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Ni-P AND AL O_3 Nano Coating on Aluminium Alloy

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ABSTRACT: *In this paper an experimental investigation on optimizing process parameters of electroless nickel -phosphorous and aluminium oxide coatings on aluminium alloy LM25 by electroless coating . A comprehensive experimental study of electroless nickel-phosphorous and aluminium oxide coatings on aluminium alloy LM25 under specific coating conditions is reported. At present nickel -phosphorous was coated on Al LM25 using electroless coating method. The stabilizer thiourea (1ppm) was added into the bath when the reaction is stable. Process parameters such as pH, Temperature and effect of Surfactant concentrations were varied and the corresponding coating thickness, wear rate and co-efficient of friction were to be measured. The level of pH, Temperature were varied and their influence on coating process was studied. The pH was varied at 3 different values such as 4-5, 6-7, 8-9, and Temperature was varied at different values such as 70ºC, 85ºC, and 90ºC. The result showed that the coating thickness was maximum when pH was 7-8, temperature was 85ºC, Surface morphology was studied using scanning electron microscope.*

KEYWORDS: *Electroless nickel coating, Nano additives, wear, Aluminium lm25*

I. INTRODUCTION :

Electroless nickel coating has received widespread acceptance as it provides a uniform deposit on irregular surfaces, direct deposition on surface activated non-conductors, formation of less porous deposits, high hardness and excellent resistance to wear, abrasion and corrosion [1]. Electroless Nickel (EN) coating first developed by Brenner and Riddell (2) has received attention as a hard coating for industrial applications (3) due to its high hardness, uniform thickness as well as excellent corrosion and wear resistance. EN coating is an autocatalytic deposition of a Nickel–Phosphorus alloy from an aqueous solution onto a substrate without the application of electric current and this property gives it an extra advantage over theconventional electroplating processes that depend on an external source of direct current in order to reduce nickel ions in the electrolyte to nickel metal on the substrate.

It improves the mechanical and tribological properties of coatings (4, 5). The alloys with different percentage of phosphorus, ranging from 2% (low phosphorus) to up to 14% (high phosphorus) are possible. EN coating has several advantages when compared with electroplating. It is free from flux-density and power supply issues. It provides an even deposit regardless of work piece geometry. With the proper pre-plate catalyst, it can deposit on non-conductive materials such as plastics also (6). Electroless nickel-phosphorus coatings are generally favored over electroplated deposits because of their enhanced corrosion-resistance properties and the coating uniformity achievable with complex objects. Each system has its advantages and disadvantages, but the properties of electroless nickel and its ability to incorporate composites have enabled the process to be exploited widely. The advantages of the electroless coatings4 include: Good throwing power Uniform coating thickness on complex objects Good wear resistance Low ductility (1-3% elongation) Low porosity, which leads to good corrosion resistance Excellent solderability and brazability characteristics Low labor cost. Electroless nickel is an engineering coating primarily used for its unusual combination of corrosion and wear resistance properties. It differs significantly from electroplated nickel as it is an alloy of nickel and phosphorus. The coating properties can be tailored by optimizing the alloy composition, that is, variation in the phosphorus content in the range of *5* to 12%. The phosphorus content of the deposit depends mainly on the pH control of the bath during plating, but it is also affected by its formulation (complexing and buffering agents), the plating bath temperature, and the molar ratio of nickel to hyphosphite (7).

A**s** the phosphite concentration increases during the life of the bath, the phosphorus content of the deposit gradually increases. Other differences in deposit properties are frequent because of variation in heat treatment temperature and time after plating. A**s** plated, electroless nickel is in a metastable state consisting of a supersaturated solid solution of phosphorus in nickel, because the equilibrium solid solubility of phosphorus in nickel is essentially zero; however, the second phase cannot form because the time interval between the deposition of successive layers is too short for the necessary diffusion. The structure of the deposit changes from microcrystalline to amorphous with increasing alloy content. The second phase, which is Ni,P, can form on annealing and results in precipitation hardening (8)

Electroless nickel is most frequently used in wear applications in the precipitation- hardened condition because of improved hardness and natural lubricity Electroless nickel is also applied to improve solderability and brazability of surfaces and is with molds and dies to improve lubricity and part release. (9,10)

II. SPECIMEN PREPARATION

Among the variety of manufacturing processes available for particulate Al LM25 alloy, parameters such as pouring temperature, speed, preheating temperature of specimen etc.
The chemical composition of the Aluminium Alloy Lm25 are Tabulated in Fig: 1

Material	**percentage** (%)
Copper	0.1 max.
Magnesium	0.20-0.60
Silicon	6.5-7.5
Iron	0.5 max.
Manganese	0.3 max.
Nickel	0.1 max.
Zinc	0.1 max.
Lead	0.1 max.
Tin	0.05 max.
Titanium*	0.2 max.
Aluminum Remainder.	

Table1: nominal chemical composition of Al LM25 alloy

III. EXPERIMENTAL:

3.1 Sample and bath preparations:

The sample is cut by wire EDM for coating and testing as per the dimensions and the sample is cut for the dimension 10*20*6mm. Polish the sample with emery sheet (300,400,800,1000,1500,2000) and then clean the sample with acetone and do the Alkaline cleaning with sodium hydro-oxide(45g/l) and tri-sodium orthophosphate(10g/l) for 65c and 20min and Acid treatment with chromium tri-oxide (125g/l) and nitric acid (100ml/l) for 40sec and then Flouride activation with HF. The bath composition[13] and all the operation parameters for the electroless Ni-P deposit with chromium-free pre-treatment are reported.

Table2: Chemical composition of electroless bath

Nickel – Sulphate	26g/lit
Sodium hypophosphate	30g/lit
HF	12ml/lit
Sodium acetate	16g/lit
Ammomium hydrogen diflouride	8g/lit
Thiourea	1PPM
Aluminium Oxide	26g/lit
Sodium hydro-oxide	Maintain pH

The samples were given thick nickel strike (at about 20 min by using electroless bath itself without any activator) and then dip into the bath having surface activator. Finally, the sample was cleaned with de-ionized water for 2 min. A scanning electron microscopy (SEM) was employed to study the surface morphology of electroless deposit.

Fig1:
Prepared bath

Fig2:
Electroless bath

Fig3:
Coated sample

3.2 *Experimental procedure*

The sliding experiments were conducted in air at room temperature in a pin-on-disk wear testing machine (Wear and Friction monitor TR-201). The pins were loaded against the disk by a dead weight loading system. The pin specimens were flat ended pins of 6mm diameter and 20 mm in length. The disk test piece was 55mm in diameter and 10mm in thickness. The pin slid on the disk at a radius of 15mm.The material of the counter disk was high quality cast iron. Before the wear test, each specimen was ground by 1µm alumina powder and the counter disk was ground by 2000 grit paper Wear tests on composite specimens and unreinforced Al alloy were carried out under dry sliding condition under two different applied loads of 9.81N (1kgf), 19.62N (2kgf) for a total sliding distance 472m at a constant sliding speed of 0.785m/s for all sample. During the tests the relative humidity and temperature of the surrounding atmosphere was about 50% and 25ºC respectively. The test duration was 10minutes at a constant disk speed of 500rpm for all the tests.

The vertical height (displacement) of the specimen was continuously measured using linear variable differential transformer (LVDT) of accuracy 1µm during the wear test and the height loss was taken as wear of the specimen. A photograph view of the pin-on-disk wear tester used in this investigation is shown in Fig.4. An experimental graph showing the height loss or wear in µm against sliding time in seconds (which is proportional to sliding distance) obtained from wear testing machine is shown in Fig.4.

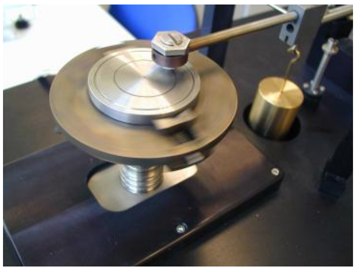


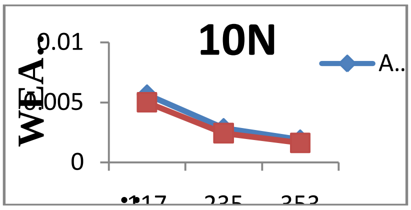
Fig.4 A photograph view of the pin-on-disk type wear testing machine

The microstructure of the composite specimens was investigated by using optical microscopy after preparing them metallographic alloy. The porosity level of the composite specimens (measured by vol. %) was determined using image analyzing techniques. The worn surfaces of the wear specimens were observed by scanning electron microscopy.

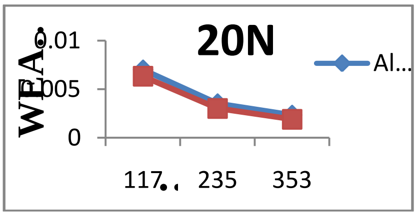
IV. RESULTS AND DISCUSSION

4.1.Wear Characteristics

The wear test results of the Al LM25 alloy specimens under dry sliding condition are presented in Fig. 5(a)&3(b)



(a)



(b)

Fig.5 Wear rate of unreinforced alloy and composites at applied loads of (a)10N, (b)20 N as a function of sliding distance.

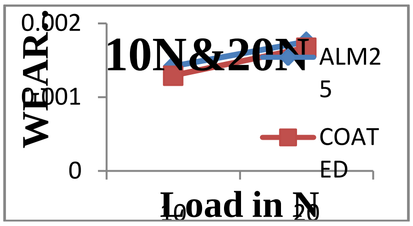


Fig.6 Wear rate of AL LM25 and ENP- Al O_3 coated AL M25 are 10N&20N

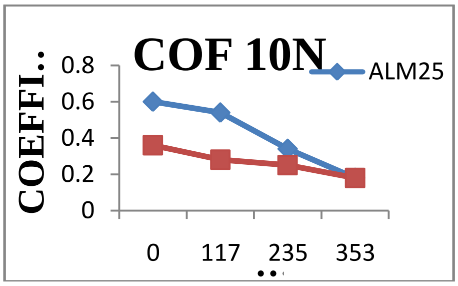
The wear rate of test specimens in mm3/m obtained from the height loss of the specimens during sliding is plotted against sliding distance in Fig.4(a) to 4(b) for two different applied loads: 10N (1kgf), 20N (2kgf). In each figure, wear rates of un coated Al LM25 composite specimens with varying ENP- Al O_3coated specimen are shown.

As expected, the wear rate of the un coated Al LM25 alloy specimens increases with increasing sliding distance. It is seen from the graphs that the wear rate of the ENP- Al O_3 coated specimens increases more rapidly with applied load compared with the alloy specimens. The graphs exhibit two regions which may be called ‘running-in’ and ‘steady state’ periods. During the running-in period, the wear rate increased very rapidly with increasing sliding distance. During the steady state period, the wear progressed at a slower rate and linearly with increasing sliding distance.

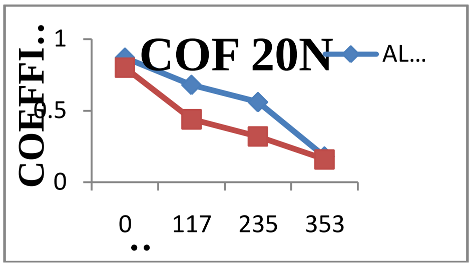
The wear rate of the alloy specimens decrease with increasing coated percentage of particulate specimen. As expected, the wear rate of a alloy specimen with a fixed ENP- Al O_3 coated increases with increasing applied load (Fig.4). At constant applied load, the alloy specimens exhibit a lower wear rate compared with the uncoated specimen.

4.2.Coefficient of friction

The Coefficient of Friction of test specimens obtained from the frictional force of the specimens during sliding is plotted against sliding distance in Fig.7(a),7(b) for two different applied loads10N (1kgf), 20N (2kgf). In each figure, Coefficient of Friction of uncoated Al LM25 specimen and NP- Al O_3 coated specimen are two different Alloy specimens with varying particle are shown.



(a)



(b)

Fig.7 Coefficient of Friction of uncoated Al LM25 and ENP- Al O_3 coated Al LM25 specimen at applied loads of (a)10N, (b)20 N as a function of sliding distance.

Fig.7 shows the variation in the coefficient of friction with Sliding Distance for Al LM25 un coated and coated ENP- Al O_3 alloy Al LM25 material possesses lower coefficient of friction when compared with the ENP- Al O_3 coated Al LM25 composites studied. A maximum of 10% and 15% reduction in the coefficient of friction of the ENP- Al O_3 coated AlLM25 alloy is observed at a load of 20 N when compared with the uncoated material.

This improvement in the anti frictional behavior of the two alloy can be mainly attributed to the excellent lubricating property of E NP- Al O_3 coated specimen. The coefficient of friction of both Al LM25 alloy and its composites decreases with increased loads. At a maximum load of 20 N in the present work, the decrease in the coefficient of friction of the coated material.

The coefficient of friction of applied load 20 N shown in Fig 6(c) the Al LM25 coated material decreases with increased sliding distance, reaching minimum at a sliding distance of 471 m. Beyond this sliding distance, an increase in the coefficient of friction of the studied Al LM25 un coated is further increase sliding distance.

The variation in the coefficient of friction with applied loads for Al LM25 and its alloy at the end of sliding distance are shown in Fig. 8.

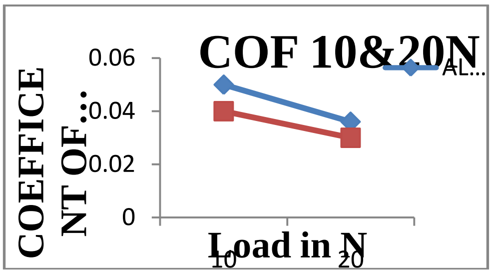


Fig.8 Coefficient of Friction of uncoatedAl LM25 and ENP- Al O_3 coated Al LM25 material at the end of maximum sliding distance (471 m) as a function of two different loads shown.

It is observed that the coefficient of friction is maximum at a load of 20N for both the coated and uncoated specimens. fraction coated specimen the lowest coefficient of friction at this load. It is found that the friction coefficients are in the range of 0.015–0.053. Generally speaking, for Al LM25 alloy and all ENP- Al O_3 coated material, with the increase in the applied load, the friction coefficient decreases. It is interesting to note that the load effect on the wear rate is as intense as on the friction coefficient. However, increasing the coating percentage at the applied load of 20N does not have a significant effect on the friction coefficient.

4.3.Micro structural studies

The optical micrographs of uncoated material Al LM25 and ENP- Al O_3 coated material Al LM25 are shown in Fig.9. The microstructure analysis of these specimens shows that the ENP- Al O_3 coated particle are uniformly distributed in the specimen. However, the presences of porosity around the ENP- Al O3 coated are particles was evident.

It was observed that the porosity was more pronounced around ENP- Al O_3 particles than the location around Al LM25 particles. This observation may be attributed to wetting behaviour of Al alloy. It is also observed from the optical micrographs that the porosity of the specimens increase with increasing coated material.

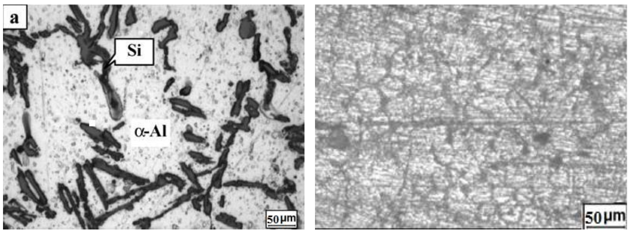


Fig: 9 Optical micrographs of (a) uncoated Al LM25 alloy, (b) ENP- Al O_3 coated Al LM25 alloy

V. CONCLUSION

The present investigation on the effect of uncoated Al LM25 material on the wear behavior of ENP- Al O_3 coated Al LM25 composites led to the following conclusions:

1. The uncoated Al LM25 alloy with ENP- Al O_3 coated has a marked effect on the wear rate. The wear rate decreases with increasing ENP- Al O_3 coating rate. The coefficient of friction slightly decreases with increasing coating.
2. The coefficient of friction and wear rates of the ENP- Al O_3 coated Al LM25 alloy are less. when compared with the uncoated Al LM25 composite.
3. The optical micrographs of Al LM25 show that the distribution of ENP- Al O_3 coated in process is uniform.
4. The scanning electron micrographs of the worn surfaces of the ENP- Al O_3 coated Al LM25 composites show the worn surface of the composite alloy is generally much rougher than that of the uncoated Al LM25 alloy composite. This indicates an abrasive wear mechanism which is essentially a result of hard ceramic particles exposed on the worn surface.

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