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Research paper

The use of abrasive wastes in the practice of wastewater treatment from nickel ions

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Abstract

The results of sewage treatment from nickel ions are given in the article. The relevance of the studies is determined by the expansion of the spectrum of effective sorbents-reagents as a result of the use of industrial wastes. Mineralogical and component compositions of abrasive waste are studied. The process of sorption and desorption of nickel ions on the wastewas studied by theconstruction isotherm method and a mixed character of sorption processes with a predominance of physical interactions was established.

Keywords: *Abrasive Waste, Sewage, Nickel Ions, Wastewater Treatment, Purification Efficiency.*

1. Introduction

The problem of reducing the amount of pollutants entering the environment with sewage, including metal containing pollutants remains relevant. Metals are an important component of the biosphere, but increasing their content in water leads to dangerous environmental consequences.
Part of the solution of this problem can be the development of inexpensive effective methods for purification of sewage from metal ions using non-traditional sorbent-reagents based on industrial wastes [1-5].
The sorption material recommended for the sorption extraction of nickel ions from the composition of model solutions is a waste formed during the abrasive processing of metal products. Abrasive treatment of metals is a frequently used technological process. Abrasive materials are used in the processes of grinding, polishing, honing, cutting materials and they are widely used both in the prepared production in advance and in the final processing of various metallic and nonmetallic materials [6]. Therefore, we can talk about the formation of the large volumes of abrasive waste.
Abrasive materials are of two types by origin:
- natural abrasive materials, which include diamond, corundum (crystalline aluminum oxide), garnet, emery (corundum, magnetite - black magnetic iron oxide Fe_3O_4), quartz)
- synthetic abrasive materials, such as mineral slag (copper or nickel slag), splitsteel shot, artificial diamond.
Ore &minerals are the raw materials containing a large number of solid crystals, such as alumina (Al_2O_3) and quartz (SiO_2). The natural supplier of aluminum oxide for the production of abrasives is bauxite clays containing at least 60% Al2O3 (corundum).
According to literature data, abrasive materials include aluminum oxides, which are actively used for sorption treatment of sewage from heavy metal ions [7-10].

2. Main body

2.1. Materials and methods.

The object of the study was model sewage with a concentration of nickel ions from 50 to 30.0 mg / l. Model drainage was prepared by diluting a sample of six molecules of water chloride nickel salt market "CH", in distilled water. The determination of the mass concentration of nickel was carried out colorimetrically with dimethylglyoxime. X-ray phase analysis of abrasive waste, grinded in an agate mortar and pressed into a tablet was carried out on a DRON-3 diffractometer with an X-ray tube BSV-27 (Cu). The component composition of the waste was determined by the method of wave X-ray fluorescence analysis using the ARL 9900 spectrometer. The granulometric composition was determined by sieving the powder on sieves of high accuracy with different cell sizes. The surface analysis of the waste particles is performed on a scanning electron microscope MIRA 3 TESCAN.
Determination of the nature of sorption was carried out according to sorption curves. For this purpose, the sample of waste of 0.5 g was placed into the solutions of a volume 50 cm3 with nickel ion concentrations: 5.0; 10.0; 15.0; 20.0; 25.0; 30.0 mg / dm3 than it was held during 24 hours in order to set balance the sorption and desorption processes. After reaching balance, the liquid phase was filtered off. In the liquid phase, the balance concentration of nickel ions was determined.
The solid phase from the filter was placed into 50 cm3 of distilled water during 24 hours, after which the balance concentration of nickel ions was determined in the filtrate.

2.2. Results and discussion.

The chemical component composition of the abrasive waste was studied in an averaged sample by the method of wave fluorescence spectrometry.

The results of the analysis are presented in Table. 1. and indicate a significant content (up to 56%) of aluminum oxide in the composition of abrasive waste of turning treatment. Along with aluminum oxides, iron oxides (as a result of turning metal products treatment) withcontent up to 27%, silicon oxide (11%) and other compounds are found in the waste composition.

Table 1: Chemical composition of waste

Component	Al_2O_3	Fe_2O_3	SiO_2	Na_2O	other
Content, %	56.07	26.79	11.70	1.97	3.47

Mineralogical composition of abrasive waste turning metal products treatment was established by X-ray o-phase analysis, which showed the presence of the following minerals (Figure 1): calcium oxide, d (A) = 2.39; 1.69; aluminum hydroxide (gibbsite), d (A) = 4.84; 2.38; 1.99; 1.747; 2.081; 1.599; 2.543; 2.374; 1,738; Mayenite (12 CaO · 7 Al_2O_3), d (A) = 4.89; tricalcium aluminate (3CaO · Al_2O_3), d (A) = 4.23; 2.7; 2.2; 1.908; single-calcium aluminate (CaO · Al_2O_3), d (A) = 5.51; 2.76; 2.99; β - quartz (SiO_2), d (A) = 3.34; 1.71; 1.57; 2.55; 2.22; 3.81; 4.3; 3.73; 2.49; 1.52; 2.07; the hydrate (α-Fe_2O_3), d (A) = 2.513; 1.69; 2.69; magnetite ($FeFeO_4$), d (A) = 2.541; 1.612; 2.098.

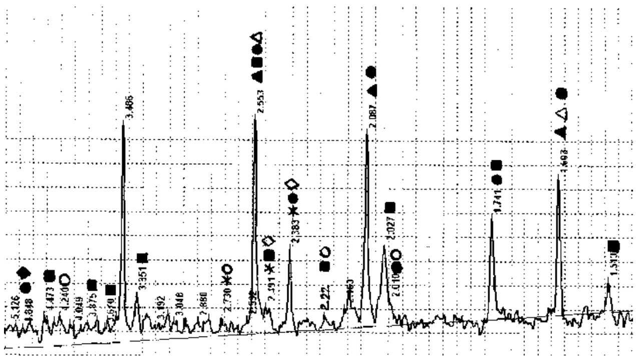


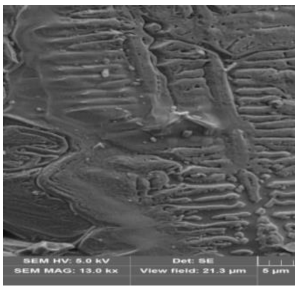
Fig. 1: X-ray analysis of the abrasive waste metal products treatment

◇- Calcium oxide
●- Aluminum hydroxide (gibbsite)
◆- Mayenite (12 CaO · 7 Al_2O_3)
▲ - Magnetite ($FeFeO_4$)
○ - Tricalcium aluminate (3 CaO · Al_2O_3)
X - Single-calcined aluminate (CaO · Al_2O_3)
■ - β-quartz (SiO_2)
Δ - Gymatite (α-Fe_2O_3)

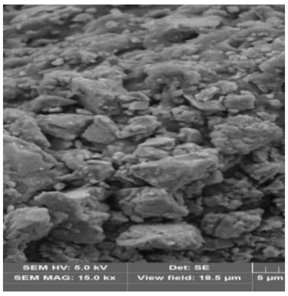
Microscopic analysis of waste particles (Figure 2) showed the presence of a developed surface with numerous defects, chips and cracks, which in turn can affect the efficiency of the sorption purification process.

A

C



B



A: General view of abrasive waste
particle size 1.0-0.63 mm

B: Field of view 18.5 microns

C: Field of view: 21.3 μm.

Fig.2: Microphotographs of abrasive waste metal products treatment

The results of a sieve analysis of abrasive waste are presented in Table 2 and show that fractions of 0.63-0.315 (34.7%) and 0.25-0, 1 (32.3%) occur very often.

Table 2: The results of the sieve analysis of the waste

Cell size, mm	≥2.0	2.0-1.4	1.4-1.0	1.0-0.63	0.63-0.315	0.15-0.25	0.25-0.1	0.1-0.05	≤0.05
Sieve residue, %	2.65	0.36	0.9	7.0	34.7	12.1	32.3	8.3	1.7

Researches were conducted to determine the dependence of the purification efficiency (%) of model solutions containing nickel ions with a fixed concentration from the coarseness of fractions of waste particles. The purification module is the ratio of the volume of water to be purified to the mass of the sorbent was 100. The results are shown in the diagram (Figure 3).

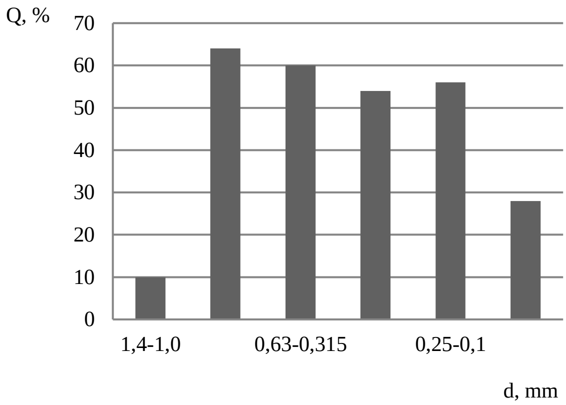


Fig.3: Diagram of the dependence of the efficiency of the solution purification, (Q,%) on the coarseness of the fraction of waste particles (mm)

The greatest efficiency concerning the model solution purification showed fractions of 1.0-0.63 and 0.63-0.315 with a purification rate of 64% and 50%, respectively. These fractions were selected for further research.
The weight of the reagent and the purification module play an important in the process of extraction of pollutants. The graph (Figure 4 :) shows the dependence of the purification efficiency on the mass of the added reagent at a constant volume of the solution to be purified. From the data presented it follows that the efficiency of the purification process raises under the increase of the purification module and reaches a maximum value of 84% for the fraction 1.0-0.63 and 75% with the use of the fraction 0.63-0.315.

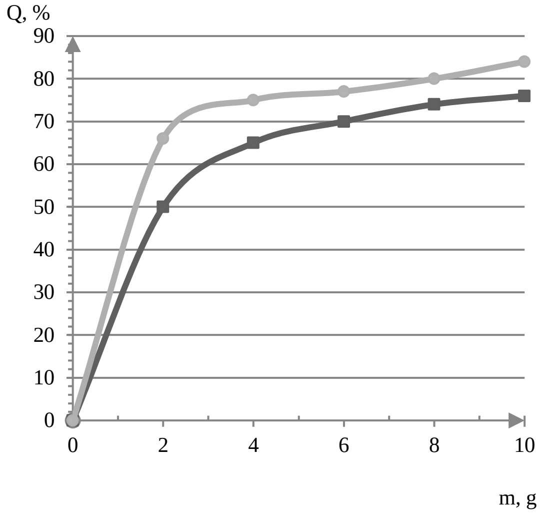


Fig.4: The graph of the dependence of the purification efficiency on the mass of the reagent:
■ – waste fraction 0.63-0.315; ○ – waste fraction 1.0-0.63

According to the literature data, the purification efficiency is directly proportional to the concentration of pollutants. The experiments were carried out with solutions containing nickel ions in the following concentrations: 5.0; 10.0; 15.0; 20.0; 25.0; 30.0 and purification module 100. The results are shown in Figure 5.
The maximum purification degree of 80-85% was achieved for solutions with nickel ion concentrations in the range 15-30 mg / dm3. Further increase of concentration of the solution to be purified does not influence the increase of the efficiency of the process.

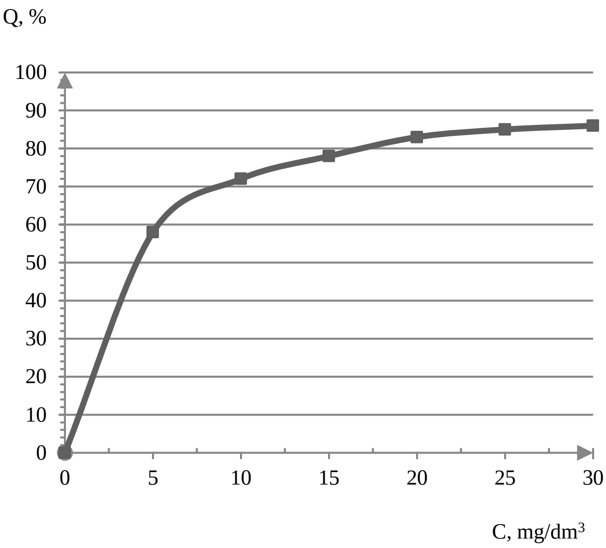


Fig.5: Graph of the dependence of purification efficiency on the concentration of nickel ions in solution.

The developed surface of the particles of waste allows assuming the presence of sorption properties of the investigated material. Information on the sorption properties of the material and the nature of the sorption of certain substances on it can be obtained from sorption isotherms characterizing the dependence of the sorption capacity on the concentration of the sorbed component (Figure 5).

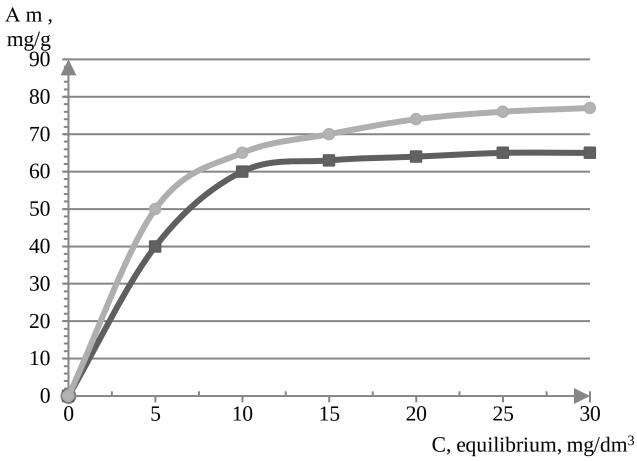


Fig. 6: Nickel Sorption and Desorption Isotherms:
○ – sorption isotherm; ■ desorption isotherm.

According to the BET theory, the isotherm shown in Figure 6 is of the first type. The convex section of this isotherm indicates the porosity of the sorbent the degree of the isothermal steepness testify the presence of a micro porosity. [12].
The singularity of the sorption and desorption isotherms location relative to each other indicates the possible of both physical and chemical processes between a sorbent and a sorbate with a predominance of physical sorptioncharacter.

3. Conclusion

As a result of the conducted researches the principal possibility and the sufficient efficiency of using abrasive waste in technology of wastewater treatment from nickel ions are established.

4. Acknowledgments

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