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Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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NEW ACHIEVEMENTS IN THE ELECTROREFINING OF COPPER[1/]

by

Galina Nikolaevna Pakhomova
Senior Research Engineer
"GINTSVETMET"

Moscow, USSR

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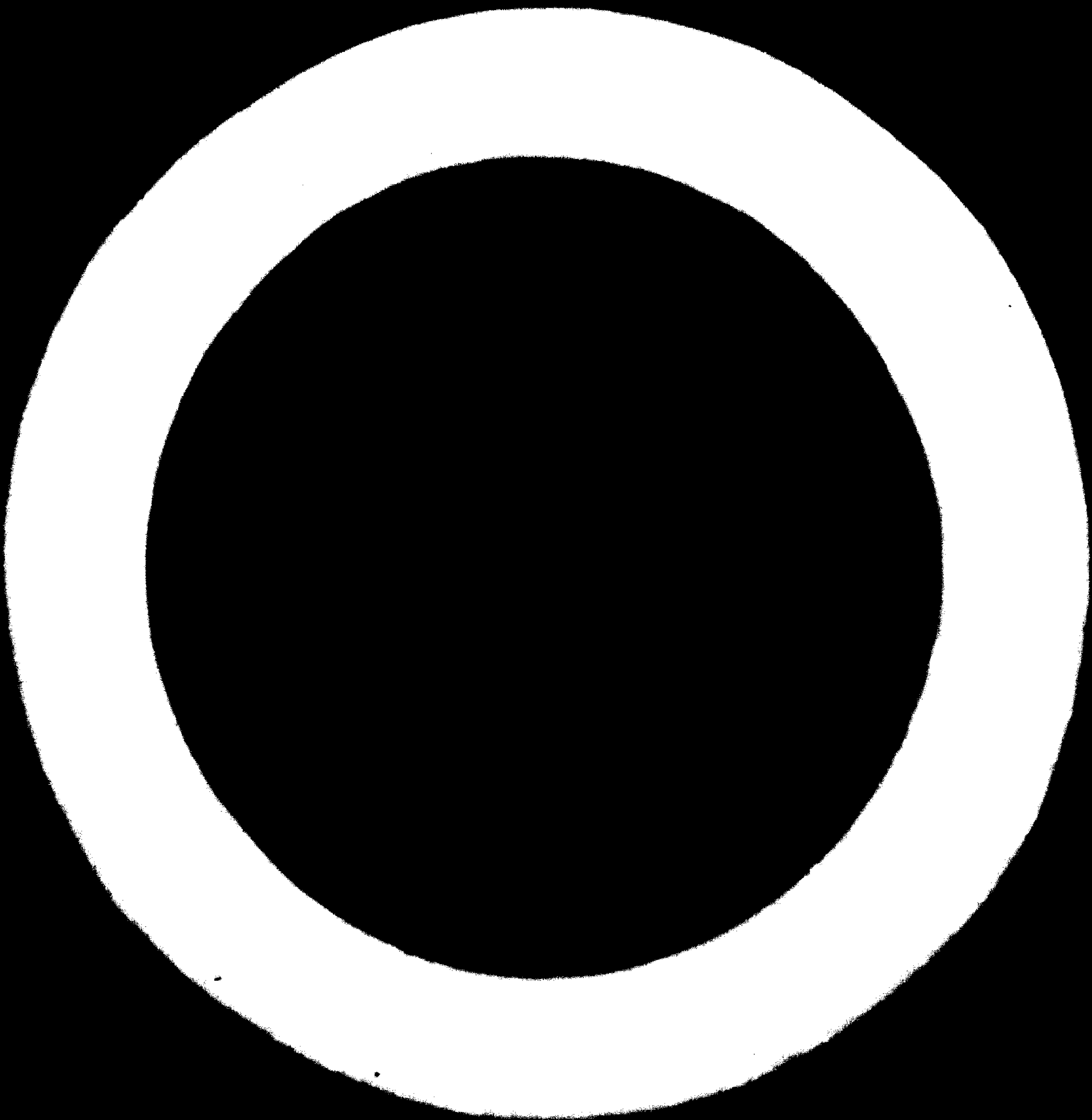

Theses.

1. Over the past 5-10 years the process of electrolytic refining of copper has attained great achievements.

Though this process did not undergo fundamental changes and has been till now performed in box-type tanks with fixed electrodes, its intensity enhanced and the technical and economic indices have considerably improved as a result of big work carried out at relevant enterprises, scientific and research and educational institutes.

In the Report the reference is made to characteristics and indices of the operation of some large plants of the Soviet Union, the United States, Canada and Japan.

Basic trends of the improvement of the process are as follows:

- the stabilization of the regime
- the application of new materials for tanks and communications
- the intensification of the electrorefining process
- the mechanization of production operations
- the search for new methods in the electrorefining of copper

2. The following technical developments have contributed to the stabilization of the regime and improvement of technical and economic indices of the process.

a) the substitution of current semi-conductor rectifiers for motor-generator sets;

b) the switching over to the heating of electrolyte by means of tubular heaters instead of tanks with lead coils previously used;

c) the introduction of new instruments for automatic control and regulation of the process (acidmeters, level meters and others);

d) the introduction of effective substances which lower surface tension for improving the quality of cathode sediments and for flocculation of sludges as well as proportioned feeding of these to the electrolyte;

e) the application of new apparatus for detecting short circuits in tanks.

It is noted in the Report that the general level of the automation of the copper electrolytic production is still low.

3. New materials proved to be good have been introduced in the copper electrolytic production. This refers, above all, to the corrosion resistant thermoplastic materials for lining of tanks, making communications, etc.

The substitution of thermoplastic materials for the lead lining of tanks decreased the leakage of current. The application of acid resistant stainless steel for pumps and other equipment has sharply reduced the corrosion of equipment and increased its service life.

Good results were obtained from the use of titanium as a material for dies. Titanium sheets don't corrode in copper electrolyte and cathode bases are readily stripped of them. The use of titanium creates prerequisites for the complete mechanisation and automation of the process of removal of bases from dies.

4. The stabilisation of the electrorefining process, introduction of new materials, mechanisation of operations have made it possible to considerably intensify the copper electrorefining process by increasing ampere load on the tank.

There are two ways for increasing the production capacity of the tank:

a) increase in the electrode surface in the tank and b) rise in current density . The present level of the copper electrolytic production makes it possible in technical terms and expedient from the economic view-point to operate with current density of 250 a/m^2. The operation with high current density necessitates the application of high-quality anodes, effective circulation of the electrolyte, the thorough checking for correct use of admixtures, strict control and elimination of short circuits. There has been studied the experience of the plants of the Soviet Union and Japan with regard to the operation of the copper electrolytic production with the current density of 250 to 300 a/m^2.

5. In the copper electrolytic shops the progress has been made in the field of mechanisation of laborious processes. The laborious removal of copper sheets from dies and preparation of cathodes have become much easier. It has become possible due to the change over from horizontal removal of copper sheets from dies to the vertical removal by machines of various designs and due to the introduction of dies made of titanium. Labour productivity of one worker at this conversion process has doubled.

Mechanised continuous process lines were set up and introduced for making bases, comprising: the straightening of bases, cutting and rivetting of lugs to the base and others.

The mechanised method of cleaning tanks of sludges by means of centralized vacuum system has been introduced which contributed to reducing the losses of electrolyte and precious metals and to increasing the use of machine time of electrolyte tanks.

The design of washing machines has been modified due to which the labour of the worker engaged in the washing of cathode remains become much easier and the effectiveness of washing improved.

6. Research work in the field of the copper electrorefining is aimed at the further intensification and mechanization of the process, search for new materials and at other development.

The intensification of the process by increasing the current density up to 400-600 a/m^2 is achieved by means of current reversals in electrolyzer of a new design with the rapid circulation of the electrolyte parallel to the electrode surface under transient conditions of operation that is the pulsating current, application of a.c. on d.c. and others.

The feasibility has been substantiated of considerable increase in the current density up to 400-600 a/m^2 without current reversal for many grades of copper. Through technical and economic analysis is necessary to evaluate the expediency of such conditions of operation. Attemps are being made to fully mechanise the process of preparation of cathode bases and for this purpose new designs of continuously operating electrolisers are being elaborated such as drum-type and loop-type electrolysers wherein the copper band for making bases is being produced. The work is in progress aimed at creating the machine for stripping a base of the titanium dies without its discharging from a tank. For this aim designs of mechanised stripping machines were proposed which allow to remove bases and dies outside the tanks.

Research work has been conducted on direct making by electrolysis intermediate products such as bands, wire rods and others.

New instruments are being made for the automatic control and regulation of the electrorefining process.

7. In the Report conclusion is drawn regarding marked growth of technical level of the electrorefinning process, its intensification and mechanization.

The level of automation of the process is not sufficient .The following technical developments are being recommended to be introduced:

a) The complete substitution of semiconductor rectifier for motor generators.

b) The application of new materials such as thermoplastic materials for lining tanks, titanium for dies, stainless steel for pumps, details of machines and machine tools.

c) The use of tubular heaters instead of containers with lead coils.

d) The utilisation of effective additions which lower surface tension such as thiourea mixed with size or gelatin, separane.

e) Mechanised method of cleaning tanks of sludge by means of vacuum.

d) In case of necessity to increase the output of the copper electrolytic conversion it is possible and expedient to increase the current density up to 230-250 a/m^2.

Research work has to be aimed at increasing the level of automation of processes in the copper electrolytic production, research for new corrosion - proof thermoplastic materials for lining tanks, communications and container apparatus, increasing the current sensity above 300 a/m^2, when this is reasonable from economic view-point, and at the creation of new equipment securing the complex mechanization of all the processes in copper electrolytic shops.

INTRODUCTION

The copper electrolytic refining process has lately attained big achievements. Though this process did not underge fundamental changes and has been till now performed in box-type tanks with fixed electrodes, its intensity enhanced and technical and economic indices have considerably improved as a result of a big work carried out at relevant enterprises, scientific and research and educational institutes.

Indices which characterize the operation of some plants of the Soviet Union, USA, Canada and Japan are summarized in table 1.

Main trends in the development of the copper electrolytic refining process are as follow: 1) the stabilization of the technological regime; 2) the application of new materials for tanks and communications; 3) the intensification of electrorefining process; 4) mechanization of production operations; 5) search for new methods of the electrorefining of copper.

Let us examine in detail each of these trends:

1. The stabilization of the electrolytic refining regime.

At each plant depending upon the quality of raw materials and local conditions there are determined the basic parameters of the electrorefining process that is the make-up of electrolyte its temperature and speed of circulation, the current density, the consumption of colloid additions.

The determinant of stabilizing the process lies in the incorporating into it of up-to-date equipment for feeding direct current and for automatic control and maintaining preset conditions of operation.

The technical innovation of recent years is the substitution of semiconductor rectifiers for converting alternating current into direct current for motor generator sets in copper electrolytic shops. At all the plants of the Soviet Union silicon rectifiers have superseded motor generator sets. The silicon rectifiers are also under operation at a new plant at Baltimore (USA), at a plant in Bulgaria and at other plants. They are characterized by a big heat risistance, simple design and high efficiency.

The replacement of silicon cells may be accomplished in operation without lowering the load (2). At some foreign plants, namely, Lowrel-Hill (USA), Mufulira (Zambia), Great-Falls (USA), Montreal (Canada) and others there are installed germanium rectifiers with high efficiency of 95 to 96%.

The application of semiconductor rectifiers in comparison with old types of rectifiers reduces the consumption of electric power, improves technical and economic indices of electrolytic shops as well as reduces capital expenses for building rectifying substations proper and allows to effect the more exact automatic maintaining of the amperage in electric circuit in preset conditions of operation.

The stabilization of the temperature regime has become possible due to the improvement of the method of heating the electrolyte. Instead of tanks with lead coils at present the use is made of airtight tubular heat exchangers which have reduced the consumption of steam and evaporation of the electrolyte. This allowed to regulate automatically the temperature (3). The electrolyte temperature at the outlet from the heat exchanger is measured by a thermometer connected to the automatic bridge which regulates the delivery of steam into heating tubes by means of actuating mechanism. Good results have been obtained at plants of the Soviet Union from the use of heat exchangers with stainless steel pipes, in other countries heat exchangers of Carbate type or plastic coil heaters of stainless steel are being successfully used.

To decrease harmful evaporations and losses of heat from the surface of electrolysers at Zambian plants Nkana and Mufulira and at Japanese plants provision is made for covering the tank surface by floats made of porous polysterene (4). This has allowed to reduce by 70% heat losses resulting from evaporation.

To regulate the content of copper and sulphuric acid in the electrolyte the instruments were developed allowing to control these components of the solution.

Acid meters have been introduced with transmitters submerged into solution and solution-running through transmitters. According to readings of these instruments the manual correction of the electrolyte composition is performed which is very useful.

Electronic, hydrostatic, piezometric level meters have been introduced. By means of magnetic starters and press button contr the interlocking of pumps is effected. Lamps or hooters give signals of the shutdown of pumps.

The selection of type and consumption of additions which lower surface tension depend upon conditions of the electrolytic refining and are determined for each enterprise as a result of research work.

Over the past 10 years the combined addition lowering surfa tension which represents the mixture of thiourea with gelatin or size has been successfully used in the Soviet Union. The introdu tion of this addition instead of sulphite pulp lye, previously used, has contributed to the improvement of cathode remains and to an increase of the yield of copper in terms of current with simultaneous increasing of current density. At the plants of Great Falls (USA) Onahama (Japan) and the plant named after Damianov (Bulgaria) besides additions which lower surface tensio and improve the quality of cathode copper, the use is made of the addition of floculent-separane which contributes to reducing the content of antimony and other admixtures in the electrolyte and to reducing the formation of so called "floating sludges" upsetting the normal course of the process of the copper electro lytic refining and resulting in contamination of cathode copper with arsenic and antimony and other admixtures.

The action of additions which lower surface tension is of the most effectiveness when they are precisely proportioned in the electrolyte. In recent years proportioning devices have been introduced at plants for adding each addition into the circulati system, and the quantity of dissolved addition is measured by means of electronic rotameters connected to an electronic differ tial-transformer regulating device.

To obtain the good yield of copper in terms of current it i necessary to detect quickly and eliminate short circuits of electrodes in tanks. Till now this was accomplished by means of an electric feeler and this took much time from the electrolysis attendants. Moreover, the harmful effect of short circuits continues for a long time. At Japanese plant Onahama there is installed and is under operation an electronic computer for the rapid detecting of short circuits in a tank (5).

Despite the successes achieved in the realm of the stalilization of the copper electrolytic refining regime with the application of means of automation, the automation of control over the copper electrolytic production still remains at low level.

The Application of New Materials

With a view to increasing the duration of equipment operation, enhancing the coefficient of utilisation of the machine time of tanks at all copper electrolytic plants, research work is being conducted for the discovery of heat and acid-- proof materials for making tanks, tank lining, troughs, container apparatus. At present almost everywhere the wood in the structure of electrolytic tanks is being replaced by reinforced concrete.

Combined tanks with precast reinforced concrete walls and wooden bottom have prooved themselves to be good in operation at plants of the Soviet Union. The work is being conducted aimed at the substitution of heat resistant plastic materials for lead lining of tanks. Polyvinyl choride which is called in the Soviet Union "vinylplast" is being widely used. At the plants under operation in the Soviet Union the polyvinyl chloride supersedes the lead lining and at new plants all the tanks are lined with this material. Polyvinyl chloride is being used for lining tanks at Onahama plant in Japan and at the plant in Chile. Polyvinyl chloride possesses dielectric properties and high resistance to aggressive media. Its drawback is a fragility because of which it cracks. This results in a quicker wearing of tanks and their standing idle for repair purposses lasts for more time. Because of this fact researches continue aimed at selection of new heat resistant plastic materials for lining tanks. Tanks at Bulgarian plant named after Damianov are lined with polyvinyl chloride which possesses better plastic properties (so called vinylite). Its service life lasts for more period and it is not fragile. The duration of the operation of these tanks is still not long, therefore it is impossible to determine the exact period of the service life of this material. To prevent the leakage of current the pipelines at all the copper electrolytic plants are made of plastic materials.

Acid resistant steel is being widely used for fabrication of equipment and pumps. The fabrication of some details of washing machines, machines for rivetting and straightening of die cathodes, load lifting devices of stainless steel instead of steel of grade St.3 has sharply decreased the corrosion of this equipment and its service life increased by several times.

There are achievements in the field of selection of materials for dies. Very good results were obtained over the last years at the plants of the Soviet Union with regard to operation with dies made of titanium. Titanium sheets don't corrode in the copper electrolyte and cathode bases are readily stripped from them. The necessity is eliminated to polish and lubricate dies prior to charging them into electrolyte tanks. The process can be fully mechanised and automatized (5).

Intensification of the Electrorefining Process

As one can see from the analysis of the operation of the copper electrolytic plants the production capacity of many of them has increased in recent years. At the same time the copper output has increased not only owing to the introduction of new capacities but alsoowing to the more complete utilisation of the existing equipment. It is known that the production capacity of an electrolyte tank is a function of ampere load, the coefficient of the utilization of current and the coefficient of the machine time of a tank.

Ampere load on the electrolytic tank may be increased either at the constant current density by increasing the useful surface of electrodes in a tank or by the electrorefining with a higher current density.

At the plants of the Soviet Union all possible ways are used for increasing the production capacity of the electrolyte tank. For this purpose the cathode surface is increased at the expense of increasing the depth of a tank, decreasing between--electrode distance and increasing the size of cathode sheets. The presence of polyvinyl chloride lining in tanks which does not conduct current has furnished an opportunity to solve successfully this problem. The distance between electrodes of the same pole has been reduced from 110-120 mm to 100-102 mm.

However this method has not yielded the radical increase in the production capacity of a tank. The necessity to increase the output of the electrolytic copper at the existing production areas necessitates the use of a higher current density. This furthers reducing the capital investment per 1 ton of copper, decreasing the quantity of dead metal in unaccomplished production, the cost of which is estimated in hundreds of thousands of rubles and in the big shops--in millions of rubles, as well as reducing depreciation expenses per ton of product.

The limit of increasing the current density is associated with the determination of the cathode copper sediment. Cathodes with developed surface contain more admixtures and the washing of them is more difficult.

In connection with the fact that in recent years requirements on the purity of the cathode copper have become higher, the operation with the high current density necessitates determining at each plant the optimum regime which ensures obtaining the dense and smooth cathode sediments with good technical and economic indices.

The production of the black copper at plants of the Soviet Union is growing and generation of electric power keeps increasing, therefore the determination of conditions of the copper electrorefining with the high current density is a pressing problem.

Over the past years owing to big work carried out on the stabilisation of the electrorefining regime, improvement of the methods of heating the electrolyte, introduction of addition of thiourea mixed with size and other materials which lowers the surface tension it has become possible to raise the current density up to 230 to 250 a/m^2 without deterioration of the cathode sediment and individual shops operate with the current density of 260 to 270 a/m^2 (6,7). This necessitated the reconstruction of some shops which resulted in an increase in the section of skirting busbars on the bank of electrolytic tanks, replacement of leads from rectifying substations to banks of tanks.

Operation with the high current density necessitates the application of high-quality anodes, effective circulation of the electrolyte, increase in the copper and sulphuric acid content in the electrolyte, thorough checking of the electrolyte for admixters and colloid additions.

Supervision over the operation of electrolytic tanks that is elimination of short circuits, cleaning of contacts and so on also acquires an especial significance.

The analysis of the operation of Soviet plants reveals that high current density from 200 up to 250 a/m^2, with the increase in the production capacity of an electrolytic tank by about 25% results in an increase in the consumption of electric power and in a reduction of the consumption of steam. At the same time labour consumption per unit of products have reduced thanks to the work simultaneously conducted on the mechanization of laborious processes and the improvement of the organisation of labour processes. On the whole the cost of the copper electrorefining conversion did not rise (8).

Thus, an increase in the current density up to 250 to 270 a/m^2 is in our conditions the task feasible from a technical view-point and expedient from economic view-point.

The further increasing of the current density for some grades of black copper is confined to the origination of the phenomenon of anode passivity and the deterioration of the quality of cathode sediment. Because of this an ample research work is being conducted in the Soviet Union and other countries aimed at the searching for such regimes of operation which could allow to perform the electrorefining of copper at a higher current density (see further).

The tendency to operate with a higher current density may be observed at Japanese plants. Thus, at the Nishama "Besshi" of "Sumitomo Kinzoku Kozan" Company the current density was increased up to 225, 260 and 300 a/m^2 (9).

With the increase of the current density from 225 up to 300 a/m^2 the yield of copper in terms of current lowered from 98.5% to 94.9% while the electric power consumption raised from 350 up to 372 kwhr/t and the period of dissolving anode reduced from 17 to 13 days.

"Hitachi" and "Saganoseki" plants (10) turned to the intensified regime of the electrorefining. The Japanese specialists regard this intensified regime to be expedient since it has resulted in increasing the production capacity of the plant with the reduction of expenses for the depreciation of equipment.

Mechanization of Production Operations

The rising of the cathode density of current without increasing labour expended per unit of products would have been impossible if new methods of the mechanization of production operations had not been systematically introduced.

Main efforts are aimed at mechanizing processes in the die conversion. The big achievement at all the Soviet plants is the switching over from the horizontal removal of sheets from dies to the vertical removal of them.

There are various designs of machines for the vertical removal of sheets. The simpliest one is the housing on which dies are being placed after the discharging of every second of them from a tank by means of a special barrow. The doubled distance on the machine between dies allows workers to carry out the vertical removal of sheets without shifting dies. The introduction of titanium dies has made the process of the removal of sheets from them still easier and the labour of workers more productive. Instead of 500 sheets with the horizontal removal every worker removes now up [illegible] sheets a shift.

Operations have been mechanized for straightening die sheets by special roll machines which in addition to the straightening make stiffeners. The designs of rotary shears for cutting lugs and of machines for fixing lugs to die sheets have been modified. All these developmentswere responsible for creating mechanized semi-automatic lines for preparing die sheets.

"Boliden" Ko (Sweeden) has been developed and manufactured the automatized continuous line for assembling cathode bases (1). At plants of the Soviet Union the methode of cleaning electrolyte tanks of the sludge has been improved. In recent times this was a laborious process of discharging sludge from tank manually or over sides into a portable tank or by draining the sludge pulp through the bottom hole in a tank and through troughs to a receiving tank. At present the sludge is pumped out by means of a centralized vacuum system directly from tanks into an airtight pre-fabricated tank. This furnished an opportunity to get rid of draining holes in tanks, of the cumbersome system of suspended troughs and tanks in the shop cellar, reduced losses of the electrolyte and precious metals and increased the utilization of the machine time of tanks.

The design of the machine for washing cathodes has been improved . Cathodes discharged from a tank by means of the harrow are suspended by small crowbars to horizontal rings of calibration chains of the washing machine. In suspended position cathodes pass under a showering device after which they are thrown down from calibration chaines and laid into a car. The fabrication of calibration chains of stainless steel of grade IXI8H9T of the same profile as that of St.3 has allowed to increase their service life from 3 months to 3 years without breakings which took place earlier. The fabrication of special guides of stainless steel at the outlet of cathodes from the machine prior to their laying into cars has contributed to the facilitation of this operation which previously required the use of manual labour. The worker engaged in washing copper cathodes now switches on and out machines, changes the position of a car for loading by means of an electric pin.

Trends of the Research in the Field of the Electrorefining of Copper

The research work in the field of the electrorefining of copper is aimed at the intensification of the process, mechanization of laborious operations, selection of new materials for lining tanks. The considerable intensification of the refining process (the current density is over 300 a/m^2) is feasible only when the good intermixing of the electrolyte is secured which does not lead to the decrease of copper in the before-cathode area and to the beneficiation with it of the before-anode area.

The present slow circulation of the electrolyte in the direction perpendicular to the electrode surfaces does not ensure the effective intermixing of the electrolyte in the before-cathode and before-anode layers, which confines the possibility of the considerable rise in the current density. The increase of the speed of circulation at the same time leads to the turbidity of the anode sludge and to the fall of it on the cathode, i.e. to losses of precious metals with cathode copper. This accounts for researches on conducting the electrorefining of copper under transient conditions of operation that is revolving or vibrating cathodes, the application of a.c. on d.c., the a lication of the pulsating current, the application of current reversals (the alteration of current direction), as well as the electroliser with the rapid movement of the electrolyte paralled to planes of electrodes, the intermixing of the electrolyte by air by means of ultrasonics and other methodes (11,12,13).

Researches by Sweedish scientists on refining copper with the current density being 500 a/m^2 in the electrolizer with the rapid flow of the electrolyte at a speed of 13 m/min parallel to the surface of electrodes showed that at the same time the copper yield in terms of current reduces and the content of antimony and silver in the cathode sediment increases (11). Similar results were obtained by the Soviet researchers.

In the recent years the ever increasing use has been made of the reversed current which aroused a wide interest for it in specialists engaged in the electrochemical industry. The reversed current substantially changes the character of cathode deposits and in a number of cases is more effective for rising the current density than known technological factors (temperature, additions which lower the surface tension and others). This served as the main cause for its application in the electroplating on an industrial scale for obtaining fine coatings. Researchers on the application of the riversed current for the electrorefining of copper have been conducted in the Soviet Union, People's Republic of Bulgaria since 1960 and lately in Japan.

In People's Republic of Bulgaria the method has been developed and patented in many countries (14,15) of electrorefining copper with the application of the reversed current at its high density of 300 to 400 a/m^2 (up to 700 a/m^2 is also possible). The method has been effected on an industrial scale and in the opinion of the Bulgarian specialists is expedient from the economic view-point for the construction of new plants and reconstruction of enterprises under operation.

In the Soviet Union researches were conducted on an industrial and experimental scale in the electrorefining of copper at the high current density of 400 to 600 a/m^2 with the reversal and without reversal of current.

These researches revealed the feasibility of refining all the grades of black copper (except one which was anode passivated with high current density) both with the reversal and without reversal of current. Conditions which ensure the normal conducting of the process with obtaining a good cathode sediment at the current density of 400 to 600 a/m^2 are as follows: a higher speed of circulation and electrolyte temperature of 60 to 70 °C, a high purity of the electrolyte (nickel content should not exceed 10 to 20 gr/l) as well as considerable increase in the consumption of colloid additions. When the reversed current was applied no improvement of the cathode sediment of current was noticed. The degree of the utilisation of current when operating with the reversal is lower and the consumption of electric power is correspondingly higher than in the case of the refining with direct current.

In case copper is refined with the current density of 400 to 600 a/m^2 the coefficient of the utilisation of current at direct current makes 90% while that at reversed current makes 82 to 86%.

In connection with obtaining such results the Soviet specialists have no common opinion with regard to the expediency of the current reversal for the intensification of the electrorefining process. For the most grades of black copper it is feasible to use the intensified process of electrorefining without the current reversal.

The conducting by Japanese scientists research work on the nature of the anode passivation of copper and the influence of the reversed current on it is the indication of the interest being shown in this country for the possibility to further intensify the copper electrolytic refining process (16,17).

In the Soviet Union a new design of direct-flow tanks is under industrial test, wherein the electrolyte flows parallel to the surface of electrodes with the velocity of 0.2 to 0.3 m^3/min which by 10 to 15 times exceeds the generally accepted velocity of the electrolyte circulation in standard electrolyte tanks (18).

This design of tanks is perspective for the realization of intensification of the electrorefining process by applying the high current density.

The next new trend of researches are attempts to fully mechanize and automatize the process of preparing cathode bases for electrorefining.

With this aim an automatic continuous process line is being developed in the Soviet Union comprising a drum-type electroliser with insoluble anode for obtaining a thin copper band by precipitating copper from a solution to the rotating drum cathode (19) at the current density of 2500 a/m^2. The length of this band is raised in the loop electrolizer up to the thickness of the base at the current density of 1000 a/m^2 and cathode bases are manufactured of it.

Titanium Metal Corp. (USA) elaborates for obtaining cathode bases the design of an electrolyte tank with bipolar electrodes made of titanium to which it is contemplated to add a movable stripping machine to be fed by electric current from a trolley wire. This machine is intended for the removal of a cathode base without extracting electrodes from tanks which will contribute to the full automation of the process of preparing bases (20).

The above-mentioned firm maintains that several electrolytic plants in USA have shown an interest for this proposal and work together with it for creating an industrial automatized unit.

Japanese specialists proposed a design of the machine for the automatic removal of cathode copper bases from dies in which a vibrating hammer knocks against a die sheet suspended to hooks and transferred by a conveyor and air which separates the base from sheet is blown into a gap between the base and die sheet (21).

There is no so far any information regarding the tests of such a design.

Japanese specialists made also a proposal to manufacture dies by the method of metalloceramics of the mixture with I-I5 parts of copper powder. As the authors of this proposal maintain, with this method the dense, uniform in terms of thickness sediment of cathode base is produced which is readily removed from a die.

Researches are being conducted for the obtaining by the electrolysis of intermediate products such as band, wire rods. The process has been developed of the direct production by the anode copper electrolysis of cathode copper rod for the subsequent drawing of wire. The dies for this process are made of stainless steel and each side of the sheet has a spiral groove of a small depth which is filled with an insulating mass. Copper is deposited at the high current density on the smooth surface of a steel sheet between the groove. The deposition is conducted till the sediment spreading on the electricity non-conducting "partition" of the insulating mass between turns starts to close neighbouring turns.

When the sediment is taken off there is obtained a spiral rod of pure copper suitable for the subsequent drawing into wire (22). Technical and economic expediency of such a process is not evident because of the high consumption of electric power and big labour consumptions for making intermediate products. The non-availblability of wear-resisting thermoplastic materials for lining electrolyte tanks forces to explore new materials for this purpose. In the Soviet Union industrial tests are being conducted on the lining made of polypropylene which is more plastic than polyvinyl chloride. Internal stresses in it are less and owing to this a spontaneous cracking does not take place.

With the aim of creating instruments capable of stable operation for an automatic control over the electrolyte make-up, concentrate meters of "Photon 3" and "Photon 5" types have been developed for continuous measurement and registration of the concentration of copper in solutions of the copper electrolyte production. The instrument has been made on the basis of spectrophotometric method based on the selective absorbtion of a light energy by hydrated ions of copper. To eliminate the effect of ions of nickel which are always present in an industrial electrolyte the method of the automatic deduction of the absorbtion of light by ions of nickel is being applied. The instrument is undergoing tests which prove its high accuracy and the stability of operation under conditions of the high temperature and electric field (23).

Conclusion

When analysing the operation of the existing copper electrolitic shops, one can note big achievements in the intensification and mechanization of this production.

In cases of necessity to increase the production of electrolytic copper it is expedient to raise the current density up to 250 a/m^2. At the same time there is no any deterioration of cathode sediments and technical and economic indices of the process don't worsen. This became possible thanks to the development of various kind such as the heating of the electrolyte, automatic control any regulation of its make-up, introduction of additions which lower the surface tension, application of new materials (corrosion-resistant thermoplastic materials, titanium, stainless steel).

In recent years the level of mechanisation of electrolytic shops and die conversion, in particular, has considerably heightened. The introduction of titanium as a new material of die, switch over from the horizontal removal of cathode bases from dies to the vertical removal, setting up of new mechanised continuous lines for making bases, introduction of new methods of the mechanised cleaning of electrolyte tanks have reduced labour-consuming character of these processes and enhanced the labour productivity. The growth of the production capacity of copper electrolytic shops requires the corresponding increase in the production capacity of shops engaged in making blue vitriol.

If this condition is not fulfilled, admixtures hindering the normal course of the copper electrorefining process will accumulat in the copper electrolyte.

To improve the copper electrorefining process it is necessary to raise the level of automatic control and regulation of the regime which contributes to an increase in the copper cathode sediment at the simultaneous increase of the current density. For lining electrolytic tanks thermoplastic materials of the bigger wear-resisting ability have to be selected which would increase the between-repair period and highten the machine time factor of a tank.

The further intensification of the copper electrorefining process by increasing the current density necessitates the elaboration of special methods, regimes and apparatus for electrorefining and conducting detail technical and economic researches for the establishment of the optimum current density for each enterprise. The research work is being conducted in all these directions.

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Some data on the operation of copper electrolytic plants

Indices	Enterprises						
	FCMP (USSR) 1930 to 31	"Copper-Clift" (Canada) 1930 to 31	Montreal East (Canada) 1930 to 31	Balkhash plant (USSR) 1950 to 52 (I)	Garfield (USA) 1950 to 52	Almalyksky (USSR) 1964 to 65 (I)	Onakhama (Japan) 1964 to 65
...ensions of tanks, mm	3720x1000x 1195	3429x1067x 1156	5055x1105x 1257	4050x1000x 1200	4140x1092x 1219	4150x1000x 1200	4700x1170x 1130
...ber of anodes in tank, pcs	34	38	48	35	40	35	43
...rent converters	Silicon rectifiers	m.g.s.	m.g.s. and Silicon rectifiers	Silicon rectifiers	m.g.s.	Silicon rectifiers	Silicon recti-fiers
...ode make-up, %							
copper	99.27	99.18	99.3 to 99.4	99.48	99.4	99.7	99.4 to 99.5
nickel	0.22	0.5	0.02 to 0.05	00.28	00.75	0.006 to 0.008	Not known
arsenic	00.42	0.007	0.0007 to 0.00012	0.052	0.062	0.003 to 0.0035	-"-
antimony	0.058	0.0015	0.001 to 0.075	0.044	0.023	0.002 to 0.03	-"-
lead	0.055	0.006	0.006	0.157	0.023	0.006 to 0.05	0.1
Dimensions of anodes, mm	820x820x 38 to 40	914x914x 38	914x914x 38	820x920x 32 to 41	890x990x 41	920x820x 33 to 38	960x 980x 38

...t of anode, kg	210 to 220	265	283	245	308 to 326	280	345
...ation of dissolving, ...	19 to 20	28	24	19 to 20	27	20 to 23	28
...eld of scrap, %	15.3	12 to 13	14 to 16	14.3	15	17.05	15
...ectrolyte make-up							
Cu	30	39	40 to 44	44	42	40 to 45	45 to 50
H_2SO_4	188	200 to 210	170 to 190	178	200	160 to 180	190 to 200
Ni	17 to 20	20	8	5 to 10	10	8 to 9	15
Sb	0.3 to 0.8	-	0.07 to 0.3	0.2 to 10	-	0.2 to 0.3	+
As	1 to 2	0.54	0.7 to 0.9	3 to 8	7	2 to 3	0.4
Fe	0.4 to 0.6	0.16	0.5 to 0.66	0.2 to 10	0.5		
...ditions into electrolyte, .../ton	gelatin: 50 to 60 thiourea: 50 to 60	size:75 benda-rine	size:75 aviton:45	gelatin: 50 to 60 thiourea: 40 to 50	size: 60 to 75 nrzal "A" 185 to 200	size: 35 to 45 thiourea 40 to 50	size: 90 to 100 thioure... 80 to 9...

Temperature of electrolyte, °C	60	65	65	57	65	58 to 60	58 to 60
Dimensions of cathodes, mm	880x880	940x940x 0.66	952x940x 0.58	860x930	940x1046x 0.6	980x860	1016x 1016
Weight of cathode, kg	70 to 90	118	75 to 111	70 to 80	136	60 to 80	150
Current amperage, a	13,000	11,800	18,800	12,500	15,000	12,200	19,000
Current density, a/m²	248	175	210	825	200	219	211
[illegible] voltage, v.	0.36	0.25	0.275	0.37	0.21	02 to 0.3	0.3
[illegible] consumption at d.c. [illegible]	335	212	226	336	193	348	260
[...] of utilization of current, %	90.3	96	96	94	95	89.1	97 to 98
[illegible] consumption ton/ton	0.6	-	0.9	0.5	-	0.9	0.4

[redacted]

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