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# APPLICATION OF COBALT COATING BY BIPOLAR ELECTRONIC METHOD

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**Abstract**

*There were proposed an electrochemical method of obtaining a cobalt coating using a bipolar electrolyzer. The potential distribution at the bipolar electrode is more uniform than at the monopolar for others conditions that are the same. The combination of the uniformity with the optimal limit current gives us a try to get compact metal precipitates with microhardness, that is high enough, small crystalline and well-clutched with the base. The obtained results indicate the possibility of using a bipolar electrolyzer in practice for the application of cobalt on wire, and also using it as a protective is decorative.*

**Keywords:** cobalt coating; bipolar electrolyzer; potential distribution; electrolyte of the cobalting; microhardness of precipitate

## 1. Introduction

Physics-mechanical, corrosion and special properties of galvanic coatings depend on the method of their getting and area of definition of their using. The speed of the electrochemical process of metal application is determined by the current density, which is a function of such properties as: composition of the electrolyte, temperature, circulation speed, electrode movement, and the other [1,2]. High-quality galvanic coatings should have small crystalline structures, be without pores and coat the products uniformly. The most effective and controllable method of coating is electrochemical sedimentation from electrolyte solutions [3].

## 2. Formulation of a problem

One of the main problems with the electrochemical processing of the wire, ribbon, netting is impossibility of getting the current densities uniformly over the length of the electrode, and as a consequence the impossibility of getting uniform coatings, so it is observing the decreasing of potential in it and low-quality coating [4].

The bipolar electrode has many advantages, because of its using achieves high current density [5]. At the same moment productivity increases and the quality of processing is improving. The structure of the metal emission, its uniformity depends on the potential distribution. So, it's interesting to consider the potential distribution along the wire.

The comparison of the potential distribution along the length of the wire with conventional current supply and the method of bipolar electrode with electrochemical cobalt deposition was studied. Such coatings are used as a layered application, as independent protective and decorative [6].

## 3. Materials and investigation methods

There was proposed an electrolyte of the cobalting for studying the effect on process of the metal sedimentation. The electrolyte composition: $CoSO_4$ $7H_2O$ 110-150 g/l, HF - 0,15 - 0,25 g/l, Bipolar and monopolar material is a steel wire.

## 4. Discussion and results

There was carried out a comparative study of the potential distribution, the influence of current density, and other components of the electrochemical process for monopolar (with current removal) and bipolar (without current removal) electrodes . On the Fig. 1 is presented the potential distribution along the length of the electrode – monopolar. You can clearly see that there is anuniformly distribution of the potential while removing from the contact place, which is associated with increasing the resistance of the electrode - a wire. At direct current removal to a wire, you can see its heating and metal overgrowing of the contact place.

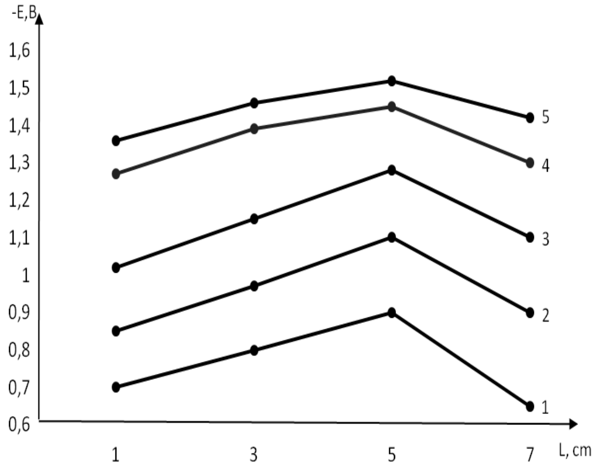


Fig. 1. The dependence of potential distribution on the length of the wire - monopolar, at current density, A/dm$^2$: 1 – 50, 2 – 60, 3 – 70, 4 – 80, 5 – 90

So, a bipolar electrolyzer is exploring (Fig. 2). The using of such electrilyzer allows to avoid these unwanted effects, and to bring in a cobalt coating on the rolling wire.

The electrolyzer (7) is made of dielectric, the current is supplied to the alternative cathodes (2) and the anodes (3), they looked like plates which area is much more than the area of the bipolar electrode (wire) (1). The wire moves from the cathode chamber (5) to the anode (6), where the electro sedimentation of cobalt on the wire happens.

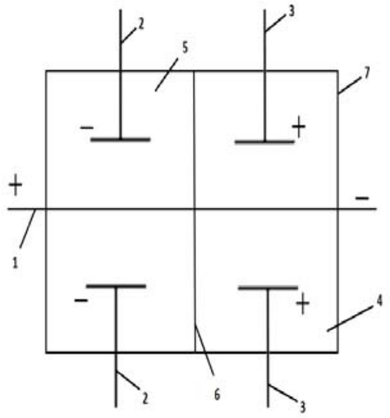


Fig. 2. Scheme of the bipolar electrolyzer
1 – bipolar wire; 2 – alternative cathode; 3 – alternative anode; 4 – anode chamber; 5 – cathode chamber; 6 – diaphragm; 7 – electrolyzer

The potential measurements were performed with the normal calomel electrode over the entire length of the wire, through the uniform intervals. For this goal, there was used a special current pickup, which called the probe (Fig. 3).

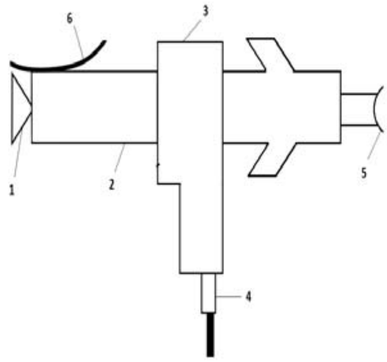


Fig. 3. Probe
1 – spring for contact with the electrode; 2 – tube, 3 – frame; 4 – power line; 5 – head that controls the spring; 6 – Luggin's capillary

The probe is arranged as follows: with the head (5), a spring (1) is pulling out, which grips and presses tightly the electrode, which provides reliable electrical contact. To the tube (2) attached fluoroplast Luggin's capillary (6) which is connected with an electric wrench to the reference electrode.

The potential registration was carried out by the B7-20 voltmeter. The reproducibility of the measurements was (±10-15mV). In the bipolar electrolyzer, the lower potential values respond to the minimum distance from the diaphragm (Fig. 4). With the same potential values, the current density in the bipolar cell is several times higher than the current density at the direct power line. Overvoltage of the process is much lower, with the process of electro sedimentation happens with a lower cost of electricity, which makes the process economically available.

For the obtained cobalt coatings, was determined the microhardness, which varies from 280 to 420 kg/mm$^2$, depending on the concentration of metal ions ($CoSO_4$ $7H_2O$ 110-150 g/l) in the electrolyte and the method of power line. The characteristic for monopolar samples (with less micro hardness) are: a wide size distribution of 2 to 20 microns, the precipitate is not dense, the coatings have defects. Sediments which are obtained on bipolar wire with micro hardness up to 420 kg/mm$^2$ are small crystalline with narrow size distribution - from 2 to 6 microns.

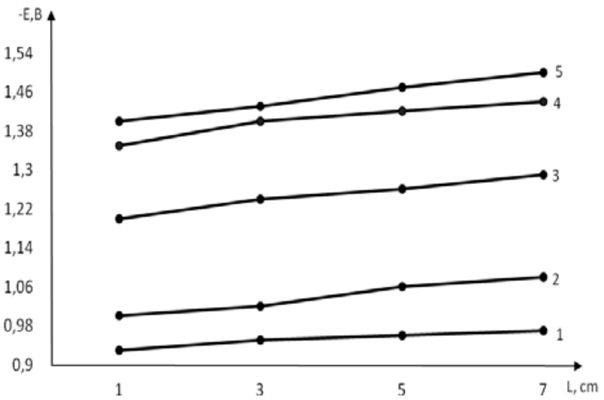


Fig. 4. Dependence of potential distribution on the length of the wire - monopolar, at current density, A/dm$^2$: 1 – 5, 2 – 10, 3 – 15, 4 – 20, 5 – 25

When deformation of the coated wire prior to bending of the peeling of the coating from the base (bipolar wire) did not occur, this indicates a high adhesion strength of the cobalt coating with the wire. With the coating thickness of 3 mkm or more, it has no pores.

Due to the physicochemical and mechanical properties of the cobalt coating, it can be summarized that the deposition of this metal by electrochemical way in a bipolar electrolyzer can be promising and appropriate.

## 5. Conclusions

- The potential distribution at the bipolar electrode is more uniform than at the monopolar for others conditions that are the same.
- The combination of uniformity of potential distribution with the optimal limit current, and getting compact metal precipitates are characteristic features of the explored process.
- Precipitates which were got on bipolar wire with high microhardness up to 420 kg/mm$^2$ - small crystalline with a narrow size distribution - from 2 to 6 microns.
- The coating has a very high wear resistance.
- The obtained results indicate the possibility of using a bipolar electrolyzer in practice for the application of cobalt on wire, and also using it as a protective is decorative.

## References

[1] Bayrachny B.I., Orekhov V.V. (1988). Spravochnik gal'vanika [The reference of the galvanic]. Kharkov: Prapor, p.180. (in Russian)

[2] Yurtov E.V., Matveeva A.G. (2013). Shablon dlya prigotovleniya pokrytiya iz nanostrukturirovannogo nikelya [Template for the production of nanostructured nickel coathing]. *Chemistry technology*, 14(1), pp. 24-29. (in Russian)

[3] Barsukov, I.V., Johnson, C.S., Doninger, J.E., Barsukov, V.Z. (2006). New Carbon Based Materials for Electrochemical Energy Storage Systems. Springer, p. 512.

[4] Jerebtsov D.A., Tolstoguzov D.S., Shtin S.V. (2017). Elektroosazhdeniye nikelya iz rastvorov soderzhashchikh zhidkiye kristally [Electrodeposition of nickel from solutions containing liquid crystals. *Newspaper of South Ural State University*, 17(2), pp. 108-118. (in Russian)

[5] Ivanova N.D, Gerasimchuk A.I, Vlasenko N.E. (2002). Kinetika protsessa eletroosazhêdeniya medi (II) iz rozbavlennyakh eletrolitov pri ispol'zovanii bipolyarnogo eletroda [Kinetics of copper (II) electroextraction from dilute electrolytes using a bipolar electrode]. *Jurnal prikladnoyi himii*, 75(7), pp. 1096-1098. (in Russian)

[6] Plavan V.P., Vlasenko N.E., Tarasenko N.E., Potaskalov V.A. (2015). Elektrokhimichnyy metod otrymannya spoluk na osnovi oksydu kobal′tu. [Electrochemical method for producing cobalt oxide compounds]. *KNUTD Bulletin "Technical Sciences"*, 3, pp. 215-219. (in Ukrainian)

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**Нанесення кобальтового покриття методом біполярного електрода**

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Запропоновано електрохімічний метод отримання кобальтового покриття за допомогою біполярного електролізера. Розподіл потенціалу на біполярному електроді є більш рівномірним чим на монополярному за інших однакових умов. Поєднання рівномірності з оптимальним граничним струмом, дають змогу отримати компактних металічних осадів, з достатньо високою мікротвердістю, дрібнокристалічні, гарно зчеплені з основою. Отримані результати свідчать про доцільність застосування на практиці біполярного електролізера для нанесення кобальту на дріт, а також використані його у якості захисно – декоративного покриття.

**Ключові слова:** кобальтове покриття, біполярний електролізер, розподіл потенціалу, електроліт кобальтування, мікротвердість осадів

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**Нанесение кобальтового покрытия методом биполярного электрода**

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Предложено электрохимический метод получения кобальтового покрытия с помощью биполярного электролизера. Распределение потенциала на биполярном электроде более равномерное, чем на монополярном при прочих равных условиях. Сочетание равномерности с оптимальными плотностями тока дают возможность получить компактные металлические осадки, з достаточно високой микротвердостью, мелкокристаллические, хорошо сцепленые с основою. Полученые результаты свидетельствуют о целесообразности использования на практике биполярного електрода для нанесения кобальта на проволку, а также использования его в качестве защитно-декоративного покрытия.

**Ключевые слова:** кобальтовое покрытие, биполярный элетролизер, распределение потенциала, электролит кобальтирования, микротвердость осадков

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