International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017),e-ISSN:2455-2585
International Conference on
Recent Explorations in Science, Engineering And Technology (ICRESET'19)
Volume-5, Special Issue-March, 2019.

# Mechanical Properties of Ni - $TiO_2$Nanocomposite Coating by Pulse Electro Deposition

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***ABSTRACT - The present study illustrates the mechanical properties of Ni- $TiO_2$ composite coatings, electrodeposited on steel substrate. Titanium oxide nanoparticles were codeposited with Ni on a EN 8 steel substrate using pulse electro deposition method. The experiments were carried out using different combinations of pulse parameter using response surface methodology and the trials were conducted to study the effect of pulse parameters.The micro structure, hardness and coating strength were studied by means of SEM, XRD, micro hardness tester and scratch tester. Evaluation of the coated surface represents the improved micro-hardness value about 10 to 20 percent of the base material. The adhesion and scratch test show the coating done at optimum value of the parameter like frequency, duty cycle and current density results at high bonding between the coating and the surface.***

***Key words: Ni- $TiO_2$ Nano composite coating, pulse-plating, Adhesion, Scratch resistance.***

## I. Introduction

The electrodeposited nano material results in superior characteristics than the conventional coating methods[1]. The metal matrix components can posses high tribological characteristics, wear and corrosion properties[2].
The electro deposition method is the most efficient method to produce nano coating composite with high purity, low porosity also gains the control over grain size, shape and distribution of particles, which can enable to attain desired mechanical and thermal properties[3].
Nickel protective coatings are widely used to improve hardness and wear properties the ceramic incorporated into nickel coating in the form of powder and the coating is electrodeposition to have wider control over the microstructure by the regulation of pulse parameter[4].
Corrosion and wear resistance of mechanical parts are the major issue for the development of wear resistance materials by the electrodeposition of hard particles in to a metal matrix composite, the electro deposition coatings are studied and the results are evaluated due to their improved mechanical, electrical, triboloicalbehaviours[5].
The electro deposited nickel matrix with nano $TiO_2$ coatings will have improved surface properties; the surface will enhance wear and corrosion resistance. The electrodepositon method can produce homogenous surface layers at nanometer and micro meter sizes, where the normal DC plating methods cannot produce homogenous layer also it resist the control of pulse parameters. Low fatigue properties can be achieved from Watt's bath also the finer particles deposition on the surface can decrease the residual stresses and friction coefficient. The grain size and the volume of deposition vary the hardness and temperature properties [6], [7] .
The present study focuses on the surface properties like hardness, scratch resistance and adhesion property of a coated sample at standard test conditions.

## II. Experimental work

The specimens prepared for the coating having the dimensions of 30 X 30 mm and thickness of 6 mm are prepared by polishing, degreasing and followed by anodizing process for creating valence or holes to receive the electrons. The bath is prepared for coating is a typical Watt's bath maintained at constant stirring speed of 500 rpm, temperature at $50^0$C and the pH value of the bath is maintained at level of 4 and often checked using lab thermometer and pH buffer periodically, the pH is controlled by adding nickel carbonate for increasing and concentrated sulphuric acid for decreasing the pH.

The coating substrate is made as cathode and pure nickel bar is kept as anode the electron will diffuse from the nickel bar will be deposited on the surface of the substrate by the flow of charges. The nano $TiO_2$ present in the bath gets attracted and deposited on the surface with nickel. The current density, frequency and duty cycle are varied for different values and coatings are obtained.

The pulse parameters are set with reference to earlier developed DOE, which has 5 levels and 3 factors (frequency, duty cycle, current density). The plating time for each specimen is calculated for depositing 75 micron thickness coating on the substrate.

## III. Results and discussion

### A. Test for micro hardness

The hardness of the coating is evaluated using different testing methods, each method yields different hardness. Commonly adopted conventional testing methods are static (Brinell hardness, Vickers hardness, Rockwell hardness, etc.) and dynamic (hammer hardness test, Shore hardness, etc.). The unconventional methods of testing hardness are the micro-hardness testing and Hoffman scratch hardness testing.

The coated specimens are tested for micro hardness using Vicker`s micro hardness testing machine shown in the figure 4.6. Each sample is tested for 5 trails and the average is taken as the micro hardness. The load of Hv(50) is used to find the micro hardness confirms that the hardness value of the substrate is increased after coating.

The average micro hardness values of the coated samples. From the study it confirms that higher hardness falls on the values of frequency 30 Hz, duty cycle 30% and current 0.6 A/dm2.

It denotes that at higher current and lower values of frequency, current can give better properties of hardness and other mechanical properties. The incorporation of TiO2 particles in Ni matrix produces higher value of micro hardness than pure Ni deposit.

The increase in micro hardness is due to soft orientation and less powder loading of surfactant the maximum hardness of the composite is achieved by adding 0.3 g/l surfactant with 0.5 g/l TiO2 in the bath the hardness value falls below the average line and moves downwards showing that decreasing value.

In micro hardness testing method the hardness of the composition of the coating is studied in microscopic scale. The testing method is similar. The Ni-W electrodeposition produced by pulse plating from ammonical citrate bath is found homogenous the grain size of the deposit studied by the SEM analysis found to be 50-80nm, the hardness of the alloy incresed by the additionof W with decreased atomic size (Zhou et al. 2010).

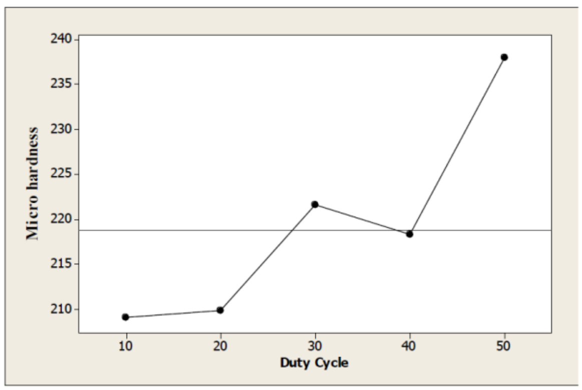


**Fig 1 micro hardness vs duty cycle**

The Ni-SiCnano composite prepared by the direct current and pulse plaring method from Watt`s bath is invetsigated and shown that pulse plated Ni-SiC has higher percentage of incorporation than direct current methods (Boonyongmaneerat et al. 2010). The presence of SiC particles results in the deposition of smaller grains. The pulse plating methods produce micro hardness at high duty cycle and low frequencies With increase in current density the hardness is increased above the average line and no fall back is seen in the graph like frequency and duty cycle. Hence the current density has main direct effect on the hardness of the material. The Zn-TiO2 nanocomposite coating achieved by electrodepsoition has improved the crystal size resulted in the better micro hardness property by adding the fine grains of nano TiO2 particles in the composite is confirmed by the SEM images.

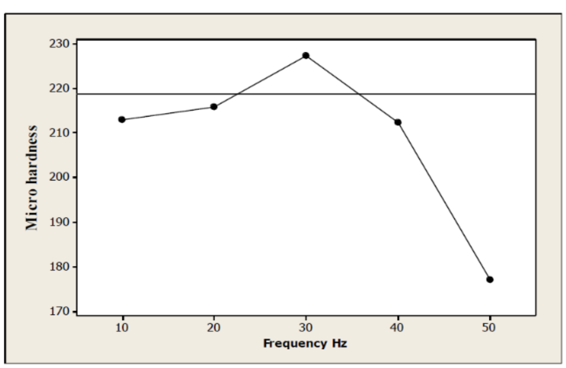


**Fig 2 Frequency vs micro hardness**

The mechanical property of electro deposited Ni-C-Cg nano composite coating influenced by pH parameter studied by SEM and EDS results states that amount of SiC particles at pH 4.8 will exhibit maximum micro hardness of 593 Hv[8]. At the bath temperature of $45^0$C the deposition of CeO2 nano particles and N are co-deposited with smaller grain size results in achieving the micro hardness range of 620 Hv.
Further increase in temperature will increase the grain size of the deposit which will reduce the hardness drastically. The intensity of peak current density has a direct effect on grain size and homogenous surface, it always produce reduced grain size which results in increase of micro hardness produce by pulse plating methods compared with direct current method deposition

**B. ADHESION TAPE TEST**

The surface of materials like metal, ceramic plastic can be pprotected against wear by surface modification and deposition of high wear resistant material. The surface can be altered by means of electroplating and coatings of thin film

In elelectrodeposition the substrate and coating material align themselves in opposite charge for creating interatomic forces between the surface and the coating material which forms a bonding nature. Good adhesion property in electroplating can be achived by increasing the thebonding strength higher than tensile strength of thethe substrate. Failure occurs mainly in the regions of coating material thickness and substrate, but not at the interfacing region. Good quality of adhesion property achieved by means of standard preparation methodsThe adhesion property of the coating depends on the amount of surfactant added, the maximum range of surfactant added to Watt's can give more hardness and wear property leads to more adhesive bonding.

A lattice pattern with either six or eleven cuts in each direction is made in the film to the substrate then pressure sensitive tape is applied over the lattice and then removed and adhesion is evaluated by comparison. The experiments were carried out as per ASTM D 3359 standards. It is observed that there is no material of the deposit is detached from the surface so it has obtained the grade 5b.

**Fig 3 Adhesion Test**

**C. SCRATCH TEST**

The nano indention method for finding the micro scratch of the surface on electrodeposited Ni and DC plated Ni surface, reveals that the electrodeossited has no scratch and erosion of material compared with DC plated surfaces. This is due to finer and uniform grain structure produced by the electrodepositon methods.

The scratch hardness can be measured using a indentation of sharp tool of known tip geometry the progressively increasing load were conducted for evaluation of the coatings adhesion and scratch toughness The indentation of the ball to make scratch with 4 Newton force is observed that for visible scratch mark. The observation of the experiment is to see the visible scratch mark on the surface.
The result of the scratch test is observed that there is no visible scratch mark on the surface after the removal of load. The surface with high hardness is highly resistant to scratch is being confirmed the observation.

**IV. Conclusions**

In this study, an attempt was made to co-deposit Ni- $TiO_2$ on EN8 steel substrate from TiO2 dispersed bath and the mechanical properties are studied .From the detailed investigation, the following conclusion can be drawn:

(i) The microhardness closely depends on the content of the titania nanoparticle.
(ii) Adhesion property of the coating was also good and confirms to the standard.
(iii) No visible scratch mark on the surface During scratch test and the nickel – titanianano composite coating exhibited a good scratch resistance property.

**References**

[1] InjetiGurrappa and Leo Binder(2008), Electrodeposition of nanostructured coatings and their characterization — a review,Science and Technology of Advanced Materials, vol. 9, no. 4, pp.043001– 043012.

[2] C. S. Ramesh and S. K. Seshadri (2003), Tribological characteristics of nickel based composite coatings,Wear, vol. 255, pp. 893–902.

[3] R. Sen, S. Das, and K. Das (2011), The effect of bath temperature on the crystallite size and microstructure of Ni–CeO2 nanocomposite coating, Mater. Charact, vol. 62, no. 3, pp. 257–262.

[4] M. E. Bahrololoom and R. Sani (2005), The influence of pulse plating parameters on the hardness and wear resistance of nickel – alumina composite coatings,Surf. Coat. Technol., vol. 192, pp. 154–163.

[5] G. N. K. R. Bapu and S. Jayakrishnan (2012), Surface & Coatings Technology Development and characterization of electro deposited Nickel – Titanium Carbo Nitride ( TiCN ) metal matrix nanocomposite deposits,Surf. Coat. Technol., vol. 206, no. 8–9, pp. 2330–2336.

[6] D. E. Rusu, P. Cojocaru, L. Magagnin, and C. Gheorghies (2010), Study of Ni-Tio 2 nanocomposite coating prepared by electrochemical deposition, vol. 12, no. 12, pp. 2419–2422.

[7] G. Parida, D. Chaira, and A. Basu(2011), Synthesis and characterization of Ni-TiO 2 composite coatings by electro-co-deposition, Surface and Coatings Technology, vol. 205(21-22), pp.4871-4879.

[8]M. Surender, R. Balasubramaniam, and B. Basu (2004), Electrochemical behavior of electrodeposited Ni – WC composite coatings,Surface and Coatings Technology,, vol. 187, pp. 93–97, 2004