ABSTRACT

Galvanic coating in engineering. Development of technological process of zinc coating on steel details.

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Zinc coatings are applied on steel parts:

- which are exploited in the atmosphere of different climatic regions, in the atmosphere of industrial areas contaminated with SO_2, in closed rooms with moderate humidity or polluted with gases and products of combustion;

- which are in contact with fresh water at a temperature not exceeding 60-70 ºC (water pipes, feeding tanks);

- which are in contact with fuel containing sulfur-containing compounds (gas tanks).

To increase corrosion resistance, zinc coatings are subjected to additional processing, applied chromate or phosphate films. Zinc coatings with chromate film have a satisfactory corrosion resistance whendetail contact with hydrogen sulfide compounds.

Protective zinc coatingcover on the elliptic bottom of the receiver, which is made of carbon steel St3. The outer diameter is 133 mm, the thickness is 4 mm. The detail is made by hot stamping on a stamping hydraulic press (GOST 6533-78).

The product is exploited in an area with moderate climates, in the open air. The part needs to be applied protective coating, with its chromatization and lacquer coating, according to GOST 9.303-84 the thickness of the coating is 9 microns.

The main demand for the electroplating is a strong grip with thesteel surface, so the surface should be carefully prepared before applying the coating.

Preparing the surface of the details before applying the electroplating coating affects on the quality of the coating itself. Therefore, before zinc deposition, it is necessary to take a series of operations to clean the surface from rust, scale, various grease and lubricants.

There are use mechanical, chemical and electrochemical methods to preparing the surface of the detail.

Mechanical machining is used to eliminate scale, rocks, scraps, burrs, as well as to provide the required surface roughness.

In our case, it is advisable to use a hydroabrasive treatment. This is a process of removing rust, scale and other contaminants from the parts by using jet water with granular abrasive material, which is carried out under pressure of 0.5 - 4 atm. Ratio of quartz sand to water will take 1: 3 (by volume). Optimum angle of inclination of a suspension jet to the treated surface is 30-45 °.

Degreasing is used to remove fats and greases from the surface of the detail. For the complete removal of contaminants use chemical and electrochemical degreasing.

Chemical degreasing is carried out in alkaline solutions to remove the bulk of fatty contaminants.

Consequently, for the chemical degreasing use this solution:

$NaOH$	40-50 g/l
Na_3PO_4	5-15 g/l
Na_2CO_3	5-20 g/l
Na_2SiO_3	10-30 g/l

Work parameters:

Temperature - 60-70 ◦C;

Processing time - 5-15 min.

Electrochemical degreasing is carried out for the final removal of thin fatty films that remain after chemical degreasing.

In electrochemical degreasing use solutions of the same composition as in chemical but lower concentrations.

The steel parts are degreased by a combined method. First, on the cathode, but there is a hydrogenation of the metal, which adversely affects the properties of steel. Then degreasing is carried out on the anodes to reduce the hydrogenation of the metal.

Electrochemical degreasing is carried out in a solution:

NaOH	10-20 g/l
Na_3PO_4	30-50 g/l
Na_2CO_3	20-30 g/l
Na_2SiO_3	10-25 g/l
Avirol OG	0,05-0,1 g/l

The temperature of the process is 50-70 °C, the current density is 2-10 A/dm^2. The time for degreasing on the cathode is 5 – 10 minutes, at the anode – 1-2 minutes.

The process of etchingmaking for removal rust and scale from the metal. This is a chemical dissolution of metal oxidation products in solutions of acids or alkalis.

For etching steels, usually use solutions of sulfate or chloride acids. Since digestion occurs not only dissolution of oxides, but also iron located under the layer of oxides, injected inhibitors in the etching solution. They protect metal from digestion and hydrogenation.

In our case, the following solution is used for digestion:

HCl	200-250 g/l
Urotropin inhibitor	0,5-1 g/l

The process temperature is 18-25 ◦C

Processing time: 3-5 minutes.

The activation process is carried out immediately before the coating is applied to remove the thinnest oxide films and light etching of the metal, which contributes to the strong adhesion of the coating to the surface.

The composition of the solution for activation:

HCl	50-100 g/l

The process temperature is 18-25 ◦C

Processing time: 0,5-1 min.

The main task of the washing is to remove from the surface of parts of solutions and products from previous operations, as contamination can cause the formation of a defect.

Simple and complex electrolytes are used for zinc coating. The simple include – sulfate, boronhydrofluoric and chloride electrolytes, to complex – pyrophosphate, cyanide, zincate, ammoniac and aminocomplex.

For simple electrolytes, higher performance is characteristic because high current densities are used, and high zinc current output. Also, the benefits of acidic electrolytes include their stability during operation and ease of preparation and correction.

In complex electrolytes zinc is in the form of complex ions. The zincate electrolyte, according to the dissipation power, is closest to the cyanide electrolyte. Unlike cyanide, these electrolytes are non-toxic, more stable and economical.

Zinc electrolytes are a good substitute for cyanide electrolytes.

The excess of free alkali is directly proportional to the increase in zinc concentration.Free alkali is required for the stability of the complex zinc compound and the normal dissolution of zinc anodes. The ratio of zinc concentration to alkaline concentration is 1: 9.

With low concentration of NaOH, the possibility of formation of zinc hydroxide. Higher concentration of alkali leads to lower current output, deterioration of the quality of coatings, as well as chemical dissolution of the anodes. At high current density, anodes can passivate.

Electrolyte composition is chosen, according to the technological card of PJSC "Radar":

ZnO	10-15 g/l
$NaOH$	100-150 g/l
Blot-forming additive "Protolux 3000"	4-5 ml/l
Modifier "Protolux 3000"	3 ml/l

Conditions of electrolysis:

Cathodic current density 200 A/m^2

The temperature is 18-35 ° C

pH 11-12

Preparation of electrolyte is carried out according to the following technology.

For the preparation of zincate electrolyte, the required volume of NaOH is dissolved in water (1/10 of the volume of the bath) and heated to 90-100 ° C. Then zinc oxide is dissolved in water to form a porridge-like suspension. Next, the suspension is added to the previously prepared alkali solution. After this, dilute the solution with water to half the volume of the bath and allow to stand. The solution, which is settled, is decanted into a galvanic bath and heated to 60-70 ° C, then the warm water is added to the working volume of the bath.

Enter the necessary supplements and analyze the solution. The electrolyte works under working conditions untillight, compact precipitates are obtained.

After application of the coating, the parts are illuminated in the solution of the following composition:

HNO_3 5 g/l

Processing time: 0,25-0,5 min.

Temperature of the solution: 18-25 ° C.

Anticorrosion resistance of zinc coatings is increased by chromatic passivation.

Since hexavalent chromium is toxic and it is forbidden to use it in machine building, then the composition of trivalent chromium will be used in this project.

The mechanismof hromatizationusing Cr^{3+} has not studied, but it is known that the formation of a passive film occurs from Cr^{3+} salts:

$$x\,Cr^{3+} + y\,Zn^{2+} + z\,OH^- \rightarrow Cr_xZn_y(OH)$$

Blue chromate films are obtained in the solution of the following composition:

Tridur Zn B 15 ml/l

Processing time: 0,5-1,5 min

pH: 1,9-2,5

To reduce the removal of the solution after the passivation process, washing the parts in the bath catching.

Drying of details is carried out at a temperature not higher than 50 ° C for 10-20 minutes. The heating to higher temperatures leads to the destruction of the chromate film due to its dehydration. After drying, the parts are kept at room temperature for 48 hours, to solidify the passive film.

Visual control is carried out on 100% of the parts. Coverage is examined visually with the naked eye in order to detect the following defects: flushing, peeling, cracking, fogging on the surface of the detail.

The thickness of the coating is determined using thickness gauges and must conform to the technical documentation.

The strength of the clutch is controlled by the method of drawing a grid scratch. On the surface of the product, the steel edge is made by 4-6 parallel lines and 4-6 lines perpendicular to the first. The distance between the lines should be 2-3 mm. After applying all the lines, the surface of the parts should not be a detachment of the coating.

To apply a zinc coating, choose a bath with the following sizes:

L = 1600 mm - the length of the bath;

B = 710 mm - the width of the bath;

H = 1000 mm - height of the bath.

As anodes we use zinc plates Zn0.

The diploma project provides ways for automating the process of applying zinc coating.

Zinc plating is carried out at an electrolyte temperature of 18-35 ° C. It can be measured with different types of thermometers.

During electrolysis, it is necessary to control the charges of the electrolyte in the galvanic bath and in the tanks for its preparation. Since part of the electrolyte is carried out from the bath together with the details and at the release of gases, which leads to a decrease in its volume. Therefore, it is necessary to automatically maintain a constant level of solution in a galvanic bath.

The application of zinc coating is accompanied by a change in the chemical composition of the electrolyte, which adversely affects the quality of the parts that are covered. The structure of the sediment is much worse, therefore, it is necessary to predict the maintenance of the permanent composition of the solution. Also, electrolysis may change the pH of the electrolyte and this will lead to the deposition of poor quality coating. It is necessary to include in the scheme of measurement and control of pH.

Another factor to be controlled is the cathode current density. It significantly affects the rate of zinc deposition and its quality.

The project was designed for the main economic indicators:

1. Annual output	10 100m^2/year
2. The cost of fixed assets	1 391 000 UAH
3. Working capital	1 618 784,97UAH
4. Investment in the project	3 009 784,97UAH
5. The market value of the product	270 UAH/m^2
6. Profitability of production	30,4%
7. Term of investment return	47 years
8.Economic efficiency coefficient	0,31
9. Return on assets	1,96 UAH/UAH
10. Fund Capacity	0,51 UAH/UAH

Having analyzed the technical and economic indicators of the galvanic plant, one can come to the conclusion that it is cost-effective. The investment return period is 4,7 years, which is a good result for a galvanic company.

Taking into account the technological part of the diploma project, the company uses harmful, fire hazardous materials and materials, as well as electric energy. The work of the plant equipment causes constant noise and vibration in the shop, which is undesirable.

After analyzing the harmful and dangerous factors in the industry, measures have been developed to optimize working conditions and safety. All measures are taken in accordance with the requirements of labor protection.

Galvanic production refers to hazardous technologies that are characterized by a large amount of wastewater contaminated with toxic substances. The main components of electroplating are inorganic compounds, mainly ions of heavy metals – chromium, lead, iron, zinc, cadmium, copper.

The main effluents of galvanic production include acid-alkaline effluents, chromium-containing effluents and effluents with heavy metal ions. Since the hromatization is carried out with solutions containing only Cr^{3+}, there is no need for additional reduction of Cr^{6+} to Cr^{3+}. Therefore, all sewage is fed into tank.

According to the project, the electrocoagulation method of sewage treatment is used in the plant. This method is used for the removal of fine-dispersed and organic impurities, emulsions, lubricants and heavy metal ions.

The main advantages of the electrocoagulation method in comparison with reagent are the compactness of the installation, the relative simplicity of its operation and the reduced use of reagents. The disadvantage is the cost of iron anodes and electricity.

The method of electrocoagulation is based on electrolysis of waste water with using steel or aluminum anodes that are dissolved under the action of electric current. As a result of dissolution of steel anodes, ions of iron (II) pass into water:

$$Fe \rightarrow Fe^{2+} + 2e^-$$

After contact with oxygen in the air, the oxidation of the divalent Fe to trivalent occurs:

$$2Fe^{2+} + O_2 + 2H_2O \rightarrow 4Fe^{3+} + 4OH^-$$

Ions Fe^{2+}, Fe^{3+}, Cr^{3+}, which are present in the solution, hydrate to form the corresponding hydroxides of these metals. The resulting hydroxides of iron are good collectors for the deposition of hydroxides of other metals present in waste water. Colloidal particles, organic matter and other impurities are also adsorbed on formed hydroxides.

In order to increase the electrical conductivity of solutions and prevent the passivation of anodes in solutions, sodium chloride is introduced in the larger quantity, the greater the concentration of the passivating components - organic substances, phosphates, carbonates, nitrates, chlorates.

Key words: protective coating, zinc, zincate electrolyte, chromatizing, automatization scheme, economic indicators, wastewater.