Optimization of the ore flow quality characteristics in the quarry in road-rail transport

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Abstract
The article presents the results of science-based problem-solving to improve and create a technology of automated homogenization asbestos ore through the block-oriented approach to the formation of the ore pile. Using the results given in the work provides a solution to important applied tasks such as operational management of the quality of the ore fed to the benefication plant and solving of the important challenges in the field of rational development of the subsoil.

In quarries of medium and high capacity combination of road and rail transport is widely applied. It provides high and economical labor productivity
[1-3].

A characteristic feature of combined transport is their close interrelation. When loading ore through the homogenization stockpile from one mode of transport to another an important technological process is carried out. It connected with ensuring conformity of the quality characteristics of the raw materials outputted from the quarry to the beneficating processing requirements. Figure 1 is a graph of actual indicators of quality values of ore mined compared with the tolerances extremes standard of the enterprise in mining of asbestos in May 2009 at the enterprise JSC "Kostanay minerals".

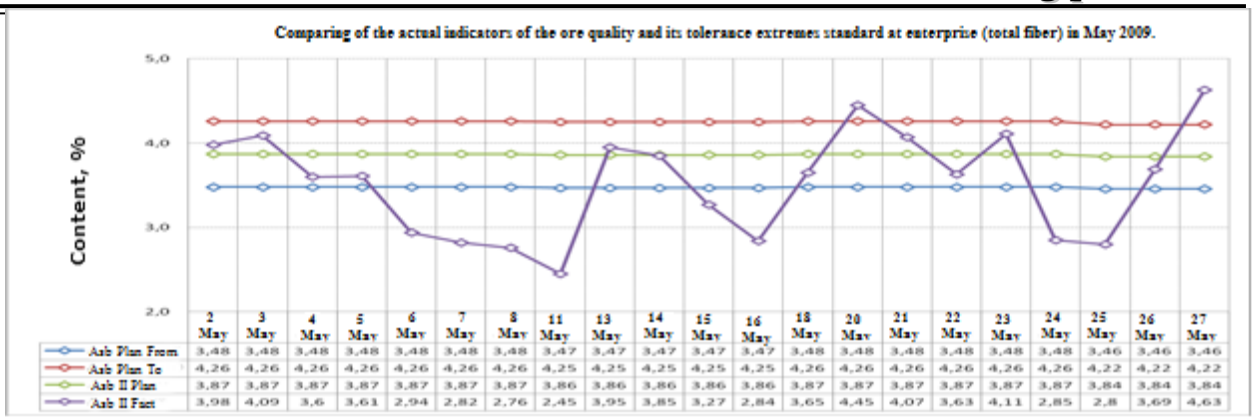


Figure 1. Actual indicators of the ore quality and its tolerance extremes standard at enterprise JSC "Kostanay minerals" in May of 2009.

As seen in Figure 1, the actual content of asbestos in the ore mined during the month is outside the corridor of acceptable values, and in the technological process on the benefication processing is set to a specific value of qualitative composition of processed minerals. Under these conditions, one of the ways to improve the technical and economic efficiency of the mining enterprise is a method, providing the stability of quality indicators and uniformity of the qualitative composition of the ore fed to the benefication processing.

In order to achieve these objectives within the framework of doctoral research work, a method of block-oriented ore pile forming for homogenization stockpiles and its software were developed [4].

Block-oriented ore pile forming on the stockpile consists of the passes, blocks, sectors and shown in Figure 2. As seen from the figure, passes form a block , the block forms the sector. The number of sectors is determined in accordance with the parameters of the using winning and transport equipment [5].

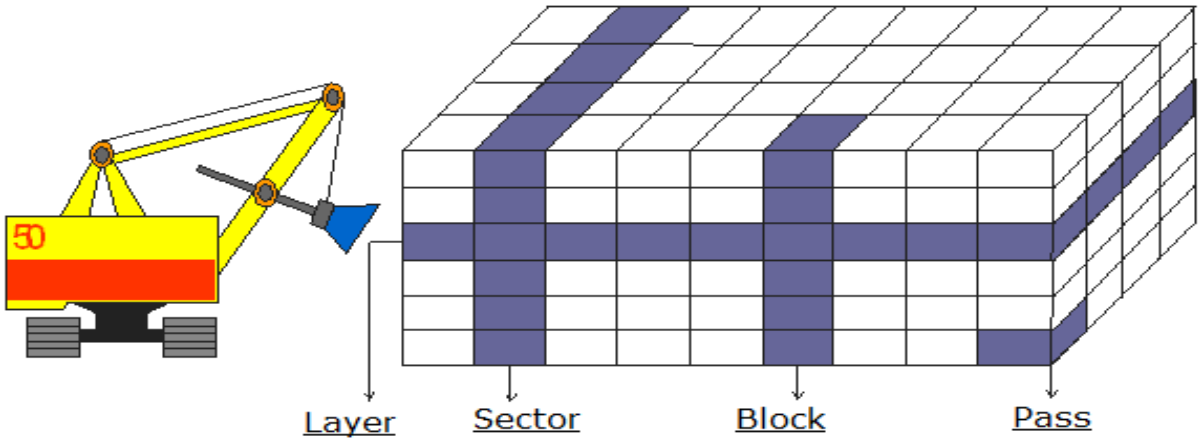


Figure 2. Block-oriented ore pile forming on the reload- homogenization stockpile

Stages of implementation of the quality characteristics accounting methods and the management of the ore production inside the quarries reloading- homogenization stockpile formation process are based on a clear identification of the item unloading ore. To identify the characteristic loading and unloading technical means of Automated monitoring and dispatching system «NetMOM» (ASMID «NetMOM») were applied, allowing to determine the location of a moving object with an accuracy of one meter.

The accuracy of positioning the quarries stockpile was reached on the basis of a new technological platform Nanotron and wireless Mesh-Network [6] [7]. Figure 3 shows the network infrastructure. The peculiarities of the application of this framework are:

- minimal error in positioning;

- possibility of using underground mining conditions in the positioning of transport and people;

- large network bandwidth.

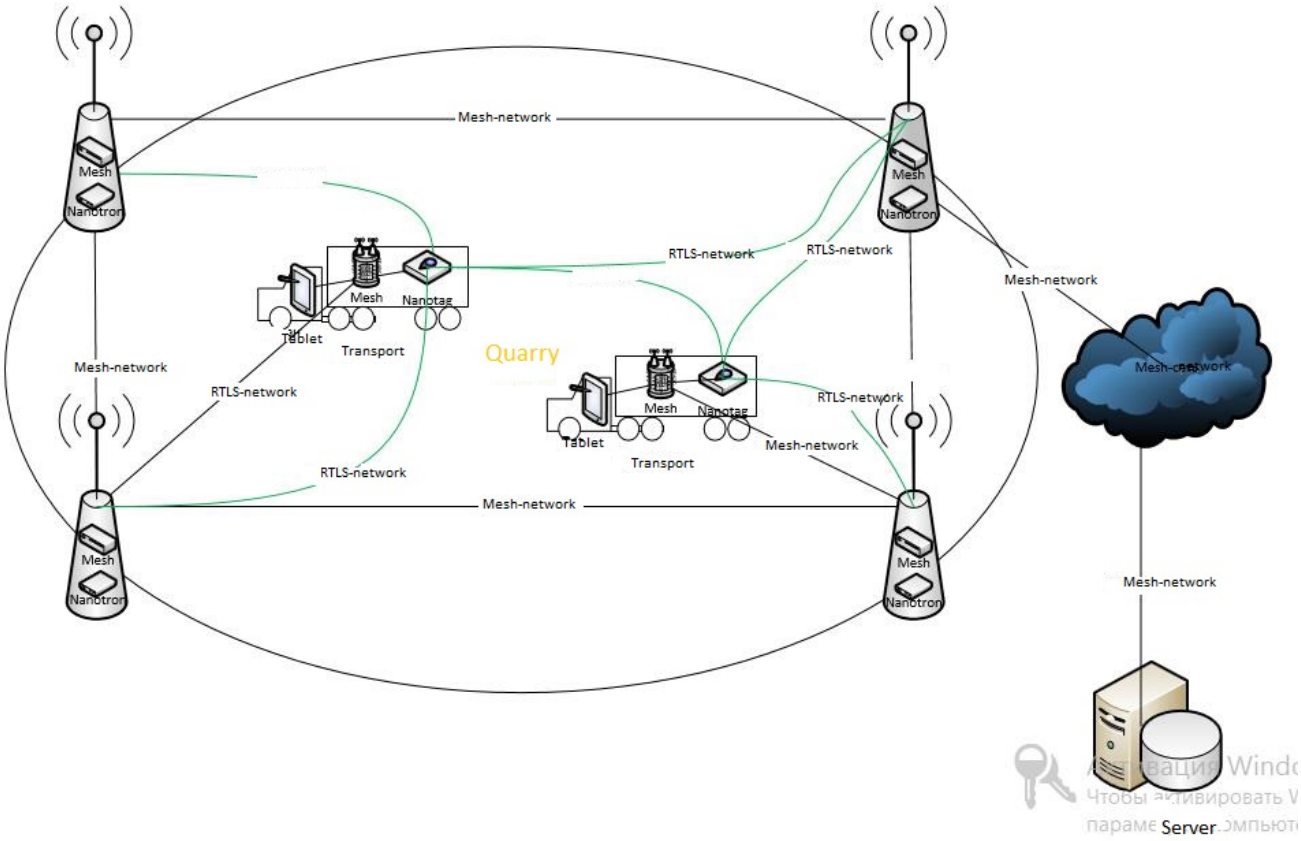


Figure 3. Network infrastructure of the system ASMIDA «NetMOM»

This information organization for movable objects, in turn, allows to accumulate information on the operational quality content of the ore being brought to the stockpile by dump truck. In ASMID «NetMOM» geologists introduce in an operative mode an information on mine faces, giving the volume, density and qualitative characteristics of the ore mass. When loading ore into dump truck this information is assigned to each dump truck and when getting the stockpile the system determines in automatic mode the location for unloading on the stockpile and forms information about the workload of the stockpile.

During the formation of the ore pile the variable quality settings of the forming block according to the allocation algorithm keep count (Figure 4).

In block 1 at the beginning of the shift master of ore-preparation works distributs and enters the information about mined face sections (planned volume and content in the mine).

In block 2 when loading dump trucks are assigned the value of the transported volume and content of useful component.

In block 3 the cycle of checking all sectors of the ore stockpile begins.

In block 4 a check on the filled sectors is carried out. If the sector is empty, it is assigned a sign “unloading” before unloading. These conditions make it possible to minimize the range of the useful component content during the homogenization.

In block 5 dump trucks is assigned a sign of discharge.

In block 6 the algorithm ends.

In block 7 a count of the number of unloading sectors is performed.

In block 8 a new cycle begins, checking the sectors according to serial numbers in the stockpile.

In block 9 a check on the search for the first unfilled sector takes place.

In block 10 the counting of the number of sectors ready for their use in the homogenization process is carried out.

In block 11 there is a calculation of the sectors quality characteristics.

In block 12 the checking of the number of sectors for unloading is carried out.

In block 13 a new cycle begins in the sectors according to the serial numbers in the stockpile.

In block 14 there is a check on the search for the best sector for unloading.

In block 15 the content is calculated in the sectors when mixed with the feed ore.

In block 16 there is a check for establishing the optimal unloading sector.

According to the information formed in block 15 sectoral comparison with the desired content is made and the most acceptable optimal option is considered [8].

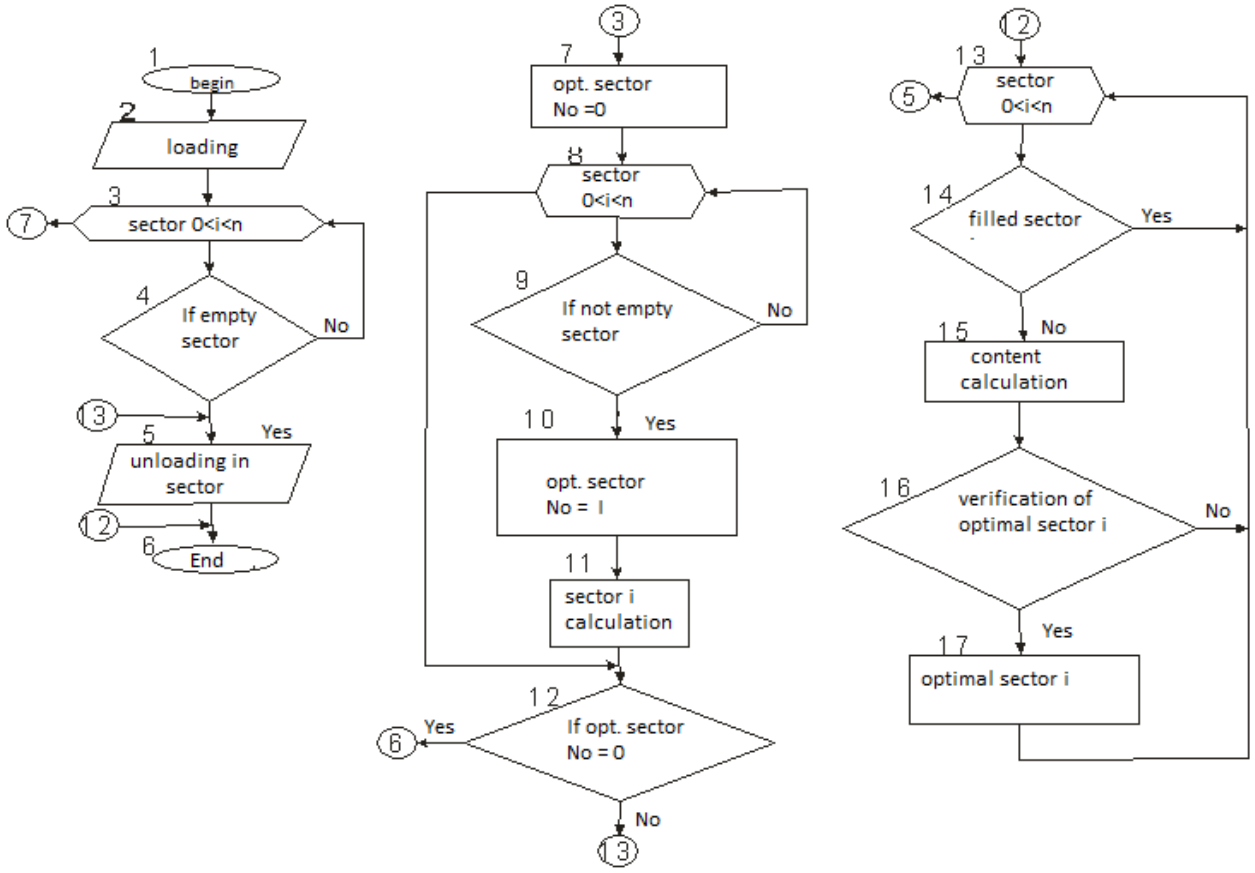


Figure 4. The homogenization organization works algorithm when implementing block-oriented approach

The information formation about the contents of the stockpile space at the beginning of the cycle of pile forming is implemented in the format of Table 1. In the last line the general data on the quantitative and qualitative content of each sector are formed, and the boundaries of a limited content in the sector are its available options.

Table 1. The stockpile content across sectors and blocks

block №	**Sector 1**	**Sector 2**	**Sector 3**	**Sector 4**	**Sector 5**	**Sector 6**	**Sector 7**	**Sector 8**	**Sector 9**
1	α ;m;v								
2									
3									
4									
Total in sector:									

The provided information according to ASMID «NetMOM» data are formed in accordance with Table 2.

Table 2. Status data forming

№	Event definition	Parking car number	Dump truck load capacity t.	Event time	Type of mined rock	Qualitative characteristics
1	Sector 1	№51	M=110	08.09.56	Ore	$\alpha = 3{,}2$
		№59	M=110	08.36.16	Ore	$\alpha = 4{,}7$
		№38	M=110	09.18.19	Ore	$\alpha = 4{,}1$
2	Sector …	№18	M=110	08.09.00	Ore	$\alpha = 3{,}2$
		№28	M=110	08.40.32	Ore	$\alpha = 4{,}7$
		№14	M=110	09.09.43	Ore	$\alpha = 4{,}1$
n	Sector n	№58	M=110	12.09.56	Ore	$\alpha = 3{,}9$

When feature of unloading in the sector being identified, it assigned unloading fact. All information in real time mode is displayed on the monitor computer in user system and stored in the database. Reporting form for the ore formation in the stockpile is shown in Table 3.

Table 3. Reporting form for the formation of the ore pile on reloading stockpile

Stockpile №04		Sector 1		Sector …		Sector …		Sector n	
Date	24.02.10	volume t.	content	volume t.	content	volume t.	content	volume t.	content
time	9:06	120	5,0						
time	9:33			120	4,5				
time	10:01					110	4,5		
time	10:10							120	5,0
time	10:41					120	1,5		
time	11:20	110	1,50						
time	11:29							110	1,5
time	12:08			120	4,5				
Sector workload		**230**	**3,326**	**240**	**4,5**	**230**	**2,935**	**230**	**3,326**
						The content of useful component in the pile:			**3,533**
									930

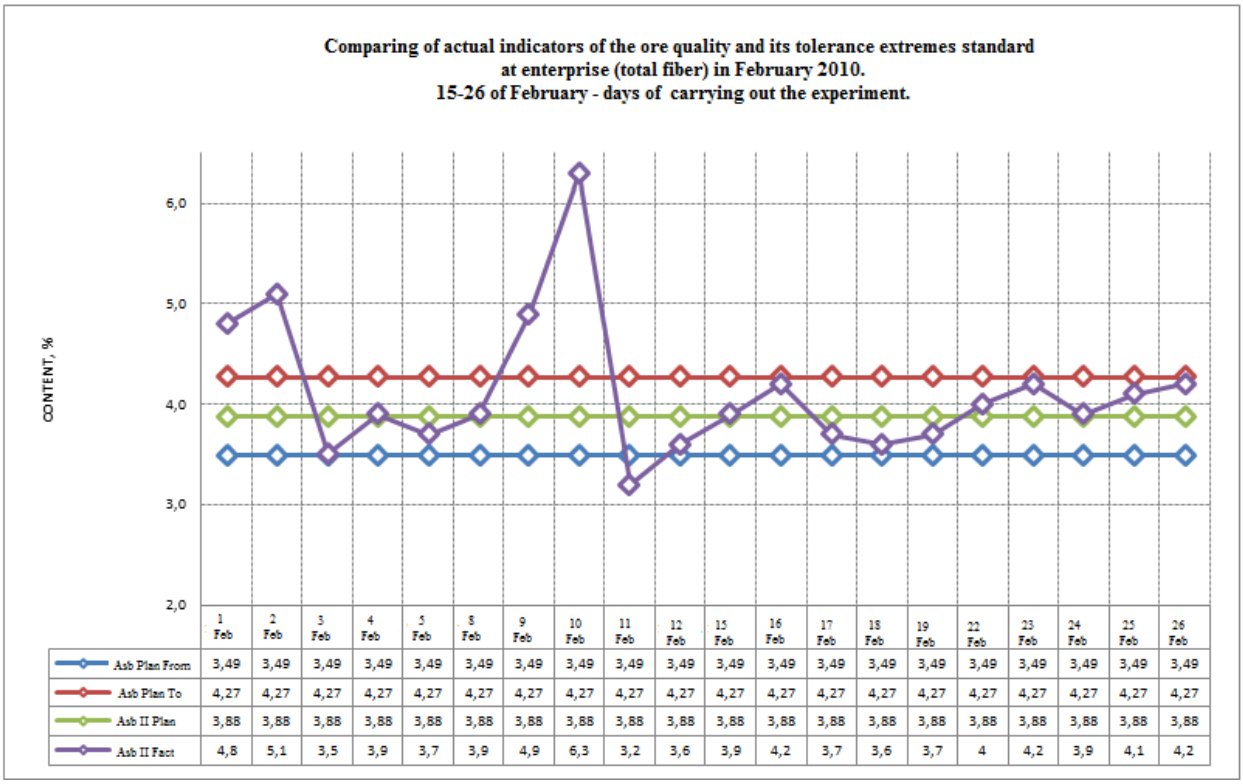
The implementation of block-oriented method for forming pile inside the quarry reloading-homogenization stockpile via developing software provides uniform qualitative composition of the ore in the stockpile even if unplanned exit from the operating status of the mining or transport equipment. This ensures the stability of the work on beneficiating plant. Moreover, using the method, one may solve the problems associated with not only the dispatch control but also with engineering supervision, such as:

- rational use of working time;
- control of technical operations, projects and mining plans;
- exploitation rates of machinery and organization of planned repair and maintenance of mining-transport equipment.

The developed method was tested in conditions of mining of asbestos at Zhitikarinsky quarry of JSC "Kostanay minerals". During the experiment seven excavators and nine dump trucks were involved in the work. Recalculation of planned and actual monitored indicators of mining works on volumes and quality characteristics of the ore during the shift and day were formed automatically. The information on the results of works is stored in the database. Tested the functionality of the monitoring system worked without failures and showed quite adequate result of what is happening in a quarry.
In the period (from 15 to 26 February 2010) the experimental formation of the ore pile at stockpile

with using a block-based approach, the actual quality parameters were within the tolerances of the standard enterprise α_f - the average actual content of asbestos was 3.93% at α_p - 3 88% (see Figure 5). [9]

The use of block-oriented method for forming ore pile inside the quarry on the homogenization-reloading stockpile significantly improved the performance of the beneficiating plant. So, in the benefication process of technological change in the performance of chrysotile fibers was registered, namely increasing the extraction fiber ratio by 1.5%, reducing fiber in tailings by 0.1%, and increasing the production of marketable chrysotile products of 3-6 groups by 1.1%, decreasing in power for processing ore took place etc. These developments had a positive impact on the general technical and economic indicators of the enterprise that improves the company competitiveness in the market of minerals consumers.



	1 Feb	2 Feb	3 Feb	4 Feb	5 Feb	8 Feb	9 Feb	10 Feb	11 Feb	12 Feb	15 Feb	16 Feb	17 Feb	18 Feb	19 Feb	22 Feb	23 Feb	24 Feb	25 Feb	26 Feb
Asb Plan From	3,49	3,49	3,49	3,49	3,49	3,49	3,49	3,49	3,49	3,49	3,49	3,49	3,49	3,49	3,49	3,49	3,49	3,49	3,49	3,49
Asb Plan To	4,27	4,27	4,27	4,27	4,27	4,27	4,27	4,27	4,27	4,27	4,27	4,27	4,27	4,27	4,27	4,27	4,27	4,27	4,27	4,27
Asb II Plan	3,88	3,88	3,88	3,88	3,88	3,88	3,88	3,88	3,88	3,88	3,88	3,88	3,88	3,88	3,88	3,88	3,88	3,88	3,88	3,88
Asb II Fact	4,8	5,1	3,5	3,9	3,7	3,9	4,9	6,3	3,2	3,6	3,9	4,2	3,7	3,6	3,7	4	4,2	3,9	4,1	4,2

Figure 5. The actual and allowable quality indicators and its tolerance extremes standard of asbestos in carrying out of the test-industrial experiment from 15 to 26 February of 2010.

Thus, the implementation of the proposed updated concept of ore preparation process is referencing to its new information basis provided the use of the operational monitor the work of the main mining equipment and realization of multi-level block-oriented approach in the formation of the ore pile to the homogenization-reloading stockpile.

Conclusion

During the period of the experimental formation of the ore pile at stockpile with using a block-based approach, the actual quality parameters were within the tolerances of the standard enterprise (α_f - the average actual content of asbestos was 3.93% at α_p - 3 88%).

The extraction fiber ratio in tailings increased by 1.5%. The fiber reduced in tailings by 0.1% and the production of marketable chrysotile products of 3-6 groups increased by 1.1%, the decreasing in power for processing ore took place etc.

These developments had a positive impact on the general technical and economic indicators of the enterprise that improves the company competitiveness in the market of minerals consumers.

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