

Quality Improvement of Chrome-Diamond Coatings on Flowing Chrome Plating

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Abstract. The research results of the process of flowing chrome plating of internal surfaces of long-length cylindrical articles with the usage of electrolyte with ultra-dispersed diamonds when continuous article rotation, while chromium-plating, are presented. During experiments the following varying technological parameters: electrolyte temperature and article frequency rotation were chosen, and experimental samples were obtained. Estimation of porosity, micro-hardness, thickness of chrome coatings and uniformity were performed as well as the precipitation structure by the method of scanning electron microscopy. The results showed that the use of ultra-dispersed diamonds and realization of the scheme with rotation of detail-cathode when flowing chromium-plating allows one to increase servicing characteristics of the coating due to the decrease of grains size of chrome coating and porosity, and due to the increase of micro-hardness, so confirming the efficiency of using the suggested scheme of coating application and the given type of ultra-dispersed fillers when chromium-plating.

Introduction

High hardness, low friction coefficient, heat-resistance and high chemical stability make chrome-electroplated parts high wear-resistant. Chrome plating is widely used for improving wear-resistance of different articles, including cylindrical parts of inner friction surface with large length/diameter ratio. The process of electroplating in flow-through electrolyte, or flowing chrome-plating [1], is used for these long-sized articles.

Special set-ups providing forced supply of electrolyte in space between surfaces of the part to be electroplated and anode are used for chrome plating in flowing electrolyte. Forced supply of electrolyte provides its continuous substitution and uniform gas saturation in inter-electrode volume. It is advisable that these setups should be applied for chrome plating of inner surfaces of long articles when electrolyte saturation with the formed gases is too high that it prevents the standard process from depositing chrome. Maximum current efficiency (about 20%) is achieved on flowing chrome plating at a flowing electrolyte speed of 1 m/sec. The deposit is smoothed in flowing electrolyte making it possible to obtain solid glittering coatings or milk-white wear-resistant coatings at high current densities.

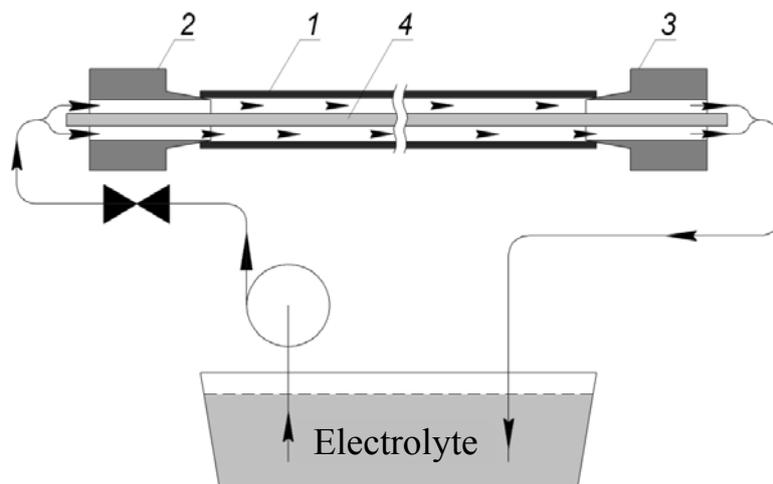
The most important problem both on chrome electroplating and depositing other coatings is achievement of uniform parameters, including geometric ones, along the surface and the volume of coating. It is especially actual for the chrome plating process as the change in deposition conditions along the inner surface of an article is added to the worst among other electrolytes dispersion ability.



It is necessary that stable electrolyte flow with the predetermined speed of near-surface anode and cathode layers should be firstly generated to get uniform quality parameters of chrome plating of inner surfaces along the length of long articles. At the same time, it is necessary to provide process parameters of chrome plating, airtightness of the set-up connection units with an article and the ultimate fast and complete removal of hydrogen from the deposition area [2-4]. The use of electrolytes with ultra-dispersed diamonds (UDD) and continuous article rotation during chrome plating instead of low-concentrated electrolytes recommended for flow-through chrome plating, make it possible to get high-quality chrome-electrochemical coatings. It gives higher micro-hardness parameters, less irregularity of geometrical parameters of chrome deposits, low number of pores per unit of surface area and what is more to get the necessary intensity of the process [5,6] due to increased current densities.

Experimental procedure (part)

The diagram of flowing chrome plating is given in Figure 1. The flowing chrome plating set-up using UDD consists of an article 1 to be rotated during chrome plating relative to its axis, header 2 and drain units 3 and anode 4. The picture of electrolyte flow, speed and pressure distribution in near-surface layers of the deposition area making possible to select optimal geometric parameters of units 2 and 3, have been received due to the earlier performed computer modeling of electrolyte hydrodynamics.



1 – Article to be plated, 2 – Header, 3 – Drain unit, 4 – Anode

Figure 1. Diagram of flowing chrome-plating setup of inner surface of long-size articles

Experimental specimens (Figure 1) were obtained in the course of experimental investigations and the following modifying process parameters: electrolyte temperature (of 50 to 70°C), frequency rotation of article (of 50 to 500 rev/min), working current density being equal to 50 A/dm² [3], were selected. Cylinder parts of submerged type sucker rod pumps (GSHN) GSHN RH 1/16 d=27 mm, 700 mm long, chrome plating deposited on their inner surface have been used as articles for investigations. Specimens 100 mm in length were cut out of different parts of articles to carry out investigations.



Figure 2. Chrome plating specimens

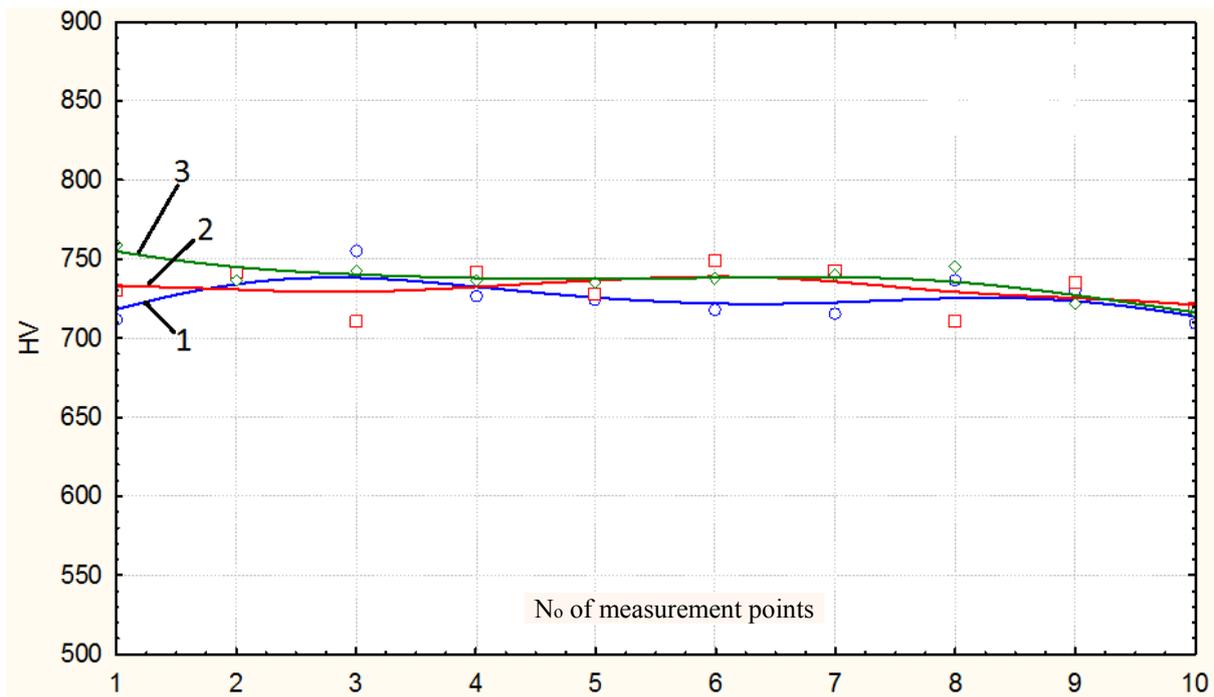
Results

The following parameters of specimens coatings: channel and point porosity, surface micro-hardness of coating, thickness of coatings and its distribution along the article forming have been investigated. The coatings have been studied with the SEM method.

Porosity was determined under GOST 9.302 – 88 «Inorganic Metal and Nonmetallic Coatings. Methods of Control» by superimposing a paper filter. Sodium chloride solution was used for controlling. Average number of pores was calculated as the number of pores along the total specimen surface divided into the specimen surface area (37 cm^2).

Due to the use of electrolyte with UDD and article rotation in the course of chrome plating we managed to get deposits practically without pores average porosity being – 0.063 pores/cm^2 .

Micro-hardness is measured on the specimen forming line 100 mm in length with averaging out of eight measurements in each point of measurement. Altogether, each specimen has been studied in 10 points. Measurement have been performed with the hardness gage Constanta TU. Micro-hardness measurement results showed stable surface micro-hardness along the length of all specimens within the range of 710-760 HV. Distribution of surface micro-hardness of specimens is shown in Figure 3.



1 – specimens from the zone of feed of the electrolyte; 2 – specimens from the Central zone; 3 – specimens from the zone of discharge of the electrolyte

Figure 3. Distribution of surface micro-hardness of chrome coating.

The coating thickness was determined with the eddy currents method using multipurpose device for measuring geometric parameters, Constanta K6 fitted with ID0 type transducer. The measurement of each specimen has been performed in 10 points along the forming line with averaging in four measurements. The mean thickness of coating in all specimens was 64 μm . The thickness non-uniformity (irregularity) along articles is 5 μm .

The obtained specimens coatings were investigated with the help of scanning electron microscope (SEM) at JSC FR&PC ALTAI. Photographs of coatings and fracture surfaces are presented in Figure 4. Analyzing the image we can draw conclusions. The grains size is getting stable, cracks on the chrome surface on depositing at full rotation of a specimen are less expressed than in case of discrete rotation. Fine-grained structure on the transition boundary chrome-support is clearly.

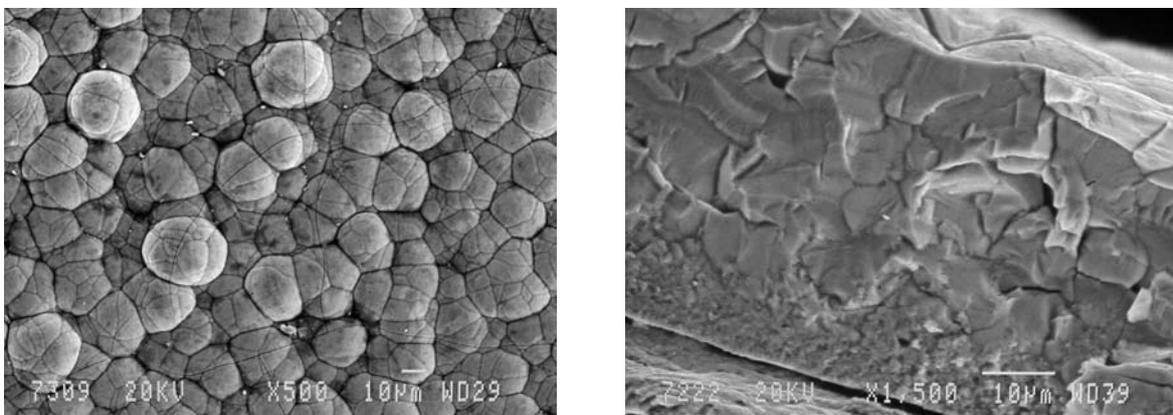


Figure 4. Fracture surface and outside surface chrome coating

Conclusion

1. The structure of chrome plating obtained on full rotation with frequency of 500 rev/min at a temperature $57\pm 1^\circ\text{C}$ is the most fine-grained (reduction in size of coating sub-grains), homogeneous without visible pores. On comparing the coatings obtained at different rotation frequencies, the reduction in sub-grains size of chrome coating vs the growth of rotation frequency can be seen. The grains size is getting stable. The number of dendrites on coating surface also reduces with the growth of rotation frequency.

2. Cracks on the chrome surface on depositing at full rotation of a specimen are less expressed than in case of discrete rotation that testifies less internal stresses.

3. The structure of coating change in thickness is observed on analyzing the fracture surfaces of specimens with chrome plating. Fine-grained structure on the transition boundary chrome-support is clearly seen on specimens. The thickness of fine-grained chrome is of 10 to 15 μm .

Application of electrolytes with UDD for flowing chrome plating of long-sized articles is very promising for obtaining wear-resistant composite electro-chemical coating that are widely used at present, including for special-purpose articles.

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