ENHANCEMENT OF INDUSTRIAL WASTEWATER TREATMENT PROCESS USING NEW GENERATION FILTERS

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1. INTRODUCTION

Filters are used for integrated wastewater treatment by removing suspended particles after mechanical, chemical, physical and chemical, as well as biological wastewater treatment. Wastewater from industrial facilities contain contaminants specific for the industries, even after biological treatment. Therefore, the output of filters at one industry cannot mechanically transferred to the performance of filters at other industries. Floating medium filters (FMF) are used over recent years for removing organic and mineral contaminants from wastewater [1-3].

The purpose of this study is to develop the electrochemical wastewater treatment methods in order to save the energy costs, to reduce the consumption of metal for electrodes, as well as to improve the wastewater treatment efficiency. Following tasks have been performed within the frame of the above-mentioned purpose:

1. Performance analysis of existing filter designs
2. Elaboration of a composition for electropositive electrode
3. Elaboration of design for new generation filters.

Concentrated effluents are purified using electrochemical methods based on electrolytic wastewater treatment, i.e. they receive flow of direct current through immersed electrodes. At the cathode, hydrogen gas is produced, water-dissolved metallic ions are discharged with relevant metal cathode deposits being formed, certain ions and organic compounds present in water are reduced, followed by formation of new substances and ions [7]. At the anode, oxygen and halogen gases are produced of materials that are not subject to electrochemical dissolution, depending on composition of salt in wastewater and on electrolysis conditions, certain ions and organic com-pounds present in water are oxidized with formation of new substances and ions. Using iron, alu-minum anodes or some other metal anodes results in their electrodis oxidation with formation of new substances and ions [7]. At the anode, oxygen and halo-gens are produced of materials that are not subject to electrochemical dissolution, depending on composition of salt in wastewater and on electrolysis conditions, certain ions and organic com-pounds present in water are oxidized with formation of new substances and ions. Using iron, alu-

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As can be seen from the above, wastewater electrolysis may be followed by a number of physico-chemical processes that provide removal of dissolved and dispersed contaminants from wastewater. These treatment methods have sometimes certain advantages over chemical wastewater treatment:

- numerous valuable products can be extracted during treatment process,
- process flow diagrams and production plant operation can be considerably streamlined and simplified,
- automation of their performance is relatively simple,
- processing area required for treatment facilities can be reduced.

The main issue of electrochemical wastewater treatment seems to be high power and metal consumption in numerous cases. Sometimes electrochemical processes that follow wastewater treatment show low current yield (anodic oxidation and cathodic reduction of organic foreign matters), at low concentration thereof, electrodialysis treatment of concentrated wastewater. The treat-performance may be enhanced by combining operating principles of floating medium filters and electrochemical source of current [8-11].

Water passes through the filter grain material from the bottom upwards. Filter material is placed between two perforated disks: aluminum anode and mineral carbon cathode. Anode has electropositive potential, cathode has positive, so that water is filtered opposite the electric lines of force. Simultaneously, aluminum dissolves, hydrolyzes and produces coagulant Al(OH)3 that forms flocs on the surface of filter grain material. Coagulant and electrical field polarizing mineral filters, facilitate binding of removed particles to the grains of filter material. The deposit that appears is removed by washing. However, the internal surface of the filter steel case is subject to corrosion during the filter operation. This reduces the efficiency of treatment [12-16].

Using rapid filters also seems to be possible. Rapid filter includes steel case, flushing water inlet and outlet, lower drainage system, flushwater collecting launder, filter medium, underdrainage bed. Filter medium of this type of filter contains bar electrodes made of electropositive (anode) and electro-negative (cathode) materials arranged in alternating series, the electrodes being placed chequerwise. Siliconized calc-spar with a 2-5 mm grading fraction is used as filter medium. An-o-de-to-cathode separation is within the range of 187-241 mm [17-21]. Aluminum is used as electronegative material; mineral carbon is used as electropositive material. Main issues of this type of filter are:

- internal corrosion of its steel case,
- no transfer of electric power produced by the source of current;
- low efficiency of contaminant removal from wastewater.

### 2. RESEARCH TECHNIQUES

A complex of lab and production techniques was used in order to solve the tasks set, including X-ray phase and differential thermal analysis, electron microscopy, traditional chemical and physico-chemical techniques for examination of filtration processes in developed filter design and for observation of wastewater treatment processes.

### 3. FINDINGS

We propose to use the new filter design that allows to solve the tasks of enhancement of industrial wastewater treatment process, improvement of corrosion protection efficiency inside the steel case of the filter, as well as enhancement of current collection. This filter includes steel case filled with filter material, water supply, distribution and collection systems. Inside the filter, vertical alternating series are placed parallel to the filter case walls arranged as closed circuits of electro-positive and collecting launder, filter medium, underdrainage bed. Filter medium of metals (Table 1).

The proposed composition for electrodes is prepared as follows. Oil calcined coke breeze of a certain grainometric consist is mixed in normal conditions with tall oil pit and pyrrhotite tailings at a preset ratio, the obtained compound is heated up to 60-80°C with a simultaneous agitation. The obtained composition is placed into a special container with a pre-mounted metal core in the center. After 3h the ready-made electrode is drawn out of the container. Example 1. Composition of 60%wt calcined coke breeze, 8-10%wt pyrrhotite tailings from the tailing storage facility of a mining and refining plant was added containing high concentrations of metals (Table 1).

| Element  | Component percentage in the waste material |
|----------|-------------------------------------------|
| Iron     | 38                                        |
| Aluminum | 3                                         |
| Silicon  | 8                                         |
| Zinc     | 4                                         |
| Copper   | 0.86                                      |
| Titanium | 0.31                                      |
| Magnesium| 1.7                                       |
| Sulphur  | 35.93                                     |
| Sodium   | 5.4                                       |
| Calcium  | 2.8                                       |
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The best result was obtained with a pyrrhotite tailings concentration of 10%wt, the electric resistivity decreased by 26.7%. Further increase of pyrrhotite tailings concentration degrades electrode mechanical strength.

| Concentration of pyrrhotite tailings, %wt | Electrical resistivity, Ohm·mm²/m² | 0 | 3 | 5 | 8 | 10 |
|------------------------------------------|----------------------------------|---|---|---|---|---|
| 450                                      | 390                              | 366| 338| 330 |    |

Example 2. Industrial wastewater treatment tests were carried out with a water salinity of 1000 mg/l. Corrosion rate and current collection parameters were evaluated (Table 3). Based on the test results it follows that filter design elaborated by us allows to increase current collection from electrodes and to reduce the corrosion rate.

| Filter parameters | New generation filter | Common filters |
|-------------------|-----------------------|----------------|
| Corrosion rate, mm/year | 0.03                  | 0.09           |
| Current collection from 1 m² of electrode surface area, W/hr | 32                    | 20             |

Example 3. Tests were carried out on removal of iron from natural water. Inlet iron concentration was 4.6 mg/l. Tests were carried out at a filter rate of 6 m/h (Table 4). The proposed utility model allowed to obtain a higher quality of treated water.

| Iron residual concentration, mg/l | New generation filter | Common filters | MPC (maximum permissible concentration) |
|-----------------------------------|-----------------------|----------------|----------------------------------------|
| 0.18                              |                       | 0.32            | 0.30                                   |

5. CONCLUSION

Electroplating industry is one of large consumers of nonferrous metals and considerably expensive chemicals. This industry consumes minimum 30% of stannum, 15% of nickel and 50% of cadmium produced in Russia. In cases of chemical conversion and preliminary operations, loss of chemicals with flushing water exceeds sometimes by decades the amounts consumed for surface treatment. Environmental pollution comes not only from flushing water, but also from spent stock solutions in the electroplating industry. When treating the electroplating effluents, particular attention is paid to electrochemical treatment methods. The developed new generation filter design renders possible treatment of electroplating and other industry effluents, as well as its efficient usage for natural water treatment.

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