Isakov B.E., Kakenova M.ZH., Akhmetova A.Zh.**Features of justification parameters of dumps of factories for coal enrichment***Karaganda state technical University
(Kazakhstan, Karaganda)**doi: 10.18411/lj-04-2020-06**idsp: ljjournal-04-2020-06***Аннотация**

Данная статья посвящена актуальной проблеме отвалообразования при обогащении шахтных углей Карагандинского бассейна в условиях центральной обогатительной фабрики «Восточная».

На основании исходных данных по горно-геологическим условиям, физико-механическим свойствам пород, известных аналитических исследований приведены расчетные параметры устойчивого отвала, включая его предельную высоту и параметры ярусов с учетом технологии отвалообразования. Были сделаны расчеты по фактору устойчивости основания отвала и расчеты по фактору устойчивости тела отвала. На основании известных теоретических знаний выполнены исследования и расчеты на численной модели по определению устойчивых параметров ярусов и внешнего породного отвала в целом, разработаны рекомендации по оптимальному количеству и высотам ярусов.

Ключевые слова: обогатительная фабрика, складирование породных отвалов, параметры породного отвала, устойчивость отвалов, аналитический метод расчета, отвалообразование, предотвалы, основание отвалов, отвальная масса.

Abstract

This article is devoted to the actual problem of dump formation during the enrichment of coal mines in the Karaganda basin in the conditions of the Central processing plant "Vostochnaya".

Based on initial data on mining and geological conditions, physical and mechanical properties of rocks, and well-known analytical studies, the calculated parameters of a stable dump are given, including its maximum height and tier parameters, taking into account the technology of dump formation. Calculations were made on the stability factor of the blade base and calculations on the stability factor of the blade body. Based on the known theoretical knowledge, research and calculations were performed on a numerical model to determine the stable parameters of the tiers and the external rock pile as a whole, and recommendations for the optimal number and height of tiers were developed.

Keywords: processing plant, storage of rock dumps, parameters of rock dumps, stability of dumps, analytical method of calculation, dump formation, dumps, base of dumps, dump mass.

One of the main problems of processing and enrichment of coal in any mining method is the development of technology and organization of removal of residues after enrichment. As a rule, this is the search for the most optimal solution for the location of storage of rock waste of enrichment, usually in the form of dumps in the designated areas.

The main factors affecting the stability and safety of dumps are: geological, hydrogeological, mining and climatic conditions, as well as the technology of dumping.

A significant impact on the stability of the waste dumps can also provide aquifers in rocks (aquifers), water bodies, open and underground waterways near the dump. Hydrostatic pressure acting on the sliding surface reduces the normal component of the rock weight,

which leads to a decrease in the friction forces on the sliding surface and, ultimately, to a decrease in the degree of stability of the dumps.

Ensuring the stability of dumps is a complex task, the solution of which is associated with the interconnection of mining processes, taking into account the features associated with the mechanics of the array of loosened rocks of dumps and soils that lie at their base, as well as improving the technology of dumping under optimal conditions for the main parameters of dumps.

Another problem is to ensure fire safety, mainly endogenous, during the operation of the dump, since the dump mass after the coal enrichment process in the waste contains coal-containing rocks that can self-ignite under certain conditions.

According to the technological purpose, the extracted coals are divided into coking for metallurgy, energy for thermal power plants and especially fatty ones used in the chemical industry for the production of components of household products.

Since the coal and brown coals of almost all deposits contain rock inclusions that determine the quality of coal, such as ash content, there is a problem of cleaning the coal from the rock. The ash content of coal, especially from open cuts, reaches 30-40%, which leads to a large slag formation and creates various difficulties during combustion and subsequent ash removal [1,2,3].

Waste from the coal processing process is divided into the following types: dump mine rocks, sandstones, limestones, mudstones, siltstones - all of them have a solid structure and can contain up to 10% of coal [3,4].

Overburden waste obtained by crushing and sieving the rock contains up to 15% of the coal rock.

Containing rocks that surround the coal seam, or are contained in the rock, without having clear distinctions with coal, the concentration of coal in them can reach up to 25%.

Flotation enrichment technology cleans coal most thoroughly, leaving up to 120 m³ of rock per ton of processed coal.

Raw material components of coal processing waste are coal dust, crumbs, and combustible material; during the drying process, ash, burnt clay rocks, clay, loams, mudstones, gravel and sand, and natural stone remain.

The choice of location and arrangement of rock dumps during coal enrichment becomes one of the most acute problems over time, which includes economic, environmental issues, as well as issues of land use, subsequent reclamation, etc. [4,5,6]. Especially if the concentrator is located within the city limits, this often happens due to various reasons or circumstances. In this case, there are two most important questions:

- the possibility of increasing the height of the rock pile without increasing the occupied area with ensuring its stability for the planned period of operation; this is dictated by the condition that it is impossible to increase the area for the dump;
- exclusion of the processes of spontaneous combustion of the dump, since a certain proportion of the fuel component is necessarily present in the total dump mass.

These important questions are raised when designing external rock dumps in conditions of open or underground coal mining, the organization of waste heaps and coal enrichment.

Currently, the following measures are used to increase the stability of high rock dumps.

Filling of glasses. In this case, the stability of the dumps is ensured by overloading the parade areas adjacent to the dump slopes. Usually, the dump is constructed before the main dump is filled in, followed by filling the space between the dump and the main dump. The

stability of the blade depends on the height of the blade, since with increasing height of the blade, the overall angle of the slope of the blade is plowed out.

Engineering preparation of Foundation piles. During the engineering preparation of the base of the dumps, one of the following actions is performed:

- terracing of the soil at the inclined base of the dump;
- removing a weak layer with a power of up to 2 m;
- special-shaped anti-landslide recesses;
- preparation of the base of the dump by an explosive method to increase the friction forces that prevent the slide of the dump rocks in contact with the base;
- creation of recesses or zones of loosening at each stop at the base of dumps by borehole charges.

Deformation of dump slopes by artificial means. Usually, landslides cause drainage of the dump slopes, so in order to prevent landslides, they artificially cause deformation of the dump slope in order to give it a stable profile. For example, when dumping rock dumps with a height of 130 m at the Altyn-Topkan plant, due to insufficient adhesion, a landslide in the form of a "tongue" 80-100 m long was formed in the lower part of the dump after sometime between the dumped mass and the bed of the dump. Moreover, it was noticed that the deformation of slopes stops at a certain volume of landslide and they always occur in the same sequence when each dump is filled in.

In order to prevent spontaneous destruction of the upper part of the dump, artificial deformation of the dump slope was performed. For this purpose, the following works were performed in a certain sequence. When the dumped rock reached the upper part of the edge of the dump, a shelf was built on the slope by the excavator below the edge of the dump for 15-20 m. after that, the dumping continues in the usual way. The rock dumped on the newly formed shelf increases the pressure on the embankment and causes deformation of the slope. The upper platform of the dump was then in a stable state for a long time.

Forced planting of weak soils at the base of dumps. Practice shows that bulldozer dumps can be built on a weak Foundation without any preliminary preparation of the Foundation, provided that under weak rocks of relatively small capacity, there are rocks with a high load-bearing capacity. In this case, weak rocks are squeezed out, which does not prevent the construction of high-altitude dumps. Under the weight of the piled rocks, the dump approach pushes through (displaces) weak rocks and reaches a stable base without disturbing the earthen dump path.

An example is the placement of empty rocks of the Uchalinsky Deposit directly in the lake Uchaly. Full-scale observations have shown that the main condition that ensures the stability of the dump is forced subsidence of the lower dump approach until it reaches a stable base. To do this, the heaviest rocks are placed in the lower part. Under the weight of the upper layer of rocks, the lower podustup pushes through weak rocks and reaches a stable base. Therefore, when dumping strong rocks on the weak soil covering the bedrock, a high dump ledge can be stable without significant deformation of the dump surface.

A review of the literature on dump formation allows us to draw the following conclusion: the deformation of the dump slopes is not an obstacle to the construction of high dumps. Dangerous are deformations that cause sudden collapses of the upper working platform of the dump. Knowledge of the patterns of occurrence and manifestation of dump deformations in specific conditions allows you to ensure real safety of dump operations even in conditions of their deformations.

To study this topic, stability parameters and the maximum height of the rock pile were determined at the Central processing plant "Vostochnaya".

In the geological structure of the dump site, alluvial Quaternary deposits are represented by sandy loams, loams, medium-sized Sands, large and gravelly ones.

Table 1.

Physical and mechanical properties of the base soils obtained from different sources

Name of soil	Physical and mechanical properties for calculating bases					
	by bearing capacity			on deformations		
	Clutch	External friction angle	Specific weight	Clutch	External friction angle	Specific weight
Laboratory tests for shear according to ГОСТ 12248-78						
Sandy loam	0,009	26	2,01	0,013	27	2,02
Loam	0,008	22	1,98	0,014	23	1,99
Sand medium, large	0,007	32	1,94	0,01	35	1,94
Laboratory tests have been established for IGE-2						
Loam				0,033	32	2,06
Loam				0,050	29	1,76
Clay compacted sand				0,080	30	2,08

The resistance of piles depends mainly on physico-mechanical properties of rocks in the dumps and soils that produced by dumping, from the hydrogeological and climatic conditions of the area the formation of the blade.

In dumps, as a rule, heterogeneous rocks are stored, which are mixed during the dumping process, resulting in a qualitatively new mass with different properties than the original components.

Of the physical and mechanical characteristics of the dump mass, the bulk mass, the angle of internal friction of rocks, adhesion, and humidity are of paramount importance when calculating the stability of the dump slopes.

The results of the study of the composition and quality of the dumped dump masses performed by the laboratory at the Central processing plant "Vostochnaya" are given below:

- granulometric composition:
- class +20 mm – 26.04%;
- class 2-20 mm – 67.94%;
- class 0.5-2 mm – 6.02%;
- yield of volatile substances in the rock W-9.58%;
- content of combustible substances – 51,95%;
- sulfur content – 0,35%;
- humidity – 13-26%;
- ash content – 78,3%;
- weighted average volume weight – 1,6 t/m³.

The calculation of the stability factor of the base of the blade is solved using the formula:

$$H = \frac{c}{\gamma \cdot \tan \varphi} \left[\tan^2 \left(45^\circ + \frac{\varphi}{2} \right) e^{\pi \cdot \tan \varphi} - 1 \right], \text{ m} \quad (1)$$

where c - coupling of the base rock in the array, t/m²;

γ - volume weight of the breed, t/m³;

φ - internal friction angle of the rock, degrees;

H - maximum height of the blade according to the stability condition of the base, m.

To calculate the maximum height H of the dump using this formula, numerical values of the above physical and mechanical properties of rocks are required.

As follows from the description of the mining and geological conditions of the dump formation site, the most representative in terms of power among the lithological differences in the base of the dump is sand in sediments. Table 2 below shows the physical and mechanical characteristics of clay Sands averaged by calculated values under strain conditions.

Table 2.

Calculated maximum height of the blade according to the condition of physical and mechanical properties of the base rocks according to formula 1

Lithological type of rocks the base of the blade	Volume weight, t/m ³	Coupling in an array, t/m ²	Internal friction angle in the array	Maximum height of the blade, m
The compacted clayey sand (silt)	2.08	8.00	30	84

Taking into account that the dump is in operation for a long period and no noticeable deformations have been observed so far, it can be argued that the presence of a weak layer in the base does not significantly affect the stability of the dumps.

In addition, it is necessary to take into account the remark in the geological characteristics of the massif of the area of formation of the dump that the weak subsidence of the Foundation soils does not significantly affect the stability of the external rock dump.

Thus, the calculations performed (table 2) allow us to state that the maximum height of the external blade at the Central processing plant "Vostochnaya" by the factor of strength and shear properties of the array in the base can be taken to be about 85 m.

For the stability of the dumps under the conditions of the base state, it is necessary that the ultimate shear strength of the base rocks τ_{shifts} , expressed in t / m², is numerically not less than $0.4 * N$ (the height of the dumps), expressed in meters.

For the height of the blade $H=85$ m, the condition must be met:

$$[\tau_{shifts}] \geq 0,4 * 85 = 34 \frac{t}{m^2} = 0.34 \text{ MPa}$$

According to the "Rules for ensuring the stability of slopes in coal mines" (Annex 3), the adhesion in the sample (shear strength) for porphyrites is 6-9 MPa in the array, and taking into account the structural weakening of 0.7 is 1.12 MPa.

Thus, the condition for the stability of the blade according to this criterion is met.

As a result of the research work, the following parameters are set that are recommended for the operation of the blade.

According to the stable parameters of the blade:

- the maximum height of the blade, calculated according to the stability conditions of the base and the array of the blade itself, can reach 85 m;
- the recommended number of blade tiers is 3;
- recommended maximum width of a working platform of each tier 22 m; the height of the first layer 26 m, 31 m of the second, third tier 28 m, slope angle of 35° storeys. At these sizes, the total angle of the dump is 27°, the volume of stored rocks is 54 million m³;
- geomechanical calculations of the blade stability parameters are performed with a stability margin coefficient of 1.4 (standard 1.2).

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