Factors Effecting on Nano-composite Coating (Ni-P-CNTs) Under Hardness and Corrosion by ANOVA

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Abstract: Electro- less Nano-coating of Ni– P was mixed with carbon nano tube (CNTs) and then deposited on low carbon steel substrate. Electro- less Nano-coating was done using different temperatures and times. Nickel (Ni) was added by 4.4 wt.%, phosphore (P) was added by 4.2 wt. %. While carbon nano tube (CNTs) was added various content by 2wt.% and 3Wt%. The results of this work showed that the surface micro-hardness for CNTs increases with decreasing time and temperature which is 450 Hv for. While the rate of corrosion had different results but the best was 0.265 according to Taughi selection. The microstructure of the deposite coating of Ni–P was analyzed by micro-structure test . Taughi method using to select the best values of Micro-hardness and corrosion from the samples.

Keywords: Electro- less coating method, low carbon steel, nickel, phosphor, carbon-nano-tube, Micro-hardness and Corrosion.

1.   Introduction

For many years ago, the coating process was known by Brenner and Riddell whose studied the Electro- less Coating [1]. This process has not any electricity but having many different conditions influence factors on method. So then it had developed into a subject of development and research today according to various of applications[2]. Ni- P which is using in many various domain. using in different application like aerospace, knitting needles applications, these applications were used extremely for electro less coatings of Ni- P coatings as given in Figure 1. Hence, many applications about electro- less coatings of Ni- P are depend on their properties such as corrosion and wear resistances [3].However, the micro-hardness and surface roughness which obtained for optimal parameters which gave the better value of both micro-hardness and roughness [4,5]. the purpose of study the influence of solution composition of nano-composite coating on both roughness and micro-hardness, and choice excenellent final surface according to select the better specimens between many other specimens that tested.
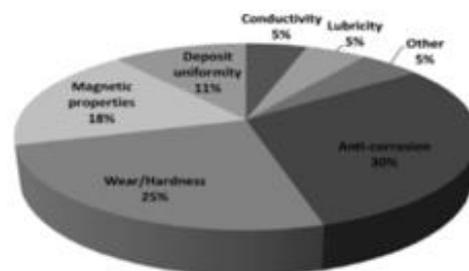

Figure 1. Main applications of electro- less Ni- P coating[7].

2. Experimental procedures:

2.1. Materials and Method proportion :

A Base material is L.C.S, the samples are manufactured by the dimensions (1 cm x 1 cm). Table 2. shows a chamical composition of a base material.

Table1. nominal composition analysis of L.C.S(7).

Nominal composition	Fe	C	Si	Mn	Cr	Mo	Ni	Al
	99.5	0.075	0.014	0.181	0.036	1.61	0.032	0.023
	Co	Cu	Nb	Ti	V	W	Pb	-
	0.0070	0.082	0.0078	0.002	.051	0.01037	0.0250	-

Table 2. Actual composition of L.C.S. base material Test.

Actual composition	Fe	C	Si	Mn	Cr	Mo	Ni	Al
	99.5	0.0855	0.0100	0.199	0.0341	0.0050	0.0250	0.0441
	Co	Cu	Nb	Ti	V	W	Pb	-
	0.0050	0.0260	0.0050	0.0010	0.0050	0.0500	0.0250	-

The specimens have been grinded using emery papers with 2000 µm, and etched by a 0.5% dilute H_2SO_4 acid. Afterward, the samples were cleaned with water and then washing by alcohol. Finally, specimens have been dried by electrical oven. The Prepared specimens deposited using electro- less Ni- P coating bath. Table (3) gives the content of cell Ni- P electro- less coating. The cell is act at (75 °C - 95 °C) with PH =4.5 to 5.5 of the solution for (30 min. to 90 min.).

Table 3. The content of Ni- P coating bath.

Base	Content (g/L)
Ammonia Cloride	50
Nickel Chloride	40
NaH_2PO_2	20
SDS	20
Zno	1-3

Table (4) illustrates the contents of Ni-P-CNTs bath for coating process. Through the deposition process, the magnetic stirring was produced at a different rate. The deposition process is doing under desired condition which done at (75 ° C to 95 ° C) in the bath content, while PH = 4.5 ± 5.5 for 30 min. to 90 min. of coating time.

Table 4. The bath contents for Ni-P-CNTS coating.

Base material	Cotent (gm/L)
NiSO4-6H2O	8
NaH2PO2	10
CH3COONa.3 H2O	20
NA3CgH5O7.2H2O	5
Ammonia Cloride	50
Nano CNTs	2-3

Table 5: Characteristics of electro-less Ni- P coating [6].

Property	advantage
Better corrosion resistance and durabile	Accepted coating
Micro-hardness	Less wear resistance
Less co-deposits available	Self-lubricating coating
Homogeneity deposition	Minimize the post finishing
Better polishing	Good finish
Good coating rate	Excellent output of producing
High resistance for chemical corrosion	Good protection

3.Results and Discussion:

Constraints for optimizing individual response characteristics, such as (micro-hardness and surface roughness) Table was included in table. To reliably evaluate their effect on individual desirability, goals, and limits were set for each answer separately. For each answer characteristic that must be optimized, There is a maximum, and minimum standard listed, Also the main factors the using in single optimization showed in table (6), There are factors that affect the hardness, which are (temperature, time, nano- matels, in addition to the percentage of weight added to the mixture nano-coating (Ni - P)), which we will refer to with the following symbols, respectively (A, B, C, D). We note that these symbols will It indicates the digital response that will be issued by the computer programming system (Taguchi), and after the mathematical and numerical process of these samples and its calculation by means of (Taguchi) and (ANOVA), it will give the optimal factors that the program refers to, and then these factors will be clarified in the form of figures, which were previously extracted from the experimantial tests used, which will be explained during the chapter.

Table 6. micro-hardness and Corrosion test for Nano- Composite Coating.

Specimens	Temp.(c)	Time(hr)	Nano-cationg	G/L	Micro-hardness	Corrosion Rater (CR)
1	75	0.5	CNT	2	450	0.02
2	75	1	CNT	2	441	270
3	75	1.5	CNT	2	395	0.053
4	85	0.5	CNT	2	387	0.09
5	85	1	CNT	2	338	0.09

6	85	1.5	CNT	2	434	0.013
7	95	0.5	CNT	2	318	0.0014
8	95	1	CNT	2	315	0.01
9	95	1.5	CNT	2	376	0.056
10	75	0.5	Gra.	2	513	0.33
11	75	1	Gra.	2	276	0.047
12	75	1.5	Gra.	2	220	0.047
13	85	0.5	Gra.	2	320	0.04
14	85	1	Gra.	2	359	0.04
15	85	1.5	Gra.	2	343	0.024
16	95	0.5	Gra.	2	388	0.002
17	95	1	Gra.	2	359	0.0049
18	95	1.5	Gra.	2	341	0.002
19	75	0.5	CNT	3	294	0.002
20	75	1	CNT	3	318	0.014
21	75	1.5	CNT	3	449	0.001
22	85	0.5	CNT	3	434	0.016
23	85	1	CNT	3	411	0.002
24	85	1.5	CNT	3	356	0.0024
25	95	0.5	Gra.	3	334	0.001
26	95	1	Gra.	3	310	0.044
27	95	1.5	Gra.	3	379	0.0031
28	95	2	Gra.	3	369	0.00385
29	75	0.5	CNT	2	299	0.012
30	75	1	CNT	2	315	0.008
31	75	1.5	CNT	2	434	0.095
32	85	0.5	CNT	2	310	0.124
33	85	1	CNT	2	380	0.105
34	85	1.5	CNT	2	399	0.004
35	95	0.5	CNT	2	388	0.005
36	95	1	CNT	2	425	0.105
37	95	1.5	CNT	2	423	0.109
38	75	0.5	Gra.	2	366	0.09
39	75	1	Gra.	2	405	0.006
40	75	1.5	Gra.	2	344	0.002
41	85	0.5	Gra.	2	215	0.018
42	85	1	Gra.	2	303	0.052
43	85	1.5	Gra.	2	317	0.01
44	95	0.5	Gra.	2	424	0.004

45	95	1	Gra.	2	321	0.058
46	95	1.5	Gra.	2	308	0.27
47	75	0.5	CNT	3	301	0.09
48	75	1	CNT	3	405	0.163
49	75	1.5	CNT	3	343	0.018
50	85	0.5	CNT	3	358	0.0309
51	85	1	Gra.	3	433	0.005
52	85	1.5	Gra.	3	452	0.036
53	95	0.5	Gra.	3	420	0.002
54	95	1	Gra.	3	435	0.006

Table 7. The main factors effected on the single optimization

Factors	Level		
	1	2	3
Time (A)	0.5	1	1.5
Temperature (B)	75	85	95
Nano-matels (C)	CNT	Ge	-
Weight percentage (D)	2	3	-

Table 8. The main factors of ANOVA for micro-hardness

Analysis of Variance				
Source	DF	Adj SS	Adj MS	contribtion %
A	1	21	21.41	0.010831
B	2	10026	5012.91	5.17092
C	2	1210	605.02	0.624059
D	2	17938	8969.02	0.624059
Error	46	164697	3580.37	9.251542
Lack-of-Fit	10	45309	4530.91	-
Pure Error	36	119388	3316.33	-
Total	53	193892	-	-

**Table 9. The main response for signal to noise ratios for micro-hardness**

Level	A	B	C	D
1	50.95	51.37	50.78	50.93
2	51.05	50.36	50.91	51.60
3		51.27	51.30	50.46
Delta	0.10	1.01	0.52	1.14
Rank	4	2	3	1

Table 10. The main response for signal to noise ratios for corrosion rate

| Level	A	B	C	D
1	23.95	15.56	14.94	14.08
2	27.51	29.00	29.17	28.83
3		32.62	33.08	34.27
Delta	3.56	17.06	18.14	20.18
Rank	4	3	2	1
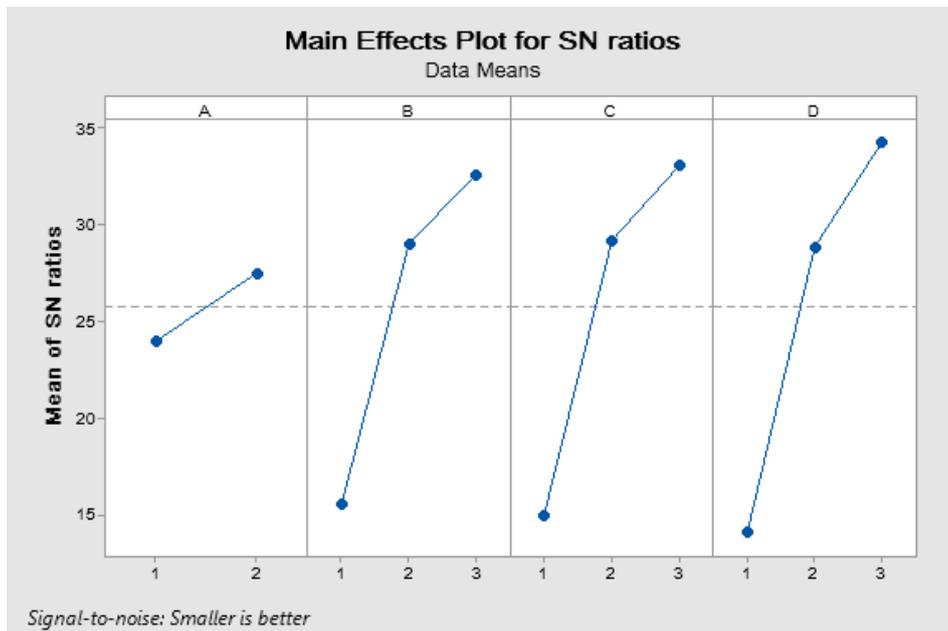
Figure 2. Main effect plot For Noise of Ratios optimum sample (Corrosion Rate)
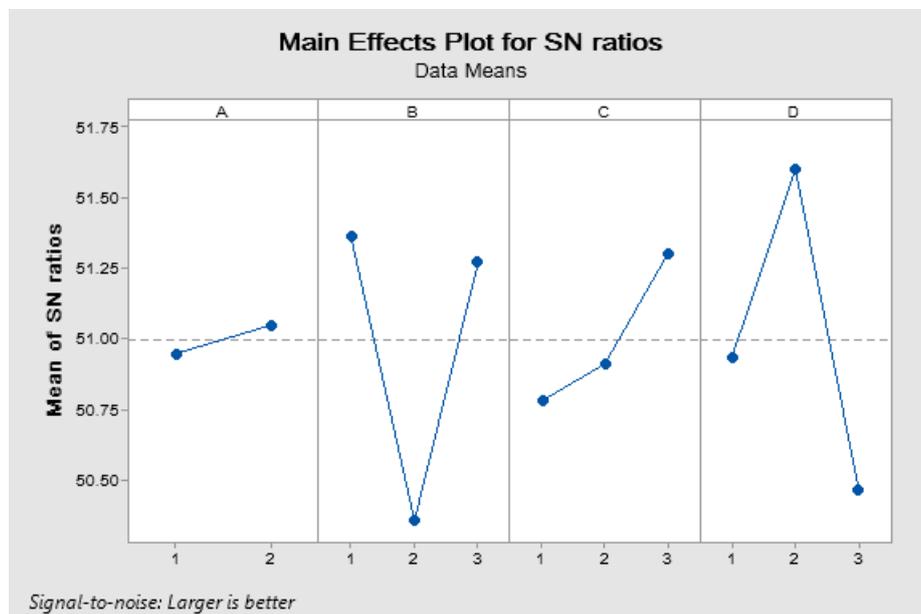
Figure 3. Main effect plot For (Micro-Hardness)

According to the above tables and figures that the factors (A2, B1, C3, D2) for micro-hardness and (A2, B3, C3, D3) for corrosion rate indicated that the optimum values, and this is what appears in the above table (4.4), as the influencing factors are present in the axis X as for micro-hardness would be in the Y axis. After that, the optimum sample that was referred to in the program was taken and tested using (XRD, SEM, Optical micro-struture, Optical Profilemetey and cross section) tests, which are:
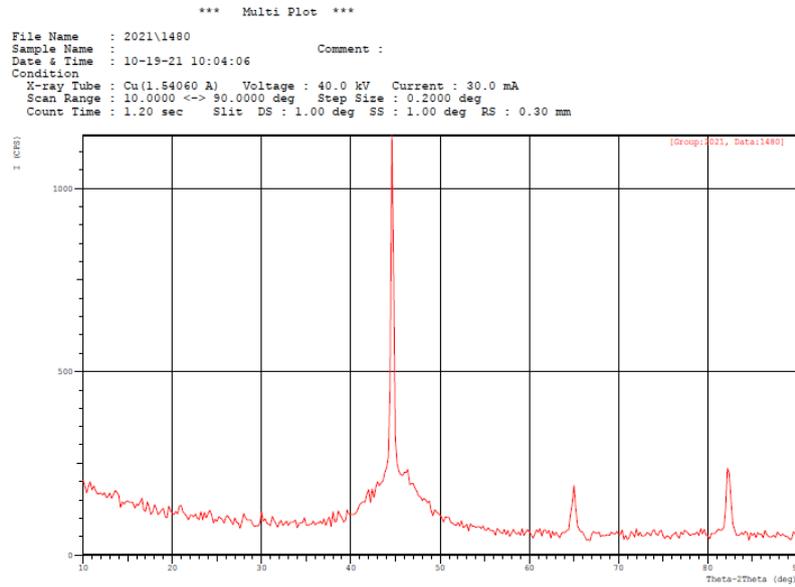
Fig4.show the peaks for optimum nano-coating (Ni-P-CNT) (XRD).

From table 4, showed that the diffraction of X-rays indicated the presence of peaks related to the materials present on the surface of the sample after nano-coating, which were:
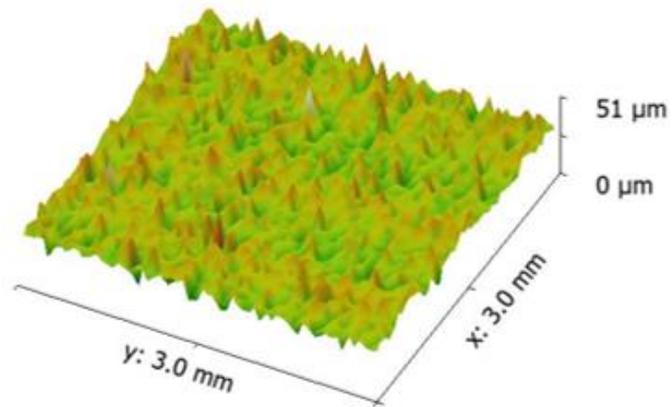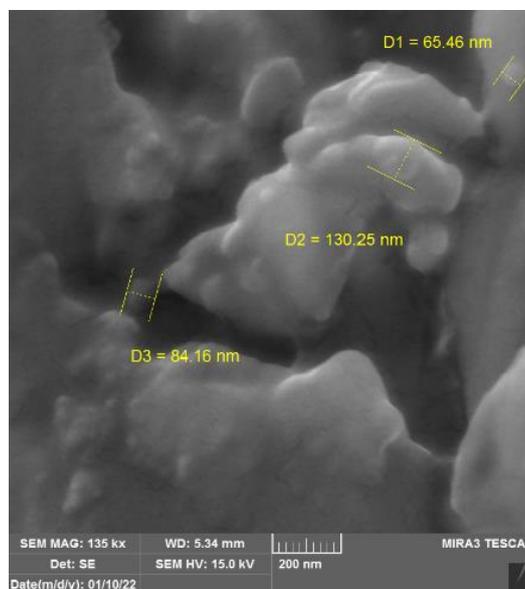
*Ni-P

*Ni-P-CNT

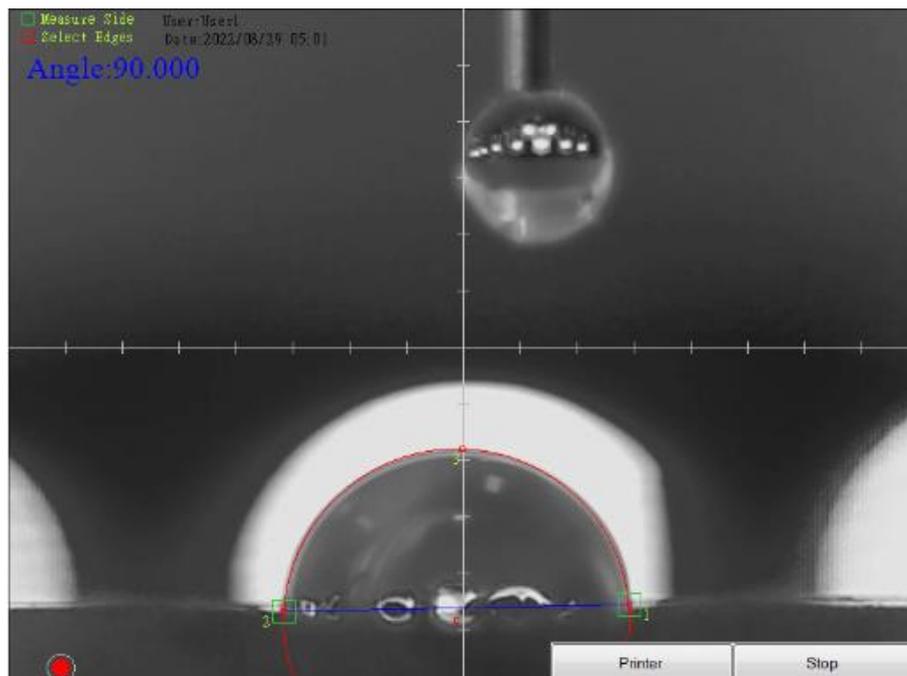**Fig5. The optimum sample for optical micro-sturcture.**
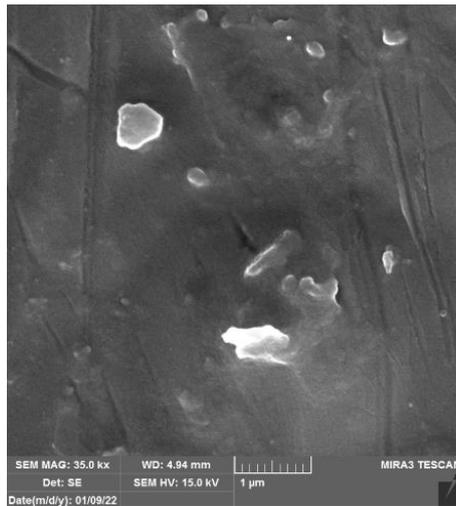
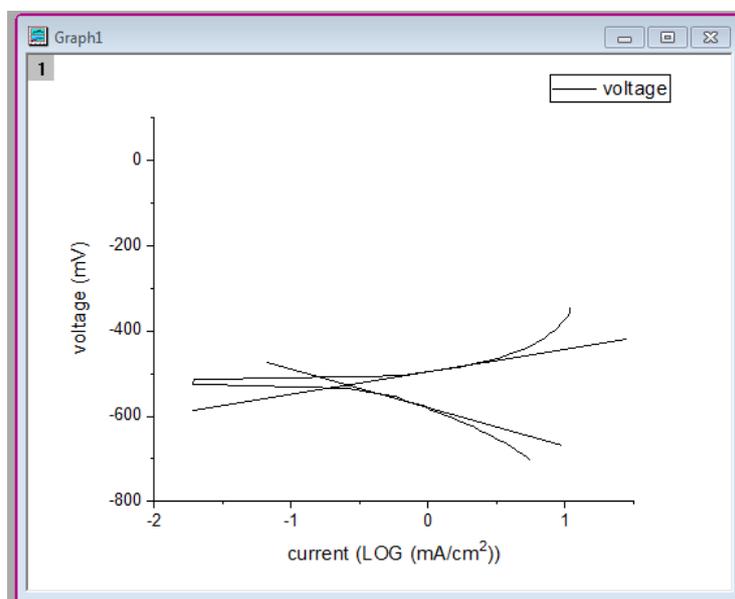**Fig6. SEM of Ni-P-CNT particles for nano-coating.**

Fig 7. profilemeter for Ni-P-CNT particles Nano-coating

Fig8. SEM(Cross section) for Ni-P-CNT particles Nano-coating

Fig9. contact angle for Ni-P-CNT particles Nano-coating.

Fig10. Tofel curve for the optimum sample

After the optimum sample was tested, the results appeared in the figures from(4 to 10) above for all tests that were taken for the optimum sample. As it was made clear that it was in relation to the surface imaging of the sample, it showed clear images of the sample. The contact angle of Ni-P-CNT nano-composites coating for the carbon nano tube was 90°, which is in accordance with the higher hydrophobicity of neat Ni-P Nano-coating but less than the optimum sample for the micro-hardness, the contact angles increased from (90° to 90°), Which refer to between hydrophobicity from that coating for the optimum sample of single optimization.

While The morphology and cross-section of the coatings were analyzed by SEM and EDX and Cross section area were similar to the optimum sample for a (MPRI) but with different condition as showed above. 3D optical profilometer was also used to determine the surface roughness of the coatings and the co-deposition percentage

was calculated by the photo analysis of micrographs. The results showed that Ni-P particles in the existence of cationic surfactant whereas maximum. Moreover, the phosphorus content and especially the deposition rate of Ni–P-CNT matrix coating were strongly influenced by the concentration of the particles in plating solution.

Also the optical profilemetey showed the Z axis had a value of (51 µm) which refer to particles were very combined as showed in figure (7), which indicated that the surface of the nano-coating of optimum sample.

4.Conculsion:

In this study, CNTs was mixed with nickel alloy (Ni-P-CNTs) was applied on the L.C.S. base material, the effect of facters that influence on electro-process coating were investigated and selected according to these factors, the best selected specimen under corrosion resistance and micro-hardness another were calculated by using numerical (Taughi) method.

*the coating Ni-P-CNTs was the better selection, micro-structure show the Ni-p the spheres was reinforcement with CNTs nano-particles coating the L.S.C substrate.

*Many condition applied during the electro-coating process which were time, temperature, wt% and change in particles (CNTS).

* Both corrosion and micro-hardness were tested (54) specimens.

* Taughi method using numerical number lead to the tests and parameters that effect on coating and drawing these factors in curves and selected the parameters were affected.

*Best selected according to numerical method for corrosion curves (75C,1.5hr,2wt%,CNTs) which were temperature, time, present of CNTs respectively was 0.265.
*Best selected according to numerical method for micro-hardness curves (75C,0.5hr,2wt%,CNTs) which were temperature, time, present of CNTs respectively was 450.

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