ABSTRACT

«Galvanic coatings in machine building. Development of technological process of applying hard wear-resistant chrome coating on steel parts»

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In this diploma project the technological process of applying hard wear-resistant chrome coating on a steel guide part is developed, in order to increase its wear resistance and surface hardness. Coating is carried out with diluted sulphate electrolyte at a current density of 40 A dm^{-2} at 55 °C. The main equipment and suspension device for coating are calculated. Technological calculations and calculations of energy consumption, anode material, chemical reagents and water are carried out. The scheme of automatic control parameters of hard wear-resistant plating is developed. The expediency of realization of the developed technological process according to technical and economic indicators is estimated. In the technological process, for the treatment of industrial wastewater, a reagent treatment method is used. All technical decisions in the project are made according to the current requirements of labor protection.

The chosen part is made of steel (Ст3кп) hot-rolled rod with a diameter of 12 mm; on the one hand it has an external thread, on the other - a through hole for fastening. In the longitudinal direction of the milling cut 16 slots for rigid fixation fasteners in different positions.

After manufacturing, the part may have sharp edges and burrs at the cuts, unsatisfactory surface roughness - all this will contribute to the deposition of poor quality chrome coating (with burns, growths, with significant uneven thickness), so be sure to grind the surface at the beginning.

During the manufacture of the part, when threading, cutting recesses and through holes, lubricating and cooling fluid is used - in case of significant contamination of the

surface it should be degreased in organic solvents, before entering the part in the galvanic department.

The chosen steel part operates under periodic tensions in the absence of lubricating fluids, so to prolong its operation it is advisable to apply a protective coating antifriction.

A solid wear-resistant chrome coating with a thickness of 30 μm, which provides the necessary protection of the surface of the part, improving its tribological properties (reducing the coefficient of friction, speed and intensity of wear). In addition, the chrome coating gives the parts surface hardness and corrosion protection.

When applying chromium directly to steel, the thickness of the coating must be sufficient to ensure the absence of through pores and microcracks. Otherwise, in the places of their formation, in the presence of corrosive agents, contact corrosion of steel will take place, which is due to the cathodic mechanism of protection of steel with chromium.

At the beginning of the technological process the input control of the surface condition of 100% of details for quality control of machining is carried out.

Degreasing in an organic solvent is carried out in the presence of significant contamination of the coolant on the surface of the parts. It uses Nephras S3-80 / 120 whith addition anti-static additive Syhbol (in an amount of 0.001...0.02%).

Drying is carried out under exhaust ventilation until complete removal of the solvent from the surface of the parts. If necessary, additional wiping with cotton swabs is used to remove traces of solvent in the through hole or on the thread.

Before installing the parts on the suspension device, the threads on the parts are insulated - put on a fluoroplastic sleeve with an internal thread. Because the coating thickness is quite large, after chrome plating the thread may have unsatisfactory screwing.

Electrochemical degreasing is carried out in an alkaline solution and is carried out to remove from the surface of the parts of thin films of fatty contaminants that could get on the parts during their inspection and installation.

The composition of the solution is chosen so that the alkalinity was provided necessary environment and its minimum corrosivity. To do this, use a solution diluted in sodium hydroxide, and the required alkalinity is provided by the introduction of trisodium phosphate, carbonate and sodium silicate. In addition, trisodium phosphate and sodium silicate facilitate flushing from the surface of parts of emulsified fats.

To intensify the degreasing process, electrode polarization is used, which reduces the surface tension at the "surface of the part - solution" and, accordingly, increases the wettability of the part with the solution - this, together with the release of gas bubbles (hydrogen and oxygen), details.

After degreasing, warm and then cold washing is performed.

Chemical etching is performed in a solution of hydrochloric acid with the addition of urotropine - steel corrosion inhibitor composition.

After digestion, cold washing is performed. The use of warm or hot water will cause the surface to reseal. In order to reduce the cost of water for rinsing, this operation is performed twice (in two separate baths with the same water temperature and duration of treatment).

Anode activation is carried out in the chrome-plated bath. Before switching on the current for 2÷5 min, the parts should be warmed up in the solution, as this is necessary to prevent cracking of the coating at the beginning of its formation. During surface activation, a thin oxide film that could have formed during the pre-washing of the parts is removed, and the surface layer of metal with a deformed structure is removed, providing the best conditions for reliable adhesion of chromium to steel.

For the process of galvanic application of a hard wear-resistant chrome coating, a sulfate dilute electrolyte was selected. Electrolysis is performed at the cathode current density 40 ± 5 A dm^{-2} and temperature 50 ± 3 °C.

At the initial moment of electrolysis for 30 seconds "current shock" is provided 80÷90 A dm^{-2}, further reduction of the cathode current density to the working is carried out for 1÷1.5 minutes. Shock current is used to form a large number of crystallization centers chromium, which in turn increases the ability of the coating electrolyte.

Coatings of the selected electrolyte have the highest hardness and wear resistance, which is achieved by co-precipitation of the corresponding chromium precipitates. In the dilute solution, the conditions for the deposition of solid and wear-resistant sediments match best.

The use of a dilute solution provides a more uniform distribution of chromium in thickness on the surface of the part, a higher current yield and a higher rate of chromium deposition among other sulfate electrolytes. In addition, reducing the concentration of the solution results in lower wastewater treatment costs.

Correcting the electrolyte is held once a week, determining the content of the main components. The content of impurities is carried out once a month.

The adjustment is made based on the results of the analysis by adding the main components to the required concentration. To do this, the calculated amount of chromic anhydride is dissolved in a small volume of electrolyte in a separate container, and then this solution is decanted into a chromium bath. Sulfuric acid is added with stirring directly to the bath.

During electrolysis, the constant ratio of concentrations of chromic anhydride and sulfuric acid is automatically adjusted by adding the required amount of chromic anhydride solution after passing a certain amount of electricity through the bath.

The anodes are made of lead-alloy alloy «Ccy8». To hang them on the anode rod using copper flat hooks, which are inserted into the alloy when it is cast into molds. The introduction of the addition of antimony to lead increases its corrosion resistance and, accordingly, the service life of the anodes.

The use of soluble chromium anodes is not advisable, as it has significant disadvantages:

1) the accumulation of chromium ions in the process of electrolysis, because the anodic current output is much higher than the cathodic, as well as because the dissolution of chromium occurs with the formation of ions of different valences;

2) at the chromium anode, chromium (III) is not oxidized to chromium (VI), as is the case at the lead anode;

3) complicated machining of chromium due to its fragility.

After chrome plating, a capture bath is placed. The operation is performed in order to reduce the loss of electrolyte in the washing baths and, thus, leads to lower costs of reagents for the treatment of chromium-containing wastewater.

To increase the washing efficiency of the parts from the electrolyte containing chromium (VI) compounds, the subsequent cold washing operation is performed twice (in two separate baths with the same water temperature and treatment duration).

Washing hot on the final wash makes it possible to reduce the drying time of the parts. Drying is carried out in a drying bath for 10÷20 min at a temperature of 105 °C.

At the end of all operations, after dismantling the parts from the suspension device, the insulating sleeves are removed from each part and the quality control of the coating is carried out.

Quality control of hard wear-resistant chrome coatings is determined in accordance with ГОСТ 9.302-88 by their appearance, thickness and strength of adhesion. The color of the coating should be light gray with a bluish or milky hue, shiny or semi-shiny according to ГОСТ 9.301-86.

The chromium precipitate must be smooth, uniform in thickness over the entire surface operating under friction conditions, free of dendrites, swelling and exfoliation.

The control of the coating thickness is carried out in places that do not have surface defects, in accessible areas, at least 5 mm away from the edges, holes and mounting points of the contact. From 0.1 to 1% of parts are selected for control, but not less than three parts. The thickness of the layer of chrome coating is determined using a thickness gauge magnetic МТ-41НЦ.

Control strength adhesion coating produced by the method of polishing or heating.

To apply the method of polishing wheels of calico or felt and paste ДОІ. The surface is polished for at least 15 seconds at a polishing speed of 20÷30 meters per second. After polishing the surface should not be swollen and peeling coating. There should be no swelling and peeling of the coating on the surface.

Removal of substandard coatings. The chrome coating is removed by anodic dissolution in an aqueous solution of sodium hydroxide (50÷100 g L^{-1}) at a temperature of up to 60 °C and a current density of 5÷10 A dm^{-2}.

The number of parts that are loaded into the bath at once is determined taking into account the fact that per 1 m of cathode bar length should be 0.1÷0.2 m^2 of the total surface area of the parts on the suspension.

For loading selected parts of the bathroom hanging device frame type. The suspension is made of hot-rolled steel strips. Contact of a suspension bracket with a cathode rod is carried out by means of five copper hooks which fasten to a suspension bracket on rivets. In the middle of the lower part of the suspension is vertically welded additional strip for structural rigidity.

Contact of details with a suspension bracket is carried out through a through aperture by means of a steel spacer fastening which, creating strong clamp to an internal part of an aperture of details, provides reliable contact.

To reduce the consumption of serum and to increase the service life of the suspension, the non-working part of its surface is insulated with non-conductive chemically resistant material "Plystygerm™ 38".

Since the plating process uses high cathodic current density, cross-sectional dimensions of the suspension elements is selected so as to avoid overheating. For suspension elements that are above the level of the solution, the following values of the allowable current density are taken: for copper 6÷8 A mm^{-2}, for steel 2 A mm^{-2}; for elements below the electrolyte level, the allowable current density can be 3÷4 times higher.

Polypropylene, which has high strength and chemical resistance in chromic acid solutions, was chosen as the material for the bath. The thickness of the walls of the bath is 40 mm.

The selected equipment for electroplating ensures the implementation of the annual production program and has an optimal load factor (0.75÷0.85).

Conducting electrolysis at an anode current density of 3.8÷4.8 times less than the cathode current prevents excessive accumulation in the solution of chromium (III), because reducing the anode current density increases the proportion of current spent on the oxidation of chromium (III) to chromium (VI).

The following thermal regime is set for the galvanic chrome plating process: at the beginning of the shift the bath is heated to the operating temperature (55 °C); then, in the process of electrolysis, the bath must be cooled to operating temperature, because due to the release of the Joule temperature it is heated to 74 °C.

The heating bath by using flexible TEH with PTFE coating: the power of 13 kW (380 V), the overall diameter of 12 mm.

Cooling is carried out by means of two tubular coils, which are placed along the side baths above the interelectrode space. The tubes are made of aluminum and have a fluoroplastic coating, the total diameter of the tube is 25 mm.

The process of galvanic chromium plating from sulfate dilute electrolyte is characterized by a significant change in the composition of the solution during electrolysis. To obtain a quality coating that meets these requirements, it is necessary to constantly maintain a given mode.

In the conditions of industrial galvanic chromium plating, taking into account large volumes of production, it will be expedient to automate the main process for improvement of quality of production, and also for increase in productivity.

The set parameters to be controlled in the process of galvanic chromium plating: temperature (52÷58 °C), electrolyte level in the bath (0.84 m), voltage and current (11.2 V, 2069 A) and the ratio of concentrations of solution components (chromic anhydride and sulfuric acid).

For automatic temperature control there are 2 circuits: to heat the bath with the heater to the operating temperature and to maintain this temperature in the process of electrolysis using coils. Both circuits consist of a local temperature meter, from which the readings are transmitted to a recording device located on the control panel, which in turn is connected to a remote control device, from which the signal is already transmitted to the local control device.

The level of the electrolyte in the bath is supported by the third circuit. To measure the level in the bath there is a device with remote transmission of readings, from which these readings are transmitted to the control panel to the indicating and recording device connected to the regulating device that transmits a signal to the local device with a valve on the pipeline.

The voltage and current in the bath are regulated by a fourth circuit. A voltmeter and an ammeter are installed on the DC source, the readings of which are transmitted to an automatically regulating device located on the control panel.

The concentration ratio is automatically maintained by the fifth circuit. A local ammeter from the fourth circuit after each hour of operation transmits readings to the control panel to the software controller, which regulates the valve on the pipeline from the tank with the solution to replenish the required amount of chromic anhydride.

Galvanic chrome coating, as well as any other galvanic costly process water for different purposes, of which about 75% is the cost of washing operations.

Water consumption for washing operations consist of the cost of washing after surgery electrochemical degreasing, chemical etching and plating.

In the process of technological process development, the choice of the type and number of washing operations is primarily justified by the need to ensure high-quality washing of parts and prevent mixing of components of solutions from different baths.

However, the developed technological process should not only ensure the production of quality products, but should also be feasible in the implementation from an economic point of view.

Based on the calculations, in this diploma project not only provide high quality washing parts, but also cause lower water consumption for washing, so that the technological process is feasible in the implementation from an economic point of view.According to the results of economic calculations, namely the profitability and payback period, the developed technological process of applying a hard wear-resistant chrome coating is worth implementing from an economic point of view.

In the process of galvanic production, after flushing operations, large volumes of wastewater accumulate, which need to be treated before being discharged into the sewer. These wastewaters are divided into acidic, alkaline and chromium-containing effluents. A reagent method is used to neutralize and purify them from chromium (VI).

The technological process of applying a hard wear-resistant chrome coating is implemented in a galvanic shop. In the process of implementing the production program, harmful, chemically aggressive, flammable and explosive substances and materials are used, as well as electric and thermal energy.

All technical decisions in the project are made according to the current requirements of labor protection. Based on the study of harmful and dangerous factors, a number of measures have been developed to optimize working conditions and fire prevention.

To prevent exposure to harmful substances, on-board extractors are placed on the sides of each bath, which are used to remove vapors from the surface of the solutions. In addition, the shop has general ventilation to remove harmful substances from the air and supply clean air.

The galvanic department uses systems of artificial working, emergency, evacuation, repair and security lighting. Natural lighting system - combined (combination of top and side lighting).

In the galvanic department special danger comes from current sources and current-carrying elements of the equipment. The material of the bath cases is made of polypropylene, so the possibility of electric shock due to leakage currents disappears. However, in case of non-observance of safety precautions, it is possible to receive a blow by a stum owing to contact to copper rods through which current is brought to baths of degreasing and chromium plating.

In order to ensure electrical safety, the following measures are provided: zeroing of electrical equipment, protective shutdown of installations, low supply voltage of hand power tools, insulation of live parts, electrical separation of networks, fencing devices, blocking, alarm, safety signs and warnings.

The use of the following protective equipment is provided: dielectric rubber gloves, tools with insulating handles and current detectors, rubber insulating stands.

During maintenance baths working at elevated temperatures or at high voltage, danger is particularly high temperature and pressure. Injury is also possible due to careless handling of the auto-operator line, where there are open rotating parts. An emergency can occur in the event of a failure of automation.

In the production process there may be sources of ignition due to overload of electrical equipment, the formation of oxides in the gases leaving the bath, the formation of a flammable mixture of hydrogen and air. The causes of fires can also be: short circuit between the electrodes and rods of the degreasing and chrome-plating baths, static discharges in the bath with an organic solvent, mechanical damage to equipment and electrical wiring. There is also a risk of a direct lightning strike on the object and the entry of high potentials through the above-ground and underground metal communications in the department.

To extinguish fire sources in the workplace are equipped with fire shields with a set of fire extinguishers, fire extinguishers, foam fire extinguishers and sandboxes. Also, production facilities and warehouses are equipped with internal fire hydrants - an element of the internal fire water supply. Fire gaps of 10 m are provided between production buildings. To prevent explosions of gas pipelines, they are periodically checked for leaks.

The building is protected from direct lightning strikes by means of a lightning arrester consisting of a lightning receiver, which assumes the lightning discharge, grounding conductor and conductor.

Key words: chrome, hard wear-resistant coating, sulfate diluted electrolyte galvanic bath.