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STUDY OF DYNAMIC CHARACTERISTICS OF CLAY SOLUTION UNDER THE INFLUENCE OF VIBRATION

©**Suleimanov T.,** *Azerbaijan State Oil and Industry University, Baku, Azerbaijan*
©**Khairabadi G.,** *Azerbaijan State Oil and Industry University, Baku, Azerbaijan, qezale@mail.ru*

ИССЛЕДОВАНИЕ ДИНАМИЧЕСКИХ ХАРАКТЕРИСТИК ГЛИНИСТОГО РАСТВОРА ПОД ВОЗДЕЙСТВИЕМ ВИБРАЦИИ

©**Сулейманов Т. С.,** *Азербайджанский государственный университет нефти и промышленности, г. Баку, Азербайджан*
©**Хайрабади Г. С.,** *Азербайджанский государственный университет нефти и промышленности, г. Баку, Азербайджан, qezale@mail.ru*

Abstract. It is known that with the help of a vibrating sieve for vibration separation (separation) of a clay solution, the following technological problems are solved: cleaning the clay solution from drilled rocks and separating it into fractions, i.e. sorting. Signs of separation of drilled rocks from clay solution using vibration are the size of the drilled rocks, the shape and density of the clay solution itself, etc. It has been shown that in order to improve the basic technological characteristics of the vibrating sieve, it is necessary to study the behavior of the clay solution in the vibrating sieve.

Аннотация. Известно, что с помощью вибросита для вибрационного разделения (сепарации) глинистого раствора решаются следующие технологические задачи: очистка глинистого раствора от выбуренных пород и разделение его на фракции, т. е. сортировка. Признаками разделения выбуренных пород от глинистого раствора с помощью вибрации являются крупность выбуренных пород, форма и плотность самого глинистого раствора и т. д. Показано, что для улучшения основных технологических характеристик вибросита необходимо изучить поведение глинистого раствора в вибросите.

Keywords: clay solution, density, vibrating sieves, harmonic vibrations, model-motion, equations of motion, relative motion, floating.

Ключевые слова: глинистый раствор, плотность, вибросита, гармонические колебания, модельное движение, уравнения движения, относительное движение, всплытие.

Using a vibrating sieve for vibration separation of clay solution, the following technological problems are solved: cleaning the clay solution from drilled rocks and separating it into fractions, i.e. sorting [1, 8].

Signs of separation of drilled rocks from clay solution using vibration are the size of the drilled rocks, the shape and density of the clay solution itself, etc. Main technological characteristics of a vibrating sieve: productivity — the amount of initial solution processed per unit of time; number of rocks; coefficients characterizing the number of components of the sifting clay solution; coefficient of "purity" of the fraction. The vibrating sieve is a continuous vibration machine and characterized by high productivity. For its effective operation, stability is required, i.e. continuity in quantity, composition and properties of the initial mixture [2].

To improve the basic technological characteristics of a vibrating sieve, it is necessary to study the behavior of the clay solution in the vibrating sieve. To date, at least preliminary studies have not been carried out on the hydrodynamic features of the clay solution in a vibrating sieve, on the processes of separation into fractions, and the necessary conditions for the continuity of the separation process. Therefore, our field research allowed to draw the following conclusions. Vibrating sieve machines, such as commercial sieves, are characterized by several regular modes of vibration movement. Vertical harmonic vibrations without tossing with two-way movement and instantaneous stops, usually used to separate mixtures applying thin-sheet sieves with round and rectangular holes or woven metal sieves. Continuous contact of the solution with the sieve and the absence of intervals of relative rest increases the probability of sifting the solution from the lower layer and reduces the dynamic loads on the sieve, characteristic of intensive tossing [3, 4].

Uniform circular fluctuations in horizontal density ensure the separation of drilled rocks of various shapes. In these cases, two-tier sieves favor loosening and self-sorting of mixtures, but require the use of durable and rigid sieves. Let's consider the movement of a rock particle relative to the medium (clay solution). Let us accept the simplest model — the movement of a solid particle with mass M in a liquid vibrating according to the law $\xi(t)$. If a particle is completely entrained by a clay solution (i.e., a medium), then it is acted upon by a force $m\ddot{\xi}$, where m is the mass of the medium in a volume equal to the volume of the particle. In contrast to the motion of particle B, the motion of the medium, some part of the medium (added mass m_0) moves together with the particle [5]. Therefore, the equation of particle motion will be:

$$M\ddot{x} = m\ddot{\xi} - m_0\left(\ddot{x} - \ddot{\xi}\right) \qquad (1)$$

Integrating under the conditions, $t = 0,\ x = 0,\ \dot{x} = 0,$ depending on the given law of motion of the clay solution, we obtain:

$$x(t) = \frac{m + m_0}{M + m_0}\xi(t) \qquad (2)$$

Added mass for a ball with r radius;

$$m_0 = \frac{2}{3}\pi \cdot \rho \cdot r^3;$$

where ρ is the density of the medium. Then:

$$x(t) = \frac{3\rho}{2\rho_M + \rho}\xi(t) \qquad (3)$$

where ρ_M is the particle density. From (3) it follows that the relative motion depends on the density ratios and does not depend on the particle sizes. Expressions (1)-(3) do not take into account the resistance to movement Φ and the force of attraction. If we take them into account, then (1) will look like:

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$$M(\ddot{x}+g)=m(\ddot{\xi}+g)-m_0(\ddot{x}-\ddot{\xi})+\Phi \tag{4}$$

In the case of purely viscous resistance $\Phi=\Phi(\ddot{x}-\ddot{\xi})$ the body sinks ($M<m$) and floats up ($M>m$). When the medium oscillates around this averaged motion, the body oscillates, which is described by dependence (3). Fundamentally different dependencies may appear if the resistance force is of the nature of dry friction:

$$\Phi=\begin{vmatrix}-F_+ & if\ \dot{x}>\dot{\xi} \\ F_- & if\ \dot{x}<\dot{\xi}\end{vmatrix} \tag{5}$$

Typically, the resistance to floating $(\dot{x}>\dot{\xi})$ is less than when moving towards the bottom of the vessel, i.e. $F_- > F_+$. In the presence of dry friction forces, the particle will move together with the medium ($x\equiv\xi$) until

$$-F_+\le(M-m)(\ddot{\xi}-g)\le F_- \tag{6}$$

This means that a mixture consisting of particles with masses M and the medium will behave as a continuous mass if inequality (6) is satisfied and mutual movement (fluidization effect) will be observed if at least at some moments of time the inequality is violated. The fluidization effect will be stronger the more of the period inequality (6) is violated. Particles lighter than the medium $(M<m)$, in the presence of fluidization with symmetrical vibrations, will certainly float up. A more complex picture occurs if the particles are heavier than the medium $(M<0)$. If the maximum amplitude value of the accelerations and symmetrical oscillations is large enough to violate inequality (6), then not only the immersion, but also the floating of heavier particles is possible. Let us write (5), introducing the relative motion of the particle $z(t)=x(t)-\xi(t)$ and denoting the entire mass involved in the relative motion, $M_0=M+m_0$. Then (5) can be given the form:

$$M_0\ddot{z}=-(M-m)(\ddot{\xi}+g)-\Phi \tag{7}$$

When the particle moves relative upward $(\dot{x}>\dot{\xi})$, the greatest force will act on it [right side of (7)

$$P_b=(M-m)(g-a)-F_+,$$

and when moving down

$$P_H=-(M-m)(a+g)+F_-.$$

Obviously, floating can take place if $P_b+P_H>0$, i.e. If

$$F_{-1}-F_+>2(M-m)g \tag{8}$$

But upward movement can only begin when

$$(M-m)(g-a)\le F_+ \tag{9}$$

From (8) and (9) it follows that floating can only take place when

$$\frac{F_{-} - F_{+}}{F_{+}} > \frac{2g}{a - g} \tag{10}$$

The floating of a heavier particle, than the environment, is a consequence of the difference in the forces of resistance to floating and immersion, and this difference should be quite large. This result also allows to explain the fact that when vibration acts on a mixture of particles of the same density, at different sizes, large particles under certain conditions are located above small ones, since the mass of large particles in the same volume is greater *(M > m*) [6]. The level of vibration a also has a significant impact on floating. So, at different values of *a*, the heaviest particle can both float and immerse. The different behavior of the particle can be even more noticeable if asymmetric vibrations are applied. It is possible, for example, that particles heavier than the medium may float up. All this shows that by regulating the oscillatory process in vibrating sieves, it is possible to achieve a more rational separation of the clay solution. Work of this kind has not been carried out in the field of purification of clay solution from drilled rocks using a vibrating sieve [7].

This research shows that the correct choice of technological process, along with other operating parameters, significantly influence the strength properties of the node elements. The calculation of the nodal elements of a vibrating sieve is currently of actual importance. The collection and analysis of field data on the work of vibrating sieves shows the strength properties of the key parts, namely the elastic elements, directly depend on the operating vibration parameters.

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