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DIAGNOSTICS OF MINE HOISTING SYSTEMS AT MINES OPERATING IN ROCK SHEAR ZONES

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Abstract. The paper considers the issues of diagnostics of the “hoisting vessel - reinforcement” systems at mines under the rock shear influence on the operational condition of vertical hoisting shafts. The purpose of these works is to improve the technical condition of the mine hoisting complexes in such conditions to increase their reliability and hoisting speed, to significantly increase the volume of minerals produced to the surface as the main indicator of mine productivity. The rock shear causes the risk of loss of stability of the shaft massif, which causes its displacement during long-term operation and leads to a violation of the vertical shafts geometry. The curvature of the shaft walls affects the buntons and conductors of rigid reinforcement and leads to their deformation and relaxation of the embedment in the shaft reinforcement, which creates emergency and hazardous situations during the movement of hoisting vessels. The results of studies of the dynamic state of the “hoisting vessel - reinforcement” system are presented for the conditions of rock shear on the example of vertical shaft of a Ukrainian mining enterprise. We analyzed the distribution of force load in the sections of the examined shaft, calculated the safety margins of the reinforcement elements with an assessment of risk factors, and determined the technical condition of the shaft reinforcement with recommendations for its improvement. During the test, methods were used to manage the operational condition of mine hoisting equipment based on modern technologies and technical means of computerized rapid diagnostics of existing equipment. Based on the results of the shaft inspection, recommendations are provided to improve the safety of its operation in conditions of rock shear. This is the basis for developing repair plans and determining the order of their implementation in accordance with the annual mining plan of the enterprise. The expected results will make it possible to move to a qualitatively new level of safety management of mine hoisting in coal and ore shafts and optimize repair and restoration work in risky conditions during long-term operation of the hoisting shafts.

Keywords: mine hoisting, shafts, vessel, reinforcement, conductors, buntons.

1. Introduction

The development of scientific basis for reliable control of operational safety of mine hoisting complexes based on modern means and technologies of computer rapid diagnostics of existing equipment has been carried out by the Poliakov Institute of Geotechnical Mechanics of the National Academy of Sciences of Ukraine since 1995 and is currently being adapted to the conditions of specific mining enterprises of Ukraine in accordance with [1].

The purpose of these works is to improve the technical condition of the equipment of mine hoisting complexes to increase their reliability and hoisting speed, and to significantly increase the volume of minerals produced to the surface as the main indicator of mine productivity. Using the technology of diagnostics of mine hoisting complexes with hardware control of the smooth movement of hoisting vessels, more than 650 compartments in almost 100 shafts at 17 mines in Ukraine have been examined.

It has been shown that in a number of Ukrainian coal mining enterprises shafts are working in rocks that are more prone to shears during the mining of mineral mines, unlike in granite massif with iron ore deposits. The causes of rock shear may include:

- uneven mining pressure around the shaft;

- the presence of loose sandstones, shale rocks, and large amounts of salt around the shaft;
- the closeness of the shaft to the mining area, to a rock shear mulch, to a large reservoir or groundwater, to underground pumping stations for pumping water out of the mine;
- mining of pillars before mine closure, when there are a shaft shear and roof failure.

The above factors determine the risks of loss of stability of the shaft massif, which causes its shear during long-term operation and leads to a violation of the geometry of vertical shafts, resulting in the following:

- vertical deformation of the shaft support;
- curvature of the vertical axes of the hoisting compartments and conductors;
- violation of the design shape of the cross-section of the shaft;
- appearance of ledges at the joints of conductors, which cause increased individual shock loads from the hoisting vessels;
- local distortions of the conductor profile, which cause increased shock-cycle loads from the hoisting vessels;
- uneven distribution of corrosion and mechanical wear of conductors and buntons in the shaft under the influence of aggressive mine environment;
- increase in dynamic loads on the reinforcement from moving hoisting vessels during the operation phase.

The curvature of the shaft walls when they hit the buntons and conductors of rigid reinforcement leads to their deformation and relaxation of the embedment in the shaft support, which creates emergency situations when the hoisting vessels move at design speeds. For shafts with rope conductors, such deformations most often lead to the inability to keep the hoisting vessel within safe clearances from the walls of the curved shaft.

For the conditions of rock shear, using the example of a vertical shaft of Ukrainian ore mining association, the results of tests and studies of the dynamic state of the "hoisting vessel - reinforcement" systems are presented. The purpose of this work is to analyze the distribution of force load in the sections of the shaft under investigation, calculate the safety margins of the reinforcement elements with an assessment of risk factors, determine the technical condition of the shaft reinforcement with recommendations for its improvement.

The presented materials are the main basis for the development of plans for repair work, determining the order of their implementation, as well as their objective distribution into priority, gradual and planned according to the annual plan of mining operations of the enterprise.

2. Methods

When testing and studying the dynamic state of the "hoisting vessel - reinforcement" systems of vertical shaft compartments, methods of control the operational state of mine hoisting equipment based on modern technologies and technical means of computer rapid diagnostics of existing equipment are used [2-9]. The developed models of the functioning of potentially dangerous geotechnical systems of mine hoisting, taking into account risk factors, are the scientific basis for mine research and the development of recommendations for improving the operational condition of the vertical shaft reinforcement [5, 6].

Preliminary inspection of the shaft reinforcement and study of the surveyor's documentation on conductor profiling reveals the areas with a high level of conductor and buntons wear, deviation of conductors from the vertical on adjacent layers more than the permissible 10 mm, excessive narrowing and widening of the conductor track. In accordance with the provisions of [1], due to this state of reinforcement, a dynamic method of diagnosing the "hoisting vessel - rigid reinforcement" system is used.

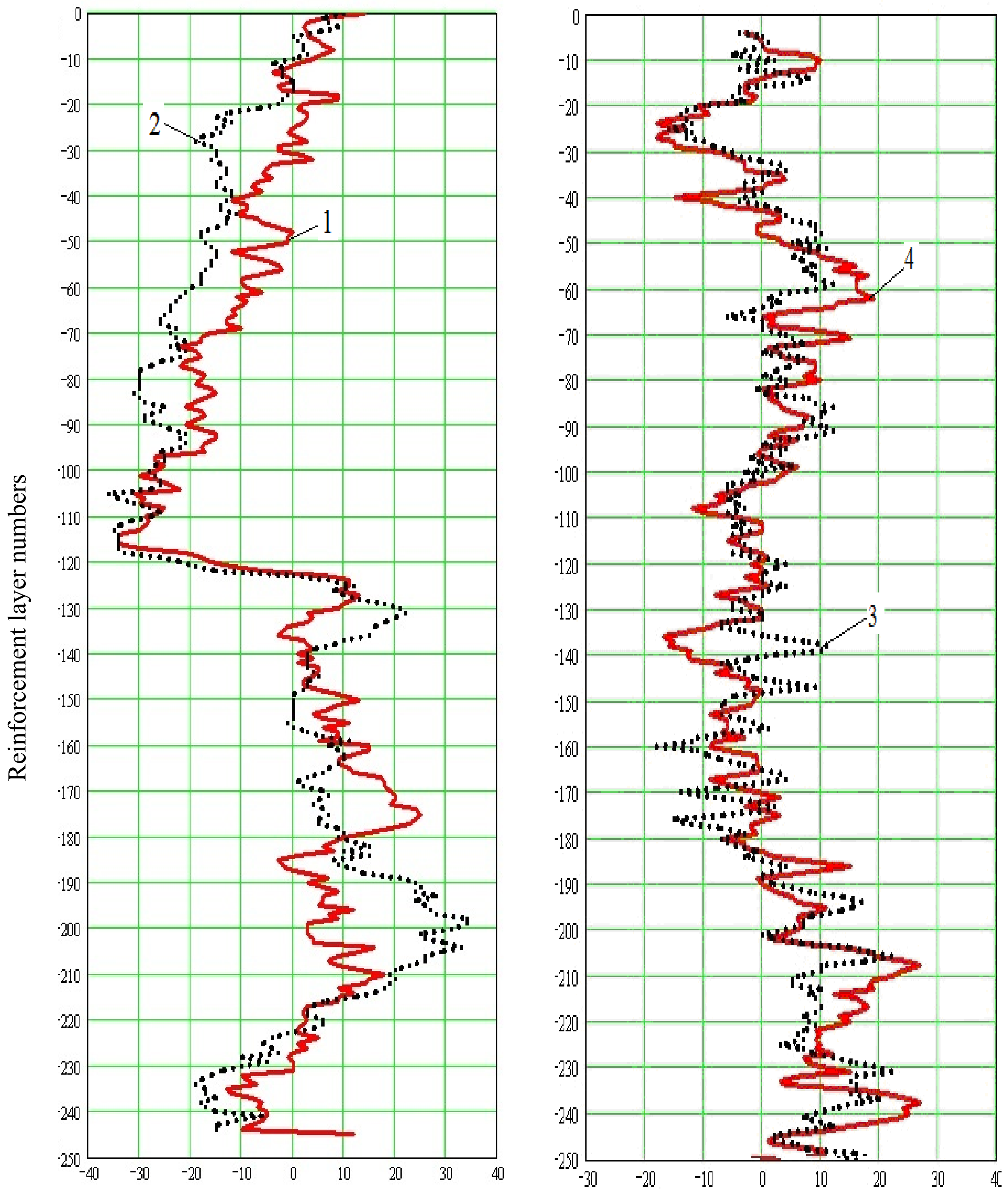
In the process of mine tests, the highest values of dynamic overloads are revealed, which occurred during a part of test cycles of the vessel movement with a frequency that depends on the reinforcement geometry, kinematic gaps between the guides and conductors, the position of the load in the vessel, the speed and direction of movement, the mass of the vessel, etc. Based on the test results, a database of informative parameters is formed that determine the production risks in the vessel-reinforcement system. These include:

- parameters that determine the dangerous dynamic properties of conductors system of mine shaft compartments (deviation of the conductor from the vertical on adjacent layers, track width of a pair of conductors on a layer, absolute and relative angle of inclination of the conductor to the front and side at the reinforcement step, absolute and relative angle of twisting of the track axis on a layer, absolute angle of inclination of the compartment axis along the length of the vessel to the front and side);
- parameters characterizing the dangerous level of load on the reinforcement of vertical shaft compartments (maximum contact loads in the frontal and lateral planes for each conductor, coefficient of variation of tier loads along the depth of the shaft for all test cycles of descent and hoisting, coefficient of disturbance of the smooth movement of the hoisting vessel for each compartment, reinforcement overload coefficients for each compartment);
- parameters that characterize the dangerous level of strength of the reinforcement of mine shaft sections (maximum contact loads on conductors, residual cross-sections of conductors and buntons, safety margins of vessel body elements, residual safety margins, deflections of conductors and buntons under the action of contact loads in spans and on reinforcement layers).

These parameters are the basis for the further development of recommendations for the prevention of emergency situations in mine shafts [1, 10].

3. Experimental parts

Fig. 1 shows the characteristic profiles of conductors No. 1 and No. 2 of the shaft in the rock shear zone (a) compared to conductors No. 3 and No. 4 of the shaft in the stable rocks (b). It can be seen that in a number of layers, the deviations of the conductors in the shear zone significantly exceed the deviations of the conductors in the stable rocks, which is the result of one or a combination of several factors of loss of stability of rock massif around the shaft support.



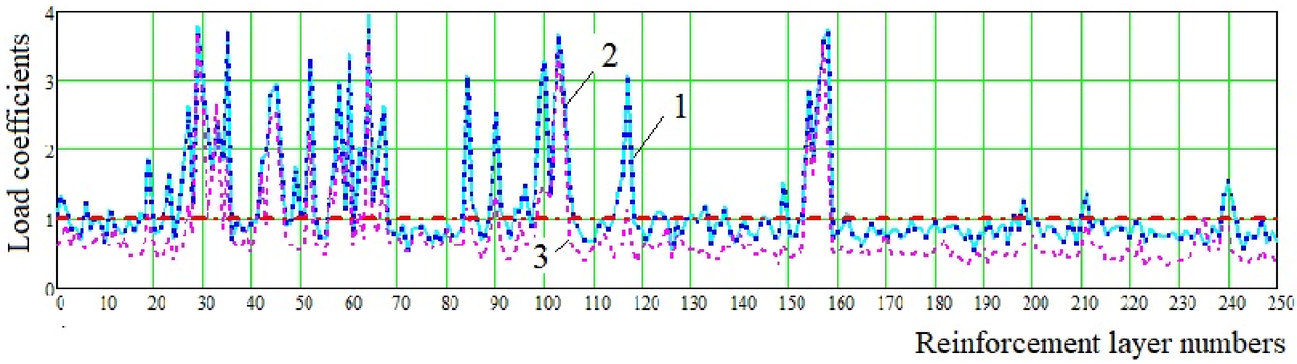
a) shaft in the zone of rock shear; б) shaft in stable rocks

1, 2, 3, 4 – conductor profiles No. 1, 2, 3, 4 respectively

Figure 1 – Absolute conductor profiles under different operating conditions

The examined shaft has four compartments: the rock skip, counterweight, southern skip and northern skip. The study of the force load and strength characteristics is illustrated on the example of the counterweight compartment.

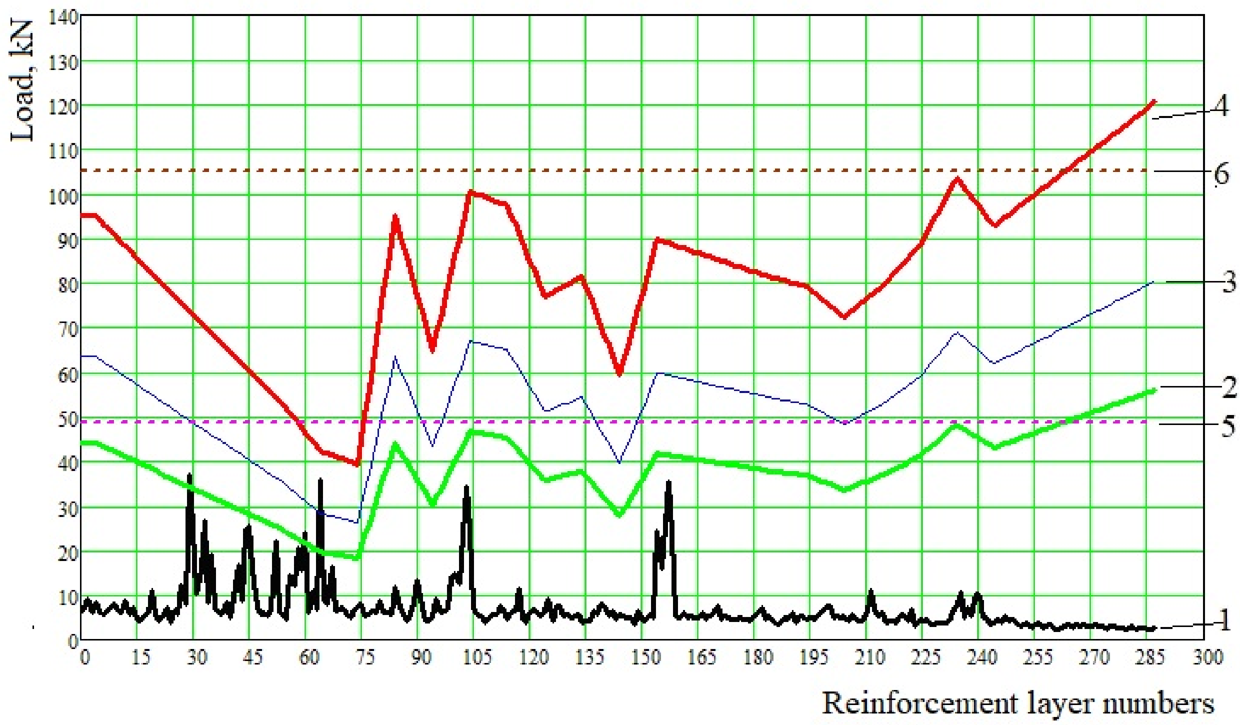
Fig. 2 shows the distribution of load coefficients of reinforcement of the counterweight compartment on the shaft layer.



1, 2 – load of conductors No. 3 and No. 4 respectively; 3 – frontal loads

Figure 2 – Load coefficients for the shaft counterweight compartment at a speed of 10 m/s for all test descents and hoisting

The loading diagram of the bunton No. 3 of the counterweight compartment under the load from the actuator No. 4 in the frontal plane is shown in Fig. 3.



1 – actual maximum loads for all test cycles;
2, 3, 4 – permissible loads with safety margins of 2.15, 1.5 and 1.0 respectively;
5, 6 – permissible loads with safety margins of 2.15 and 1.0 respectively for an unworn bunton

Figure 3 – Load diagram of bunton No. 3 of the counterweight compartment

The influence of wear of shaft conductors and buntons on the accident hazard parameters of the “vessel - reinforcement” systems was studied through combined graphs of layers-wise values of permissible loads on shaft compartment conductors and buntons, which reflect the loss of cross-section due to corrosive wear and operational loads.

Histograms of load distribution by 1 layers in the counterweight compartment of the shaft are shown in Fig. 4.

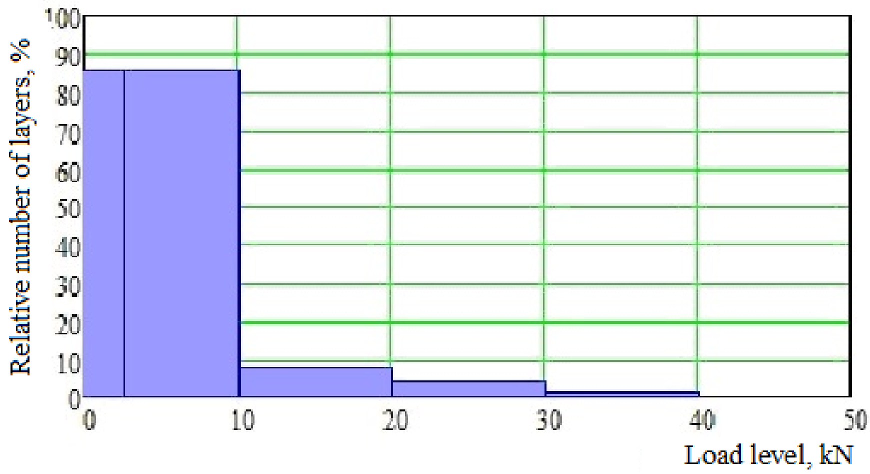
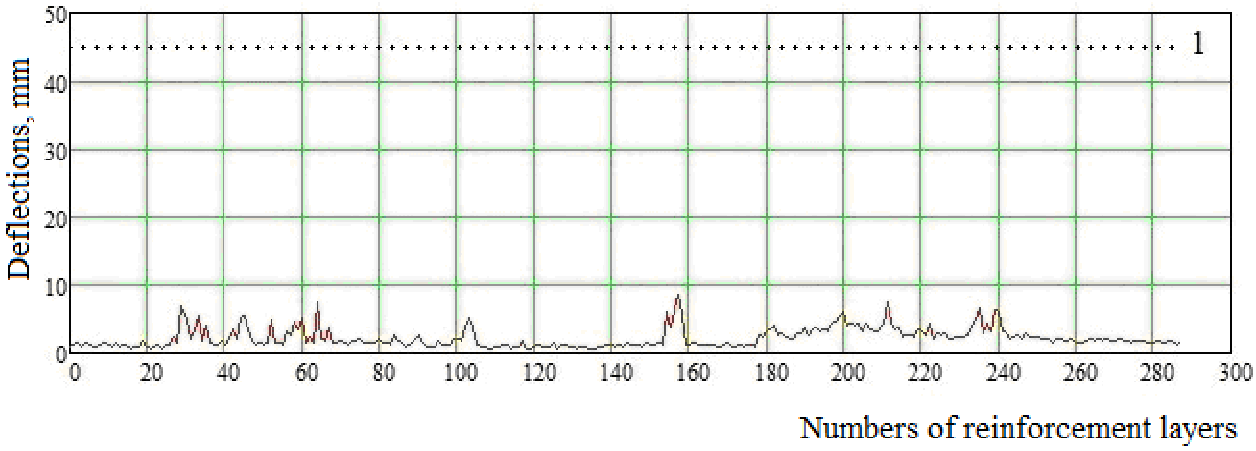


Figure 4 – Histograms of load distribution by layers in the shaft counterweight compartment

Fig. 5 shows the deflections of conductor No. 3 from the action of frontal contact loads during the movement of the counterweight in operating modes of movement at speed of 10.5 m/s. Over the entire depth of the shaft, the deflections do not exceed the maximum permissible 45 mm.

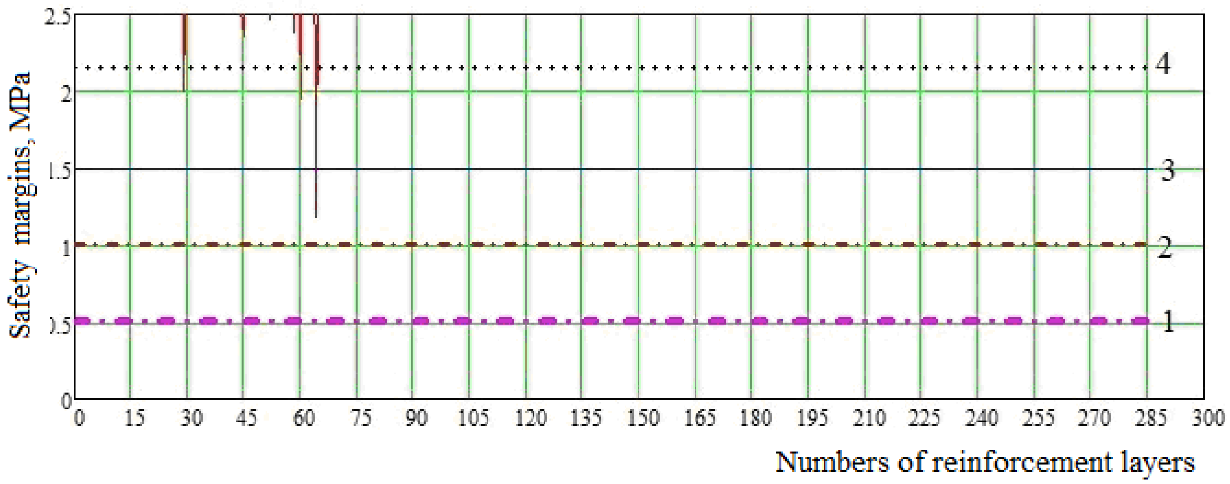


1 – maximum permissible deflections are 45 mm

Figure 5 – Deflections of conductor No. 3 from the action of frontal contact loads

Fig. 6 shows the graphs of the distribution along the shaft depth of the residual safety margins of the section No. 3 from the frontal contact loads on the conductor No. 4. The graphs have areas with safety margins below the recommended values of

2.15 according to the criterion of nonaccumulation of fatigue damage under the actual contact loads from the counterweight when the vessel moves at a speed of 10.5 m/s.



1, 2 – emergency safety margins; 3 – potentially dangerous safety margin;
4 – safety margin

Figure 6 – Residual safety margins of the bunton No. 3

The beams of the bunton No. 3 have areas with reduced safety margins, these are layers No. 29, 60, 64. This reduction in safety margins is caused by increased wear and stress on the reinforcement elements.

The same calculations of loads, deflections and residual safety margins were performed for the buntons No. 2 cut and the conductor No. 4 of the counterweight compartment. Similar studies and calculations were also carried out for the reinforcing elements of the rock, north and south skip compartments. The following conclusions were made based on the results.

In the counterweight compartment, the loads are up to 18 kN along the entire shaft depth in the lateral and frontal planes, with single peaks of up to 39 kN. The maximum value of the loads on the conductors is equal to: at a speed of 10 m/s, frontal loads of 37 kN, and lateral loads of 39 kN. The coefficient of disturbance of the vessel's smoothness along the shaft is 0.32. This means that along the shaft depth on 32% of the layers, impact-contact mode of varying severity of collision between the safety shoes and the working faces of the conductors is realized.

In the rock skip compartment, the loads are up to 15 kN along the entire shaft depth in the lateral and frontal planes, with single peaks of up to 40–49 kN in the lateral plane. The maximum value of the loads on conductors No. 1 and No. 2 along the entire shaft depth is equal to 49 kN of frontal loads and is equal 47 kN of lateral loads at a speed of 10 m/s. The coefficient of disturbance of the vessel's smoothness is 0.27. This means that along the shaft depth on 27% of the layers, impact-contact mode of varying severity of collision between the safety shoes and the working faces of the conductors is realized.

In the northern skip compartment, the loads are up to 18 kN along the entire shaft depth in the lateral and frontal planes, with single peaks of up to 33–47 kN. In the frontal plane, conductor No. 6 is more loaded, in the lateral plane, the western faces of conductors No. 5 and No. 6 are more loaded than the eastern faces. The maximum value of the loads on the conductors along the entire shaft depth is equal to: at a speed of 11 m/s, frontal loads are 47 kN, lateral loads are 39 kN. The coefficient of disturbance of the vessel's smoothness along the shaft is 0.68. There are 68% of the layers along the shaft depth, where the impact-contact mode of varying severity of the collision of the safety shoes and the working faces of the conductors is realized.

In the southern skip compartment, the loads are up to 20 kN along the entire shaft depth in the lateral and frontal planes with single peaks of up to 35–48 kN. In the frontal plane, conductors No. 7 and No. 8 are equally loaded. In the lateral plane, the western and eastern faces of the conductors are equally loaded. The maximum value of the loads on the conductors along the entire shaft depth is equal to: at a speed of 11 m/s, frontal loads are 35 kN, lateral loads are 48 kN. The coefficient of disturbance of the vessel's smoothness along the shaft is 0.95. In 95% of the layers along the shaft depth, the impact-contact mode of varying severity of collision between the safety shoes and the working faces of the conductors is realized.

The summarized data on the dynamic load of conductors by shaft compartment are shown in Table 1.

Table 1 – Dynamic load of conductors by shaft compartment

Load, kN	Shaft compartments							
	Rock skip, %		Counterweight, %		Southern skip, %		Northern skip, %	
	frontal	lateral	frontal	lateral	frontal	lateral	frontal	lateral
0-10	86	74	86	68	8	21	65	52
10-20	11	21	8	22	87	69	31	38
20-30	1	3	4	5	4	8	1	8
30-40	1	1	1	4	1	1	1	1
40-50	1	1				1	1	

Risk assessment during the operation of the shaft compartment reinforcement is carried out according to the safety margins of conductors and buntons under the operating loads in the accepted mode of operation of the hoisting using the following formula [6]:

$$R_{con}(n_{act}) = \frac{n_s - n_{act}}{n_s - n_{fr}} \cdot 100\%, \tag{1}$$

where n_{act} – actual safety margin; n_{fr} – maximum allowable margin of safety under the condition of fracture; n_s – endurance limit under alternating shock-dynamic loads.

Assuming nfr = 1.0 and ns = 2.15, we obtain the following data (Table 2):

Table 2 – Safety margins of reinforcement of shaft compartment

Shaft compartment	Reinforcement elements	Reinforcement layers, No.	Safety margin, mPa	Risk indicator, %.
Rock skip	Conductors No. 1, No. 2 Buntons No. 1, No. 2	0–287	More than 2,15	0
Counterweight	Conductors No. 3, No. 4 Bunton No. 2	0–287	More than 2,15	0
	Bunton No. 3	29 60 64	2.00 1.95 1.19	13 17 83
Southern skip	Conductors No. 7, No. 8 Bunton No. 2	0–287	More than 2,15	0
	Bunton No. 1	60 73	1.82 1.78	29 32
Northern skip	Conductor No. 5	287	2.05	9
	Conductor No. 6 Buntons No. 2, No. 3	0–287	More than 2.15	0

The generalized risk indicator for the strength criterion is set at the minimum value of the safety margin of all load-bearing elements, since the destruction of any of them causes an accident in the entire shaft.

The generalized risk indicators are as follows: 0% for the rock skip compartment, 83% for the counterweight compartment, 32% for the southern skip compartment, and 9% for the northern skip compartment.

In the rock skip compartment, in order to prevent the development of negative phenomena, it is recommended to reduce the loads to 20–30 kN on the levels No. 127–130.

For the counterweight compartment, the technical condition of the reinforcement elements is unsatisfactory in the area of layers 29, 60, 64 and section 3, where the actual loads are 1.3 times higher than the permissible loads with account for wear. To prevent the development of negative metal fatigue phenomena in this section, it is recommended to reduce the load to 20 kN.

For the southern skip compartment, the technical condition of the reinforcement elements is unsatisfactory in the layers 60 and 73, where the actual loads are 1.2 times higher than the permissible ones. In order to prevent the development of negative phenomena in the compartment, it is recommended to reduce the loads to 30 kN.

For the northern skip section, the technical condition of the reinforcement elements is unsatisfactory in the layers 287, where the actual loads are 1.1 times higher than the permissible ones.

In order to prevent the development of negative phenomena in the compartment, it is also recommended to reduce the loads to 30 kN.

4. Results

Based on the results of the shaft inspection, recommendations are developed to improve the safety of its operational condition. On all layers with high actual loads, it is recommended to carry out planned measures to improve the strength characteristics of the reinforcement. When switching to a more intensive mode of operation, it is necessary to conduct special surveys to determine the actual deformation and strength parameters of the system.

The factor of rock shear causes a number of specific tasks for diagnosing the shafts located in such zones. These are, first of all, tasks related to the need for the following:

- more frequent surveying operations to control the verticality parameters of the conductors and shaft walls;
- assessment of the impact of conductor verticality violations on the level of dynamic loads from hoisting vessels in each compartment of the shaft;
- performing hardware dynamic control of the smoothness of the movement of hoisting vessels during complex surveys in accordance with [10];
- controlling the wear of reinforcement conductors and buntons, analyzing the profiling of reinforcement conductors;
- performing deformation-strength calculations of conductors, buntons, reinforcement as a whole and hoisting vessels under the influence of actual dynamic loads.

The results of measurements of the physical and mechanical parameters of the equipment and shaft reinforcement in the form of tabular materials, diagrams and graphs contain data on localized violations and potentially dangerous areas of reinforcement. This information allows experts to obtain objective data on the interaction of several parameters, the degree of intensity of their changes, and the level of danger of various processes and conditions. The initial data on hazardous changes in indicators accumulated over a long period of time are used for further systematic risk-oriented analysis of the safety level of the mine hoisting operation in order to make corrective decisions.

Based on this information, the expert promptly develops recommendations on measures, the procedure and timing of measures implementation to eliminate the identified violations, which reduces the risks of spontaneous accidents due to uncontrolled accumulation of degradation damage to equipment in the shafts. The system of such measures contributes to solving the economic problems of the industry by increasing the hoisting speed, increasing the volume of minerals delivered to the surface, reducing the cost of accident elimination while improving the safety of mine hoisting units and reducing occupational injuries in the operation of vertical shafts.

5. Conclusions

The scientific and practical results are the basis for further development of methods for controlling potentially dangerous mine hoisting systems in difficult operating conditions, development of new risk-oriented technologies for controlling these systems to ensure efficient, reliable and safe mining operations at Ukrainian mining enterprises. The expected results will make it possible to move to a qualitatively new level of safety management of mine hoisting in coal and ore shafts and optimize repair and restoration work in risky conditions during long-term operation of the hoisting shafts.

Monitoring the technical condition of mine shaft equipment can solve the following:

- social problems by improving the safety of hoisting units, significantly reducing occupational injuries during the operation of vertical shafts;
- economic problems due to reduction of material costs and scope of repair works of the shaft equipment as a result of localization of the areas of high accident rate in the shafts.

REFERENCES

1. Ministry of Industrial Policy of Ukraine (2004), *GR 3-032-2004. Diahnostyka stanu system „kriplennia - masyv" ta „pidiomna posudyna - zhorstke armuvannia" shakhtnykh stovburiv. Poriadok ta metodyka vykonannia* [GR 3-032-2004 Diagnostics of the condition of the "fastening - array" and "lifting vessel - rigid reinforcement" systems of mine shafts. Procedure and methodology for implementation], Ministry of Industrial Policy of Ukraine, Kyiv, Ukraine.

2. Ilin, S., Adorska, L. and Radchenko, V. (2018), "The concept of a monitoring system for the operation of deep shafts of mines and quarries in Ukraine", *Geo-Technical mechanics*, no. 143, pp. 15–22.

3. Ilin, S., Adorska, L., Samusia, V., Kolosov, D. and Ilina, I. (2019), "Conceptual bases of intensification of mining operations in mines of Ukraine based on monitoring and condition management of mine hoisting systems", *Essays of Mining Science and Practice 2019. E3S Web of Conferences*, *09 July 2019*, vol. 109, 00030, https://doi.org/10.1051/e3sconf/201910900030

4. Ilin, S., Adorska, L., Pataraia, D., Samusia, V., Kolosov, D., Ilina, I. and Kholomeniuk, M. (2020), "Control of technical state of mine hoisting installations", *II International Conference Essays of Mining Science and Practice. E3S Web of Conferences, 06 May 2020, vol.* 168, 00045, https://doi.org/10.1051/e3sconf/202016800045

5. Ilin, S., Adorska, L. and Radchenko, V. (2017), "Risk-generating processes during operation of mine hoisting installations", *Geo-Technical mechanics*, no. 134, pp. 22–33.

6. Ilin, S., Adorska, L., Pataraia, D. and Ilina, I. (2022), "Risk-forming factors and processes at the stages of the life cycle of hoisting equipment in the mine vertical shafts", *Geo-Technical mechanics*, no. 161, pp. 17–30.

7. Garkusha, N., Dvornikov, V. (1974). "Some issues of interaction of a mine lifting vessel equipped with elastic guide devices with rigid reinforcement conductors", *Mining electromechanics and automation*, no. 24, pp. 3–10.

8. Dvornikov, V. and Kartselin, E. (1997), *Theoretical foundations of the dynamics of a mine hoisting complex,* Science and Technology, Sofia, Bulgaria.

9. Belobrov, V., Abramovsky, V. and Samusya, V. (1990), Brake systems of mine hoists. Scientific opinion. 174.

10. Ministry of Social Policy of Ukraine (2017), *NPAOP 0.00-1.77-16 Pravyla bezpeky pid chas rozrobky rodovyshch rudnykh ta nerudnykh korysnykh kopalyn pidzemnym sposobom* [NPAOP 0.00-1.77-16. Safety rules during the development of ore and non-ore deposits underground], Ministry of Social Policy of Ukraine, Kyiv, Ukraine.

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ДІАГНОСТИКА СИСТЕМ ШАХТНОГО ПІДЙОМУ НА РУДНИКАХ, ЩО ЕКСПЛУАТУЮТЬСЯ В ЗОНАХ ЗСУВУ ГІРСЬКИХ ПОРІД

Ільїн С., Адорська Л., Патарая Д., Ільїна І.

Анотація. В статті розглянуті питання діагностики систем «підйомна посудина – армування» на рудниках, де спостерігається вплив зсуву гірських порід на експлуатаційний стан вертикальних підйомних стовбурів. Мета цих робіт - удосконалення технічного стану устаткування шахтних підйомних комплексів в таких умовах для підвищення їх надійності та швидкості підйому, суттєвого збільшення обсягу видачі на поверхню корисних копалин як основного показника продуктивності роботи рудника. Фактор зсуву гірських порід обумовлює ризики втрати стійкості колостовбурного масиву, що викликає його зрушення при тривалій експлуатації та призводить до порушення геометрії вертикальних стовбурів. Викривлення стінок стовбура при впливі на розпори і провідники жорсткого армування призводять до їх деформації та розслаблення закладення в кріпленні стовбуру, що створює аварійно-небезпечні ситуації під час руху підйомних посудин. Для умов зсуву гірських порід, на прикладі вертикального стовбуру рудовидобувного підприємства України, наведено результати випробувань та досліджень динамічного стану систем «підйомна посудина - армування». Виконано аналіз розподілу силової навантаженості відділень обстеженого стовбуру, розрахунки запасів міцності елементів армування з оцінкою ризикоутворюючих факторів, визначення технічного стану армування стовбуру з рекомендаціями щодо його поліпшення. При випробуванні використано методи керування експлуатаційним станом шахтних підйомних устаткувань на базі сучасних технологій та технічних засобів комп'ютерної експрес-діагностики діючого обладнання. За результатами обстеження стовбура надаються рекомендації щодо підвищення безпеки його функціонування в умовах зсуву гірських порід. Це є основою щодо розробки планів ремонтних робіт та визначення черги їх виконання згідно річному плану гірничих робіт підприємства. Очікувані результати дозволять перейти на якісно новий рівень управління безпекою роботи шахтних підйомів в вугільних і рудних стовбурах та оптимізувати ремонтно-відновлювальні роботи в ризиконебезпечних умовах при тривалій експлуатації підйомних стовбурів.

Ключові слова: шахтний підйом, стовбури, посудина, армування, провідники, розпори