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Review paper

INJURIES FREQUENCY OF EMPLOYEES IN UNDERGROUND COAL MINES IN SERBIA

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Abstract: The work in underground coal mines is one of the most difficult activities. General characteristic of working condition these mines are contained in the fact that all coal mines are in the low mechanized level which produce heavy manual work, low productivity and high financial costs. High risk level of injuries and occupational diseases are special problems in these working conditions. The workers disability is also huge problem. All of these produce a production and financial loses. Based on a comprehensive overview of the natural and geological conditions in the coal seams, technical and technological solutions for exploitation in active mines and injuries analysis in this paper, the frequency of injuries with the basic influencing parameters for the period 2014-2016 is given. In the analysis of this topic, the methods of analysis and synthesis were mainly used, and real parameters were obtained and from them high quality conclusions were coming out.

Keywords: coal mine; coal; injuries; safety and health at work;

1 INTRODUCTION

In underground coal mines in Serbia, which are organized as a state-owned company PE PEU - Resavica, exploitation of quality anthracite, bituminous coal and lignite is carried out. Currently, eight coal mines are active with 11 underground productive units which are located in western, central and eastern parts of the country. The main characteristic of underground coal mining is the mutual coherence and cohesion in time and space of the main working processes starting from exploration, opening, development, excavation hauling and hoisting to the following processes such as ventilation, dewatering etc. Human work is included in all of these phases and high risk level of injury is also attendant.

The general characteristics of underground coal mines, including working conditions and high risk level of injuries during the working processes, are (Ćurčić et al., 1981):

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- Working operations of coal excavation process are performed in the underground mining drifts with limited work space;
- The mining drifts and crosscuts are exposed to constant influence of mine pressure and the employees are also exposed to potentially dangerous of working space collapses, the fall of coal and overburden from the sides and roof;
- Geological conditions of exploitation and applied technical solutions cause separation of congestion, toxic and explosive gases and dangerous and harmful concentrations of coal dust.
- Potential possibilities for irruption of large amounts of water and sludge into underground mining facilities that can cause sinking of mines and employee injuries.
- The possibilities to provide and changing clean air are difficult in mining drifts;
- The employees in the coal mines are exposed to the influence of higher temperature differences in different parts of mine and other unfavorable ergonomic conditions;
- There are potential possibilities for the occurrence of endogenous and exogenous fires in the coal mines, which can lead to mining disasters, group or individual injuries;
- Limited lighting possibilities of mining drifts may be potential causes of injuries;
- Exposure of workers to the harmful effects of noise and vibration, which is the cause of occupational diseases.

These characteristics make work under conditions of underground exploitation particularly harmful and dangerous to the life and health of workers, resulting in personal and collective cases of injuries and occupational diseases. The most important research on the topic of injuries in coal mines in Serbia was done by Stojadinović et al. (2012). Injuries for a 10 years period in PE PEU were analyzed in this paper.

This work will result from the fact that in the meantime, the mines have introduced new legal acts and measures that have been implemented based on them, among which the most important Risk Assessment Workplace Act. This led to a significant reduction in the number of injuries on mines.

2 INJURIES OCCURENCE IN COAL MINES

When solving the problem of protection and safety of work in underground coal mines it is necessary to analyze in detail the natural and technical-technological conditions and to evaluate the possible negative effects on the functioning of the work process and the emergence of potential hazards to the safety and health of employees.

According to the current law dealing with occupational safety and health at work, accidents at work are any injury caused by immediate and short-term physical, chemical or mechanical action, as well as injuries caused by sudden changes in the physiological state of the organism, when this injury is causally related to the performance of work on specific workplace. Related to the concept of an accident at work is the concept of an mishap at work, and he represents an unplanned, unforeseen, unwanted and uncontrollable events, which may result in injury or property damage, or both.

A dangerous event is the unsafe contact of a man with a material factor, or the harmful effect of a material factor on man, which occurred in connection with the performance of the work during which the employee was injured. Knowing the type of dangerous event determines the immediate causes or circumstances related to the site where the injury occur, which directly acted on its occurrence.

In the case of mining accidents, there are usually several causes that have occurred in some order, so that at least one immediate and a number of indirect causes are affected by the injury.

3 FREQUENCY ANALYSIS OF INJURY AND CHARACTERISTICS OF INJURIES

In order to show the frequency of injuries of employees in underground coal mines in Serbia, numerous documentary sources have been used: reports on injuries in mines, annual reports on the state of safety and health at work, expert analysis of serious and fatal injuries, reports on the work of the mines (monthly and annual), both in underground mining units and mines, as well as in total for all mines in the company JP PEU - Resavica. The data (JP PEU, 2016; Ivković, 2010, 2012) were selectively collected, and then systematized by key factors and then analyzed in detail and calculated the basic parameters of the injuries. In addition to the presentation of the key parameters of the frequency of injuries, the causes and sources of injury were specifically addressed, with a correlation with the locations of the injuries.

The cause of the injury is the irregular procedure, that is, the action of workers in the conditions of existence of a particular danger, while the source of the injury is defined as an objective or subjective factor (object, matter, person, place, which occurs at the place of the injury or in its adjacency and contains defects, etc.) which resulted in an injury to the employee. In practice, sources or cause of the injuries are wrong identified or incorrectly stated, and the quality of the injury analysis depends on the experience of the person who performs the analysis and its knowledge of the technological process and theoretical knowledge of the occurrence of the injury.

The paper also presents the working day losses due to sickness, both caused by injuries and illnesses, and a comparison with the productive working days.

Table 1 Injuries by mines that are the subject of analysis

Year	MINE										
	Vrška Čuka	Ibarski rudnici	Rembas	Soko	Bogovina	Jasenovac	Lubnica	Štavalj	Aleksinac	Administration	Total
2014	7	8	139	93	17	24	17	51	78	1	435
2015	8	10	171	85	16	31	28	66	81	0	496
2016	6	13	119	68	21	18	43	59	57	1	405
Σ	21	31	375	246	54	73	88	176	216	2	1336

The largest number of injuries, in the observed period (table 1), occurred in RMU "Rembas", considering that in this mine, mining works are performed in 3 underground mining units, and this mine has the largest number of employees. After Rembas, in Aleksinac mines there is also a high number of injuries. This is the result of more intensive work and the application of a drilling and blasting system of making drifts, because their workers work exclusively in the drifts making.

Table 2 Summary view of injuries by category

Year	Categories of injuries			
	Light injuries	Heavy injuries	Fatal injuries	Total
2014.	394	40	1	435
2015.	450	46	0	496
2016.	350	55	0	405
Σ	1194	141	1	1336

Out of the total of 1,336 injuries that occurred in the observed period, 1194 injuries were categorized as light, with a percentage share of 89.3% in the total number of injuries.

Table 3 Injuries rates according to qualification structure

Year	Injuries qualification structure						
	NK	PK	KV	VKV	SSS	VSS	Total
2014.	151	74	186	12	11	1	435
2015.	168	72	231	5	19	1	496
2016.	143	69	177	4	8	4	405
Σ	462	215	594	21	38	6	1336

According to the qualification, the highest number of injuries is recorded in qualificate workers group, with a share in the total number of injuries of 44.4%, table 3. Such a trend of injuries is expected given that coal excavation is done by qualified miners, and they are exposed to the highest risk of injury. Unskilled workers are mainly engaged in the delivery of the necessary material, which is usually performed manually in the excavation area and preparation crosscuts.

Table 4 Injuries rates according to workers age structure

Year	Age							
	20-25	25-30	30-35	35-40	40-45	45-50	50 and more	Total
2014.	41	54	72	77	85	57	49	435
2015.	36	68	83	79	105	63	62	496
2016.	26	55	72	70	70	64	48	405
Σ	103	177	227	226	260	184	159	1336

Interesting is the analysis of the number of injuries according to the age structure where the highest number of injuries was recorded to the workers who have over ten years of work experience, Table 4. This generation of workers relaxed and without fear accessing to the working activities, therefore they are less cautious and therefore exposed to the highest risk of injury. Workers with a working experience of up to five years approaching with their work tasks with great care, so the number of injuries in this category is lower. Workers who have several years to retire are also behaving the same way.

Table 5 Injuries by days of the week

Year	Day of the week							
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
2014.	71	68	75	58	56	46	61	435
2015.	80	80	63	88	70	51	64	496
2016.	78	59	54	68	69	39	38	405
Σ	229	207	192	214	195	136	163	1336

From the Table 5 can be seen that the day of the week does not have any effect on the occurrence of injuries.

Table 6 Injuries by working shifts

Year	Working shift			
	I	II	III	Total
2014.	201	132	102	435
2015.	222	154	120	496
2016.	171	153	81	405
Σ	594	439	303	1336

The number of injuries in the 1st shift is the largest (44.4%), considering that the most of service jobs are carried out in the 1st shift, and that in the first shift works the most workers.

Table 7 Injuries according to hours of work in shifts

Year	Hours of work in shifts								
	1	2	3	4	5	6	7	8	Total
2014.	20	52	74	68	88	78	41	14	435
2015.	37	61	86	77	93	90	35	17	496
2016.	26	46	74	87	64	59	33	16	405
Σ	83	159	234	232	245	227	109	47	1336

The first and last two hours in shift are for hours with the lowest number of injuries. In these parts of the shift there preparatory and final operations are performed at the work sites. Therefore, the number of injuries is the smallest, while in the production part of the shift from the third to the sixth working hour the greatest number of injuries is occurred.

Table 8 Injuries according to the injured parts of the body

Year	Injured part of the body								
	Head	Arm	Leg	Internal organs	Eye	Spine, back	Face	Other	Total
2014.	24	167	154	4	16	28	9	33	435
2015.	25	187	182	3	14	31	13	41	496
2016.	29	155	140	2	6	31	11	31	405
Σ	78	509	476	9	36	90	33	105	1336

It is extremely high number of injuries of extremities (hands, feet) in percentage 73% in the total number of injuries.

Table 9 Injuries by source of injury

No.	Source	Year			Σ
		2014.	2015.	2016.	
1.	Slippy hauls floor	83	61	56	200
2.	Elements of the timber	45	118	51	214
3.	Piece of coal	105	90	87	282
4.	Piece of overburden	41	71	66	178
5.	Manual tools	13	12	13	38
6.	Parts of the chain conveyor	30	16	8	54
7.	Chain	2	1	0	3
8.	Nail	4	6	12	22
9.	Rope driven monorail	30	19	7	56
10.	Ele. motors and equipment	11	21	46	78
11.	Drilling tools	1	0	0	1
12.	Bunker	1	3	0	4
13.	Lifting of ballast	2	1	2	5
14.	Lime milk	1	1	0	2
15.	Steel support segment	53	28	25	106
16.	Plank	3	3	0	6
17.	Wire	2	0	0	2
18.	Steel door	1	0	0	1
19.	Belt conveyor	1	32	8	41
20.	Ventilation door	1	0	0	1
21.	Chain crane	1	4	7	12
22.	Lathe	1	0	0	1
23.	Fall from height	3	4	7	14
24.	Motor vehicle	0	2	3	5
25.	Coal dust	0	1	0	1
26.	Boiler, pressure vessels	0	1	1	2
27.	Sports hall	0	1	0	1
28.	Radiator	0	0	1	1
29.	Pump	0	0	1	1
30.	Timber segment	0	0	2	2
31.	Mining wagon	0	0	1	1
32.	Steel hook	0	0	1	1
33.	Total:	435	496	405	1336

According to the source of the injuries, the largest number of injuries occurred after fall pieces coal or overlaying rocks. Also, injuries from heavy objects carried through the mine are also dominant (arched support segments, segments of chain conveyor) as well as parts of rope driven monorail to which the cargo is delivered to the mine, table 9.

Table 10 Injuries by causer of injury

No.	Causer of injury	Year			Σ
		2014.	2015.	2016.	
1.	Carelessness at work	373	409	297	1079
2.	Carelessness during the walk thru the mine	33	31	39	103
3.	Sudden drop of coal, waste	14	17	21	52
4.	Suddenly craking the keys	1	0	0	1
5.	Ignoring Guidelines for the work	5	14	27	46
6.	Breaking of screw	1	1	0	2
7.	Unused protection equipment	2	2	3	7
8.	Device breakdown	2	0	0	2
9.	Unsafe work site	4	14	14	32
10.	Inattention another worker	0	3	2	5
11.	Slippery tread	0	2	0	2
12.	Suddenly breaking the hose	0	1	0	1
13.	Uncontroled delivery system	0	1	0	1
14.	Sudden activation of manual drilling equipment	0	1	0	1
15.	Sadenly breakig of the delivery conteiner	0	0	1	1
16.	Sadenly breakig of overlapping clamp joint	0	0	1	1
17.	Total:	435	496	405	1336

Table 11 Number of day lost arising from injuries and occupational illness per year

Year	Days lost due to injuries			Days lost due to the occupational illness			Total days lost		
	Up to 30 days	Over 30 days	Total	Up to 30 days	Over 30 days	Total	Up to 30 days	Over 30 days	Total
2014.	12530	4245	16775	41068	9660	50728	53598	13905	67503
2015.	13892	6297	20189	45510	10758	56268	56603	17055	76457
2016.	13180	7241	20421	51532	11803	63335	60887	19044	83756
Σ	39602	17783	57385	138110	32221	170331	171088	50004	227716

Tables 11 show the days lost due to injuries and illness. In state-owned enterprises, illnesses and injuries are often used for longer absence from work than necessary, so the data in these tables are based on existing data, but do not represent a realistic picture of absence from the work as a result of occupational illness or injury.

Table 12 Days lost due to injuries vs. works shift which were done

Year	Days lost due to injuries or illness			Works shift which were done			%		
	underground	outside	total	underground	outside	total	2/5	3/6	4/7
1	2	3	4	5	6	7	8	9	10
2014.	52327	15176	67503	475735	282771	758506	11	5,4	8,9
2015.	60458	15999	76457	483537	279175	762712	12,5	5,7	10
2016.	66873	16883	83756	496670	277420	772090	13,5	6,1	10,8
Σ	179658	48058	227716	1455942	839366	2293308	12,3	5,7	9,9

Table 13 Indicator of injuries

Year	Number of injuries	Production (t)	Works shift which were done	Number of injuries	
				per1000 t	per 1000 shiftss
2014.	435	565229	758506	0,76	0,57
2015.	496	560651	762712	0,88	0,65
2016.	405	453413	772090	0,89	0,52
Σ	1336	1579293	2293308	0,84	0,58

The methods which are used for coal mining in Serbia's mines are at a very low technological level with a large part of manual work. This is also shown by this analysis (Tables 12 and 13) where a large number of injuries can be noticed in relation to the amount of coal excavated. The introduction of mechanization in the development of the mine and preparation drifts and for coal excavation, as well as the additional training of workers would lead to a reduction in the number of injured workers.

4 CONCLUSION

On the basis of the conducted research it follows that injuries at work are a constant companion of exploitation work in underground mines in Serbia, and that their cause is related to natural and technological solutions for the works on coal excavation. The frequency of injuries is expressed and a special problem is the high level of serious injury, which results in a longer sick leave and a certain degree of disability.

As the injuries have multiple negative impacts, it is imperative that mandatory safety measures are applied and consistently control their application in order to reduce the number of injuries. In addition, it is inevitable to modernize the technological phases of the underground exploitation process by strengthening the introduction of mechanized equipment, devices and plants in order to reduce the contribution of hard physical work and lead to a secure and safer work. The fact arising from the analysis is that injuries are caused mainly by carelessness and insecurity, which again indicates a low level of

technological discipline and training of workers. The high frequency of injuries caused by excavation activities requires the modification and changing of existing excavation methods, ie the reduction of the share of manual work on excavation, the development works and the delivery of materials. This can be effectively solved by the introduction of continuous miners or by introducing longwall excavation in parts of the deposit, where natural - geological conditions allow it.

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