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# INVESTIGATION OF THE PROCESS OF DESTRUCTION OF A LAYER OF MINED ROCK BY THE TOOTHED DISC OF THE ROLLER CLASSIFIER

*The problems associated with efficient classification of hard-to-sieve wet and sticky mined rock masses are far from being solved and require further theoretical and experimental efforts. It is the purpose of the present investigation to determine the values of impact energy required to destroy the layer of mined rock by the vibrating roller classifier executive tool, which could be implemented either with rubber or steel material. The authors carry out the experiment to compare different material types of the teeth of vibrating roller classifier in order to get the maximum value of impact energy. Experiments involved measurements of height of fall H, thickness of a mined rock layer h with taking into account different sizes and humidity of the rock lumps. As a result of the experiments we can conclude that at sieving wet materials rubber teeth disks show characteristics similar to steel ones, what confirms the efficiency of their use for the classification of hard-to-sieve wet mined rock.*

***Keywords:*** *rubber, steel, toothed disc, vibrating roller classifier, impact energy, wet and sticky mined rock.*

***Formulation of the problem.*** In foreign practice, new promising designs of roller classifiers with high specific productivity [1,2], so to solve an actual problem of effective separating of hard-to-sieve wet and sticky rock lumps, the Institute of Geotechnical Mechanics under the NAS of Ukraine developed a vibrating roller classifier [3]. The sieving surface of the device is formed by rotating rollers of different configurations: metal rollers with cylindrical surface or rubber rollers surfaces with lobes.

***Analysis of recent research and publications.*** During theoretical and experimental researches one of the most effective surfaces of the vibrating roller classifier is proposed, where the rollers consist of a set of polymeric disks with various types of petals. One of the options is a polymer disc  having six petals as presented in Figure 1.

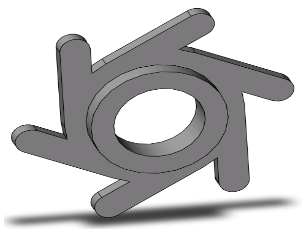


**Fig. 1 - The polymer disc with six petals**

The design of the roller with the petals in the vibrating roller classifier allows not only to transport the mined rock, but also to loosen its layer, using the vibro-impact mode to destroy the stuck together pieces, which remain in the oversize product during normal screening, which finally leads to a decrease in the classification efficiency.

In the studies [4] of the impact interaction of a piece of material with the petal executive surface of a mining machine, there was a case considered when a piece of mined rock was already on the surface of its processing, without taking into account its fall on the last one from a certain height, on which a material feeder was installed. Also, the case is considered when a piece of mined rock is sufficiently large and capable of exerting elastic deformation effects on the executive tools themselves of the classifying machine.

In contrast to the above work in this paper there was considered the case when the energy is a change in the potential energy of a piece of material, that means that $E=mg(H-h_0)$, where $h_0=0$.

It is also worth noting that the mechanical energy does not go into internal energy, or it is so small that the temperature changes of the colliding bodies have not been fixed by the measuring devices. Thus, the experiments of this study did not take into account the dissipation energy of the impact.

In [5] the dependence of the impact force on the mode and design parameters of the machine was established experimentally. The results of the power values in [5] were recorded by obtaining digitized signals obtained from the strain gauge sensor due to impact of the consoles of executive surface on a piece of material. In summary experimental studies of the productivity and efficiency of a roller vibro-impact classifier (having petal rollers) showed improved characteristics in comparison with an ordinary roller vibrating classifier (having cylindrical rollers) due to the presence of impact pulses, what proves once again the prospect of investigating impact interactions.

***The purpose*** of the present investigation is to determine the values of impact energy required to destroy the layer of mined rock by the petal of vibrating roller classifier executive.

***Main results of the research.*** To achieve this purpose the authors of the research developed a laboratory stand, shown in Fig. 2. The stand consists of support base 1, pillars 2 for a movable frame with locks 3, by means of which the height of the falling petal 4 with a load was set. The container for the mined rock in the form of a box 5 is installed on the supports 6. Under the bottom of the box there is a strain gauge 7 for measuring the time of impact, and on the surface of the box there is a layer of mined rock 8. The experiment varied such properties of the mined rock as its thickness, grain size and humidity. To obtain reliable experimental results, standard planning and processing methods were used, which allow to minimize the number of necessary tests, establish a rational order and conditions for carrying out the studies, depending on their type and the required accuracy of the results [6-10].

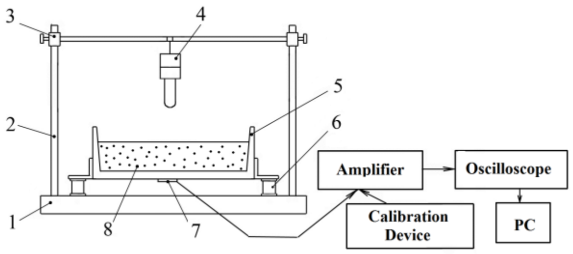
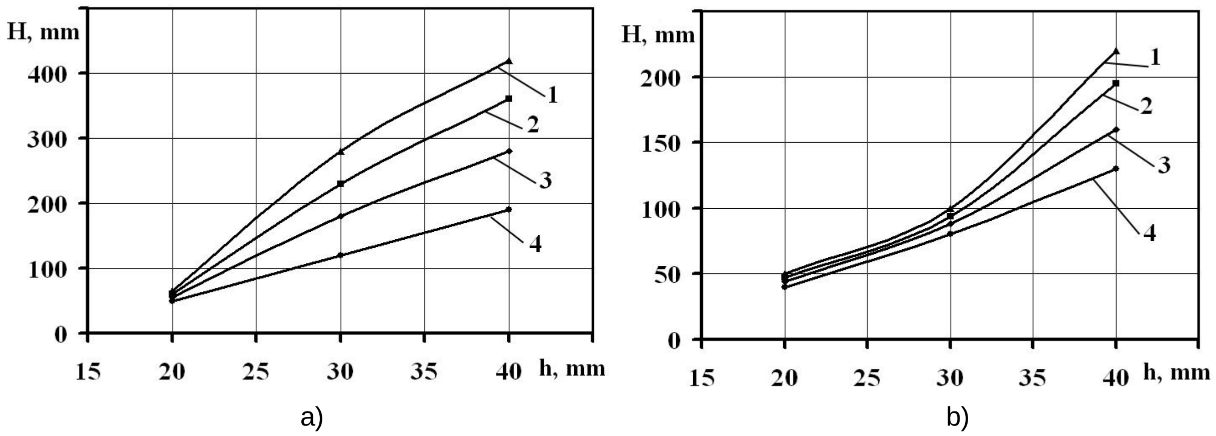



**Fig. 2 - Laboratory stand for measuring the energy of a petal impact**

The principle of operation of the stand is as follows. Under the influence of gravity petal 4 with the load hits the mined rock 8, depending on its thickness, grain size and humidity experimenter is selecting such a drop height *H* (directly proportional to impact energy *E*), which allows petal to penetrate through the whole layer of mined rock mass. The given drop height is fixed, and knowing the mass of the petal 4 with the load and the height of its fall, the impact energy necessary to destroy the layer of mined rock of different thickness, size and humidity is determined.

The initial parameters during the experiment are as following: material of mined rock - granite, weight of the petal with the load - *0,945 kg*, the petal material - rubber or steel. Despite the fact that all disks with vibrating roller classifier petals are made of polymer (rubber), during the experiment, the possibility of making vibrating roller classifier petals from steel was checked. The granite size was from *d = 1.75mm* (+ *1mm - 2.5mm*) to *d = 8.5mm* (+ *7mm -10mm*). The moisture content of granite *W* varied from 0 to 9%.

In Fig. 3 there is a graphical representation of the dependence of the drop height H of the rubber (a) and steel (c) petal on the thickness *h* of the granite layer and its different grain size *d* obtained during the experiment.

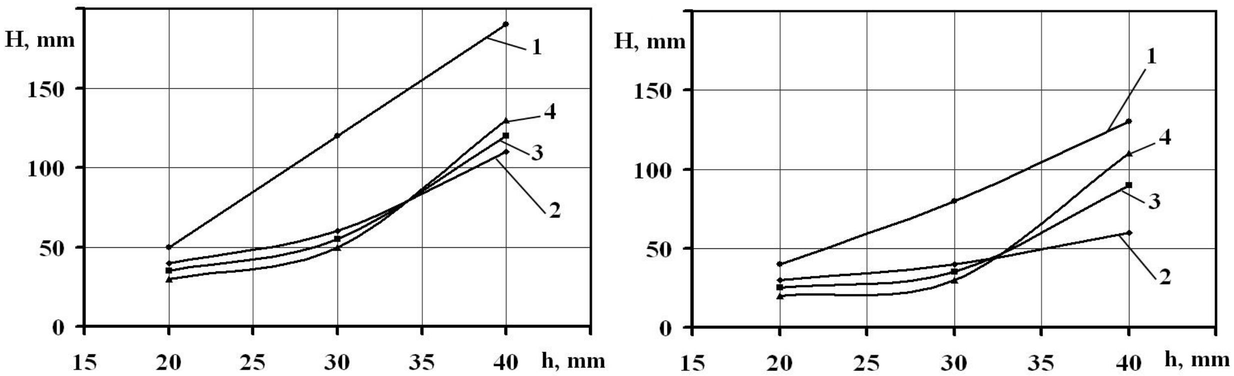



*1 – d = 8,5 mm; 2 – d = 6 mm; 3 – d = 3,75 mm; 4 – d = 1,75 mm*

**Fig. 3 – The dependence of the drop height *H* of rubber (a) and steel (b) petals on thickness of a layer of dry granite *h* at different granite sizes *d***

In the analysis of presented dependences in Fig. 3 it is obvious that for destroying a layer of dry mined rock having similar characteristics the steel petal requires twice less efforts compared with the rubber petal what can be explained by the increased coefficient of friction of the rubber petal on the mined rock in comparison with the steel petal, especially this difference is visible for larger pieces of mined rock. At the same time, with the growth of the thickness of the dry mined rock layer a relative decrease in the growth of the required impact energy by the rubber petal is observed to destroy the dry mined rock layer, since the rubber petal begins to lose its damping properties the time of impact action decreases and the penetrating power is increasing. Also, the obtained dependences allow us to determine the effect of the size of the mined rock; the larger it is the greater the effort will be necessary to break down the dry mined rock with both rubber and steel petal.

In Fig. 4 there is a graphical representation of the dependence of the drop height *H* of the rubber (a) and steel (c) petal on the thickness of the granite layer *h* with an average diameter *d = 1.75 mm* for different moisture *W* of the material.




a) b)

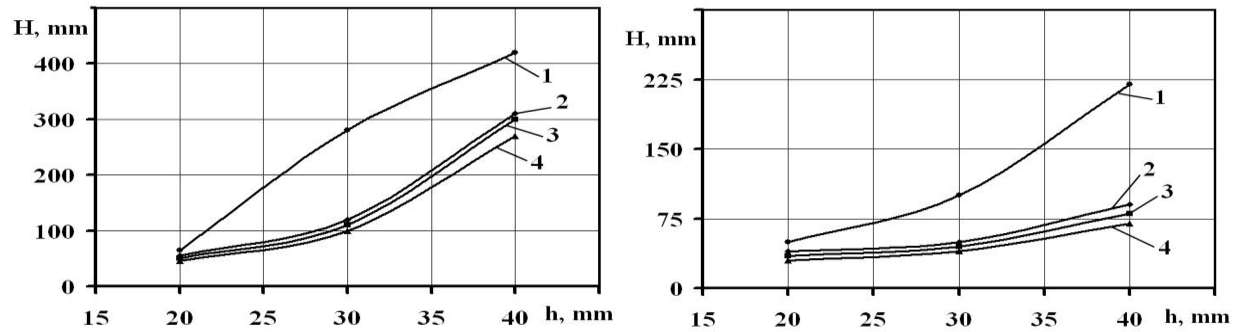
*1 – W = 0 %; 2 – W = 3 %; 3 – W = 6 %; 4 – W = 9 %*

**Fig. 4 – The dependence of the drop height *H* of rubber (a) and steel (b) petals on thickness of a layer of granite *h (d = 1,75 mm)* at different material humidity *W***

Analyzing the dependences in Fig. 4 it is established that, in comparison with dry mined rock the moist mined rock mass requires less effort which is necessary for the destruction of its layer by the impact of the petal, especially its noticeable when it is struck by a rubber petal, where at the humidity increase the impact force decreases almost twofold. This is due to the reduction in the coefficient of friction, which is especially important for rubber petals.

At the same time with a moisture content of the mined rock *W = 6 and 9%* and an increase in the thickness of the material layer a relative force increase necessary to destroy the mined rock is observed, because when the given moisture level inside of the mined rock is reached the viscosity of the medium changes, due to the formation of surface bonds of fluid layers between the moist particles of the mined rock, and for the rupture of these bonds it is necessary to expend additional energy of impact.

In Fig. 5 it is graphically depicted the dependence of the drop height *H* of the rubber (a) and steel (c) petal on the thickness of the granite layer *h* with an average diameter *d = 8.5 mm* for different material moisture *W*.




a) b)

*1 – W = 0 %; 2 – W = 3 %; 3 – W = 6 %; 4 – W = 9 %*

**Fig. 5 – The dependence of the drop height *H* of rubber (a) and steel (b) petals on thickness of a layer of granite *h (d = 8,5 mm)* at different material humidity *W***

The experiment shown in Fig. 5 differs from the previous one by an increase in the grain size of pieces of mined rock by a factor of 5 ($d$ = *8.5 mm*). With this change, there is a decrease in the effect of the increased moisture content of the material with increasing thickness of the layer on the increase in the impact force necessary to destroy the layer of mined rock.

Due to the fact that in the material layer from larger pieces than in the previous experiment, the amount of surface bonds of the fluid layers between the moist particles of the mined rock per unit area is smaller, then the energy of impact to break these bonds needs to be spent less.

***Conclusions.*** As a result of laboratory experiments the impact energy necessary to destroy the layer of mined rock by the petal of the roller vibrating classifier was determined. The obtained results will allow to confirm in the future the data of theoretical studies on the calculation of the energy of the petal impact in the vibrating roller classifier processing action, and also to develop a methodology and recommendations on the use of vibrating roller classifier for the classification of mined rock having different properties.

Manufacturing petal roller discs out of rubber for screening dry material we observe an increase in resistance to the destruction of the mined rock layer, so when dealing with dry screening it is recommended to make discs out of polymer materials with a lower coefficient of friction.

The use of steel petals despite better indicators for the destruction of the mined rock layer is inexpedient, due to the complexity and high cost of their manufacture, as well as the increased mass compared with rubber petals, which will lead to an increase in the cost of vibrating roller classifier and to higher energy costs in the classification.

At the same time when the wet material is screened the rubber petal discs show characteristics similar to steel ones what confirms again the effectiveness of their use for the classification of hard-to-sieve wet mined rock.

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## ДОСЛІДЖЕННЯ ПРОЦЕСУ РУЙНУВАННЯ ШАРУ ГІРСЬКОЇ МАСИ ПЕЛЮСТКОВИМ ДИСКОМ ВАЛКОВОГО КЛАСИФІКАТОРА


*Проблеми, пов'язані з ефективною класифікацією важкогрохотимих вологих і липких мінеральних матеріалів, ще не вирішені і вимагають додаткових теоретичних і експериментальних зусиль. Метою даного дослідження є визначення значень енергії удару, необхідної для руйнування шару гірської породи за допомогою робочого органу валкового вібраційного класифікатора, який може бути реалізований або з використанням гуми, або зі сталевого матеріалу. Автори проводять експеримент для порівняння різних типів матеріалів валків валкового вібраційного класифікатора для того, щоб отримати максимальне значення енергії удару. Експерименти включають вимірювання висоти падіння H, товщини шару гірської породи h з урахуванням різної крупності матеріалу d і її вологості W. В результаті експериментів можна зробити висновок, що при просіюванні вологих матеріалів гумові пелюсткові диски показують характеристики, аналогічні сталевим, що підтверджує ефективність їх використання для класифікації важкогрохотимих вологих матеріалів.*



**Ключові слова:** *гумовий, сталевий, пелюстковий диск, валковий вібраційний класифікатор, енергія удару, волога і липка гірська маса.*


## ИССЛЕДОВАНИЕ ПРОЦЕССА РАЗРУШЕНИЯ СЛОЯ ГОРНОЙ МАССЫ ЛЕПЕСТКОВЫМ ДИСКОМ ВАЛКОВОГО КЛАССИФИКАТОРА


*Проблемы, связанные с эффективной классификацией трудногрохотимых влажных и липких минеральных материалов, еще не решены и требуют дополнительных теоретических и экспериментальных усилий. Целью настоящего исследования является определение значений энергии удара, необходимых для разрушения слоя горной породы с помощью рабочего органа валкового вибрационного классификатора, который может быть реализован либо с использованием резины, либо из стального материала. Авторы проводят эксперимент для сравнения различных типов материалов валков валкового вибрационного классификатора, чтобы получить максимальное значение энергии удара. Эксперименты включают измерения высоты*

*падения H, толщины слоя горной породы h с учетом различной крупности материала d и ее влажности W. В результате экспериментов можно сделать вывод, что при просеивании влажных материалов резиновые лепестковые диски показывают характеристики, аналогичные стальным, что подтверждает эффективность их использования для классификации трудногрохотимых влажных материалов.*

***Ключевые слова:*** *резиновый, стальной, лепестковый диск, валковый вибрационный классификатор, энергия удара, влажная и липкая горная масса.*

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