Research of the Purification Methods of Chrome-Containing Manufacturing Water

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Abstract. The article describes the most common current methods for treating industrial wastewater containing chromium compounds. Possible methods of recycling chromium-containing waste and difficulties associated with this process are identified, as well as increasing factors are noted. Concepts of electrocoagulation and reagent methods are presented, their advantages and disadvantages are noted. A process scheme for treatment of contaminated effluents of industrial enterprises is proposed, which provides for their release into the city drainage network. An example of a successful existing technology for recycling chromium-containing waste water is given. The most effective integrated method of treating industrial effluents is justified for industrial enterprises that have chromium-containing wastewater. It provides for the combination of the electrocoagulation method with the post-treatment of wastewater by the reagent method. As reagents, it was proposed to use barium chloride 2-aqueous and iron sulphate (II) 7-aqueous (iron sulfate). Comparative calculation of the required amount of reagents and its cost was made.

1. Introduction

In the current conditions of the world's limited drinking water supply and its acute shortage, both for drinking and production needs, the problem of wastewater treatment is especially urgent. For example, many industrial enterprises, in particular the construction industry, are the largest consumers of water resources and, at the same time, have production with a high level of pollution of effluents with compounds containing chromium (for example, galvanic and repair shops, paint and varnish production, cement mixture production, etc.).

Water-soluble chromium is one of the most toxic industrial wastes in which its content reaches 8-10%. Chromium-containing industrial wastes belong to hazard class 1-3, since chromium is a strong oxidizing agent affecting the skin [1]. Enterprises with chromium-containing wastes are obliged to comply with the requirements of Russian environmental legislation and to dispose of (neutralize) them [2].

2. Literature review

Scientists A K Sinha, V G Havanagi, B K Kanaujia (geotechnical engineering division of CSIR-CRRI, New Delhi, India) in their research of chromium slag - waste of appropriate production, prove that such waste can be used in the construction of embankments and roads [3]. They explain that there are different types of waste generated in industrial production. Their disposal, resulting in contaminated
wastewater, and use in the road construction industry are increasingly becoming an option to solve environmental problems and deplete natural resources. Chromium slag is formed during the extraction of chromium from concentrate ore. As part of a research project carried out by these scientists to study the characteristics of chromium slag for use in road construction, they considered two types of slag (large and small) for physicochemical and geotechnical characteristics, finding out the suitability of these mixtures for the construction of embankment, base taking into account specifications. The design and stability of the embankment were calculated under various conditions: with partial, complete saturation and sudden subsidence in the conditions of the seismic factor. These studies have experimental significance. Not yet applied for large-scale practical projects. They show the interest of these and other scientists from different countries, to which the authors of the study refer, in the use of waste with chromium for road construction work.

A large number of scientists, including A K Strelkov, S Y Teplykh. H X Cao, A T Hamad and others were engaged in research on the water purification process of enterprises with chromium-containing effluents [4-8]. However, only part of the work is devoted to the problem of the disposal of hexavalent chromium, there are little-studied issues that need additional research.

3. Materials and methods
The disposal of chromium-containing waste can be carried out by:
- by use as additives in the manufacture of concrete or ceramic articles;
- use as a dye in glass production;
- by addition to cement mixtures, etc.

The implementation of these methods of recycling chromium-containing waste involves many expensive factors. For example, because such wastes are highly toxic, there are special requirements for their collection, storage and transportation. The transportation of wastes containing chromium is possible only by special transport and under the control of specialists who have permission to work, which entails an increase in disposal costs.

The method of recycling chromium-containing effluents is the installation of environmental equipment, which makes it possible to treat waste water discharged to the maximum permissible concentration value established by the project [4, 5].

There are main methods of recycling chromium-containing effluents:
- electrothermic coagulation;
- reagent method.

The electrocoagulation method is a process of cleaning chromium-containing effluents under the influence of electric current, as a result of which hexavalent Cr (VI) is reduced to trivalent chromium Cr (III) [6].

The reagent purification method consists in converting the soluble substance (water-soluble chromium) to insoluble substance when adding the reagent and then removing the substance as a precipitate [7, 8].

The application of the above methods of treating chromium-containing wastewater has advantages and disadvantages. The complex method involving the use of electrocoagulation with post-purification reagents is more effective, since it allows to maintain the advantages of both methods and reduce the influence of negative factors.

4. Process unit for effluent treatment
An example of a successful existing and promising technology for the disposal of chromium-containing waste is a manufactured, installed and implemented plant at waste water treatment facilities of fur plants using barium chloride with a capacity of 548.4 m3/day (patents of Samara State University of Architecture and Construction RU No. 155231 MPK C02F9/08, C02F1/24, C02F1/28, C02F1/40, Waste water treatment plant, publ. 27.09.2015 and patent RU No. 2574053, MPK C02F9/08, C02F1/24, C02F1/28, Waste water treatment plant, publ. 27.01.2016) [4, 5]. The choice of the type and composition of environmental equipment to be installed depends on the specifics of the
production processes of the enterprises of the construction industry and the proportion of chromium-containing effluents based on the total volume of production waste water [4, 5]. The process diagram implementing this complex cleaning method at the construction industry enterprises is shown in the figure.

Figure 1. Is a process diagram of waste water treatment of construction industry enterprises with output of:

1 – grid; 2 – electrocoagulator; 3 – beaded mixer; 4 – reagent economy; 5 – chrome sedimentation settler; 6 – filter press for chromium-containing precipitate; 7 – averager; 8 – settler; 9 – pump; 10 – pressure head floater; 11 – blower; 12 – granular filter; 13 – installation of ultra-violet disinfecting; 14 – filter press; I – general production stream; II – chrome bearing stream; III – intake of reagent; IV – the cleaned chrome bearing stream; V – chrome bearing deposit; VI – deposit; VII – the purified sewage.

The following reagents were considered: barium chloride 2-aqueous (BaCl₂), and iron sulphate (II) 7-aqueous (iron sulfate) (FeSO₄·7H₂O) [7, 8]. The reagent feed concentration was 8 and 29 g/l, respectively.

In order to select the optimal suppliers of reagents, a market analysis was carried out, which made it possible to determine the average prices for the above reagents, respectively - 112.5 rubles/kg and 223 rubles/kg [9]. The cost of barium chloride per 1 liter (0,001 m³) of water was:

\[
\text{BaCl}_2 \cdot 2\text{H}_2\text{O} = 0,008 \times 112,5 = 0,9 \text{ rub.}
\]

The cost of iron sulfate per liter (0,001 m³) water was:

\[
\text{FeSO}_4 \cdot 7\text{H}_2\text{O} = 0,029 \times 168 = 4,87 \text{ rub.}
\]

Taking into account the data on the effluents of the construction industry enterprises of the 1st group (up to 10 m³/d), to be treated for the year (2200 m³/year) and the share of chromium-containing water in the total effluent (3%), the cost of the required amount of reagents was determined:

- barium chloride: 0,03*2200*103*0,9 = 59400 rub.
- iron sulphate: 0,03*2200*103*4,87 = 321420 rub.

As further studies have shown, if electrocoagulation with reagent post-treatment is used for effluent treatment, then the need for reagents and, accordingly, the cost of purification of chlorine-containing effluents as a whole will decrease by 1.16 times.
5. Practical results
1. A technical and economic evaluation of the use of a complex method of treating chromium-containing wastewater, including electrocoagulation with post-treatment of reagents, showed its great cost effectiveness compared to the reagent method.
2. The cost of the required amount of barium chloride for effluent treatment is 5.4 times less than iron sulfate.
3. The cost of complex waste water treatment is 1.16 times lower.
4. The hexavalent chromium concentration after the proposed treatment scheme in urban sewage networks was 0.02 mg/dm³.

6. Conclusion
Based on the above, it can be concluded that the use of a complex method using electrocoagulation and a reagent method will reduce the concentration of hexavalent chromium and increase the efficiency of treating chromium-containing wastewater.

Thus, there are potential possibilities of practical application of this technological solution in various branches of industry, including in enterprises of construction industry [9, 10].

7. Reference
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