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Satbayev University

Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
Satbayev University

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METHODOLOGY AND EXPERIMENTAL SETUP FOR THE STUDY OF RELATIVE ABRASIVENESS OF BULK SOLIDS

Abstract. This paper presents preliminary results of determining the coefficient of relative abrasiveness of various bulk materials (Ekibastuz coal, Karazhyra, Shubarkol, Oikaragai and volcanic stone). Determination of the critical velocity of the bulk solids, which eliminates the change in size of particles through grinding at abrasion of the studied material samples. In order to reveal the influence of sample and abrasive material properties, experiments were carried out to study abrasiveness at different combinations of abrasives and samples. It is emphasized that the abrasiveness of the material under study is determined relative to the material recognized as a reference material. In particular, the abrasive material is unloaded completely after a certain period, and it is checked whether the original particle size and facets of the material under examination are maintained. Determining this, a kind of critical speed of mutual movement of samples and wear material is also one of the parameters of the research. In the proposed device, the abrasiveness of the bulk material in a non-ventilated mill is determined by the intensity of abrasion of the abrasives at different temperatures. As in the case of coal grinding capacity research, this device allows to determine the abrasiveness relative to the substance declared as a reference one.

Key words: abrasiveness of bulk materials, coal, stone, abrasivity coefficient, abrasion, wear, energy, material, speed, angle.

Introduction. For the near future, the main source of energy remains mineral fuel and coal in the first place. The Republic of Kazakhstan has huge reserves of coal, and low-grade hard coal and brown coal are mainly used in power engineering [2, 12].

Kazakhstan is one of the few countries provided with primary energy resources, using modern technologies for production, conversion, and transportation of energy. The specific feature of Kazakhstan's energy industry can be considered the presence of huge coal reserves [2, 12].

To develop effective methods of determining the relative abrasiveness of bulk solids, it is necessary to know the mechanism of these processes. To this end, we propose a method of determining the abrasiveness of a particular bulk relative matter.

Laboratory research of contamination and wear processes is identified; methods of their prediction are developed [13, 4, 5].

Based on laboratory research of the wear process and their checking in the given industrial conditions was developed and approved by the *State* All-Union *standard*. This allowed to calculate the wear of natural heating surfaces and to determine the mode, providing acceptable wear of boiler tubes [1, 20].

Much scientists researched about ash wear, and abrasiveness is studied a little. A lot of scientists studied abrasiveness of different solids in the world [13, 14].

Until this time, the abrasiveness of ash has been studied. Our study investigated the abrasiveness of solid fuels and other solid bulk materials to benefit production [11, 15, 16].

Combustion of multigrade coals is associated with increased ash abrasion of heating surfaces. The currently applied protective measures are still not effective enough. Ash collecting devices in front of the heating surfaces, have a low coefficient of trapping, strongly condition the scheme and operation of the boiler unit. One of the decisive measures against ash-removal is the burning of coal with liquid slag removal. However, furnaces with wet bottom ash removal were not widely used in the Soviet Union. Ash abrasion of heating surfaces can also be significantly reduced by timely implementation of a number of constructive and regime measures on the boiler unit. In order properly and timely consider them in the design of power plants it is necessary to locate the characteristics of coals by abrasiveness of ash. Meanwhile, such data is still very scarce. Currently, there are abrasiveness coefficients, determined by the ash wear of natural heating surfaces, only for a few coals. Very often, there is a need for data, which would allow comparing different coals in terms of ash abrasiveness [6, 8, 9, 15].

Due to the painful complexity of ash wear process and influence of many factors on it in the experimental studies, the development of methodology was usually based on reproducing in the laboratory the working conditions of natural heating surfaces or observation of ash wears of boiler tubes directly at the operating power plants.

In this regard, studies of the relatively long process of ash wear of pipes are characterized, usually, by a long duration.

Coal, in its movement from the cars to the furnace wears out many elements of the fuel economy of the station. The most frequent wear is the grinding elements of crushers and mills, walls of hoppers, feeders, dumpers on conveyors and others. [7, 21].

Known studies are devoted to determining the intensity of abrasive wear by coal particles crushed in mills to a size of 100 microns or less, or formed by their combustion ash particles (of the same or smaller size), usually moving in the flow of air or flue gases. It should be noted that in these studies the abrasiveness of the material was determined indirectly - through the intensity of erosive wear, without directly determining the abrasiveness of the material itself. There were practically no data on the wear by the particles with the sizes corresponding to the crushing, interacting with the surface of the elements, in the absence of carrying air or other gaseous substance [15, 16, 17, 18, 19].

Materials and methods. The existing methods of investigating the abrasiveness of bulk solids can be divided into industrial, bench and laboratory.

Testing on industrial units and their results are described in [7, 18, 21]:

Anafin M.S. [18, 21] investigated tube bundles under upward and downward movements under identical conditions.

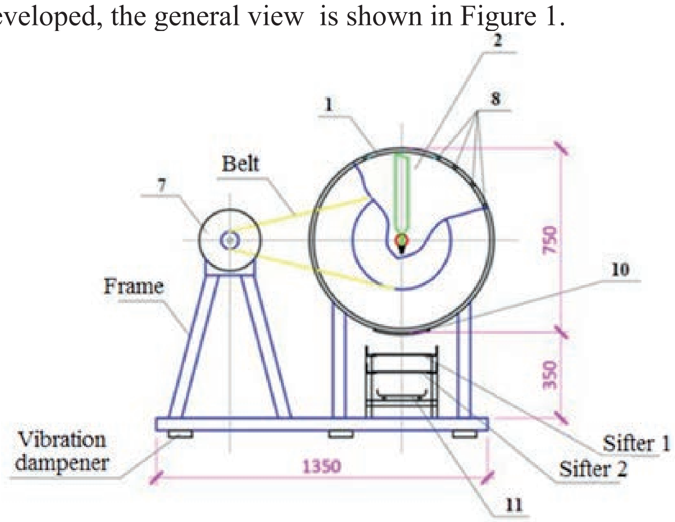
Syrkin S.N. [7], observing for a long time the wear of boiler tubes at several stations, determined the abrasiveness coefficients of ash from Kizelovsky and Chelyabinsky coals.

Investigations on bench units. In works [17, 18, 19, 20] ash abrasion was studied on the installation.

However, these works are not complete enough and until recently there are no studies necessary to determine their abrasive wear, including abrasiveness of coal particles and other loose substances.

Laboratory research methods. Created a laboratory bench to study the relative abrasiveness of bulk solids, including a method for determining the degree of volatiles. In this article we will talk only about determining the abrasiveness of bulk solids.

To study and determine the abrasive properties of (crushed and/or milled) coal, an installation very similar to an unvented mill was developed, the general view is shown in Figure 1.



a)

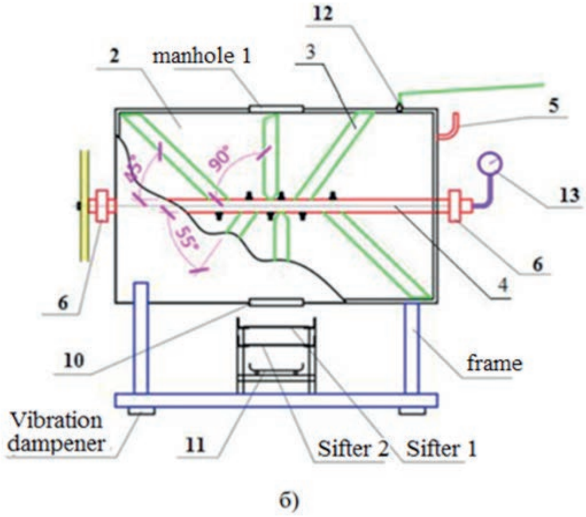


Figure 1 - Experimental setup a), b).

Description of installation: 1 - outer cylinder of steel; 2 - hopper; 3 - abrasive from steel at different angles; 4 - inner cylinder of steel; 5 - smoke exhauster for sucking out hot material when gases are released; 6 - heat-resistant bearings; 7 - electric motor with reduction gear; 8 – heater; 9 - sifter 1 and sifter 2 for determining the fraction of the material; 10 - hatch of bulk material loading; 11 - scales for weighing before and after the experiment; 12 - meter – controller; 13- revolutions - tachometer.

In the created setup for determining the abrasiveness of bulk solids, the possibility of changing the size of the particles in the process of experimentation is excluded. In particular, the abrasive material is unloaded completely after a certain period of time and the preservation of the original size of the particles and facets of the examined material is checked. Determination of this, a kind of critical speed of mutual movement of samples and wear material is also one of the parameters of the research.

The created setup allows conducting experiments with different materials at different sizes, shapes and faces of wearing particles. The abrasiveness of the material is also determined indirectly by the wear of the samples (through the change in the weight of the sample before and after a certain exposure time (with a constant duration).

Discussion and description of the created installation. 1. Getting acquainted with the design and operating principle of the experimental setup for studying the abrasiveness of particles of bulk materials of medium fractions.

2. To check the order of placement of the sieves on the vibrating screen AS 200 RETSCH. For the granulometric analysis of bulk solids the sieves in the set are placed from top to bottom in the following order 3000, 2000, 1000, 500 microns. The lower sieve should be inserted into the sieve tray.

3. Use analytical balance to weigh two test pieces of material weighing 300-1000 grams. The weighing shall be done with the accuracy of 0.01 g.

4. Load the weight of the middle fraction of the bulk material into the set of sieves. Place the material on the upper sieve.

5. Install the sieve set cover hermetically, so that the inner rubber gasket is tightly pressed to the upper rim of the sieve.

6. Tighten the set of sieves with the screws clockwise until tight.

7. Switch on the vibrating screen of the screen AS 200 RETSCH and set the set amplitude (from 0 to 100 Hz).

8. Set the sieving time (10-20 min).

9. Switch off the vibration drive of the screener after the sieving is finished.

10. Then the material with the desired fraction is weighed with the scales 11, from where it enters the hopper 2, which is the space between the outer 1 and the inner cylinder 4. To the inner cylinder 4 is attached abrasive in the number of 6 pieces at different angles 3. The rotation of the inner cylinder 4 is due to an electric motor with a reducer 7 attached to the cylinder with a heat-resistant bearing 6. The tachometer 13 attached to the inner cylinder 4 allows the number of revolutions to be measured. After examination, the loose material through a manhole 10 enters a sieve 9 (sieve1 and sieve 2), and then to the scales 11 to check the change in weight.

11. Make a sieve analysis of the bulk material to determine the wearability of each fraction.
12. abrasive, radially fixed at different angles to the axis of the inner cylinder, measure with scales.

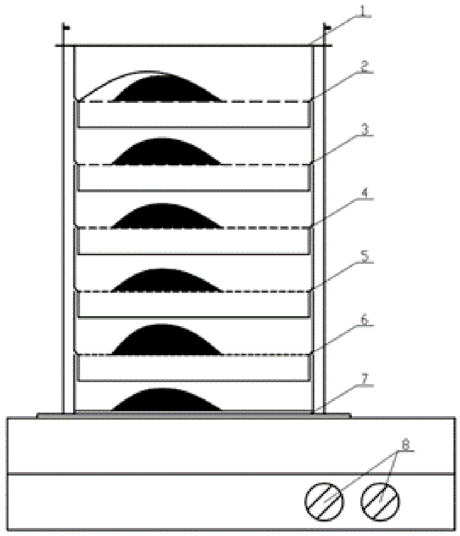


Figure 2 - Vibrating drive of the AS 200 RETSCH screen.

Description: 1) 1-7 sieve under different diameters; 2) 8- timer and vibration drive 10-100 Hz

Results.

Table 1 - Experimental data for bulk solids

Bulk materials	particle fraction, µm	LT^{-1}, m/s	the rotation speeds, r/min	ϴ, ^{0}C	Kao,	M, kg (before the experience)	M, kg (after the experience)	T, s
KARA ZHYRA	100	0,79	300	15	0,0365	1	0,87	8
	125	0,63	237	18	0,0359	1	0,987	10
	200	0,7	263	13	0,0359	1	0,91	12
	300	0,58	218	15	0,371	1	0,92	15
SHUBARKOL	100	1,19	450	18	0,0368	1	0,89	7
	125	1,1	410	20	0,0353	1	0,83	9
	200	1,3	480	22	0,0353	1	0,75	13
	300	1,28	485	20	0,0372	1	0,92	15
EKIBASTUZ	100	1,32	500	19	0,0129	1	1	10
	125	1,25	470	15	0,0123	1	1	15
	200	1,27	480	16	0,0123	1	1	17
	300	1,33	500	26	0,0332	1	1	20
VULCANIC. STONE	100	3,8	1200	23	0,0119	1	1	15
	125	3,2	1210	18	0,0113	1	1	19
	200	3,5	1300	13	0,0117	1	1	22
	300	3,45	1300	17	0,0116	1	1	25

Table 1 outlines the definition of critical velocities of bulk solids at which the change in particle size through grinding is excluded during the abrasion of the material under study by samples.

Calculation of wear by bulk solids will probably be determined by a formula similar to the one used in predicting abrasive wear by fly ash:

$$K_{ao} = \frac{h \cdot g}{ECw^{-8}\tau} \quad (1)$$

Here, h - value of change of sample weight in the course of experiment (gr)

E - coefficient of particle impact on the sample (in this setup is excluded from consideration);

C - bulk solids concentration (may be replaced with the level of filling of the setup with the test sample), kg/m^3

w - relative velocity of particles and sample, m/s;

τ - time, h.

F - a coefficient taking into account the shape of the sample

R - a coefficient taking into account the shape of the particles' edges of the material under study.

Determination of the components of this equation when changing the basic parameters of the wear material particles, the shape of the velocity of mutual interaction represents the subject of future research.

Conclusion. Based on the results of the analysis of the ash wear process and abrasiveness of bulk solids from experimental studies, a method for determining the abrasiveness of bulk solids and the critical rate of bulk solids has been developed.

An installation that allows determining the abrasiveness of particles of different materials, with different sizes and shapes at different rates of interaction was created. Preliminary results of the influence of the interaction rate on the bulk solids abrasion intensity are given.

As a result, this installation makes it possible to obtain more reliable results in the laboratory at different temperatures, which have not been investigated so far, which allows us to talk about the innovation of the device.

In the process of delivery of coal fuel to the furnace burner at TPP there is multiple interaction of moving coal mass with surfaces of many elements of equipment (fuel discharger, walls of hoppers, fuel feeding screws and others). In order to predict the timing of repair work on these elements, it is necessary to determine the intensity of abrasion wear. This wear is determined by interaction parameters: the relative velocity of the coal mass, the size of the moving particles, the degree of abrasiveness of the moving coal mass and others. Until recently, these data were determined based on statistical analysis of damageability of these elements by the results of many years of operation.

Results of researches: relative value of abrasiveness of coal particles, influence on intensity of abrasive wear of speed movement, size of particles, angle of vicarious interaction of coal mass with surface of equipment elements, form of wearing surfaces will be used at specification terms of carrying out and at planning of volumes of repair works at power stations.

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ЗЕРТТЕУГЕ АРНАЛҒАН ӘДІСТЕМЕ МЕН ЭКСПЕРИМЕНТТІК ҚОНДЫРҒЫ СУСЫМАЛЫ ЗАТТАРДЫҢ САЛЫСТЫРМАЛЫ АБРАЗИВТІЛІГІ

Аннотация. Бұл жұмыста түрлі сусымалы материалдардың (Екібастұз көмірі, Қаражыра, Шұбаркөл, Ойқарағай және жанартау тасы) салыстырмалы абразивтілік коэффициентін анықтаудың алдын ала нәтижелері ұсынылған. Зерттелетін материалдың үлгілерін уату кезінде ұнтақтау арқылы бөлшектердің мөлшерінің өзгеруін болдырмайтын қатты бөлшектердің критикалық жылдамдығын анықтау ұсынылған. Үлгі мен абразивті материалдың қасиеттерінің әсерін анықтау үшін абразивтер мен үлгілердің әртүрлі комбинацияларында абразивтілікті зерттеу бойынша эксперименттер жүргізілді. Зерттелетін материалдың абразивтілігі анықтамалық материал деп танылған материалға қатысты анықталады. Атап айтқанда, абразивті материал белгілі бір уақыт өткеннен кейін толығымен түсіріліп, бөлшектердің бастапқы мөлшері мен зерттелетін материалдың қырлары сақталғаны тексеріледі. Бұл үлгіні және тозатын материалды өзара жылжытудың сыни жылдамдығының бір түрі, сонымен қатар зерттеу параметрлерінің бірі болып табылады. Ұсынылған құрылғыда желдетілмеген диірмендегі сусымалы материалдың абразивтілігі әртүрлі температурада абразивтердің абразивтілігінің қарқындылығымен анықталады. Көмірді ұнтақтаудың өнімділігін зерттегендей, бұл құрылғы сілтеме ретінде мәлімделген затқа қатысты абразивтілікті анықтауға мүмкіндік береді.

Түйінді сөздер: сусымалы материалдардың абразивтілігі, көмір, тас, абразивтілік коэффициенті, абразия, тозу, энергия, материал, жылдамдық, бұрыш.

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МЕТОДИКА И ЭКСПЕРИМЕНТАЛЬНАЯ УСТАНОВКА ДЛЯ ИССЛЕДОВАНИЕ ОТНОСИТЕЛЬНОЙ АБРАЗИВНОСТИ СЫПУЧИХ ВЕЩЕСТВ

Аннотация. В данной статье представлены предварительные результаты определения коэффициента относительной абразивности различных сыпучих материалов (Экибастузский уголь, Каражыра, Шубарколь, Ойкарагай и вулканический камень). Определение критической скорости сыпучих твердых частиц, которая исключает изменение размера частиц за счет измельчения при истирании образцов исследуемого материала. Чтобы выявить влияние свойств образца и абразивного материала, были проведены эксперименты по изучению абразивности при различных комбинациях абразивов и образцов. Подчеркивается, что абразивность исследуемого материала определяется относительно материала, признанного эталонным материалом. В частности, абразивный материал полностью выгружается через определенный промежуток времени и проверяется, сохранены ли первоначальный размер частиц и грани исследуемого материала. Определяющая это своего рода критическая скорость взаимного перемещения образцов и изнашиваемого материала также является одним из параметров исследования. В предлагаемом устройстве абразивность сыпучего материала в невентилируемой мельнице определяется интенсивностью истирания абразивов при различных температурах. Как и в случае исследования измельчающей способности угля, это устройство позволяет определить абразивность относительно вещества, заявленного в качестве эталонного.

Ключевые слова: абразивность сыпучих веществ, уголь, камень, коэффицент абразивности, истирание, износ.

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