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PARAMETRIC STUDY ON WEAR & CORROSION RATE OF NI-WC COATED ON CI SPECIMENS

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ABSTRACT

Ni-WC composite coatings were deposited over a Cast Iron specimen using electro codeposition method. Composite materials are prepared by conventional type of electro deposition using watts bath. The primary electrocoating parameters of current density, PH value of electrolyte, temperature of bath, %wt. of tungsten carbide (WC) particles in bath & agitation speed were considered for experimental studies. The composite coated specimen surfaces was examined by Scanning electron microscope (SEM) and studies revealed thatthere was uniform coating on Cast Iron substrate. Corrosion and wear resistance tests showed much improvement in the mechanical properties of composite structure Ni-WC.

While coating on CI specimen, the solution temperature was set to be at 50^0C, by varying WC particles 3, 6, & 9g respectively. The Wear test was conducted on Pinion disc machine and corrosion test was carried out in acidic medium.

Keywords: Composite coating, Electro Co deposition, Nickel, Tungsten carbide& wear.

I. INTRODUCTION

Composite material composed of matrix and reinforcement as constituents which are combined at macroscopic level but not soluble with each other.

Nickel is a silvery –white lustrous metal with a slight golden tinge. The nickel belongs to class of transition metals which is hard & ductile. Nickel is slowly oxidized by air under room temperature. The Pure nickel plates are free from alloying elements .Nickel has a number of niche chemical manufacturing uses, such as a catalyst for hydrogenization. Nickel is one of the most common alloying elements because it refines the pearlite and graphite structure, improves toughness, and evens out hardness differences between section thicknesses. Nickel is a corrosion unaffected metal. On adding tungsten Carbide particles to nickel increases stability, wear andcorrosion resistance.

Cast iron is a group of iron-carbon alloys with a carbon content greater than 2%.Its usefulness derives from its relatively low melting temperature. Cast iron tends to be brittle, except for malleable cast irons. With its relatively low melting point, good fluidity, castability, excellent machinability, resistance to deformation and wear resistance, cast irons have become an engineering material with a wide range of applications and are used in pipes, machines and automotive industry parts, such as cylinder heads (declining usage), cylinder blocks and gearbox cases (decliningusage). It is resistant to destruction and weakening by oxidation. Cast iron's properties are changed by adding various alloying elements, or alloyants.

Electro-deposition uses electricity to deposit a smooth, thin, uniform layer of plastic coating on the surface of a metal part. There are many methods for producing composite coating like Physical vapour deposition (PVD),

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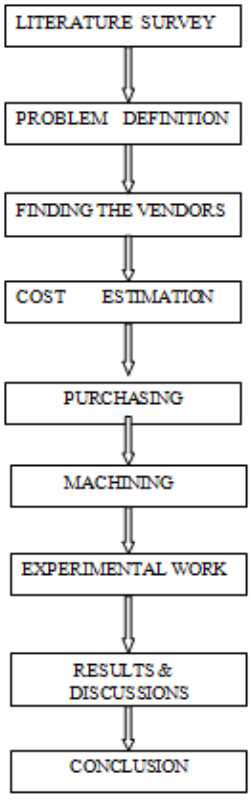
Chemical vapor deposition (CVD) and Electro deposition etc. Electro deposition is some of the effective and technically realistic and frugally greater method for making metal matrix0composites.)

II. LITERATURE SUTVEY

The Electro deposition technique has proved itself to be a convenient method by producing smoother and harder surfaces, better bonding between particles and metal, easy control of the coating thickness, the ability to deposit metallic and composite coatings and suitability for automation [1]. Electro deposition is a film growth process that consists in the formation of metallic or semiconducting coatings on conductive substrates, starting from metal ion precursors in a suitable solvent and occurring via a charge transfer process [4]. The Electro deposition of Ni-W alloy into deep recesses of 500 micronsis presented here [2]. Literature cites the influence of various plating variables on the electrodeposition of Ni-W alloys such as, concentration of metals in electrolyte, pH, temperature, current density, stress reducers and complexing agents. The current densities used by alkalies ranged from 2 to 5 amp/dm2 (20-50 mA/cm2), as cathodic current efficiencies were high in this region [3]. Singh *et al.* also investigated the various factors responsible for co deposition of reluctant metals. [6].

Nickel based WC composites, in particular, finds their main uses as hard faces for anti wear, anticorrosive and as electro catalytic cathode for hydrogen evolution reaction [1].

III. METHODOLOGY



IV. EXPERIMENTAL WORK

The experimental setup consists of temperature sensor, a 4 beaker, stirrer for mechanical agitation, speed controller, anode (Nickel), cathode – Cast iron (Piston rings) arrangement through power supply, a prepared

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solution of 1.5L is poured into the beaker. A prepared solution consists of 375 gm of Nickel sulphate($NiSO_4$ $6H_2O$), 52.5 gm of Nickel chloride ($NiCL_2$ $6H_2O$), 60 gm of Boric acid (H_3BO_3), and 1.5L of distilled water continuously are stirred continuously for about 10 to 15 minutes. After that put (WC) Tungsten Carbide of 3, 6, 9 grams for each experiment and rotate stirrer continuously for 30 minutes. In mean while maintain a temperature of 40^0Celsius by temperature controller. The Speed of stirrer can be adjusted by speed controller, after that check the pH value of the prepared solution by pH meter and maintain PH of 4 by adding required amount of sodium hydroxide (NaOH) to the prepared solution. The surfaces of the Cast iron specimens are firstly finished by Emery paper and then washed by ultrasonic cleaner, then keep the specimens in Hydrochloric acid and distilled water solution for 20 minute .Then pure Nickel is made as anode and Cast iron test specimens (Piston rings & cylinders) are made as cathode.The distance between the electrodes is 15cm for all experiments. The electrolyte is continuously stirred by stirrer at 200 rpm and heated to required temperature.

The Substrate are considered as cathode in the bath mean while supplying power by rectifier and maintain a current density of 2A by adjusting voltage and set up the timer for one hour rotating the solution for one hour and then after remove the specimens and wash the specimens by distilled water and keep drying for 20 minute by exposing the test specimens to sunlight.

Electro Co deposition Machine Rectifier

Temperature

Controller

V. MECHANICAL TEST

Some of the mechanical test are conducted to evaluate the properties such as wear, hardness, corrosion rate. The microstructure test is also carried out to examine the morphology & coating thickness of the coated test specimens.

VI. WEAR TEST

Wear test is carried out on pin on disc machine. Before starting wear test, a initial weight of specimens are note down. The rotating disc and specimens cleaned before doing wear test. The specimens are fixed on rotating disc at a certain distance (l=300mm). The time is set to be 3 minute, rotating the disc at a speed of 300rpm, with gradually applying the loads in the intervals 10,20,30,40 kg respectively and then note down the frictional force corresponding to respective loads.After the test, the specimens are weighed and the wear rate is calculated.

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Fig 1: Pinon Disc testing rig

VII. MICROSTRUCTURE TEST

The Microstructure of Cast iron test specimens coated with Nickel-tungsten Carbide is examined using Scanning Electron Microscope of 100X/500X magnification. The Coating thickness on the test specimens are also noted down. The below table describes information about M/s test

Test Conducted	**Coating thickness by Microscopic method and Microstructure test with photo.**
Instrument Used	Scanning Electron Microscope
Test Method	IS-3203-1982 , RA-2010 and IS-7754-1975, RA-2012
Description of the Sample	Nickel-Tungsten Carbide coated on Cast Iron specimen.
Etchant Used	2% NITAL.

Table 1: Details of SEM

VIII. CORROSION TEST

Corrosion test is conducted to study the effects of corrosion according ASMT-G31 standards. I have considered the basic medium to study the corrosion effect. The PH value of the solution is maintained below 7.Before test, the test specimens are cleaned with Clarks solution (mixture of Alcohol and acetone) to remove any dirt particles, unwanted particles on the surface of the coated specimens. Note down the initial weight of the specimens. The test specimens are dipped in the solution prepared by adding chemicals liquid sodium hydroxide (NaCl) and Sulphuric acid (H_2SO_4).The corrosion test is carried out between the time intervals like 12, 24, 48 and 72 hours. Note down the final weight and calculate the corrosion rate .

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Fig 2: Corrosion test samples

IX. RESULTS & DISCUSSION

9.1. Wear Test

We have considered a taugachi design quality approach for the wear test.L16 orthogonal array by taugachi design is obtained as below consisting of 4 factors and 4 level design.

Force	Reinforcement	Sliding Distance	Speed	Wear rate
10	0	200	300	0.0058178
10	3	250	325	0.003878
10	6	300	350	0.0029089
10	9	350	375	0.002327
15	0	250	350	0.0111
15	3	200	375	0.007426
15	6	350	300	0.00557
15	9	300	325	0.00445
20	0	300	375	0.00867
20	3	350	350	0.00578
20	6	200	325	0.00433
20	9	250	300	0.00347
25	0	350	325	0.014634
25	3	300	300	0.009756
25	6	250	375	0.007317
25	9	200	350	0.005853

Table 2 : Wear rate results

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9.2.Response table for means

Level	Load	Reinforcement	Sliding distance	Speed
1	0.003733	0.010055	0.005857	0.006153
2	0.007136	0.006710	0.006441	0.006823
3	0.005563	0.005031	0.006446	0.006410
4	0.009390	0.004025	0.007078	0.006435
Delta	0.005657	0.006030	0.001221	0.000670
Rank	2	1	3	4

Force	Reinforcement	Sliding Distance	Speed	Wear rate	SNRA4	MEAN4
10	0	200	300	0.0058178	-44.70482425	0.0058178
10	3	250	325	0.003878	-48.22784391	0.003878
10	6	300	350	0.0029089	-50.72542417	0.0029089
10	9	350	375	0.002327	-52.66407233	0.002327
15	0	250	350	0.0111	-39.09354042	0.0111
15	3	200	375	0.007426	-42.5849011	0.007426
15	6	350	300	0.00557	-45.0828961	0.00557
15	9	300	325	0.00445	-47.03279978	0.00445
20	0	300	375	0.00867	-41.23961805	0.00867
20	3	350	350	0.00578	-44.76144323	0.00578
20	6	200	325	0.00433	-47.27024207	0.00433
20	9	250	300	0.00347	-49.1934105	0.00347
25	0	350	325	0.014634	-36.69273899	0.014634
25	3	300	300	0.009756	-40.21456417	0.009756
25	6	250	375	0.007317	-42.7133389	0.007317
25	9	200	350	0.005853	-44.65242952	0.005853

Table 3 : S/n ratios tables

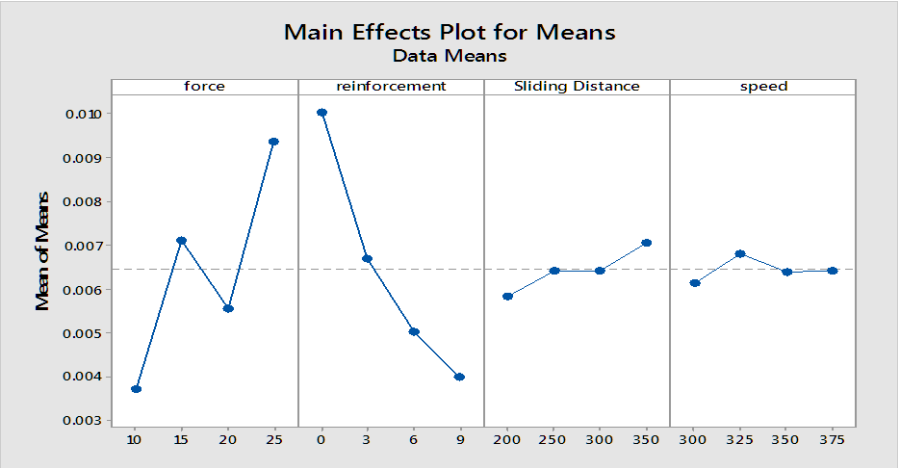

Fig 3: Main effects Plots of Means

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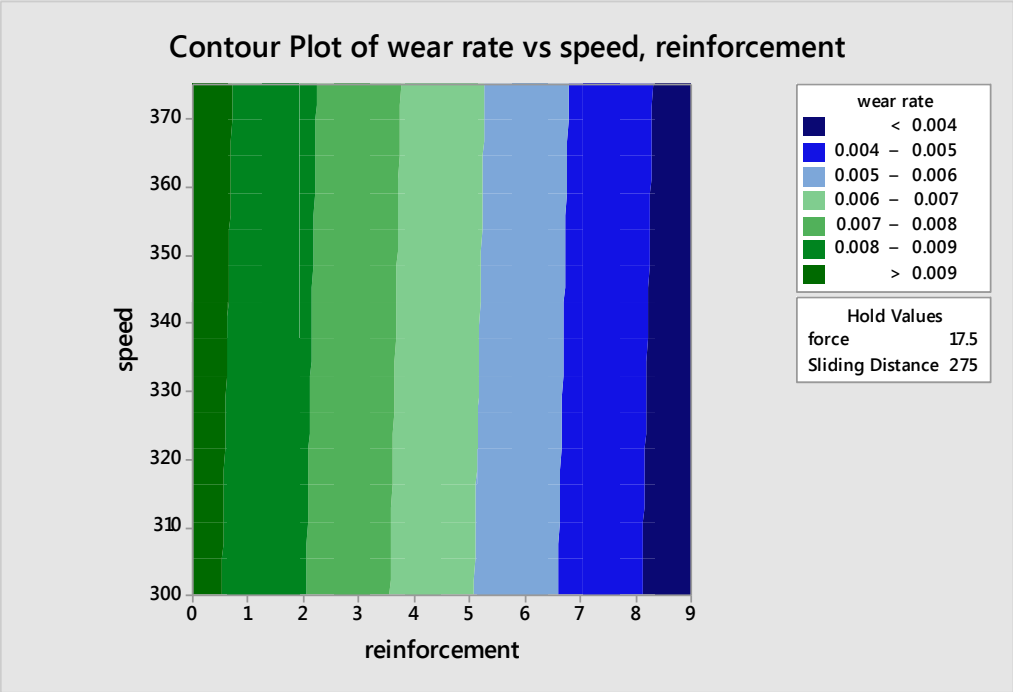

Fig4: Contour plot of wear rate vs speed, reinforcement

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	0.00143	0.00588	0.24	0.812	
force	0.000308	0.000078	3.95	0.002	1.00
reinforcement	-0.000659	0.000130	-5.08	0.000	1.00
Sliding Distance	0.000007	0.000008	0.94	0.366	1.00
speed	0.000002	0.000016	0.11	0.914	1.00

Regression Equation

wear rate = 0.00143 + 0.000308 force - 0.000659 reinforcement
+ 0.000007 Sliding Distance
+ 0.000002 speed

X.CORROSION TEST TABULATION & CALCULATION FOR pH3

Material	pH	Initial wt in (grams)	Weight after 24 Hours in (grams)	Weight after 48 Hours in (grams)	Weight after 72 Hours in (grams)
Base	3	15.789	15.786	15.777	15.729
Ni-WC (3g)	3	15.636	15.635	15.627	15.621
Ni-WC (6g)	3	14.616	14.615	14.607	14.605
Ni-WC (9g)	3	15.232	15.230	15.223	15.221

Table 4: Corrosion test table for pH 3

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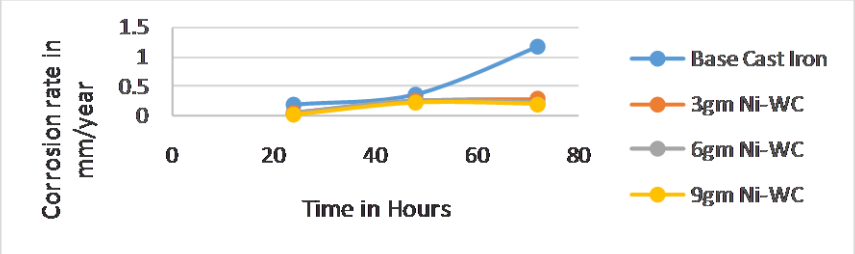

Fig 5: Graph Comparison between Base Cast Iron Specimen and Coated Specimens in Corrosion test

It is clear from the above graph non coated base cast Iron specimen have more corrosion as compared to coated specimens, by increasing the amount of WC particles corrosion rate has been decreased.

XI. MICROSTRUCTURE TEST

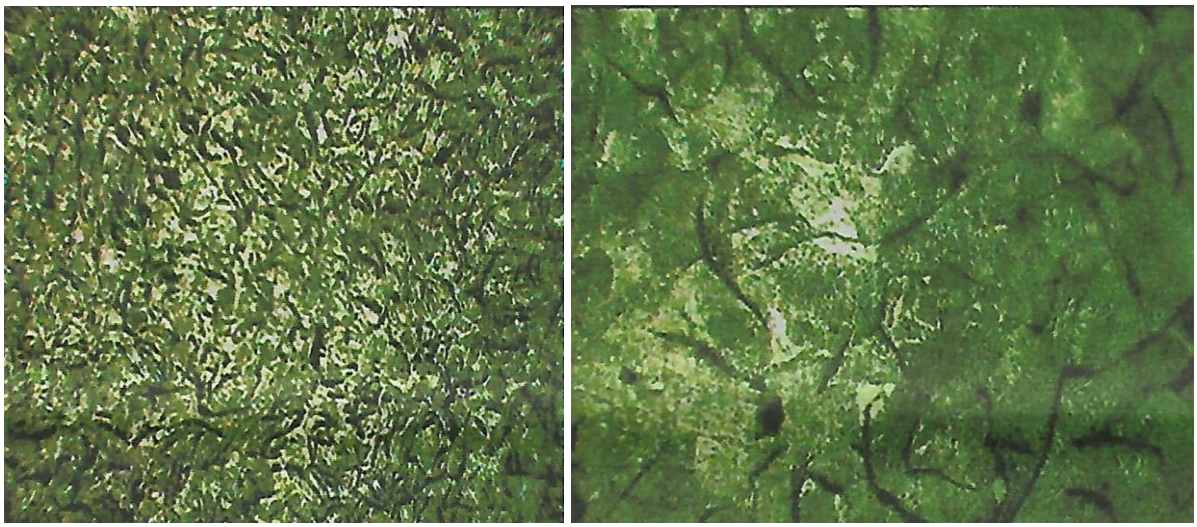

Fig 6:Microstrcture of 3g of coated tungsten carbide 100X/500X magnification

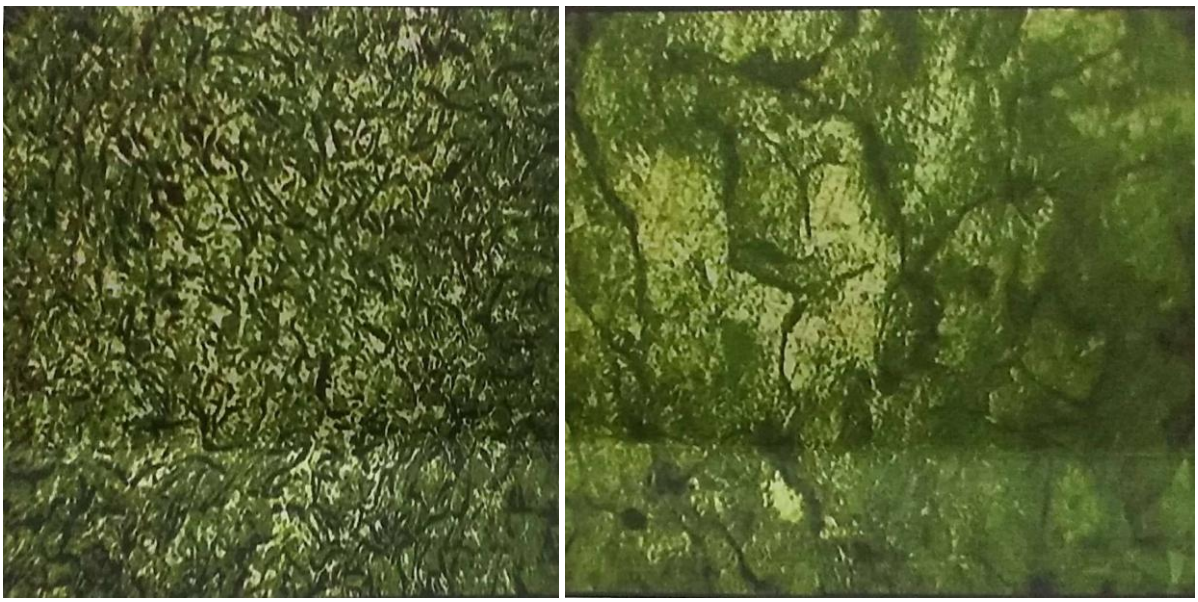

Fig 7: Microstrcture of 9g of coated tungsten carbide 100X/500X magnification

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XII. CONCLUSIONS

From this work, we can conclude that test specimens (Cast Iron) are coated successfully by electro co deposition technique using watts bath. The following observations were made and the results are concluded as below:

- The uniform coating has been achieved with increasing the WC particles, more uniform coating obtained for 6g & 9g WC coated specimens as compared to non-coated specimens.
- As compared to non-coated Cast Iron specimen, the coated Cast iron specimens have more corrosion resistance, with increasing WC particles.
- From corrosion test we can conclude that the test carried out with pH 3 has more corrosion resistance.
- In wear test the reinforcement has greater influence on load, speed & the sliding distance.

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