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The Influence of Reducing Agent on Micro-hardness and Deposition Rate ofNi-P Nano Molybdenum disulfide Composite Coatings on PlainCarbon Steel Bearing HousingComponents.

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ABSTRACT
The study aims toimprove the intermetallic layer of produced bearing housing components used by machineries. This bearing housing components usually fail due to constant wear and tear caused by environmental factors such as temperature, high loads and pressure. In this study,The Influence of reducing agent on micro-hardness and deposition rate of Ni-P nano molybdenum disulfide composite coatings on mild steel bearing housing Components were studied. As a result, five bearing housing components were produced, nickel-phosphorus and structured nano MoS_2 metal matrix composite coatings were deposited by means of electroless deposition method on plain carbon steel bearing housing components of boogies in the presence of varying NaH_2PO_2 H_20_2 at 32g / l, 44g/l, 56g/l, 70g/l, nano MoS_2 at uniform distribution of 13g/l, thiourea at 0.6g/l, citric acid at 25g/l fluorides at 50g/l, and $NiSo_4$ at 40g/l. The experiment was followed by heat treatment and oven drying at 400^oC. The effect of sodium hypophosphite with deposition rate was also studied. The investigation showed that the bath is reliable and good when compared to conventional methods of hardened chromium coatings. It was also recommended that Ni-P –MoS_2 composite coatings for other vital parts of the machinery including shafts, bearings etc. or the production of novel bio lubricants with the in-cooperation of functional nano materials that can withstand heavy loads and pressure in machineries to help mitigate the effect of wear and corrosion problems and improve productivityin the industry.

I. INTRODUCTION

Maintenance and repair expenses in the oil and gas industry caused by bearing failure are very large. Bearings play an important role in power transmission; therefore, their fitting and maintenance must be given careful consideration. A proper bearing should always be selected for a particular use. During use, excessive pressure must be avoided, as the same is likely to squeeze out the oil, causing abrasion of the metals in contact and sudden rise in temperature. The various metals used to form bearing surfaces are cast iron, steel, bronze and Babbitt metal and all bearings and bearing housing should have continuous lubrication because the shaft journal and the bearing surface should be prevented from having a direct contact with each other while the shaft is running.

A coating is defined as a coherent layer formed from single or multiple application of a coating material to a substrate [DIN ENI ISO 4618; 2.52]. According to the existing standard [DIN ENI ISO 4618; 2.53] a coating material is a material in liquid, paste or powder form which, when applied, forms a protective and decorative coating. Coating materials consist of four types of ingredients namely: binders [also called film formers], pigments and extenders, [used as colorants] most of the extenders are naturally occurring mineral fillers and insoluble in solvents and binders. Solvents; are single liquids or blends of, [liquids that dissolve other substances to form solution without reacting with the substances except reactive substance]. Additives [which can modify a large variety of properties, for instance, its flow behavior, surface tension, gloss structure and whether resistance.The electroless Ni–P based lubricating composite coatings usually contain co-deposited solid lubricants such as WS2, MoS_2, polytetrafluoroethylene (PTFE), and graphite, and they usually have a reduced friction coefficient as compared with electroless Ni–P coating. Similarly, the wear-resistant composite coatings usually have co-deposited hard particles such as WC, SiC, Al_2 O_3, B_4C and diamond, and they usually have increased hardness and wear resistance as compared with electroless Ni–P coating.

It can be rationally anticipated that the inclusion of nano-sized particles in electroless Ni–P alloy coating would be significant for broadening the scopes of the coating in engineering, because various types of nanoparticles have special natures much different from that of bulk counterparts and could endow the coating with special functionality. This has been primarily verified by the studies on electroless Ni–P alloy coating doped with carbon nanotubes (CNTs), where CNTs were found to greatly improve the wear resistance of the CNTs–Ni–P composite coating, due to the self-lubrication property and the unique antifriction structure. No doubt, the preparation of electroless Ni–P based composite coatings with excellent comprehensive properties is highly dependent on the stable dispersion of the nanoparticles in plating bath, otherwise the so-called composite coatings would have non-uniformly distributed particulates and numerous defects, owing to the segregation and agglomeration of the nanoparticles with high surface energy and activity in the plating bath.

II. MATERIALS AND METHODS

The first step of the electroless deposition technique is cleaning, grinding and activation of the surfaces with silica carbide shine paperbefore placing or inserting the article inside the liquid bath. This is followed by sensitization thereby, triggering the process of what is known as electron-donor-acceptor complex. Other chemical materials used for the experiment are thiourea, nickel sulfate, sodium hydroxide, citric acid, fluorides and sodium hypophosphite. Nickel-phosphorus-nano MoS_2 composite coatings were deposited on produced bearing housing components of plain carbon steel specimen with dimension 90-70 mm using electroless deposition method (See Plate1).The bath composition andcharacterization of Ni-P-Nano MoS_2 composite coatings are presented in (Table 1) and Table 3.2. Other bath components are 2000ml beaker,magnetic stirrer and a temperature probe.

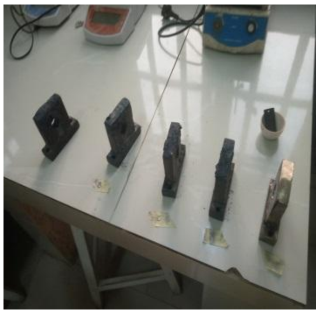

Plate 1(a)Produced Bearing Housing Plate 1(b) Coated Bearing Housing

Plate 1(c) Ni-P nano MoS_2Plate 1(d) Worn Bearing Housing

Table 1: Bath Components of Electroless Ni-P Nano-MoS_2 Coatings

Bath composition	Concentration (gl-l)	Bath b	Bath c	Bath d
	Bath a			
Nickel sulphate	40	40	40	40
$NaH_2PO_2H_2O$	32	44	56	70
Citric acid	25	25	25	25
Sodium flouride	50	50	50	50
Thiorea	0.6	0.6	0.6	0.6
Nano MoS_2	13	13	13	13

Operating conditions
Bath Temperature 70^0 C± 2
Bath ph 6.5 ± 2

Table 2: Characterization of Ni-P/ Nano MoS_2 Coatings on Bearing Housing

Specimen	nickel sulphate ($NiSO_4$), g	$NiSO_4 + MoS_2$ Ni + MoS_2,g
A w1	8.3198	w1 = 18.1560
w2	8.3098	w2 = 18.1451
B w1	5.7591	w1 = 18.9155
w2	5.7422	w2 = 18.7800
C w1	8.0556	w1 = 17.7881
w2	8.0302	w2 = 17.7091
D w1	15.6496	w1 = 17.8473
w2	15.5079	w2 = 17.6345
Blank w1	18.6317	w1 = 16.3778
w2	-	w2 = 16.3841

Deposition rate $$D_p = \frac{w_1 - w_2}{e \times a \times t} \times 10^{-3} mm/hr \qquad (3.1)$$

where :
W1 = mass of bearing housing component before coating.
W2 = mass of bearing housing component after coating.
e = density of nickel (g/lcm^2)=7.9g/l.
A= surface area of bearing housing components (cm^3).
T = coating time (h)

III. RESULT AND DISCUSSIONS

The effect of the concentration of varying sodium hypophosphite on the deposition rate of Ni – Pand Ni – P Nano MoS_2 composite coatings is presented in the plot in Figure 1

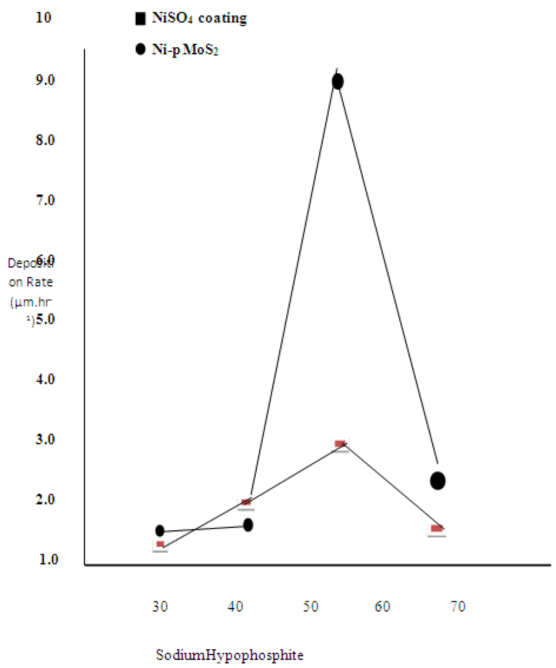

Figure 4.11: Deposition Rate with Varying Sodium Hypophosphite Concentration.

and the values of the deposition rate are given in Table 3 whose data were obtained from Table 2 during the characterization of $Ni - P$ Nano MoS_2 composite coatings where deposition rates were obtained for masses of w_1 and w_2 before and after coating of bearing housing components with density of nickel, surface area and coating time.

Table 3: Deposition Rate Obtained From The Characterization of $Ni - P/$ Nano MoS_2.

Specimen	A (μm/hr)	B (μm/hr)	C (μm/hr)	D (μm/hr)
$N_i - PMoS_2$	1.3	1.5	9.2	2.4
N_iSO_2	1.2	2.0	3.0	1.7

As seen in the plot in Figure 1, there is a slight increase of sodium hypophosphite particle concentration from $32g/l$ to $44g/l$ for both N_iSO_4 and $Ni - P/\ M_oS_2$ at the deposition rate of 1.3μm-hr^{-1} and 1.2μm-hr-^{1}, as well as 1.5 μm-hr-1 and 2.0 μm-hr^{-1} respectively. However, the sodium hypophosphate content in the plot rapidly increases at concentration of 44g/l to 56g/l and at a deposition rate of 9.2μm-hr-^{1} and 3.0μm-hr^{-1} and then rapidly declines at 70g/l of concentration of sodium hypophosphite at deposition rate of 2.4μm-hr-^{1} and 1.7μm-hr.-^{1} This change could be as a result of the aggregation of particles at increased concentration which weakens the co-depositon behavior of $N-p$ with $Ni - P - MoS_2$. The presence of hypophosphite in the bath reduces the Ni^{2+} from nickel sulphate to nickel phosphides and is deposited on the bearing housing substrate by autocatalytic process.

IV. CONCLUSION

MoS_2 particles and Ni- P matrix have been successfully co-deposited on bearing housing components of plain carbon steel to generate Ni-P/nano MoS_2 with varying reducing agents with the aim of improving the corrosion and wear resistance of bearing housing substrate materials using electroless plating technique. The dominant phases of nickel phosphite formed with Ni3p, Ni and Ni2p in the entire coating bath with MoS_2 also shows moderate intensity which could be as a result of limited bath life of electroless deposition process or high reactivity. The study reveals that an intermetallic was formed on the material surfaces. The coatings are uniformly distributed and the compatibility between the components and the coating bath are reliable and good.

REFERENCES

[1]. AdolfosSenatore, Maria sarno, paolociambelli. (2015). Novel nanosized friction modifiers for engine, gearbox and rolling bearing lubricants, contemporary materials

[2]. Agarwala, R., and Agarwala, V. (2003). Electroless alloy/composite coatings: A review, Sadhana, 28, 475-493.

[3]. Agarwala R C, Agarwala V and Sharma R.(2006). Electroless Ni-P based nanocoating technology−A review, Synthesis and Reactivity in Inorganic, Metal-Organic and Nano-Metal Chemistry, Journal of Applied Electrochemistry, 33, 807-816.

[4]. Agrawal, A., and Sahu. K., (2009). An overview of the recovery of acid from spent acidic solutions from steel and electroplating industries, Journal of Hazardous Materials, 171, 61-75.

[5]. Anthony, R., J., Kucernak, Venkata, N., NaranammalpuramSundaram.(2014).Nickel phosphide: The effect of phosphorus content on hydrogen evolution activity and corrosion resistance in acidic medium j mater. chem. A, ,2, 17435-17445.

[6]. Anthony, R.,J., Kucerenak, Venkata N. NaranammalpuramSundaram,(2015), Nickel phosphide: the effect of phosphorus content on hydrogen evolution activity and corrosion resistance in acidic medium J. Mater. chem. A.,2, 17435-17445.

[7]. Ashassi-Sorkhabi H., Aminikia H., and Bagheri R.,(2014). Electroless deposition of NI-Cu-P Coatings containing Nano-AL_20_3 particles and study of its corrosion protective behavior in 0.5 M H_2SO_4 international journal of corrosion.

[8]. Ashassi-Sorkhabi H., Moradi-Haghighi M., and Hosseini M., (2008). Effect of rare earth compounds in the electroless bath on the plating rate, bath stability and microstructure of the nickel-phosphorus deposits, Journal of Surface and Coatings Technology, 202,1615-1620.

[9]. Ashassi –SorkhabiH,andRafizadeh S.H., (2010). "Effect of coating time and heat treatment on structures and corrosion characteristics of electroless Ni –P alloy deposits"Surface and Coatings Technol- ogy,176, 3, 318–326,

[10]. Asthana R.,(2006). Coatings and surface engineering,Journal of materials processing and manufacturing science, 37, 31-34.

[11]. Balaraju J.N, SankaraT.S.N.,Narayanan, and Seshadri S.K.,(2011). "Evaluation of the corrosion resistance of electroless Ni-P and Ni-P composite coatings by electrochemical impedance spectroscopy,"

Journal of Solid State Electrochemistry,5, 5, 334–338. Balaraju,J.N.,(2007).Structure and phase transformation behavior of electroless Ni-P alloys containing tin and tungsten.Journal of alloys and compounds, 34, 156-159.

[12]. Basnyat, P.,Luster, B.,Muratore, C., Voevodin, A. A., Haasch R., Zakeri, R., Kohli, P., Aouadi, S. M., (2008). Surf. Coat. Technol, 203, 73–79.

[13]. Bangwei Zhang, (2016).Nano electroless plating,Elsevier,70,19-23.

[14]. BaosongLi,WeiweiZhang,YuxingHunn, and Jin Dong, (2018).”Synthesis and characterization of Ni-B/Al_2O_3nanocomposite coatings by electrodeposition using trimethylamineborane as boron precursor,”Journal of surface and coating technology,39,385-395.

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