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An Investigation on the Mechanical Properties of Ni-Zn-Mn Composite Coatings on Mild Steel

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Abstract: Friction in moving parts leads to loss of material in the form of wear. In this study the wear resistance of mild steel is observed by introducing Ni-Zn-Mn composite coating. The composite coating is deposited on mild steel by using the electro-deposition technique. Effect of the deposition parameters on deposition rates and surface roughness of the coat are investigated. The tribological behaviour of the both coated and uncoated samples are evaluated by pin-on-disc type. For the output response, the wear, frictional force and coefficient of friction are taken. After applying of the Ni-Zn-Mn composite coatings on mild steel, the results showed that wear resistance of the specimen is greatly improved.
Keywords: Electro-deposition; Composite; Wear resistance; Pin-on-disc; Frictional force

I. INTRODUCTION

In mankind history, friction due to the resistance to motion is challenging problem in all moving parts. For move a car the direct frictional losses is 28% and total losses 21.5%. By reducing the frictional losses will decrease the fuel consumption. There are some of the technologies, that used for reduce the friction [1].

Mild steel is well known material in all kinds of manufacturing applications for its good performance and balanced properties of strength, plasticity and weldability. It is widely used in the fabrication of mechanical components and abrasive tools in the less strict situation. However, the steel is susceptible to pitting corrosion in the natural environment because of its low abrasive resistance and chemical stability [2]. Compared to the steel, nickel has higher chemical stability, drawability and plasticity, which makes it much harder and more resistant to abrasion and corrosion as coating material. Extending element life is that the vital reality of life that several parts area unit deemed to be drained once their surfaces have degraded on the far side a preset limit. This limit could vary from the looks of minor indentation or rating marks in bearing surfaces to the removal of many millimetres of fabric from the bucket of associate excavating tool.

There are so many different techniques are available for coating on MS materials, with varying thickness from several microns to several millimeters. Structural modification of service properties of material parts area unit increased by depositing adherent tinny coatings of small and/or nano dimension on the surface of the material [3]. The deposition might either be to enhance aesthetics, engineering properties or to extend the scale of worn or undersize articles. The techniques for achieving any of those are varied. Examples are sputtering, chemical vapour deposition, galvanising, sherardizing, electro-less forming, electroplating, etc. The structural modification imparts new service properties to the materials [4].

Rejuvenating techniques also are capable of increase worn parts to their original tolerances, therefore reducing each waste and replacement prices. Electrodeposition is one of the important process of plating one metal over another. It is used for various applications such as wear resistance, corrosion resistance and decorative appearance. In addition to those classical plating applications, recent growth of composites to new areas, like electro-catalysis, photoactive materials or energy storage, has been determined. Due to the simplicity, low cost and less time consuming, the electro deposition technique is selected for this composite coating work. Most composite coatings contain micron-sized particles, though there's growing interest within the codeposition of nano particles as a result of their increasing handiness.

II. EXPERIMENT

A. Plating Sample Preparation

The samples are cut into a required size of 10 mm diameter and 32 mm length from a lengthy mild steel rod. The samples were cleaned from heavy oils and dirt by using the dilute sulphuric acid. Then samples rods are washed in distilled water and drying under a fan [5]. After the cleaning process, the samples were polished with Emery sheets, grinding/polishing machine and finally it is cleaned with acetone.

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B. Plating Procedure

The weight of the samples was taken and noted before the start-up of the plating process. The deposition parameters considered in the present investigation, varied at different levels to study their effects on the weight of composite deposited, were voltage and plating time. The parameters were considered in the following order: plating temperature is from 30° to 45°C and current density is 60-75 mA. A magnetic stirrer was used in the Watts bath at 550 rpm. The consolidated plating time is 30 minutes.

C. Solution Formula and Process of Electrodeposition

The electroplating solution is made up in the 200ml beaker. Before preparing the solution in the beaker, it is washed and cleaned by the distilled water. The electrolyte solution combinations are listed in the Table 1. Distilled water and reagents were used to prepare the plating solution. The base substrate (cathode) and anode were arranged in the electrolyte alike the Fig 1. As per the input conditions, the plating process is successfully completed in the watt bath setup.

TABLE I Basic Bath Compositions and Electrodeposition Conditions

Concentration of $NiSO_4 \cdot 6H_2O$	52 gpl
Concentration of $MnSO_4 \cdot 6H_2O$	34 gpl
Zinc acetate Dehydrate	44 gpl
Boric acid	10 gpl
Temperature	30 ± 2

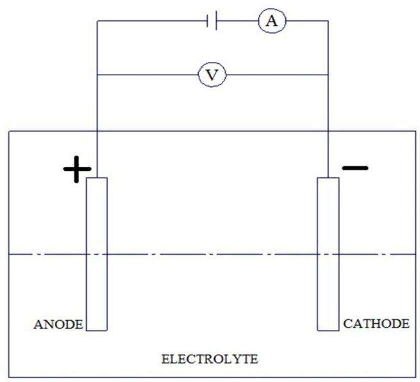

Fig. 1 Electroplating experimental setup model

After the plating process completed, the weight of the substrate was noted. That weight of the coating in the plating process can give the indication of the thickness of the electroplating. Difference between the initial and final weight calculated as 63.10 milligram. It denotes the amount of composite coating on the mild steel substrate.

III. RESULT AND DISCUSSION

Pin-on-disc test was utilized to get the tribological properties of the substrate. The experiment was conducted for the standard speed, time and sliding distance for the selected base metal with 10 mm diameter substrate. Here the wear testing time was 360 seconds. Using acetone the disc was cleaned before conducting the test. The substrates wear, coefficient of friction and frictional force were given in figure 2 and 3. In this regard, the aim of this work is to find the important combination of factors influencing the process to achieve the minimum wear and co-efficient of friction. The wear test, the graph represents the amount of wear (y axis) with respect to increasing time (x axis). From the Fig 2, the wear rate is directly proportional to the time i.e., when the time is increase, the wear rate of the uncoated substrate also increase. For the composite coated substrate, the result gave the less wear compared to the uncoated substrate. From zero to 150 seconds, constant wear was happened up to 6 micrometres. The surface roughness of the substrate is examined by surface roughness tester. Coated sample having the Ra value of 0.98 but it is high than the value of uncoated sample's 0.46.

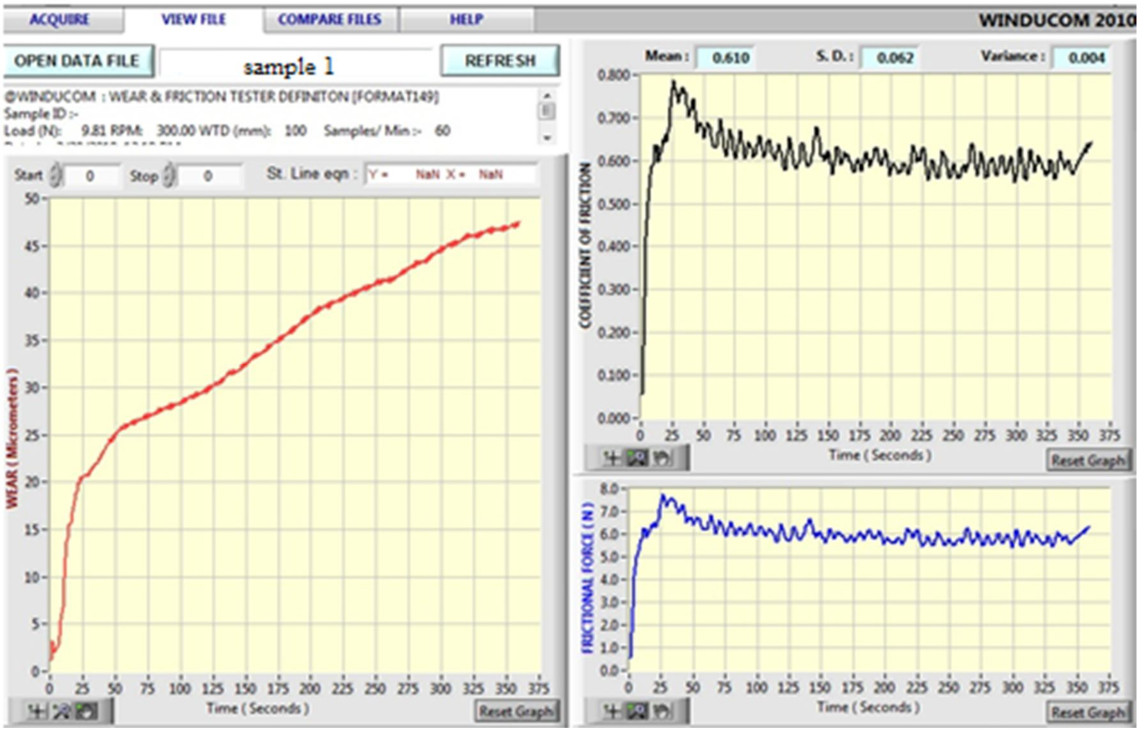

Fig. 2 Test result of wear, friction coefficient and frictional force for uncoated sample

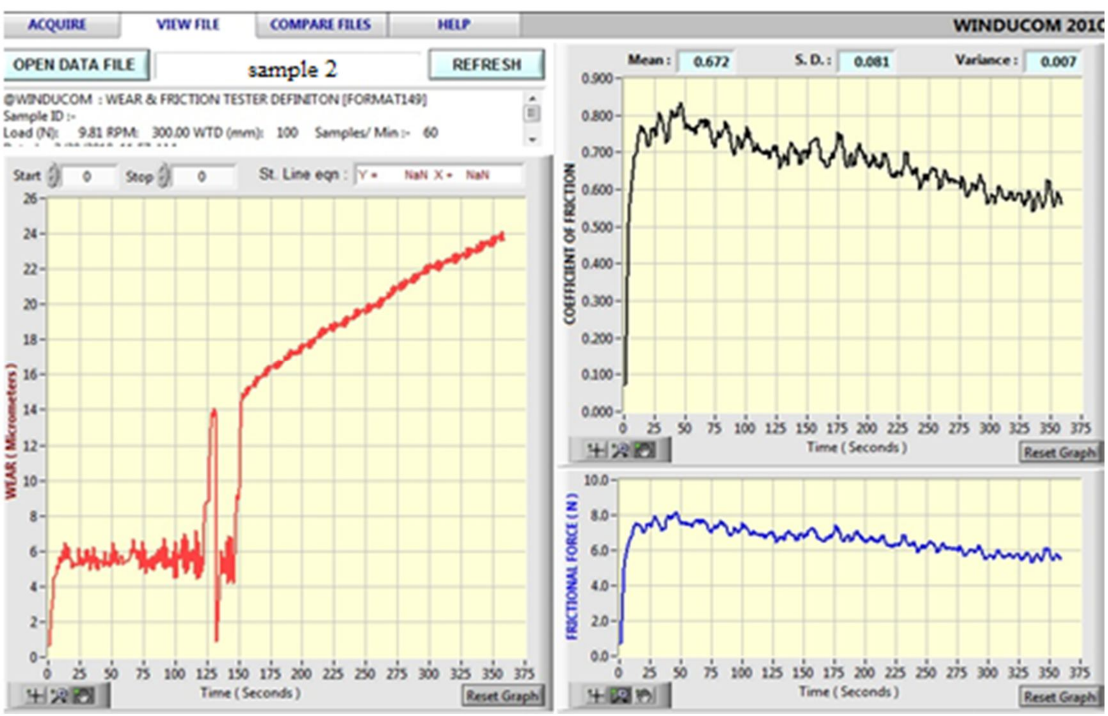

Fig. 3 Test result of wear, friction coefficient and frictional force for coated sample

IV. CONCLUSION

The effect of deposition parameter on the weight character of composite plating on mild steel are investigated. The surface roughness is not achieving the expected condition by compare with mild steel. On both coated and uncoated substrates, tribological test were conducted. Thus the coated sample proved that it has improved wear resistant. This enhancement is due to the Ni-Zn-Mn composite coating on the mild steel and the evidenced better wear resistance shown in the wear test result.

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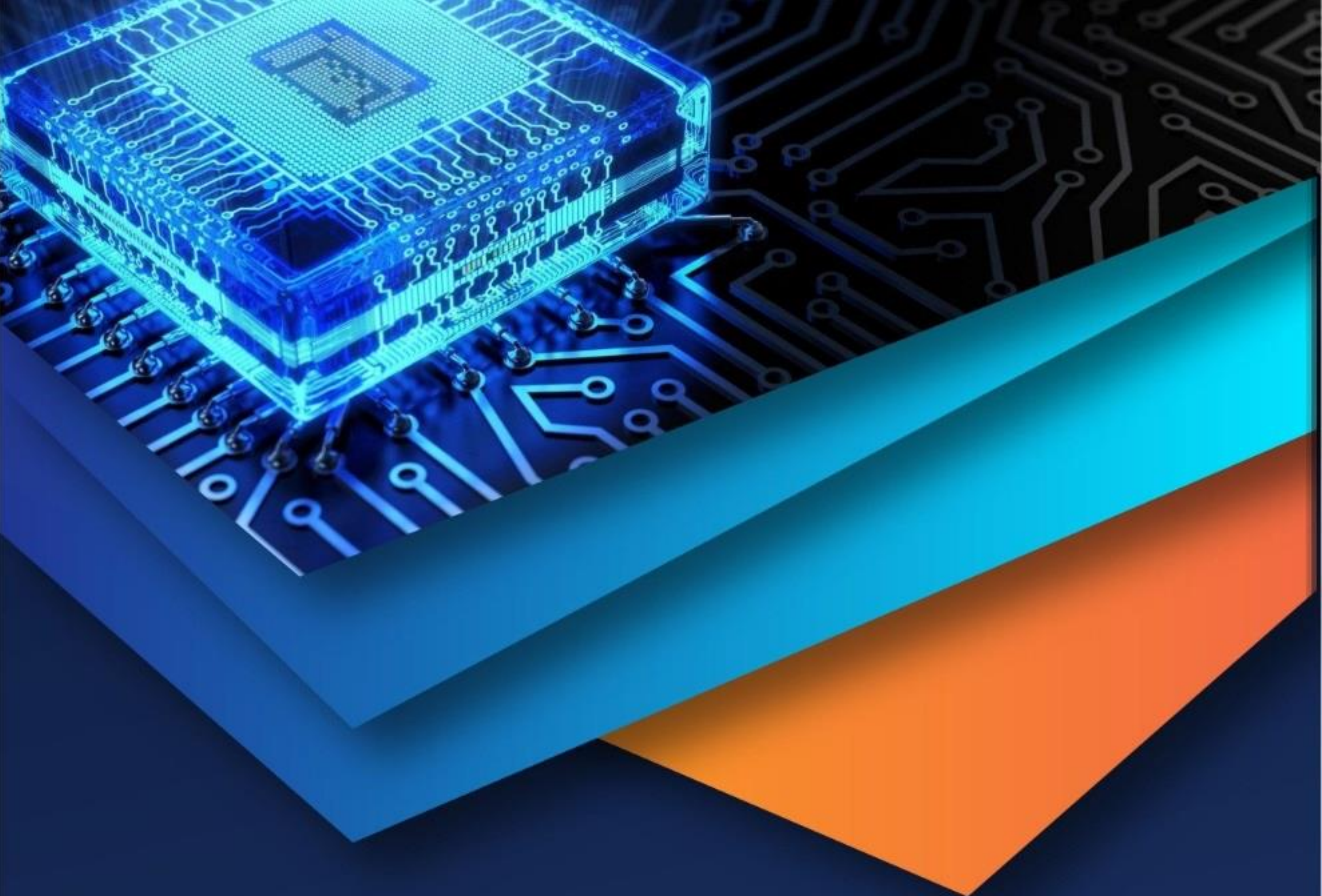

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