Dependence of the Duration of Salvage Activities on the Location of the Salvage Chamber Relative to the Previously Extracted Longwall Panel

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Abstract. Longwall salvage activities at JSC SUEK-Kuzbass underground coal mines may experience unforeseen delays. To determine the causes of the delays in the salvage activities, we have considered various factors. Firstly, we have analyzed the effect of the longwall face width on the duration of salvage activities. We have proved that this factor does not have a statistically significant effect on the duration of salvage activities. We have established that the duration of the salvage activities is determined by the location of the salvage chambers relative to the pillar and the previously extracted panel. In the event that contiguous previously extracted panel is located near the salvage chamber, the salvage time is doubled on average.

1 Introduction

The longwall mining system for mining coal seams is the most productive system. However, in some cases, during installation and salvage activities, an unexpected increase in salvage time may occur. A preliminary analysis of the salvage activities at SUEK-Kuzbass mines shows that over the last 8 years, the total number of days in excess of the standard for longwall equipment transfer amounted to more than 900 days. Therefore, reducing the time for the longwall face transfer to improve the efficiency of the mining system as a whole is a topical problem.

The findings of studies of underground stress in longwall mining systems, as well as problems of equipment salvage, are discussed in the publications [1-11]. To identify the specific causes of the unexpected delays in the longwall equipment salvage activities, in this article we analyze the operation of SUEK-Kuzbass mines operating in gently dipping seams in 2008–2018.

2 Methods

In this article we use methods of statistical analysis to establish factors affecting the duration of the salvage activities.

3 Findings

Salvage activities can be divided into two components: 1) the bolt-up phase (formation of the salvage chamber); and 2) longwall face equipment salvage (shearer, armored face conveyor (AFC), stage loader (BSL), crusher) and roof supports. Table 1 shows the average annual salvage performance in 2011–2018 at SUEK-Kuzbass mines.

Table 1. Average performance of longwall salvage activities at SUEK-Kuzbass mines, 2011-2018.

Year	No. of salvages	Average face width (m)	Bolt-up time (days)	Salvage of shearer, AFC and roof supports (days)	Total salvage time (days)	Days in excess of salvage standard
2011	11	237	18	55	73	99
2012	13	251	21	56	77	169
2013	10	276	21	59	80	160
2014	9	253	28	50	78	126
2015	10	239	23	57	80	160
2016	12	279	22	46	68	48
2017	6	273	22	44	66	12
2018	6	303	23	64	87	138

The number of days in excess of the longwall salvage standard ranges from 12 to 169 days per year. Thus, over the last 8 years, the total number of days in excess of the longwall salvage standard amounted to more than 900 days.

At the first investigation phase, we analyzed the effect of the longwall face width on: 1) the bolt-up phase; 2) the AFC, BSL and roof support salvage time; and 3) the total time of salvage activities. Graphs showing trends in these parameters are shown in Figure 1.

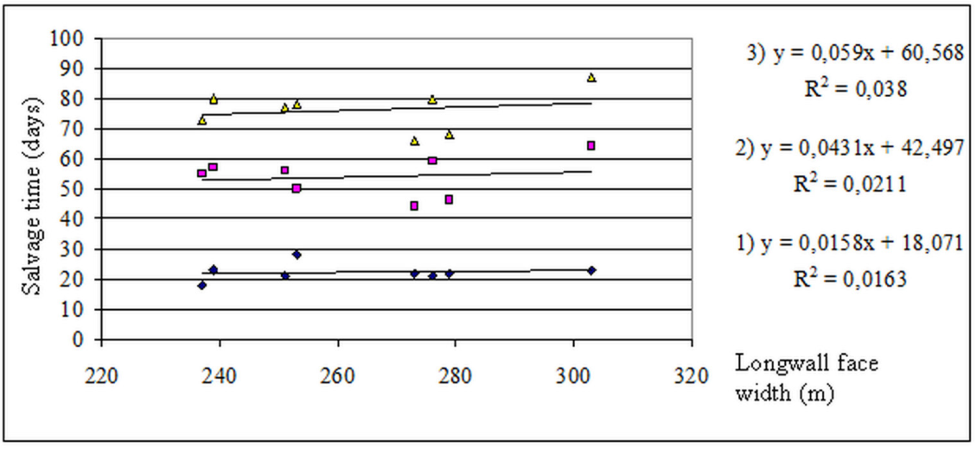

Fig. 1. Time trends for: 1) bolt-up; 2) salvage of AFC, BSL and roof supports; and 3) total salvage time.

We established regression equations showing the relation between the longwall face width and: 1) bolt-up time; 2) the AFC, BSL and roof support salvage time; 3) the total time of salvage activities. These equations are shown in Figure 2.

By using mathematical statistics techniques we managed to check whether there is any relationship between these factors. If the number of experiments is n=8, the critical value of R2=0.499 [11]. Since the estimated values of R2 are below the critical value, we conclude that the longwall face width between 230 m and 300 m has a minor effect on the duration of salvage activities.

While searching for factors determining the duration of salvage activities, we examined the location of the salvage chambers relative to the pillar and the previously extracted panel. We divided salvage chambers into three categories (see Figure 2):

1 – within a pillar;
2 – in line with the contiguous panel;
3 – next to the goaf of the previously extracted panel.

Table 2 shows data on salvage activities at Kirova mine. It shows the number designations of previously extracted panels along with their face width and height as well as salvage time including time for: bolt-up; shearer, AFC, BSL and roof support salvage; and the total salvage time.

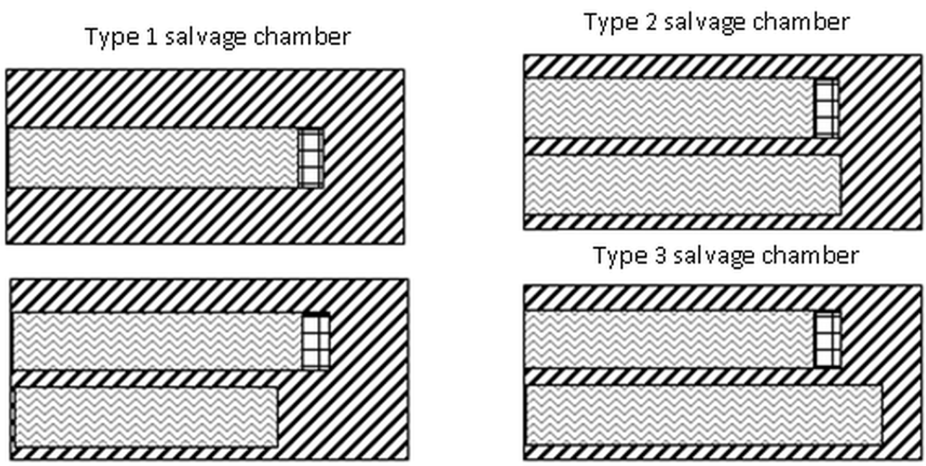

Fig. 2. Types of salvage chambers established by using the longwall face equipment.

To ensure that the comparison of time requirements is valid, the width and height of the longwall face have to be considered. Therefore, the table below shows the values of specific labor input, estimated by dividing the corresponding indicator by the width and height of the longwall face.

Table 2. Longwall salvage performance at Kirova mine.

№	Longwall number	Face width (m)	Face height (m)	Salvage time (days)			Specific labor input (days/m2)			Salvage chamber type
				Bolt-up	Face salvage	Total	Bolt-up	Face salvage	Total	
1	2590	240	2.06	9	23	32	0.018	0.047	0.065	1
2	2451	240	2.24	4	27	31	0.007	0.050	0.057	1

3	2452	240	2.33	8	14	22	0.014	0.024	0.038	1
4	2453	240	2.29	10	28	38	0.019	0.052	0.071	1
5	2454	240	2.32	8	37	45	0.014	0.063	0.077	1
6	2592	240	2.13	19	14	33	0.037	0.027	0.065	1
7	2593	240	2.18	15	23	38	0.029	0.044	0.073	1
8	2455	240	2.47	10	52	62	0.017	0.087	0.104	1
9	2456	245	2.4	35	34	69	0.061	0.059	0.120	1
10	2594	240	2.0	33	28	61	0.069	0.058	0.127	1
11	2458	300	2.35	15	31	46	0.021	0.044	0.065	1
12	2459	300	2.62	15	14	29	0.019	0.018	0.037	1
13	25101	300	2.05	23	33	56	0.037	0.054	0.091	1
	Average value for Type 1 salvage chamber						**0.028**	**0.048**	**0.076**	
14	2591	200	2.08	18	24	42	0.043	0.058	0.101	2
15	2457-1	245	2.05	14	34	48	0.028	0.068	0.096	2
16	2457-2	245	2.05	15	36	51	0.030	0.072	0.102	2
17	2595	300	2.03	20	41	61	0.033	0.067	0.100	2
	Average value for Type 2 salvage chamber						**0.033**	**0.067**	**0.100**	
18	2596	300	2.23	16	42	58	0.024	0.063	0.087	3
19	2461	300	2.26	34	64	98	0.050	0.094	0.145	3
	Average value for Type 3 salvage chamber						**0.037**	**0.079**	**0.116**	

At Kirova mine, Types 1, 2 and 3 salvage chambers were used. These are grouped in the table above, and the average specific labor inputs have been calculated for them.

The table shows that the average specific labor inputs for Type 1 salvage chambers were: 0.028 days/m2 for the bolt-up; 0.048 days/m2 for roof support salvage; 0.076 days/m2 for the entire salvage operation.

For Type 2 salvage chambers, these indicators are: 0.033; 0.067 and 0.10 days/m2, respectively.

For Type 3 salvage chambers, the specific labor inputs are: 0.037; 0.079 and 0.116 days/m2, respectively.

So there is a difference between the specific labor inputs during salvage activities, depending on the type of salvage chamber. For Type 1 chambers, the specific labor inputs are the lowest.

We did a similar analysis for Komsomolets mine, Polysaevskaya mine, and Rubana mine.

The findings for all of the mines under investigation are shown in Table 3. The table shows the average specific labor input associated with the bolt-up, salvage of the shearer, AFC, BSL and roof supports and the total time for the three types of salvage chambers. Type 1 salvage chamber has been selected as the best option. For the other types of salvage chambers, the specific labor input is shown as a percentage variance from the corresponding indicators for Type 1 salvage chambers.

Table 3. Analysis of specific labor input into salvage activities.

№	Salvage chamber type	Specific labor input					
		Bolt-up		Face equipment salvage		Total	
		days/m2	Variance from Type 1	days/m2	Variance from Type 1	days/m2	Variance from Type 1
		Kirova mine					
1	1	0.028		0.048		0.076	
2	2	0.033	+18%	0.067	+40%	0.100	+32%
3	3	0.037	+32%	0.079	+65%-	0.116	+53%
		Komsomolets mine					
4	1	0.028		0.046		0.074	
5	2	-	-	-	-	-	-
6	3	0.032	+14%	0.082	+78%	0.114	+54%
		Polysaevskaya mine					
7	1	0.034		0.062		0.096	
8	2	0.038	+12%	0.071	+15%	0.109	+14%
9	3	0.166	+388%	0.251	+254%	0.417	+283%
		Rubana mine					
10	1	0.032		0.066		0.098	
11	2	0.029	-9%	0.058	-12%	0.087	-11%
12	3	0.045	+41%	0.144	+118%	0.189	+93%
		Average for all mines					
13	1	0.029		0.053		0.082	
14	2	0.035	+21%	0.067	+26%	0.102	+24%
15	3	0.052	+79%	0.123	+132%	0.175	+113%

The analysis of average values for all four mines shows that the lowest average labor input is associated with the bolt-up of Type 1 salvage chambers. The bolt-up of Type 2 salvage chambers shows an increase in the average labor input by 21%. The bolt-up of Type 3 salvage chambers shows a sharp increase in the labor input by 79%.

Similarly, the lowest labor input into salvaging the longwall face equipment is associated with Type 1 salvage chambers. In Type 2 salvage chambers the labor input increases by 26%, and in Type 3 salvage chambers – by 132%.

The total labor input associated with salvage activities increases by 24% in Type 2 salvage chambers and by 113% in Type 3 salvage chambers relative to Type 1 salvage chambers.

4 Conclusion

1. Analysis of the status of salvage activities at SUEK-Kuzbass mines shows that reducing the duration of face equipment transfer is a topical problem. Over the last 8 years, the total number of days in excess of the longwall face transfer standard amounted to more than 900 days.
2. As a single factor, the considered longwall face width ranging from 230 m to 300 m has a minor effect on the duration of salvage activities.
3. The duration of salvage activities depends on the location of the salvage chamber (see Figure 1).
4. The most favorable conditions for salvage activities are ensured when the salvage chamber is located inside a pillar (Type 1).
5. In the event that the contiguous previously extracted panel is located near the salvage chamber, the salvage time increases. Moreover, if the longwall face finish lines of the adjacent panels are in line with each other, the specific labor input increases by 24% (Type 2 salvage chamber location).
6. The most adverse salvaging conditions occur if the salvage chamber is located next to a contiguous previously extracted panel. The goaf within this panel has an extremely negative effect on the roof of the salvage chamber being formed (Type 3), and more than doubles (on average) the duration of salvage activities.

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