemical and nuclear energy, a variety of new functional and structural materials are becoming urgent need and some single material cannot meet some special requirements, therefore, composite materials have been developed rapidly. Composite plating, also known as spread-plated, composite coatings with wear and corrosion resistance were deposited on the surface of metal matrix layer by electroplating or electro less composite plating to achieve longer life, saving material, reducing costs and improving economic efficiency (Chen, 2005; Guo and Zhou, 2000; Yang *et al*., 2009; Feng *et al*., 2010; Liu *et al*., 2008; Jin *et al*., 2010).

Electro less composite plating is a more convenient and economical way for preparation of composite coating, easy to operate, less investment in equipment, easy to control, low energy consumption. This study uses a way of adding single Sic wear particles to the Ni-P alloy bath, deposits wear and corrosion Ni-P-Sic composite coating on the surface of 45 steel by electro less composite plating that can be used for piston rings, cylinder liners, molds, bearings, crankshaft and other mechanical parts, extending its life.

EXPERIMENT

Experimental instrument and materials: Experimental instrument is shown in Table 1. Use the ordinary carbon structural steel plate Q235 as sample, Size (L×W×H) is 15×15×2 mm, respectively produced by Weifang red flag Machinery Factory. Before plating pretreatment of the sample must be carried out whose process is described below:

Table 1: Experimental instrument

Instrument name	Specification
Collector constant temperature heating magnetic stirrer	DF-101S
Desktop CNC ultrasonic cleaner	KQ5200DB
PH meter	FE20K
Electronic analytical balance	AR423CN
Vickers hardness tester	HVS-10

> Chemical degreasing→Rinse with distilled water→Ultrasonic cleaning→Rinse with distilled water→10%HCl Activating (1-2 min) →Rinse with distilled water.

Bath components are selected according to the results of a large number of single-factor test (Wu *et al*., 1997), the composition of plating solution is shown in Table 2.

The physics performance of nano-Sic particles used in this study is indicated in Table 3.

Test method: The plating speed is indicated by the coating weight gain per unit area and per unit time. First, clean degrease the substrate and then weigh on analytical balance in the parts per million, record the quality m_1. After plating, clean degrease the sample and then weigh on analytical balance in the parts per million again and record the quality m_2. Plating rate is calculated by Eq. (1):

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Table 2: The composition of plating soln

Composition	$NiSO_4 \cdot 6H_2O$ [g/L]	$NaH_2PO_2 \cdot H_2O$ [g/L]	$Na_3C_{it} \cdot H_2O$ [g/L]	CH_3COONa [g/L]	Accelerant [g/L]	Stabilizer [mg/L]	NanoSIC [g/L]
Content	25	30	35	5	5	5	

Table 3: Physics performance of the nanometer particle of SIC

Average size	Surface area	Crystal	Color	Free silicon	Total oxygen content	Purity	Bulk density
40nm	90 m^2/g	Cubic structure	Gray-green	<0.2%	<0.61%	>99.09%	0.05 g/cm^3

Table 4: Orthogonal factors and level

Factors level	Concentration of SIC [g/L]	Speed of mixing [r/min]	Surfactant [mg/L]	Temperature [°C]
1	6	200	30	77
2	4	250	60	82
3	2	300	90	87

Table 5: The influence of factor on depositing rate and analysis

Factor level no	Concentration of SIC [g/L]	Speed of mixing [r/min]	Surfactant [mg/L]	Temperature [°C]	Depositing rate [g/m^2h]
1	1	1	1	1	46.667
2	1	2	2	2	47.222
3	1	3	3	3	49.060
4	2	3	2	1	37.778
5	2	1	3	2	53.333
6	2	2	1	3	60.556
7	3	2	3	1	29.445
8	3	3	1	2	94.445
9	3	1	2	3	78.472
R1	47.650	59.491	67.223	37.964	
R2	50.556	45.741	54.491	65.000	
R3	67.454	60.428	43.946	62.696	
Differential	19.804	14.687	23.277	27.036	

Table 6: The influence of factor on micro-hardness and analysis

Factor level No.	Concentration of SIC [g/L]	Speed of mixing [r/min]	Surfactant [mg/L]	Temperature [°C]	Micro-hardness$HV_{0.1}$
1	1	1	1	1	268
2	1	2	2	2	600
3	1	3	3	3	390
4	2	3	2	1	460

$$V = \frac{m_2 - m_1}{S \times t} \tag{1}$$

Formula S-Plating area (m^2)
T-Plating time (h)

Experiments load applied is 100 g, loading time is 15s. Select three different locations in the coating surface to test their hardness, calculate the average hardness by the online system using Eq. (2):

$$HV=1854.5\times F\div D^2 \tag{2}$$

- Formula HV-Vickers micro hardness symbol
- (Kgf/mm^2)
- F-The load applied to the specimen (g)
- D-Diagonal (μm)

The $L_9{}^3$ orthogonal table has been used to study the effects of the concentration of Sic, the speed of mixing, the temperature and the surfactants on depositing rate and micro-hardness. Each factor is tested by three levels, experimental factors and levels are shown in Table 4.

The surface and cross-section morphology of composite coatings were identified by QUANTA200 environmental Scanning Electron Microscopy (SEM) under the test condition of accelerating voltage 3.0 kV. Elements of composite coatings were determined by their micro-scanning using INCA ENERGY 300 X-ray Energy Dispersive Spectroscopy (EDS) under the test condition of accelerating voltage of 25kV.

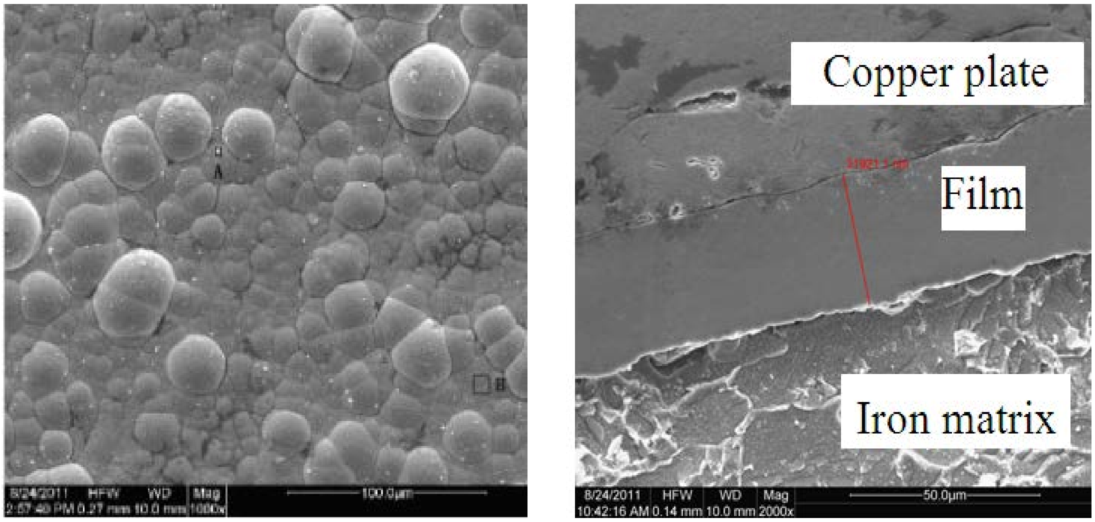
TEST RESULTS AND DISCUSSION

The influence of factor on depositing rate and analysis: The influence of factor on depositing rate and analysis is shown in Table 5.

Table 5 shows the analysis results that within the scope of this experiment, temperature is a major factor in the coating deposition rate, surfactant concentration is a secondary factor affecting the plating rate, stirring speed and amount of Sic is little effect to plating rate.

The influence of factor on micro-hardness and analysis: The influence of factor on micro-hardness and analysis is shown in Table 6.

Table 6 shows the analysis results that within the scope of this experiment, the amount of Sic are the



(a) (b)

Fig. 1: Cross-section and surface morphology of composite coatings (a) Surface morphology (b) Cross-section morphology

Table 7: Element distribution comparison about the region A and B of composite coatings

Element		Ni	P	Si	C
Position A	Weight%	73.94	12.48	4.02	9.56
	Atomic%	48.41	15.49	5.50	30.59
Position B	Weight%	85.77	14.23		
	Atomic%	76.07	23.93		

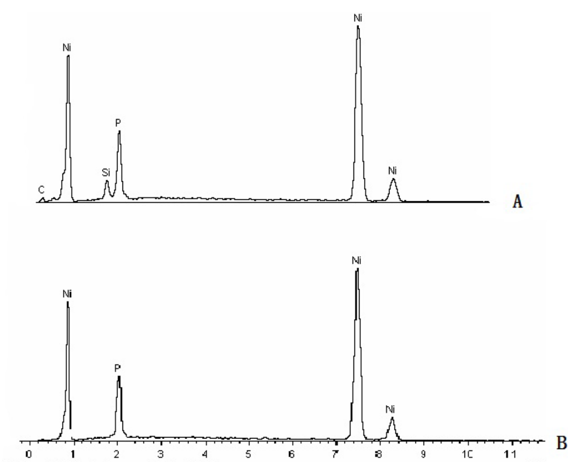


Fig. 2: ED's patterns of different positions on composite coatings in Fig.1

main factors impacting coating micro hardness, the content of surfactant is the secondary factor affecting coating micro hardness.

Surface morphologres and composition analysis: It can be seen from Fig. 1, composite coating with uniform and dense dispersed small Sic particles.

Figure 2 and Table 7 showed that the Chemical Constituents were different between the region A and B of composite coatings. The element contents of C and Si in the place of A were significantly higher than B. There were small Sic particles in the region A.

CONCLUSION

The results showed that using citric acid-acetic acid as complexing agents can obtain high speed of depositing and homogeneous coating with Sic well-distributed. Among the technological parameters, the effects of temperature on depositing rate is biggest and the mixing speed is next; the effects of the concentration of Sic particles on micro-hardness is biggest and the mixing speed is next. Give consideration to depositing rate and stability of the liquid, the temperature should be controlled at 82±2°C, the concentration of Sic particles and surfactants should be controlled in 4 g/L and 60 mg/L.

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