The effect of mechanical activation methods on the properties of local clays and waste bentonites

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Abstract. One of the most important indicators of mechanical activation of clay minerals is the effect of activation time on the strength of the mixture. One of the most important parameters in the preparation of drilling fluid based on clays is their ability to swell, and the effect on the swelling of clays during mechanical activation was studied. One of the most important parameters of clays used in the preparation of drilling fluids resistant to thermomechanical effects is their colloidal index. Therefore, the effect of mechanical activation time on the colloidal index of these clays was studied. The method of activation of bentonites and analysis of their rheological parameters was studied. In the process of mechanical activation of clays, their activation of chemical reagents created conditions for modifying the increased specific surface area of clay materials.

1 Introduction

In the process of mechanical activation of clay minerals, as a result of the reduction of its particles, the overall activity increases, the surface area increases, the particles change to the same compatible form, and the crystalline state of the structure changes dramatically [1].

Due to the properties of activated clay, coal, etc., it has the ability to absorb various substances on its surface, and based on this property, it is widely used in the purification of complex mixtures, especially in the purification of oil products. In this case, the molecules of adsorbent do not enter into a chemical reaction with the molecules of the absorbed substance, that is, substances with new chemical properties are not formed. It is known that the composition of porous adsorbents consists mainly of silicon oxides and crystallized water, and there are other metal oxides, and the structural lattice of these adsorbents consists of the following ions and complexes: Si^{4+}, Al^{3+}, Mg^{2+}, O^{2-}, OH^{-}, $(SiO_4)^{4-}$, $(AlO_4)^{5-}$. Despite the fact that the ions located on the surface of adsorbents are connected in chemical equilibrium with the opposite ions present in the adsorbent, the internal ions have electrostatic charges that partially fill the smallness of the force field. The porous adsorbent in the unfilled force field

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of the ions in the adsorbent pores creates a continuous electric field, and the adsorption of molecules of the absorbed substance is influenced by the orientation effect, which is superior to the dispersion effect [2].

It is known that as a result of the increase in the dipole moment of the absorbed substance, its absorption capacity increases. Therefore, the adsorption of non-porous substances on porous adsorbents depends on the formation of a dipole state induced by the surface force field. In this situation, the role of dispersed forces is definitely not very big. The adsorption process is known to be an exothermic process, the efficiency of the adsorption process decreases as a result of the temperature exceeding the limit that allows the substance to be separated from the pores of the adsorbent, the adsorbed substance leads to the exit of the component. In this case, if these components have higher adsorption properties than the surface of the adsorbent, they are squeezed out with the help of solvents. As the temperature of the desorption process increases, a solvent with low absorbability can be used, including to dissolve the separated product. But the depth of the desorption process is certainly less with these solvents. Sometimes desorption of oil products from the used adsorbent is carried out using water vapor. When the temperature of the desorption process increases, the speed is reduced, the speed of movement of the adsorbed molecules increases, and the bond between the molecules of the adsorbent and the molecules of the adsorbed substance is broken. The desorption process is performed after regeneration of the adsorbent after purification or separation of the adsorbed component from it. However, the above-mentioned desorption methods are not possible during regeneration after purification of the adsorbent or separation of high-temperature boiling oil components, because tarry substances, polycyclic aromatic hydrocarbons with high adsorption properties remain on the surface of the adsorbent. Therefore, they are removed by burning on the surface of adsorbents [3].

2 Materials and methods

According to the data, in addition to the chemical composition of the separated substance group, their physico-chemical properties and molecular sizes have a great impact on the efficiency of adsorption, creating opportunities for the adsorbed substance to penetrate deeper into the pores of the adsorbent. Therefore, the main indicator that characterizes the properties of adsorbents is often determined by the maximum amount of absorbed substance in relation to the mass unit of adsorbents. Adsorption activity and porosity are its main characteristics. It is known that it is divided into static activity and dynamic adsorption activity.

In this case, the balanced static activity of the adsorbent at a certain temperature, pressure and the amount of adsorbed substance is determined by the maximum absorbed substance per mass unit, and dynamic activity is determined by the rate of adsorption [4].

It can be seen that the selection of adsorbent is one of the main indicators for the purification of petroleum products, and the porosity of adsorbents is considered. In practice, the porosity of adsorbent grains (ε) is determined by the following formula.

$$\varepsilon = 1 - S_k / S_u$$

where: S_k - is the hypothetical density, which is determined by the ratio of the mass of the adsorbent grains to its adsorbent content and the volume of the substance entering the volume of the pores. S_u -water is the real density of the adsorbent, that is, it is represented by the mass of the substance that makes up the adsorbent.

The strength of the adsorbent layer is determined by the volume contribution not occupied by grains according to the following formula [5].

$$E_{sl} = 1 - S_n / S_u$$

Here: S_n -is the specific density characterizing the mass of the adsorbent layer.

Both of these indicators determine the efficiency and technical-economic indicators of the adsorption process. For example, the hydraulic resistance of oil products depends on the strength of the adsorbent layer, and its absorption activity depends on its porosity. The greater the porosity, the greater the specific surface of the adsorbent particles, and the higher the adsorption activity, determined by the amount of absorbed substance, in any case.

For the purpose of mechanical activation of our sampled clays, a mechanical-activator AGO-2S laboratory device was used. In the mechanical activation of clays, the rotations of the shaft were studied at 1200 rev/min.

One of the most important indicators of mechanical activation of clay minerals is the effect of activation time on the strength of the mixture [6], and the results are presented in Figure 1.

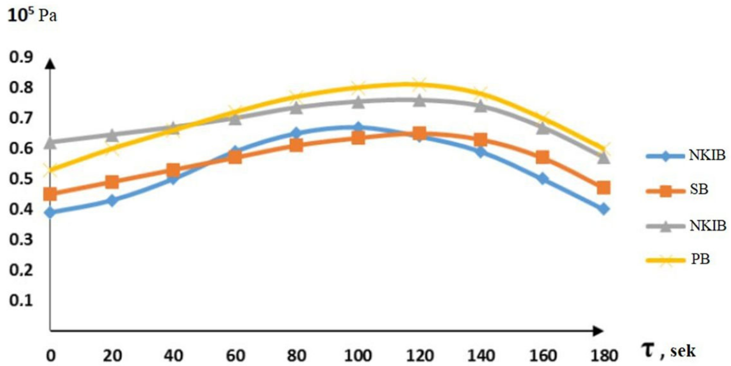

Fig. 1. Effect of activation time on mixture strength.

Increasing the mechanical activation time to 115 seconds increased the wet strength of the mixture by 0.45-0.78 105 Pa (NKIB), 0.51-0.81 NK IER, 0.52-0.79 PB and 0.50-0, 77 SB can be seen to change to 105 Pa.

If we conclude from this, we can increase the strength of low-quality clays and mechanical activation of bentonites with production waste to 0.78·105 Pa (PB) and Simferopol bentonite to 0.81 [6- 8].

One of the most important parameters in the preparation of drilling fluid based on clays is their ability to swell [9, 10]. Therefore, we studied the effect of mechanical activation time on the compaction of clays. The results are presented in Figure 2.

Stuttering

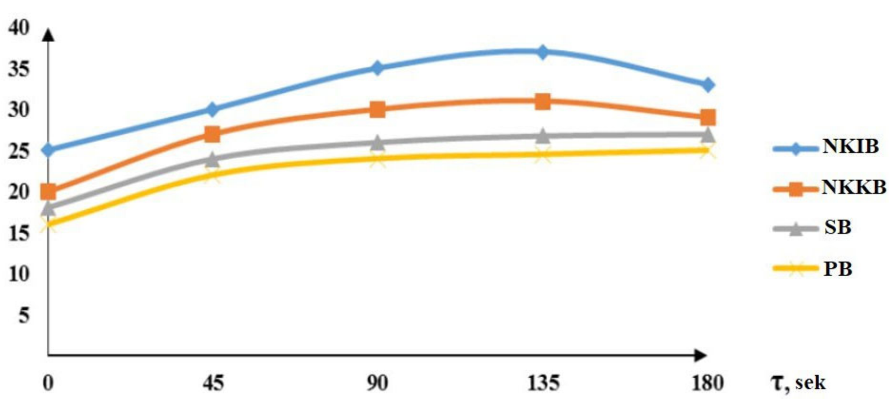

Fig. 2. Effect of mechanical activation time on clay compaction.

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As can be seen from the picture, the time of mechanical activation also affects their performance.

One of the most important parameters of clays used in the preparation of drilling fluids resistant to thermomechanical effects is their colloidal index [11, 12]. Therefore, the effect of mechanical activation time on the colloidal index of these clays was investigated and the results are presented in Figure 3.

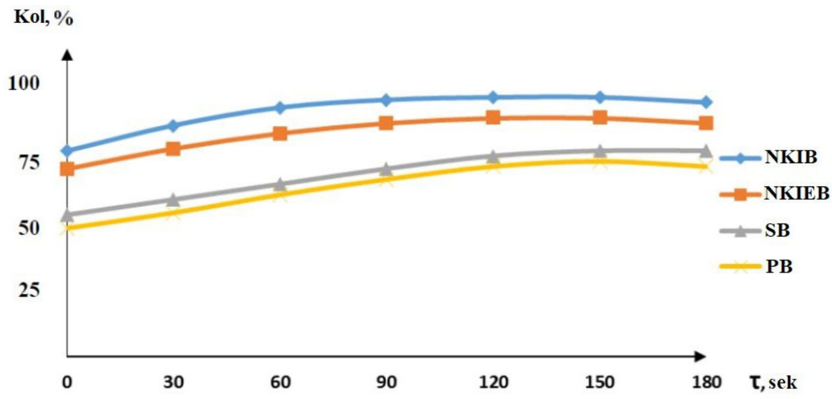

Fig. 3. Effect of mechanical activation time on the colloidal index of clays.

As it can be seen from this picture, in all samples, the colloidity of the clays increases in the range of 100-115 seconds, and after the increase of the activation time, especially at 160 seconds, we can see a sharp decrease in this indicator. The main reason for the increase in the colloidal index of clays during the activation of 100-115 can be explained by the increase in the activity of bentonite clays [13]. Further, increasing the activation time leads to the aggregation of particles, so their colloidity begins to decrease [14-16]. The crystal-chemical structure of clays plays an important role in the stability of clay drilling solutions.

An increase in the activation time during the mechanical activation of clays leads to a violation of the electroneutrality of the crystal structure of clays. As a result, it causes a large amount of negative charges to form. The formation of negative charges compensates negative charges in the form of aluminosilicates as a result of aluminum ions acting as exchange cations.

An increase in the amount of water in a clay system increases the role of capillary forces in the formation of adhesion strength between particles.

The great difference in the bending performance of bentonites can be explained by the differences in their mineralogical composition [17-19].

Taking this into account, we took the time of mechanical activation as 115 seconds and continued the work in this case in further studies.

There are basically three ways to activate clays: wet, dry, and suspension. Soda (Na, Ca, Mg) solutions are mainly used in the production, i.e. in the drilling of salt layers, to activate bentonites.

The amount of $CaCO_3$ and residual soda is important in the processing of clays using sodas. Because it is known from practice that these have a negative effect on the preparation of the drilling solution and the drilling process. Therefore, there is a need to study the effect of soda concentration on bentonite activation parameters.

It is known from the analysis of the literature that the ion exchange does not take place completely during dry activation of clays, therefore, it is more effective to activate wet bentonites and their compositions.

The method of activation of bentonites was studied and the analysis of their rheological parameters was studied and the results are presented in the following in Table 1.

Table 1. The effect of the amount of Na_2CO_3 on the activation of bentonites.

№	Modification method	Colloids, %	Effective viscosity, mPas	Drilling fluid output, m3/t
NK IB	Standard: 2,0% Na_2CO_3 Mechanical activation: 01,0%, Na_2CO_3, W=2630%	95 100	45 55	16.5 34.2
NK IER	Standard: 4,4% Na_2CO_3 Mechanical activation: 3% Na_2CO_3, 3% MgO, W=14,6%	97 100	44 63	10.1 31.2
PB	Standard: 3% Na_2CO_3 Mechanical activation: 3% Na_2CO_3, 3%MgO, W=15,7%	83 96	48 67	9.2 28.5
SB	Standard: 6% Na_2CO_3 Mechanical activation: 3% Na_2CO_3, 3% MgO	84 95	49 66	9.1 27.6

The method of activating clays used to obtain drilling fluid has an effect on their properties, that is, the output of drilling fluid increases by MF 2.5-3.0 times compared to the standard method it can be seen from Table 1.

One of the important conditions determining the effectiveness of bentonite modification is the systemization of clay and modifier. Mechanical activation the stress energy of the mechanical action of the equipment should be sufficient to form active centers and fix water and adsorbates in them.

In the process of mechanical activation of clays, the activation of chemical reagents (active hydrophilic stabilizer) creates more favorable conditions for modification of the enlarged absorbent surface of clay materials, that is, compared to the method of mechanical activation.

In the standard method of modification, grinding of clays in various mills is carried out by activating chemical reagents.

3 Conclusion

In order to mechanically activate our sampled clays, we conducted research on the mechanical activation of clays using the mechanical-activator AGO-2S laboratory device at 1200 revolutions per minute. One of the main indicators of mechanical activation of clay minerals is the effect of activation time on the strength of the mixture. If we conclude from this, by increasing the strength of clays with low quality indicators and by mechanically activating the strength index of bentonites, which are production waste, we can increase the strength index to 0.78·105 Pa (PB) and Simferopol bentonite to 0.81. one of the main indicators is their ability to swell, and the effect on the swelling of clays during mechanical activation was determined. One of the most important parameters of clays used in the preparation of drilling fluids resistant to thermogeochemical effects is their colloidal index. Therefore, the effect of mechanical activation time on the colloidal index of these clays gave positive indicators.

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