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RESEARCH AND DEVELOPMENT OF STRUCTURES OF SINGLE-ROW ROPE-PROFILE GUIDES FOR MOVEMENT OF VEHICLES IN BAR REINFORCEMENT

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Abstract. The paper studies the horizontal loads arising from the movement of vehicles under the action of dissipative forces (torsion of ropes, aerodynamic forces, loading cages with eccentricity in the frontal and lateral planes), which act on single-row rope-profile guides (hereinafter referred to as RPGs or guides).

In the paper, for the case of two moving cages of one lifting unit, in accordance with the current regulatory techniques and Safety Rules, shaft cross-sections for various types of shaft reinforcement were designed, their advantages and disadvantages were analyzed, and their comparative analysis was carried out.

On the basis of the research, the structures of single-row RPGs have been developed that have a smaller number of ropes and the structure of an enclosing profile in the form of an elongated hexagon, which makes it possible to increase the reliability of the kinematic link in the "vehicle-guide" system and ensure an increase of safety gaps between the vehicles and the shaft lining.

The development of various structural solutions for single-row RPGs for cages makes it possible to achieve:

- high reliability of a single-row RPG operation;
- increased service life due to a significant decrease in the level of dynamic effects;
- reduced labor intensity of maintenance and operation compared to rigid reinforcement;
- reduced metal consumption compared to rigid reinforcement;
- reduced level of dynamic oscillations at the meeting point of vehicles in the middle part of the shaft by reducing the RPG deflection;
- increased reliability of the kinematic link in the "vehicle–RPG" system due to the use of specially designed guide legs;
- reduced safety gaps per side (- 500 mm per side) for cage hoists along the entire depth of the shaft compared to flexible reinforcement;
- reduced operating costs due to the high service life of a single-row RPG;
- elimination of the use of fender ropes;
- increased service life of rope-profile guides to the level inherent to guides of rigid shaft reinforcement.

The result of the implementation of the developed structures of single-row RPGs with reinforcement is the extension of the service life of the reinforcement, and the reduction in the cost of capital construction and operation in the extraction of minerals from deep horizons.

Keywords: mine vertical shafts, single rope-profile guides, reinforcing guides, increasing the safety gaps between cages and the shaft lining, guiding safety devices, horizontal forces in frontal and lateral directions.

1. Introduction

Vertical shafts of any mining enterprise that mines minerals underground are long-term capital structures that provide the main transport and communication links with the underground part of the enterprise. The construction, maintenance and operation of vertical shafts determine the main part of the costs in the lifting complex. One of the most important elements in the system is the shaft reinforcement which ensures the directed movement of lifting vehicles.

To date, the following types of reinforcement have been widely used:

- rigid reinforcement (with rail and box-shaped guides);
- flexible reinforcement where steel ropes are used as guides (ropes with a steel core, closed structure, etc.)

Each of the above types of reinforcement has its own advantages and disadvantages.

Rigid reinforcement makes it possible to ensure high speed movement of lifting vehicles, reliability and durability; however, due to the action of dynamic and static loads in the “vehicle-reinforcement” system, the following problems occur:

- significant wear of structural elements;
- the need for a large amount of maintenance and repair work;
- reduction of the aerodynamic capacity of the shaft;
- the need for a significant metal consumption of the structure;
- high corrosive wear.

Flexible reinforcement (based on rope guides) with a relatively low metal consumption and low resistance against the ventilation jet has the following disadvantages:

- limited service life of rope guides;
- the need to install additional fender ropes;
- the need for additional regulatory safety gaps [1] - 350 mm per side for skip hoists and - 500 mm per side for cage hoists along the entire depth of the shaft, which leads to a significant increase in the diameter of the shaft and capital costs during construction;
- the need for a significant amount of tension weights in the sump part of the shaft;
- the need for a duplicate rigid reinforcement in the headframe and in intermediate horizons.

When creating a new type of reinforcement based on rope-profile guides (hereinafter referred to as RPGs or guides) [4, 5, 7], the task was to save advantages of the two types of reinforcement listed above, as much as possible, and significantly reduce their disadvantages.

Purpose of the Research. The research is aimed on the problem of developing the structures of a single-row RPG in the "vehicle- reinforcement" system where the carrier ropes are interconnected by a rigid enclosing box, which can significantly reduce the level of dynamic loading in the system.

The study of the processes arising in this system and the improvement of structures provides an opportunity to obtain the following results:

- to ensure high reliability of operation and service life of damper buntons;
- to ensure significant damping of horizontal loads that occur during the emergency mode of movement of vehicles;
- to ensure a long trouble-free service life of RPGs;
- to reduce the labor intensity of reinforcement maintenance and operation;
- to reduce the level of dynamic oscillations in the “vehicle–reinforcement" system;
- to increase the reliability of the kinematic link in the “vehicle–reinforcement" system.

2. Methods, Results and Discussion

Ropes of RPG are fixed at the top of the shaft in a headframe and hung along the depth of the shaft. Preload is provided using damping tension weights located in the sump part of the shaft [2], the weight of the ropes of the enclosing box and fastening elements or due to tension multi-groove pulleys located in the shaft headframe.

The vessel, when moving in guides along the shaft depth, is exposed to various factors, namely:

- torsion of the head ropes;
- loading vehicles with eccentricity;
- aerodynamic forces at the meeting point of the vehicles,

and generates horizontal forces in the "vehicle- reinforcement" system, acting in the frontal and lateral directions.

Forces acting on the RPG in the frontal direction for a loaded cage:

$$P^{(tot.)}_{(fr.load.)} = P^{(ecc.)}_{(fr.load.)} + P^{(tors.)}_{(fr.load.)} + P^{(aero.)}_{(fr.load.)},$$

where $P^{(tot.)}_{(fr.load.)}$ – is the total horizontal force in the frontal direction applied to the RPG from the moving loaded cage, N; $P^{(ecc.)}_{(fr.load.)}$ – is the horizontal force in the frontal direction applied to the RPG from the eccentricity of the suspension of the loaded cage, N; $P^{(tors.)}_{(fr.load.)}$ – is the horizontal force in the frontal direction applied to the RPG from the torsion of the ropes of the loaded cage; N; $P^{(aero.)}_{(fr.load.)}$ – is the horizontal force in the frontal direction applied to the RPG from the action of the aerodynamic forces of the loaded cage, N.

Forces acting on the RPG in the lateral direction for a loaded cage:

$$P^{(tot.)}_{(lat.load.)} = P^{(ecc.)}_{(lat.load.)} + P^{(tors.)}_{(lat.load.)} + P^{(aero.)}_{(lat.load.)},$$

where $P^{(tot.)}_{(lat.load.)}$ – is the total horizontal force in the lateral direction applied to the RPG from the moving loaded cage, N; $P^{(ecc.)}_{(lat.load.)}$ – is the horizontal force in the lateral direction applied to the RPG from the eccentricity of the suspension of the loaded cage, N; $P^{(tors.)}_{(lat.load.)}$ – is the horizontal force in the lateral direction applied to the RPG from the torsion of the ropes of the loaded cage, N; $P^{(aero.)}_{(lat.load.)}$ –is the horizontal force in the lateral direction applied to the RPG from the action of the aerodynamic forces of the loaded cage, N.

Forces acting on the RPG in the frontal direction for an empty cage:

$$P^{(tot.)}_{(fr.emp.)} = P^{(tors.)}_{(fr.emp.)} + P^{(aero.)}_{(fr.emp.)},$$

where $P^{(tot.)}_{(fr.emp.)}$ – is the total horizontal force in the frontal direction applied to the RPG from the moving empty cage, N; $P^{(tors.)}_{(fr.emp.)}$ – is the horizontal force in the frontal direction applied to the RPG from the torsion of the ropes of the empty cage, N; $P^{(aero.)}_{(fr.emp.)}$ – is the horizontal force in the frontal direction applied to the RPG from the action of the aerodynamic forces of the empty cage, N.

Forces acting on the RPG in the lateral direction for an empty cage:

$$P^{(tot.)}_{(lat.emp.)} = P^{(tors.)}_{(lat.emp.)} + P^{(aero.)}_{(lat.emp.)},$$

where $P^{(tot.)}_{(lat.emp.)}$ – is the total horizontal force in the lateral direction applied to the RPG from the moving empty cage, N; $P^{(tors.)}_{(lat.emp.)}$ – is the horizontal force in the lateral direction applied to the RPG from the torsion of the ropes of the empty cage, N; $P^{(aero.)}_{(lat.emp.)}$ – is the horizontal force in the lateral direction applied to the RPG from the action of the aerodynamic forces of the empty cage, N.

According to the data of All-Union Research Institute of Organization and Mechanization of Mine Construction, the horizontal force that arises when loading cages with eccentricity, statistically reaches 0.3-0.5 of the total load weight in the horizontal plane [8]. The total value of horizontal forces arising from the movement of vehicles at maximum speed along the shaft depth with a combination of the most unfavorable factors is approximately: 1.5-2.5 kN in the frontal direction and up to 0.5 kN in the lateral direction for loaded cages, and 0.2-0.6 kN in the frontal direction and up to 0.2 kN in the lateral direction for empty cages.

When vehicles move, the horizontal load generated by them is not static, determined by formulas (1–4), has a probabilistic character and varies depending on the coincidence of various factors, namely:

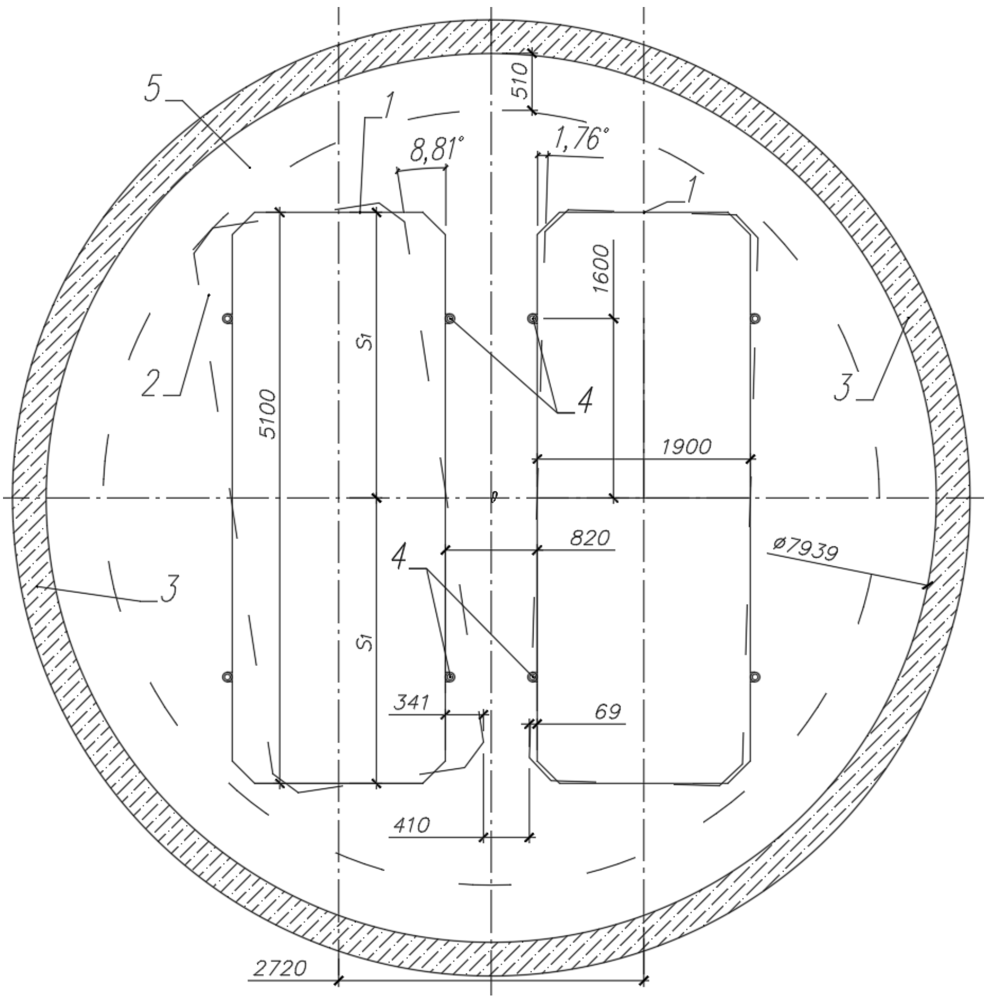
- the degree of loading of vehicles with eccentricity,
- torsion of ropes,
- aerodynamic forces,

and as a result its maximum value is 2.5 kN, and it acts for a short time on the guide when the vehicle moves along the shaft depth.

Let us conduct a comparative study by locating in the shaft cross section two cages (type 2KH4-2) of one lifting machine moving in guides located in the center of the shaft for various types of reinforcement (rigid, flexible, RPGs, and reinforced RPGs) and determine their advantages and disadvantages (see Figure 1–8).

The influence of horizontal forces arising from the movement of the cages (empty and loaded) along the guides located in the center of the shaft according to the above diagrams (see Fig. 1–8) can be: directed towards each other; directed in opposite directions from each other; and coinciding in the direction of influence.

According to the existing techniques [2, 6] and the current “Safety rules in coal mines: NPAOP 10.0-1.01-10” [3], let us perform calculations and use them to construct a shaft cross section for the movement of two cages of the 2KH4-2 type of one lifting unit for the conditions of the action of horizontal forces on the rope guides at the meeting point of the vehicles in the middle of the shaft and determine the shaft diameter over its entire depth (the scheme used for calculation is shown in Figure 1).

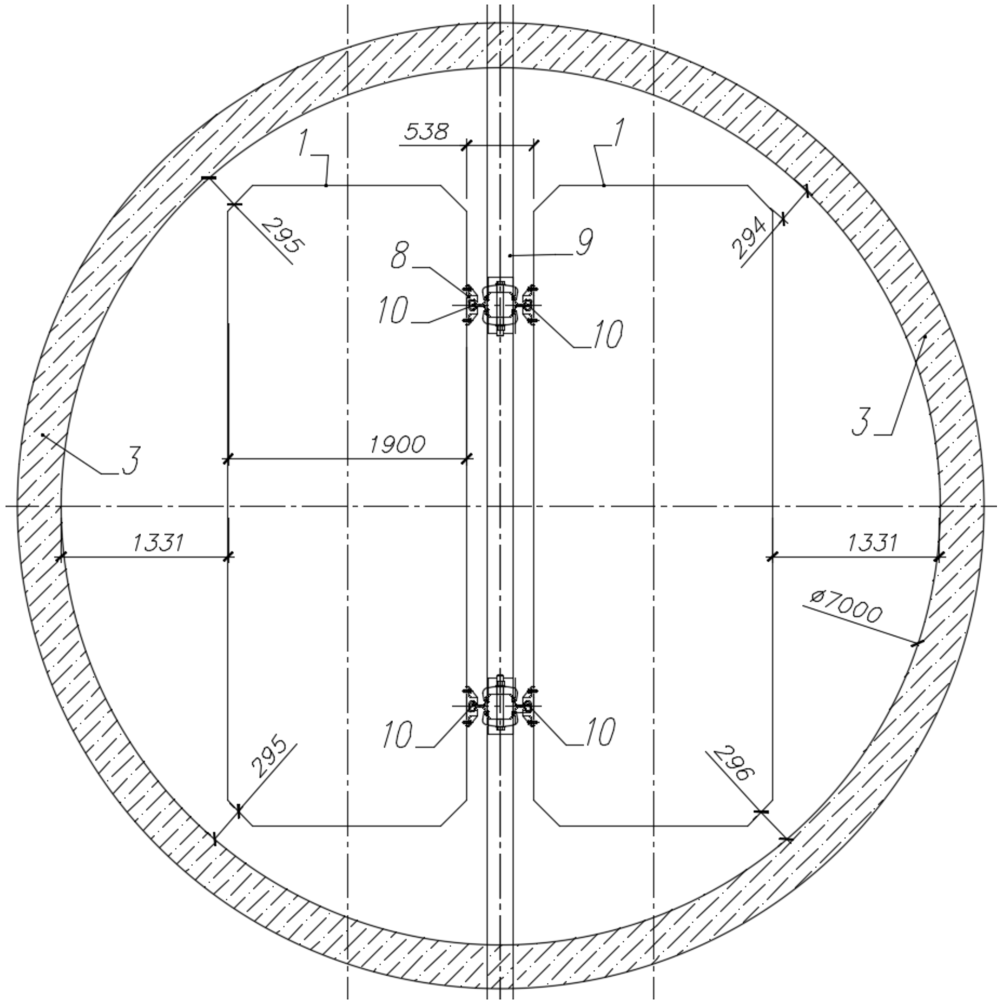


1 - lifting vehicle (cage type 2KH4-2); 3 - shaft lining; 4 - flexible rope guides;
5 - safety gap

Figure 1 – Cross-section of the shaft with cages moving in rope guides

It can be seen from Figure 1 that under the action of forces from rope torsion, without taking into account the action of horizontal forces arising from the eccentricity of the loading of vehicles, the angles of rotation of the loaded cage are 1.174 degrees, and taking into account the dynamic factor Kd=5 and the safety factor Ks=1.5 the angle of rotation is 8.81 degrees, and for an empty cage, taking into account Ks=1.5, it is 1.76 degrees. Taking into account all the gaps, we obtain the shaft diameter shown by a dashed line in Figure 1, and add (according to the technique [2]) a safety gap Δ=510 mm per side. As a result, we obtain the shaft diameter in compliance with all the necessary gap requirements.

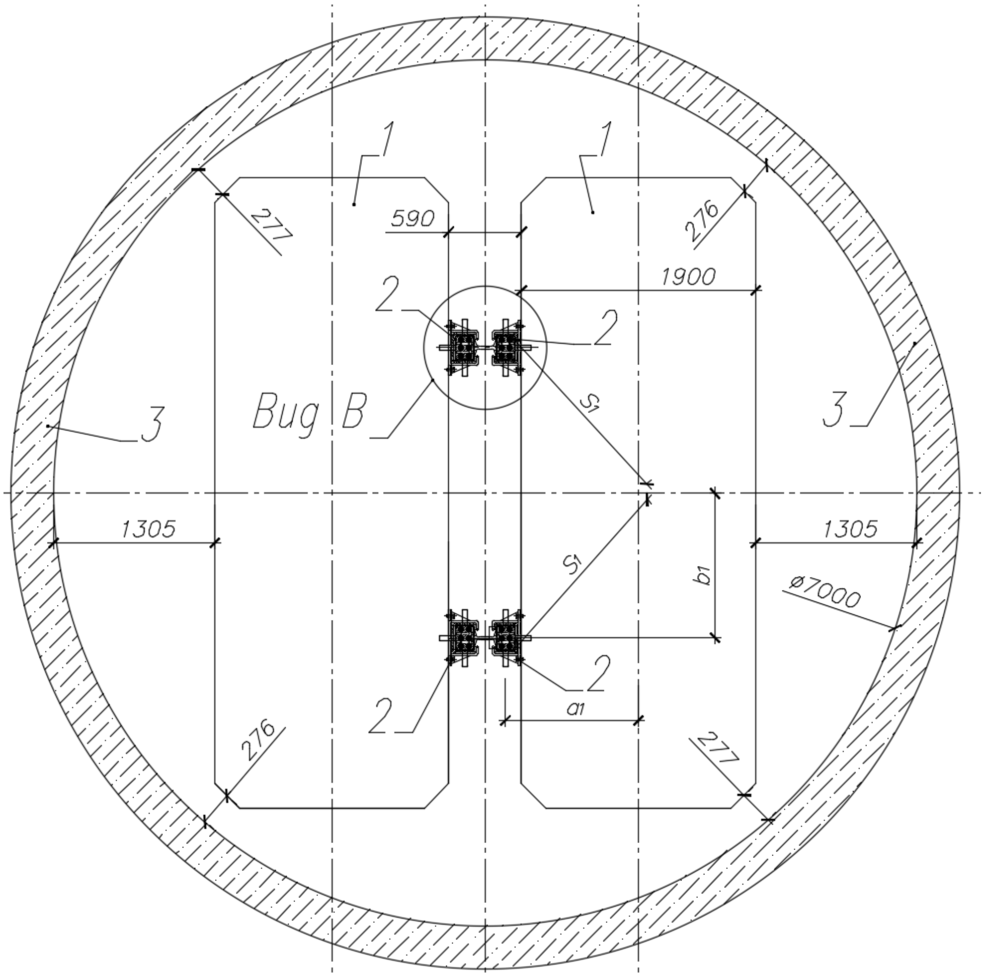
Calculation of the shaft diameter for two cages of type 2KH4-2 of one lifting unit moving in rail guides (P43) of rigid reinforcement of the shaft is carried out taking into account all the requirements of the calculation technique [1] and the current "Safety rules for coal mines: NPAOP 10.0-1.01-10" [3], and its results are shown in Figure 2. A box-shaped guide made of welded angles according to GOST 8509-86 with a cross section of 200×200×14 is installed as a central bunton. It is fixed to the shaft lining with concrete embedding on both sides and installed along the shaft depth with a step of 3.126 m. The rail guides are fixed in overlays ("floorbeams") welded to the bunton from above and below, and fastened with the help of two pairs of staples (Briar type), tightened with a bolted joint above and below the bunton. The kinematic link of the cage and the rail guide is carried out with the help of closed guided legs, as can be seen from the structure of the reinforcement tier (see Figure 3), the diameter of the shaft has significantly decreased, but at the same time, the metal consumption and aerodynamic resistance of the shaft have significantly increased.



1 – lifting vehicle (cage type – 2KH4-2); 3 – shaft lining; 8 – guiding legs of vehicles; 9 – central bunton; 10 – rail guides

Figure 2 – Cross-section of the shaft with cages moving in guides (P43) of rigid reinforcement

Figure 3 shows a scheme of the movement of two cages (type 2KН4-2) of one lifting unit in double-row RPGs located between the cages in the middle of the shaft without buntons, where the roller guides are used as main guides during the movement of cages, and the rigid guides with grippers are used as safety guides [4, 5, 7].

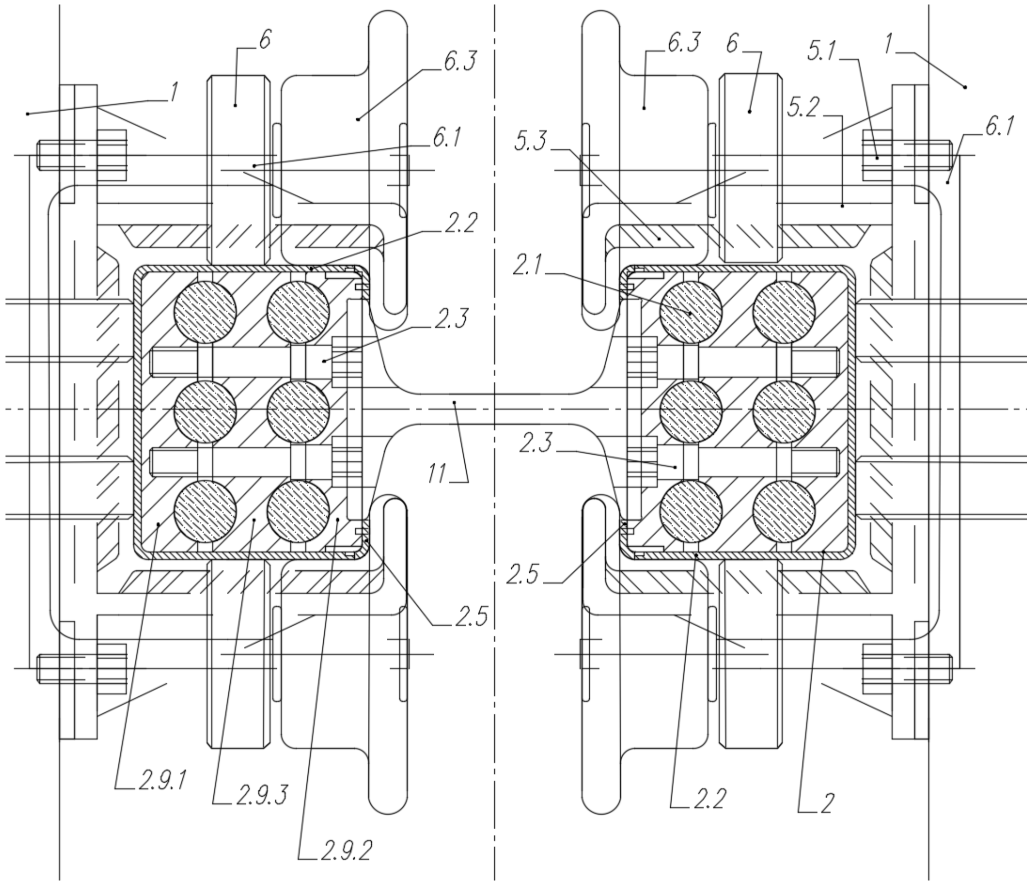


1 – lifting vehicle (cage type 2KН4-2); 2 – RPG (double-row); 3 – shaft lining

Figure 3 – Cross-section of the shaft with two cages moving in the RPG (double-row)

Figure 4 shows the interface of the RPGs and the fastening of cages to them (view B), where the cages (type 2KН4-2) move in double-row RPGs, consisting of 6 ropes d=42 (GOST 7669-80) with a steel core (item 2.1) located in the enclosing profile 2.2 (commercially available 200×180×8 channel according to GOST 8278-83) and closed with a back cover 2.5 (made of sheet 5 mm thick), assembled into a single structure with the help of lower (2.9.1), upper (2.9.2) and middle (2.9.3) parts of clamping brackets tightened with bolt joints 2.3. The main kinematic connection of the cage with RPGs is provided with the help of rollers with grips 6.3. Straight rollers 6 provide directional movement of the cage and damping vibrations due to the rubber layer. Rollers are attached to the cage using attachments 6.2. The reliable kinematic connection is ensured by a safety leg 5.2 with grips. The enclosing box 2.2 is protected against the wear due to the leg inserts 5.3. Connection of adjacent RPGs is carried out using the I-beam segment 11 attached to the sole with bolts 2.3 (see Fig. 6) [4, 5].

As can be seen from the reinforcement shown in Figures 4 and 5, the use of double-row RPGs as guides for the movement of cages significantly reduces the metal consumption of the reinforcement and the aerodynamic resistance of the shaft, eliminates the need for embedding buntons in the shaft lining and installing them, as in a rigid reinforcement of the shaft, and allows you to fit in the same shaft diameter while achieving a higher level of safe operation, taking into account all regulatory requirements [3].

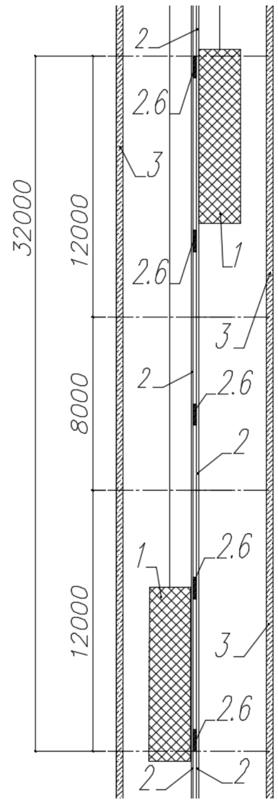


1 – lifting vehicle (cage type 2KH4-2); 2 – RPG (double-row); 2.1 – rope; 2.2 – enclosing profile; 2.3 – attachment of RPG parts; 2.5 – enclosing bar of RPG; 2.9.1 – lower part of RPG bracket; 2.9.2 – upper part of RPG bracket; 2.9.3 – middle part of RPG bracket; 5.1 – leg attachment; 5.2 – safety leg with grips; 5.3 – leg inserts; 6 – RPG roller; 6.1 – roller axle; 6.2 – roller attachment; 6.3 – roller with grips; 11 – I-beam segment (0.3 m long)

Figure 4 – View B

Deviation of cages under the action of horizontal forces arising during the movement as a result of all three exposure options is the most critical in the case of their movement towards each other at the meeting point of the vehicles in the middle of the shaft, especially in terms of the impact of the torsion of cages.

Therefore, in order to increase the reliability of vehicle movement, it is necessary to develop the structures that can significantly reduce the harmful effects of horizontal forces that arise when the cages of one lifting unit move towards each other at their meeting point in the middle of the shaft.



1 – vehicle; 2 – RPG; 2.6 – RPG of reinforcement; 3 – shaft lining

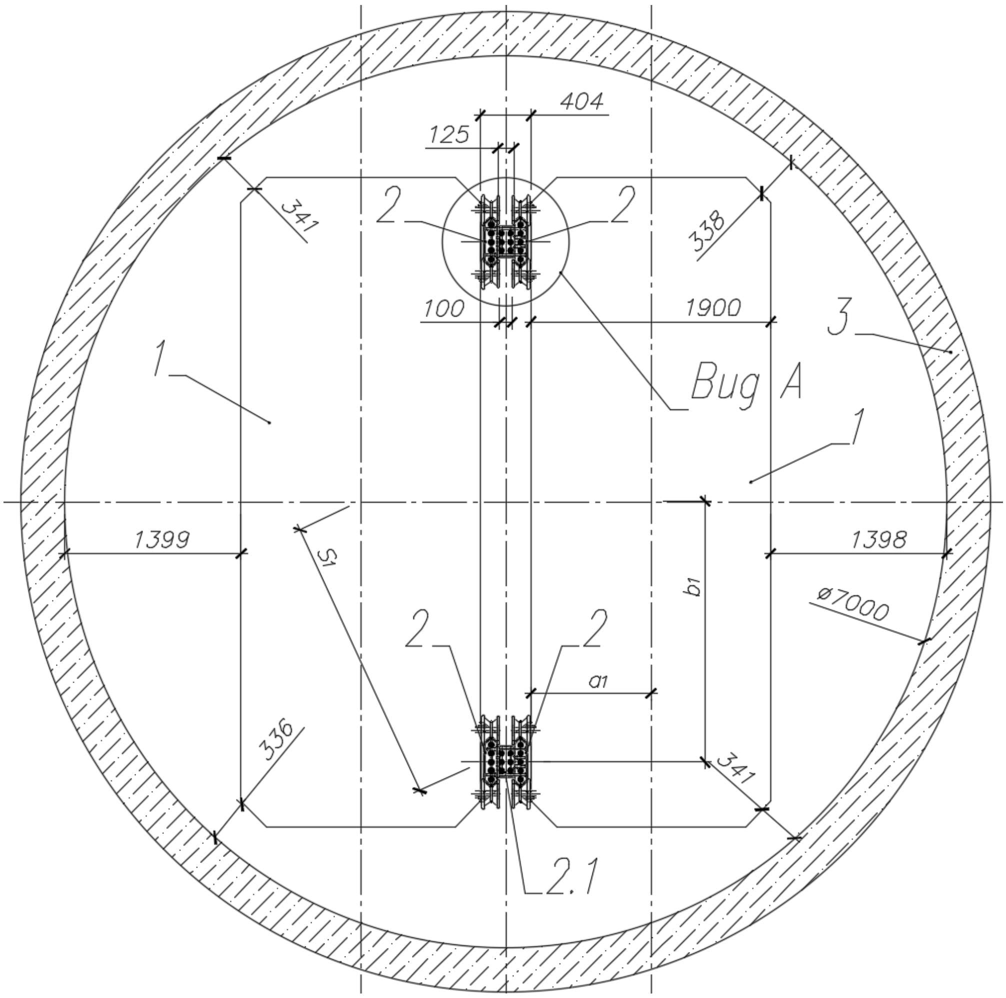
Figure 5 – Joint reinforced RPG for the movement of cages

Consider the option for cages 8 m long (see Figure 1). In addition, a single-row RPG, which structure is shown in Figure 7, is proposed to use for the main RPGs.

As can be seen from Figure 5, for a cage of type 2КН4-2 with L=8 m, the length of the meeting area of the vehicles is L=16 m. To reduce the influence of vehicle oscillations, we take a double length equal to L=32 m, in more remote places on both sides of the RPG they do not have reinforced sections of the RPG 1 m long.

Figure 6 shows the layout of cages moving in one-sided RPGs. The meeting area of vehicles in the middle of the shaft is reinforced at the length of 4 vehicles (L=32 m) with the help of a rectangular RPG section mounted between RPGs with a length of L=1 m and with a step of 8 m.

Figure 7 (View A) shows a cross-section of a double single-row RPG and cage guiding devices. A single-row RPG has an enclosing profile 2.2 (6 mm thick) made in the form of an elongated hexagon with parts of a tightening bracket (lower 2.9.1 and upper 2.9.2) inside with places for ropes. In this case, the lower part of the bracket 2.9.1 is welded into the enclosing profile 2.2, the upper part with ropes 2.1 is bolted into a single structure. On the enclosing rear bar 2.5 made of a plate 5 mm thick, a profile of a reinforcing RPG is attached (in this embodiment, 140×90×10 unequal leg angles according to GOST 8510-86) and a bar of a reinforcing RPG, with parts of tightening brackets (right 2.10.1, middle 2.10.2 and left 2.10.3) inside and the segments of ropes d=36.5 with a steel core between them according to GOST 7669-80. The entire structure is tightened into a single unit by through bolted joint 2.4 (see Figure 7). The preload of the ropes 2.1 of the reinforcing RPG is carried out in assembled state.



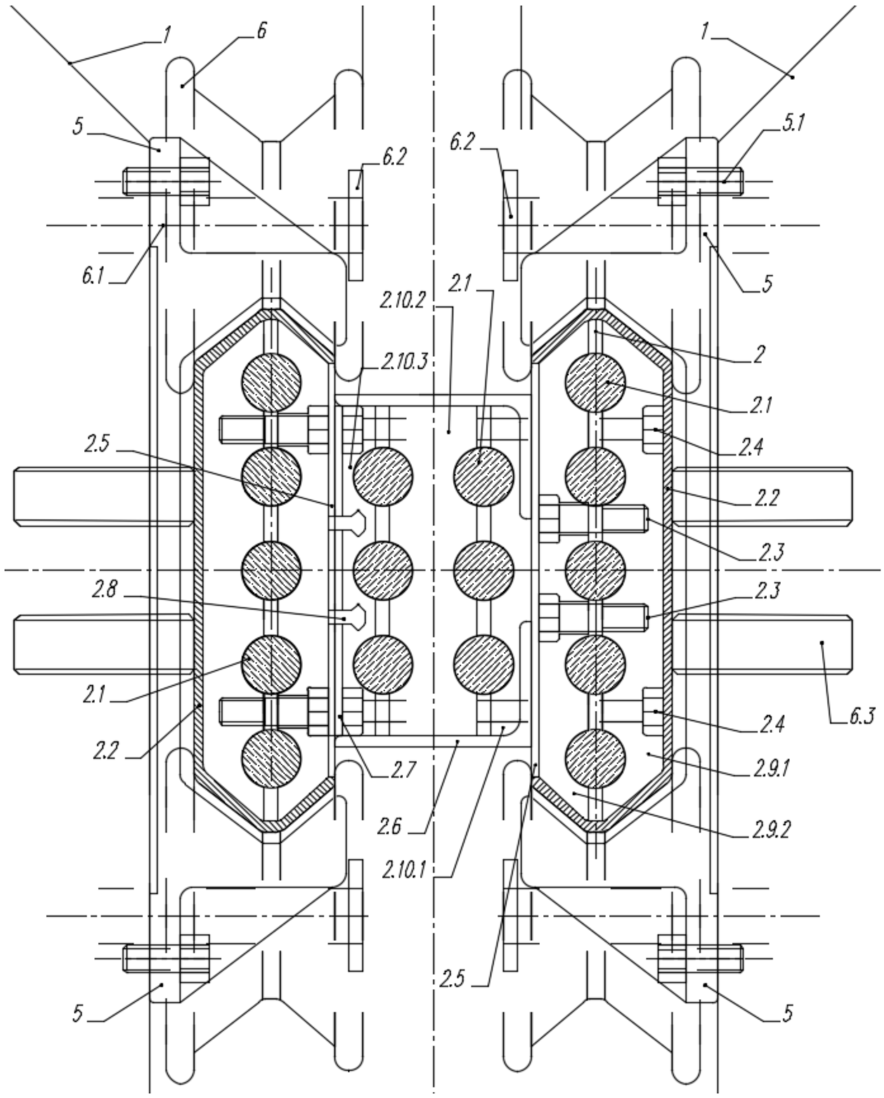
View A

1 – lifting vehicle (cage type – 2КН4-2); 2 – RPG (single-row); 2.1 – reinforcing RPG; 3 – shaft lining

Figure 6 – Cross-section of the shaft with two cages moving in single-row RPGs

The main guides that provide the kinematic connection of the cage and the single-row RPG are rollers with grips and a recess for the hexagonal single-row profile of the RPG fixed on the vehicle by means of the roller axle 6.1 and attachment 6.2. Safety guides are made as rigid legs 5 with a grip that repeats the profile of a single-row RPG. They are attached to vehicle 1 by attachment 5.1 (see Figure 7).

This structure of the kinematic attachment of a single-row RPG makes it possible to have a large contact area of the guide with the safety guide leg 5, a large number of guide front rollers 6.3, high bending rigidity of the joint guide at the meeting point of vehicles, ensuring safety gaps between the shaft lining and the moving cage up to 341 mm (see Figure 6).

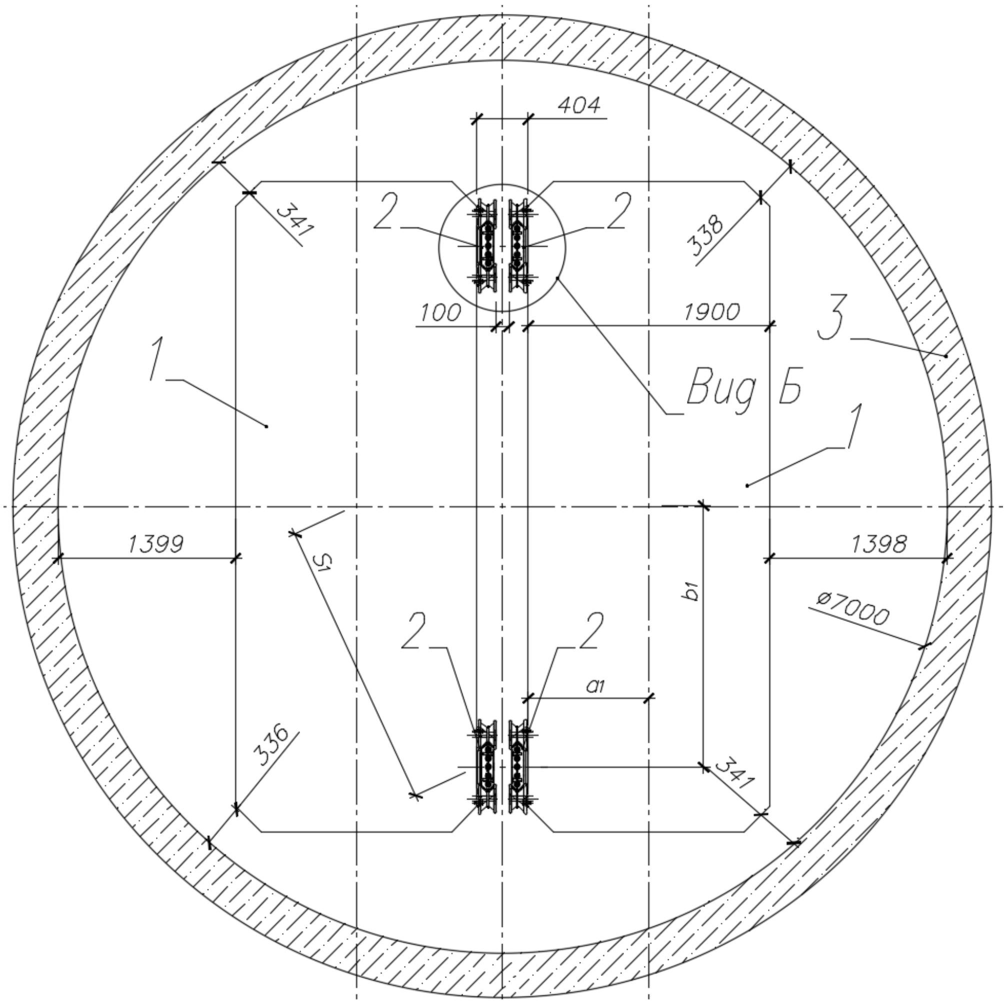


1 – lifting vehicle (cage type – 2KH4-2); 2 – RPG (single row); 2.1 – rope; 2.2 – enclosing profile; 2.3 – bolted joint of RPG parts; 2.4 – through bolted joint of RPGs; 2.5 – enclosing bar of RPG; 2.6 – enclosing profile of reinforced RPG; 2.7 – reinforcing RPG bar; 2.8 – mobile RPG connection; 2.9.1 – right side of RPG bracket;
2.9.2 – left part of RPG bracket; 2.10.1 – lower part of reinforcing RPG bracket; 2.10.2 – middle part of reinforcing RPG bracket; 2.10.3 – upper part of RPG reinforcing bracket; 5 – safety leg; 5.1 – leg attachment; 6 – side roller; 6.1 – roller axle;
6.2 – roller attachment; 6.3 – frontal roller

Figure 7 – View A

In addition, this design allows you to significantly reduce the angle of rotation of vehicles at the point of their meeting due to single-row adjacent RPGs which have many times greater torsion resistance compared to single rope guides. There is also no need to increase the shaft diameter, taking into account the safety gaps of 510 mm and hanging fender guides along the entire shaft length.

Figure 8 shows the arrangement of cages moving in single-row RPGs in a section not located in the center of the shaft, while the joint horizontal forces acting on the guide have significantly decreased due to a decrease in aerodynamic forces and vehicle torsion. At the same time, the safety gaps comply with the requirements of regulatory documents [3].



View B

1 – lifting vehicle (cage type – 2КН4-2); 2 – RPG (single-row); 3 – shaft lining

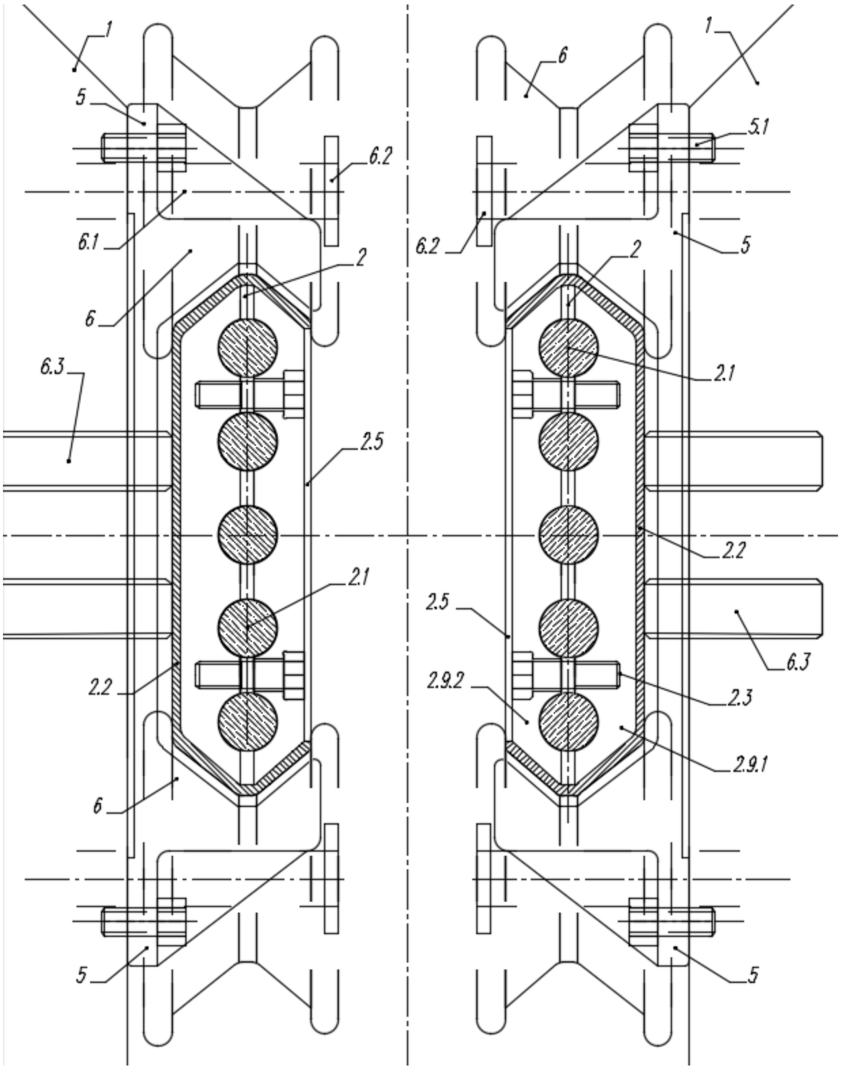
Figure 8 – Cross-section of the shaft with two cages moving in single-row RPGs

For the developed structures and schemes (see Figures 1–9), we use the finite element method software to determine the values of frontal deflections (as the most dangerous) for various guides under a maximum static load of 2.5 kN. These structures are:

- rope guides d=52 (see Figure 1);
- rigid reinforcement with P43 rail guides (see Figure 2);
- double-row RPG, consisting of 6 ropes d=42 (GOST 7669-80) with a steel core and enclosing profile (200×180×8 channel according to GOST 8278-83) and a rear cover 5 mm thick (see Figure 3);

- two single-row RPGs, consisting of 5 ropes d=36.5 (GOST 7669-80) with a steel core and enclosing profile and a back cover 5 mm thick.

The results and values are summarized in Table 1.



1 – lifting vehicle (cage type – 2KH4-2); 2 – RPG; 2.1 – rope; 2.2 – enclosing profile; 2.3 – attachment of RPG parts; 2.5 – enclosing bar of RPG; 5.1 – leg attachment; 6 – RPG roller; 6.1 – roller axis; 6.2 – roller attachment; 6.3 – frontal roller

Figure 9 – View B

Table 1 – Comparative table for determining deflections when applying a static horizontal load

No.	Name	Unit	4 rope guides per vehicle d=52	2 RPG (6×d=42)	2 RPG (5×d=42)	2 RPG (5×d=42) + 1 RPG (6×d=42)
1	Rope guide deflection in the middle of the shaft	mm	60	5.8	6.7	
2	Guaranteed gap between vehicles ΔΓ	mm	50	50	100	100
3	Guide deflection at the meeting point of vehicles	mm	-	5.8	6.7	3.8

Table 2 – Comparative table of reinforcement metal consumption

No.	Name	Unit	Rigid reinforcement	Flexible reinforcement 8 ropes d=52	2 RPG (6×d=42)	Variable 2 RPGs (5×d=42) + 1 RPG (6×d=36.5)
	Buntons					
1	Shaft depth	m	1,200.00	1,200.00	1,200.00	1,200.00
2	Bunton type		box beam			
3	GOST		8509-06	7669-80		
4	Bunton cross section	mm	200×200×14	-	-	-
5	Bunton weight	kg/rm	85.60	-	-	-
6	Buntons length in the tier	rm	8.600	-	-	-
7	Reinforcement step	m	3.126	-	-	-
8	Number of tiers	pcs	384	-	-	-
	Bunton weight in the shaft	t	**282.68**	**-**	**-**	**-**
	Guides					
1	Guide cross section	mm	P43	d=52	200×180×6	380×100×6
2	Guide weight	kg/rm	43	11.85	77.12	71.6 and 80.26
3	Guide length	rm	1,200.00	1,200.00	1,200.00	1200+32=1232
3.1	Reinforcing guide length	rm	-	-	-	32
4	Weight of fender ropes	kg/rm	-	11.85	-	-
5	Number of guides and fender ropes	pcs	-	8	4	4+2
	Weight of shaft guides	t	**821.76**	**113.76**	**370.176**	**348.82**
	Attachment					
1	Weight of attachment	kg/pc	9.10	-	28.00	25.00
2	Number of attachment per tier	pcs	8.00	-	4.00	4
3	Number of attachment per shaft	pcs	3072.00	-	300.00	310.00
	Weight of shaft attachment	ton	**27.96**	**7.68**	**33.6**	**31.00**
Total weight of shaft reinforcement:		ton	**849.72**	**121.44**	**403.77**	**348.85**

The developed structures of a single-row RPG with reinforcement make it possible to reduce the weight of the reinforcement, significantly increase safety gaps between the cages and the shaft lining, reduce the number of ropes, reduce the deflection of guides, and as a result significantly increase the service life, and also increase the safety and durability of the RPG, as well as the entire shaft reinforcement system.

3. Conclusions

The development and implementation of the structures of a single-row RPG with reinforcement between adjacent guides at the meeting point of the vehicles in the middle of the shaft makes it possible to achieve the following results:

- to ensure high reliability of operation of a single-row RPG;
- to increase the service life due to a significant decrease in the level of dynamic effects;
- to reduce labor intensity of maintenance and operation compared to rigid reinforcement, due to the complete absence of buntons;
- to reduce metal consumption compared to rigid reinforcement;
- to reduce the level of dynamic oscillations at the meeting point of vehicles in the middle of the shaft in the frontal and lateral planes;
- to increase the reliability of the kinematic connection in the "vehicle-RPG" system due to the use of special forms of side rollers and guide legs;
- to reduce safety gaps per side - 500 mm per side for cage hoists along the entire depth of the shaft;
- to reduce capital costs during installation and construction;
- to eliminate the effect of reinforcement on the shaft lining.

In general, the use of single-row RPGs with reinforcement at the meeting point of cages in the middle of the shaft with an enclosing profile made in the form of an elongated hexagon will improve the reinforcement of vertical mine shafts, significantly reduce the level of dynamic effects in the "vehicle- reinforcement" system due to the absence of buntons, and achieve high service life and reliability level of equipment.

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ДОСЛІДЖЕННЯ І РОЗРОБКА КОНСТРУКЦІЙ ОДИНАРНИХ КАНАТНО-ПРОФІЛЬНИХ ПРОВІДНИКІВ ДЛЯ РУХУ КЛІТІВ В АРМУВАННІ СТОВБУРА

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Анотація. В роботі досліджено горизонтальні навантаження, що виникають при русі судин під дією дисипативних сил (кручення канатів, аеродинамічних сил, завантаження клітей з ексцентриситетом у лобовій та бічній площині), які діють на однорядні канатно-профільні провідники (далі: - КПП; - або провідник).

У роботі для двох рухомих клітей однієї підйомної установки відповідно до чинних нормативних методик і Правил безпеки побудовано перерізи стволів для різних типів армування стовбуру, проаналізовано переваги і недоліки та проведено їх порівняльний аналіз.

На підставі досліджень розроблено конструкції однорядних КПП, які мають меншу кількість канатів та конструкцію огороджувального профілю у вигляді витягнутого шестигранника, який дозволяє підвищити надійність кінематичного зв'язку в системі «судина-провідник» та забезпечити збільшення запобіжних зазорів між судинами та кріпленням стовбура.

Виконана розробка різних конструктивних рішень однорядних КПП для клітей, яка дозволяє досягти:

– високої надійності експлуатації однорядного КПП;

– збільшення терміну експлуатації, внаслідок значного зниження рівня динаміки;

– зниження трудомісткості обслуговування та експлуатації, у порівнянні з жорстким армуванням;

– зниження металомісткості, порівняно з жорстким армуванням;

– зниження рівня динамічних коливань у місці зустрічі посудин у середині стовбура за рахунок зниження прогинів КПП;

– збільшення надійності кінематичного зв'язку в системі «посудина - КПП», за рахунок застосування направляючих лап спеціальної конструкції;

– зниження запобіжних зазорів на бік (до 500 мм на бік) для клітьових підйомів по всій глибині стовбура, як у порівнянні зі гнучким армуванням;

– зниження експлуатаційних витрат через високий термін служби однорядного КПП;

– виключення застосування відбійних канатів;

– збільшення терміну експлуатації канатно-профільних провідників до рівня провідників жорсткого армування стовбура.

Результатом впровадження розроблених конструкцій однорядних КПП з посиленням, є продовження терміну служби армування, та зниження витрат на капітальне будівництво та експлуатацію при видобутку корисних копалин з глибоких горизонтів.

Ключові слова: шахтні вертикальні стовбури, одинарні канатно-профільні провідники, посилення провідників, збільшення запобіжних зазорів між клітями і кріпленням стовбура, що направляють запобіжні пристрої, горизонтальні сили в лобовому та бічному напрямку.