Use of modified molecular sieves in mechanical filters

O R Karataev¹, V F Novikov², E S Karataeva³ and A A Kartashova⁴

¹ Federal State Budgetary Educational Institution of Higher Education (FSBEI HE) « Volga State Academy of Physical Culture, Sports and Tourism», 420010, Republic of Tatarstan, Kazan, Universiade Village, bld. 35
² FSBEI HE «Kazan State Energy University», 420061, Kazan, Krasnoselskaya st., bld. 51
³ FSAEI HE «Kazan (Privolzhsky) Federal University», Engineering Institute, 420021, Kazan, S.Saydashev st., bld. 12
⁴ 4420045, Republic of Tatarstan, Kazan, Nikolay Ershov street, 29 A Association "non-profit partnership "Kama innovative territorial production cluster"

Abstract. This article discusses the use of modified molecular sieves in mechanical filters of water treatment plants and the separation of the gas mixture, as they have sorbing properties to all heavy metals. The main indicators of the quality of separation is the adsorption isotherm, which demonstrates the structure of the adsorbent, the thermal effect of separation and a number of other physical, chemical and technological characteristics. System analysis of technological parameters of mechanical filters increases the operational period of equipment.

Synthetic zeolites are classified as hydrated aluminosilicates of alkaline elements. They are solid granular materials that have a very porous structure and have a large specific absorbing surface. Their crystal structure is represented by tetrahedra of silicon and aluminum oxides, combined into lace frames with the same cavity dimensions, which are filled with alkaline and alkaline earth metal cations and water molecules. Each pore of the structure of a synthetic zeolite has a specific size from 2 to 15 angstroms [1].

Natural zeolite-containing rocks have adsorption and ion exchange properties. The chemical composition of zeolite-containing rocks is quite complex. It includes ions of Na, K, Mg, Ca, as well as water molecules located in the crystal lattice of natural zeolites.

Zeolites are rock-forming minerals and are fairly widespread in the rocks of the earth's crust. One of the largest deposits of natural zeolites in Russia is the Tatar-Shatrashan deposit, in which about 13.3% of all natural reserves are concentrated. The chemical composition is one of the important indicators of the quality of zeolite-containing raw materials.

The composition of the zeolites of the Tatar-Shatrashan deposit differs from the ores of other deposits. The most important differences are the reduced sodium content (23 times), aluminum (2 times) and increased calcium content (5 times), that is the aluminosilicate component is reduced. This difference in the main components is explained by the presence of different rocks in the section: marly limestone and flasks characterized by specific properties of the mineralogical composition (Table 1) [2].
Table 1

Chemical composition of zeolite-containing rocks of the Tatar-Shatrashan deposit, (wt %)

| Oxides      | Pack 1 (37) | Pack 2 (83) | Pack 3 (74) | Pack 4 (22) | Average |
|-------------|-------------|-------------|-------------|-------------|---------|
| SiO₂        | 57.87       | 58.49       | 61.45       | 52.67       | 56.27   |
| B₂Ti₄SiO₂   | 21.55       | 30.08       | 27.59       | 15.94       | 26.71   |
| TiO₂        | 0.28        | 0.25        | 0.37        | 0.33        | 0.30    |
| Al₂O₃       | 6.26        | 5.24        | 5.38        | 4.94        | 5.37    |
| Fe₂O₃       | 2.48        | 2.21        | 2.27        | 2.58        | 2.30    |
| MnO         | <0.01       | <0.01       | <0.01       | <0.01       | <0.01   |
| CaO         | 15.58       | 15.84       | 12.49       | 17.24       | 14.90   |
| MgO         | 1.46        | 1.25        | 1.15        | 1.37        | 1.26    |
| Na₂O        | 0.14        | 0.13        | 0.14        | 0.20        | 0.14    |
| K₂O         | 1.18        | 1.13        | 1.36        | 1.40        | 1.24    |
| P₂O₅        | 0.10        | 0.09        | 0.12        | 0.18        | 0.11    |
| P.e.p. (H₂O+CO₂) | 19.73   | 18.12       | 15.37       | 19.15       | 17.72   |

As you can see in the table in zeolite-containing rocks the highest content of silicon dioxide and aluminum oxide is observed, which have good adsorption properties and are widely used in a pure form for water purification from related impurities. A high content in zeolite-containing rocks is observed for calcium oxide, which is an inert filler. Zeolite-containing rocks of the Tatar-Shatrashan deposit are characterized by a rather high moisture content, which is located in the mesopores of the material and evaporates when heated to 350-400°C and frees up the pores for sorption processes.

Natural zeolite-containing rocks of the Tatar-Shatrashan deposit were used for wastewater treatment from organic and inorganic impurities (Table 2) [3].

As you can see in the table, after filtration of water through zeolite-containing rocks, all indicators show a decrease in the concentration of pollutants, especially it is significant for ammonium ions: from 15.7 to 0.68 mg/l, and for chlorine ions: from 364 to 65.2 mg/l.

Table 2

Results of wastewater treatment with natural zeolites of the Tatar-Shatrashan deposit

| Indicator               | Water entering the waste treatment facilities, C, mg/l | Water after filter with zeolite, C, mg/l |
|------------------------|--------------------------------------------------------|----------------------------------------|
| pH of water            | 7.66                                                   | 7.34                                   |
| Transparency, cm       | 2.8                                                    | 1.30                                   |
| NH₄⁺                   | 15.7                                                   | 0.68                                   |
| NO₃⁻                   | 3.62                                                   | 3.50                                   |
| NO₂⁻                   | 0.67                                                   | 0.07                                   |
| SO₄²⁻                  | 65.2                                                   | 35.0                                   |
| Cl⁻                    | 364                                                    | 65.2                                   |
| PO₄³⁻                  | 4.98                                                   | 4.20                                   |
| Fe_{general}           | 0.85                                                   | 0.19                                   |
| Anionic surfactants*    | 0.20                                                   | 0.13                                   |
Zeolite-containing rocks of the Tatar-Shatrasan deposit belong to the first group of natural materials according to thermal and acid resistance and have rather good regeneration abilities. They withstand high temperatures and are resistant to aggressive media.

The pore size of zeolites is not constant: it increases with increasing temperature. The adsorption isotherm is a source of information about the structure of the adsorbent, the thermal effect of adsorption, and a number of other physicochemical and technological characteristics. Zeolites have an ordered system of internal pores. Information on the equilibrium absorption is clearly reflected in the adsorption isotherms (Fig.1).

One of the factors in choosing between using zeolites or molecular sieves is the nature of the gas mixture to be separated. Taking into account the stability of zeolites to weakly acid and weakly alkaline media and its mechanical strength and their positive filtration results and sorption results, it can be said that it is useful for water purification with a high content of impurities. They can be used at water treatment plants, as they have sorbing properties for all heavy metals. It is also possible to solve the problem of water filtration at the household level: water purification comes from physicochemical and biological contaminants. Also an important part of water treatment with zeolites is the ability to saturate water with potassium, magnesium and calcium, which has a beneficial effect on the cardiovascular system of the body [4].

References

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