# Flow-Through Chrome Plating Technology for the Restoration of Agricultural Machinery

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Abstract: During operation, machine parts are exposed to complicating factors: aggressiveness of the environment, high content of gas and mechanical impurities. It is necessary to use various methods of hardening the surfaces of the working bodies of machines. Work is constantly being carried out on the problem of improving the quality of protective coatings of the main parts and mastering hardening technologies. The article presents a device for flow-through chrome plating, where a chrome coating is applied to the surface of parts by maintaining certain parameters of the carrier flow flowing through channels in a closed system. Chrome plating technology is considered, which allows to restore worn surfaces of parts operating under conditions of increased specific pressure, high temperature and lack of lubrication, in order to increase hardness, wear resistance, corrosion resistance and reduce the coefficient of friction of machine parts.

## 1 INTRODUCTION

Electric chrome coatings have high hardness and wear resistance. Therefore, chrome plating restores the wear-resistant surfaces of agricultural machinery parts with small wear (plunger pairs, distributor spool, piston pins, etc.).

Chrome plating is performed in baths lined with lead, viniplast or other acid-resistant material. The walls of the bath are made double. The space between them is filled with water or oil, which is a coolant for heating the electrolyte in the bath. The concentration of the bath should include a hood to remove evaporation products and gases released during electrolysis. Rectifiers VAKG-12/6-300, VAKG-12/600 M with a voltage of 12 V, a low-voltage generator AND 500/250, etc. are used as direct current sources. To intensify the electrolysis process, a reversible direct current is used (the polarity changes according to a certain program).

To obtain high-quality chrome coatings, it is necessary to observe the ratio between the current density and the temperature of the electrolyte. By changing the electrolyte temperature and current density (without changing the electrolyte composition), three types of chromium precipitates can be obtained: shiny (hardness- up to HB 900, high wear resistance and brittleness), milky (hardness- HB 500-600, sufficient wear resistance and plasticity), matte (the hardest and most brittle). The increased fragility of the matte sediment reduces its wear resistance, so this type of sediment is not used when restoring parts. Shiny precipitation is used for decorative purposes (Bogorad, 1984; Equipment for electrochemical production, 2010; Khudayorov et al., 2023a; Khudayorov et al., 2023b; Mirzakhodjaev et al., 2024a; Mirzakhodjaev et al., 2024b).

The average current output value for chrome plating is 13-15%, and the chromium deposition rate is 0.03-0.06 mm/h.

Due to the poor wettability of the chrome coating surface, the wear resistance of the parts decreases. Therefore, when restoring parts operating under conditions of increased specific pressure. Due to high temperature and lack of lubrication (piston rings, cylinder liners, etc.), porous chrome plating is used. The porosity of the surface is obtained by mechanical, chemical or electrochemical methods (Zakirov et al., 1978; Vansovskaya, 1985; Vyacheslav & Shmeleva, 1985; Gorlova et al., 2010; Khudayorov et al., 2023; Djiyanov et al., 2024; Isakova et al., 2024; Alimova

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et al., 2024; Irisov et al., 2024; Astanakulov et al., 2024).

## 2 MATERIALS AND METHODS

By changing the electrolysis mode, different types of chromium precipitates can be obtained, differing in their properties and, consequently, in the field of application. The greatest technical and economic effect is achieved when using wear-resistant and flow-through chrome plating. It is important to note that hardness does not always correlate with wear resistance.

The diagrams in Figure 1 clearly demonstrate the areas of obtaining hard and wear-resistant coatings under standard chrome plating modes in "universal" sulfate electrolytes.

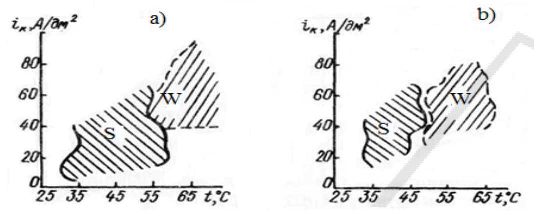


Figure 1: Diagrams of the conditions for obtaining solid (S) and wear-resistant (W) chromium coatings in dilute electrolyte (a) and standard electrolyte (b).

The wear resistance of the coatings increases with increasing temperature and, after passing through a maximum at 55-65° C, decreases to a minimum at 75° C. For precipitation obtained from a dilute electrolyte, the maximum wear resistance is shifted to the region of higher temperatures. The plasticity of electrolytic chromium also significantly depends on the chrome plating mode. Brittle chromium precipitates (shiny and matte) are obtained at low electrolyte temperatures and high current densities, more plastic coatings are obtained at high temperatures and low current densities.

Electrolytically precipitated chromium contains oxygen, hydrogen and a small amount of nitrogen. The mass fraction of oxygen is 0.2-0.5 mass fractions, and hydrogen is 0.03-0.07 mass fractions. The volume of gases included in the sediment depends on temperature and current density: with increasing temperature and decreasing current density, the volume of gases in the sediment decreases slightly. All chrome coatings are characterized by high hardness, the hardness is determined by the electrolysis mode.

Chromium is applied in a thin (0.25–0.8 microns) layer on nickel to provide an economical and highly corrosion-resistant coating. Most decorative chrome coatings are produced using hexavalent chromium electrolytes. Over the past two decades, trivalent chromium-based processes have gained increasing acceptance in the industry.

Shiny chrome can be applied in continuous (regular) or intermittent layers. Intermittent deposits are formed by applying chromium to a microporous (or microcrack) nickel plate. The choice of a continuous or discontinuous layer depends on the required level of corrosion resistance. Failure of a shiny chrome plate is often associated with deep pits resulting from corrosion starting in random cracks or pores on the chrome surface. Corrosion is an electrochemical mechanism. Since these cracks or pores are located relatively widely, the current generated by the chromium/nickel pair is concentrated at several points. Deep pits form at these points, which quickly penetrate through the nickel plaque and the substrate of the component. The creation of micro-gaps (microcracks) on the surface leads to the spread of corrosion current and a slowdown in the rate of corrosion. Typically, a conventional chrome plate is used for products with a coating for operating conditions 1/2, whereas an intermittent layer is used to cover operating conditions 3 or higher (ASTM B456).

Four types of hexavalent chromium electrolytes are commonly used:

- sulfate catalysts,
- sulfate-fluoride catalysts,
- sulfate-fluoride-organic catalysts
- and self-regulating high speed (SRHS).

The most common electrolytes used today are based on a double sulfate fluoride catalyst. This mixed catalyst has the advantages of increasing cathode efficiency, coating ability and ability to apply shiny nickel layers compared to a direct sulfate type catalyst.

Over the past decade, the popularity of the triple catalytic system has increased. This system has characteristics similar to a dual catalyst, with the advantages of higher cathode efficiency, a wider operating window and improved coverability. The operation of these systems requires regular analysis of the concentration of chromic acid, sulfuric acid and proprietary catalysts. The main differences between the systems are shown in Table 1.

Table 1: Hexagonal chromium electrolyte systems.

| Type | Single catalyst | Double catalyst | Triple Catalyst | SRHS |
|---|---|---|---|---|
| Concentration $Cr0_3$, g/l | 450-500 | 180-400 | 250 | 240 |
| Ratio $Cr0_3$:$H_2S0_4$ | 100:1 | 200-300:1 | 160-170:1 | 260-270:1 |
| Type of catalyst | Sulfate only | Mixed sulfate/fluoride | Mixed sulfate / fluoride | Mixed Sulfate/ Organic regulator |
| Cathodic efficiency factor, % | 8 | 12-18 | 20-25 | 15 |
| temperature, F | 100 | 100-104 | 104 | 104-113 |
| Cathodic Current density, asf | 80-102 | 100-150 | 90-150 | 110-160 |
| Level mixed oxides, g/l | <22 | 10-20 | <12 | <12 |
| Main Features | Ease of Preparation. Resistance to pollution. | Good Chromability. Good hiding ability | Wide Operating parameters. Excellent hiding ability. | Tolerant to Sulfate changes. Easy to use. |

The main factor affecting the coating time is the cathodic efficiency of chrome plating solutions, which is influenced by the following factors (This is shown in Table I.):

- Type of electrolyte.
- The concentration of the solution.
- The current density used.
- The temperature of the solution.
- The composition of the solution.

During operation, parts of agricultural machines are exposed to complicating factors: aggressiveness of the environment, high content of gas and mechanical impurities. As a result, manufacturers are forced to use various methods of hardening the surfaces of the working bodies of pumps. Specialists are constantly working on the problem of improving the quality of protective coatings of basic agricultural parts and such hardening technologies as flow-through chrome plating have been mastered.

For operation in an aggressive environment, increased requirements are imposed on the surfaces of agricultural machinery parts, which can be achieved using chrome plating technology, which allows to increase the surface properties of parts, such as hardness, wear resistance, corrosion resistance and reduce the coefficient of friction. The chrome coating is applied to the inner surface of the parts by maintaining certain parameters of the carrier flow flowing through the inner channel in a closed system.

## 3 RESULTS AND DISCUSSION

To achieve this task, a device for flow-through chrome plating of engine valves is proposed, consisting of a vertical cone-shaped hollow body, containing a cap with a threaded mount on top and a prefabricated poppet bottom with a centering protrusion, a ventilating element, powered by an electric motor, an apron with an observation window, a tank with a hydraulic mixer and a filter, a pump with hydraulic communication, a pressure gauge, and The hydraulic mixer is equipped with spraying tips facing the bottom of the tank from below, In this case, the device is mounted on roller wheels, and the conical body is connected to the tank body through a multi-hinged bracket, while the valve being restored relative to the inner wall of the conical body is mounted with a technological gap.

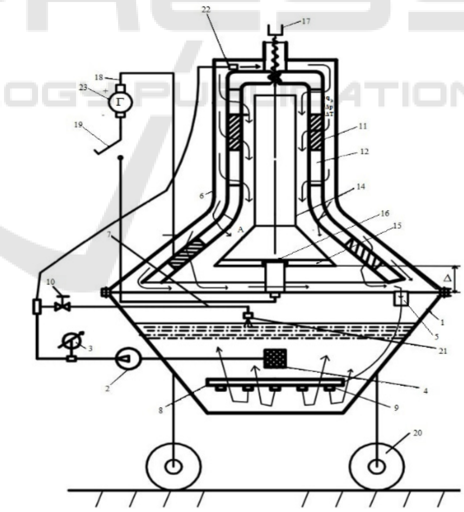

Figure 2: Schematic drawing of the device in the section.

Figure 2 shows a schematic drawing of the device in section ($q_э$ - electrolyte consumption; $\Delta p$, $\Delta T$ - operating pressure and temperature gradient of the electrolyte in the working chamber A; "+", "-" - positive and negative poles of the generator of the electric network; $\Delta$- technological gap).

The device for flow-through chrome plating of engine valves (Fig. 2.) contains a reservoir 1 for chrome electrolyte, pump 2, pressure gauge 3, filter 4, inlet 5, outlet 6 and return 7 tubes, a hydraulic mixer 8 with sprayers 9, an adjustment valve 10, a perforated tube 11 with radial channels 12 installed inside the housing 13 which describe the shape of the contour of the chrome-plated valve 14, plates 15 with a central protrusion 16 forming a technological gap equal to Δ. The body 13 and the perforated tube 11 are provided with an adjustment screw 17 from above. The cavity formed between the perforated tube 11 and the valve 14 creates a chrome plating working chamber "A". The technological gap Δ ensures intensive circulation of the chromium electrolyte around the valve 14. A positive electric charge is connected to the valve 14, and a negative electric charge is connected to the perforated tube. The electrical network 18 of the device is controlled via a switch 19. The device can be moved on roller legs 20. The return tube 7 is equipped with a nozzle 21, and the supply tube 5, with a nozzle 22, the electrical network 18 is powered by a generator 23.

The operation of the proposed device is as follows: with the start of the pump 2, the chromium electrolyte through the filter 4, the supply tubes 5 and the radial channels 12 of the perforated tube 11 enters the working chamber A, where, due to the action of positive and negative charges, intensive deposition of chromium particles occurs on the working surface of a new or extremely worn valve 14. The remaining part of the chromium electrolyte, through the discharge 6 and return 7 tubes, is returned back to the reservoir 1, where a hydraulic mixer 8 with a spray unit 9 provides high stability of the concentration of the chromium electrolyte. The working pressure $\Delta p$, the temperature gradient $\Delta T$ and the electrolyte consumption $q_э$ inside the working chamber A ensures the optimal mode of the chrome plating process. The installation of the roller leg 20 increases its mobility of the proposed device. By increasing the number of installations, it is possible to increase the replaceable chrome plating performance of heat engine valves. Due to the tightness of the design of tank 1, atmospheric air pollution in the workplace is excluded. The operating mode of the device is regulated through the adjusting screw 1.

The working pressure in the hydraulic system of the device is controlled by a pressure gauge 3. The proposed device provides chrome plating, iron plating, copper plating not only of extremely worn, but also of new valves of various heat engines, increasing its technological capabilities, eliminating atmospheric air pollution in the workplace during flow chrome plating, which will give a significant technical and economic effect to the national economy of the country.

A device for in-line chrome plating of engine valves containing a reservoir, a housing, a pump, a support plate, a hydraulic system, a perforated conductive tube, a chrome plating chamber characterized in that the internal contours of the chrome plating chamber describe the external contours of the shape of the chrome-plated valve, and the support plate is equipped with a central protrusion, and the discharge tube of the hydraulic system is equipped with a hydraulic mixer with a spray unit, as well as an adjustment valve and a tube for returning the chromium electrolyte back to the tank, while the device is mounted on roller legs.

# 4 CONCLUSIONS

The device relates to agriculture, in particular to devices and apparatuses for flow-through chrome plating of complex valves of engines and other parts of agricultural machinery. Due to the proposed device with an improved design, the application of chrome coatings on worn or new parts of agricultural machinery that are complex in shape is achieved by expanding the technological capabilities of the proposed device, which will give the national economy of the country a significant technical and economic effect.

# REFERENCES

Alimova, F., Saidova, M., Primqulov, B., & Erdem, T., 2024. Optimization of the parameters of the pneumatic feed mechanism for precise clustered sowing. *BIO Web of Conferences,* 85, 01026. https://doi.org/10.1051/bioconf/20248501026.

Astanakulov, K., Kurbonov, F., Isakova, F., 2023. Investigation of the rotation number of a fish feed distribution device disc apparatus. *E3S Web of Conferences*, 381, 01001. https://doi.org/10.1051/e3sconf/202338101001.

Bogorad L.Ya., 1984. *Chrome plating* (5th ed.) Revised and additional. L.: Mechanical Engineering.

Djiyanov, M., Xalilov, R., Isakova, F., 2024. Justification of commercialization of export-oriented harvesting apparatus for intensive processing of cotton boxes. *BIO Web of Conferences*, 85, 01034 https://doi.org/10.1051/bioconf/20248501034.

Equipment for electrochemical production, 2010. Textbook (2nd ed.), reprint. Angarsk: AGTA.

Gorlova, I.G., Tadjibekova, I.E., 2010. Plasmatron for surfacing of new and worn parts of machines. Booklet “Uz EXPOCENTER”.

Irisov, K., Gorlova, I., Khudaev, I., 2024. The method of dispersion analysis of droplets using mini droplet cards for resource-saving agricultural technologies. *BIO Web of Conferences*, 105, 01016. https://doi.org/10.1051/bioconf/202410501016.

Isakova, F., Tadjibekova, I., Kurbonov, F., 2024. Improvement methods of feeding of aquaculture. *BIO Web of Conferences*, 85, 01037. https://doi.org/10.1051/bioconf/20248501037.

Khudayorov, Z., Khalilov, R., Gorlova, I., Mirzakhodjaev, S., Mambetsheripova, A., 2023c. Mathematical model of water drop trajectory in artificial rainfall. *E3S Web of Conferences,* 365, 04011. https://doi.org/10.1051/e3sconf/202336504011.

Khudayorov, Z., Khalilov, R., Mirzakhodjaev, S., Nurmikhamedov, B., Mamasov, S., 2023b. Theoretical study of the influence of the changing environment on the process of rainfall irrigation. *E3S Web of Conferences,* 376, 02013. https://doi.org/10.1051/e3sconf/202337602013.

Khudayorov, Z., Mirzakhodjaev, S., Khalilov, R., Nurmikhamedov, B., Mamasov, S., 2023a. Deflector nozzles of rain irrigation machines. *E3S Web of Conferences.,* 390, 01033. https://doi.org/10.1051/e3sconf/202339001033.

Mirzakhodjaev, S., Djiyanov, M., Nurmikhamedov, B., Mamasov, S., 2024a. Results of Frontal Plug Tests Combined with Active Working Body. *BIO Web of Conferences,* 85, 01035. https://doi.org/10.1051/bioconf/20248501035.

Mirzakhodjaev, S., Utaganov, K., Musurmonov, A. 2024b. Field Tests of a Cultivator Proceeds between Row Soils in Vineyards. *BIO Web of Conferences,* 85, 01036. https://doi.org/10.1051/bioconf/20248501036.

Vansovskaya, K.M., 1985. Metal coatings applied by chemical means. Edited by P.M. Vyacheslavov. L.: Mechanical Engineering.

Vyacheslav, P.M., Shmeleva, N.M., 1985. Control of electrolytes and coatings (2$^{nd}$ ed.), reprint. and additional. L.: Mechanical Engineering.

Zakirov, S.Z., 1978. Hardening of machine parts by electrodeposition of iron. Dushanbe: Irfon.