Journal of Materials Science and Engineering A 9 (1-2) (2019) 38-41
doi: 10.17265/2161-6213/2019.1-2.006

The Alternative Coating Method For Zinc Phosphate Coating before Cold Deformation of High Carbon Steel Wires

Elvan Araz
Guney Celik, R&D Center, Adana, Turkey

Abstract: The metal surfaces are passed through the pretreatment steps before being subjected to the coating process. One of these steps is zinc phosphate coating. The present process has many disadvantages such as the high number of digits, the difficult and high cost of disposal of the formed sludge, and not being an environmentally friendly approach. In this study, which we planned as an alternative coating for zinc phosphate coating, the effects on the wire were studied by working with stearates in order to be sensitive to the environment. Dipping method was used to compare different pH, time, temperature and concentrations of the obtained data with the zinc phosphate coating. With the alternative coating, the coating time can be reduced. Coating process; it can be completed in 3 stages by alternative coating method while it is finished in 7 steps in zinc phosphate process with surface cleaning. In addition, the corrosion resistance with alternative coating increased and cost decreased by 70-80%. Thus, it has been understood that the alternative coating is a coating type superior to zinc phosphate coating.

Key words: Corrosion, coating, steel, zinc phosphate.

1. Introduction

The production of high-strength wires used for cortes, automobile rubber wires, high-pressure gloves and other purposes is made from wire rods with a carbon content of up to 1%. The manufacturing process of the steel wire rod includes pre-treatment, heat treatment, surface preparation for drawing, drawing and coating application [1]. Zinc phosphate coating is generally applied within the scope of pre-treatment processes. The main purpose of the zinc phosphate coating is to prevent direct contact between the material surface and the roll and to provide low friction to ensure a smooth sliding between the material and the rolling mill [2].

In different industrial areas and different applications, phosphating is applied to metals as a conventional surface treatment technique. The mechanism by which the phosphating process is formed is somewhat complex but is based on the following basic equilibrium for all processes related to heavy metal phosphate solutions.

Phosphating is essentially an electrochemical phenomenon in which micro-anode(s) occurs in the micro-cathode(s) of dissolution of the metal and the dehydrogenation of hydrogen, followed by the precipitation of hydrolysis and insoluble phosphates [3].

Nowadays, alternative and lower cost pre-coating works are applied to zinc-phosphate coating. In this study, a mixture which has the feature of stearate and niche content can be used to hold the lubricant in the wire drawing application as an alternative to the zinc-phosphate coating. Starch is one of the most abundant and renewable natural products. It is obtained from various vegetable based agricultural products such as corn, wheat, barley, potato and tapioca.

Corresponding author: Elvan Araz, chemist, BSc., chemist, research field: coating technology in steel wire industry.

Starch is used in the production of a wide variety of food and non-food products, as is or with some modifications. From this point of view, a different modification has been attempted for the starch to act as a lubricant retainer prior to the wire drawing process. This modification comprises a mixture of anionic starch and a different kind of starate.

2. Materials and Methods

In order to be able to hold the wire drawing process on the lubricant compound applied to high carbon steel wire rod, a different composition was tried to be mixed in different proportions based on starch and stearate alternative to zinc phosphate coating.

These stearates were selected from sodium (Na), calcium (Ca), zinc (Zn), aluminum (Al) and magnesium (Mg). The parameters such as temperature, pH, concentration and duration were kept at regular intervals. The average amount of chemical used when forming the mixture is given in Table 1.

Experiment time pH measurements are made with Eutech brand pH meter, temperature measurements are made with thermometer and time measurements are performed with stopwatch. Experiments were performed in the range of 4-10 pH and between 10-60 seconds in the system where the wire rod was prepared and between 40 and 75 °C in the temperature zone. It was also measured and compared with the Salt Fog Tester according to ASTM B 117 standard.

3. Experimental Studies

The chemical composition of the high carbon steel wire rod used in experimental studies is given in Table 2. Samples that used in the experiments are shown in Fig. 1.

Recipes were prepared and trials were carried out for the application of the dipping process. The recipe information for the experiment is given in Table 3.

The preparation of the high carbon wire rod with different durations was carried out to the mixtures obtained by the prepared recipes. The coating solution is shown in Fig. 2, and the samples that dipped in the coating are shown in Fig. 3.

Table 1 Average percentages of materials used in the study.

Material	Average percentage
Sodıum	5-12%
Calsıum	5-12%
Zinc	1-8%
Aluminum	1-10%
Magnesium	1-8%
Starch	1-12%
Water	The rest

Table 2 Chemical composition of steel wire rod used in the experiment.

Chemical composition (% wt)	
Carbon (C)	0.821
Manganes (Mn)	0.731
Silisium (Si)	0.217
Copper (Cu)	0.016
Chrome (Cr)	0.329

Fig. 1 Samples used in the experiment.

Table 3 Three different recipe information.

Material	Sample receipt 1	Sample receipt 2	Sample receipt 3
Sodıum	6 g	-	-
Calsium	4 g	2 g	8 g
Zinc	-	2 g	4 g
Aluminum	1 g	3 g	-
Magnesium	2 g	3 g	4 g
Starch	5 g	6 g	5 g
Water	82 g	84 g	79 g

Fig. 2 Examples of immersion.

Fig. 3 Coating image made with Recipe 1.

Table 4 Oil retention amounts of sample coated with Recipe 1.

Sample number	First weight (g)	Final weight (g)	Difference (g)
1	4.75	7.085	2.335
2	5.203	7.56	2.357
3	1.491	4.354	2.863

Fig. 4 Alternative coating salt mist test image with zinc phosphate coating.

4. Discussion

The solutions prepared according to all recipes were applied to the dipping process and the solution prepared on the wire rod was observed. Subsequently, tests were carried out to determine whether the dry lubricant used in the present system was plastered onto this starch-based solution.

Results are obtained with weighing method and visual tests and as a result of structured tests, Recipe 1 is most satisfying with the maximum amount of plastered lubricant on the dipped steel wire rod and it is more homogeneous than other recipes. The amount of plastered lubricant of Recipe 1 is shown in Table 4.

A sample made according to the Recipe 1 was placed in a sampler Salt Spray device which was made with zinc phosphate coating process by conventional method and the corrosion life was calculated. As can be seen in Fig. 4, the zinc phosphate coated specimen was rusted after 3 hours.

5. Results

The data obtained as a result of the studies are as follows:

(1) It has been seen that the solution prepared with Recipe 1 has more lubricants on the surface of the steel wire rod and is more homogenous than the other recipes.

(2) When recipes are compared, it is thought that the sodium content in Recipe 1 is superior to others.

(3) It was also observed in salt fog test that the solution prepared according to Recipe 1 has a longer life than the zinc phosphate coating made by conventional method.

(4) It has also been observed during the studies that the temperature that above 60 degrees affects negatively the coating solution.

(5) It was observed that when the pH fell below 5, the thickness of coating on the wire was reduced.

(6) It has been observed that the homogeneity of the coating on wire has not been achieved when the immersion time has fallen below 15 seconds.

Resources

[1] Matochkin, V. A. 2007. “Heat Treatment and Surface Preparation of High-Carbon Wire Rod in Drawing.” *Steel in Translation* 37 (6): 55-7.

[2] Tekkaya, A. E., Hemberg, W., and Brosius, A. 2015. *60 Excellent Inventions in Metal Forming*. Berlin: Springer.

[3] Girčienė, O., Ramanauskas, R., Gudavičiūtė, L., and Martušienė, A. 2013. “The Effect of Phosphate Coatings on Carbon Steel Protection from Corrosion in a Chloride-Contaminate Alkaline Solution.” *Chemija* 24 (4): 251–9.