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DEMIN V. F., MUSSIN R. A., ICONOPISCEVA E. O., KHALIKOVA E. R., BURAK YU. S.*

*Karaganda State Technical University, Karaganda, Kazakhstan, *e-mail: R.A.Mussin@mail.ru*

ORGANIZATION OF STAGE-BY-STAGE ANCHORING OF MINE WORKINGS

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Abstract: The technology of stage-by-stage anchoring of mine workings, conditions to maintain the workings depending on mining and process parameters are investigated. The research allowed developing the effective scheme for applying the anchor workings. The process of lining erection, even at fixing workings with anchors, is from 40 to 70 % of the tunnel cycle, it follows from this that high-performance and expensive tunneling equipment has downtime more than 40 % of its working time. Thus, the technological schemes for carrying out and fixing underground excavations, which are currently used, do not meet to the modern requirements for coal mine equipment using, and to the timing of excavation, and accordingly they do not contribute to increasing labor productivity. The conducted researches made it possible to increase the operating time of the combine and increase the speed of carrying out underground excavation spadework and to strengthen the fastening due to the technology of phased anchorage. The technology of stage-by-stage anchoring allows increasing the pace of underground workings not only by increasing the productivity of tunneling combines, but also by combining the basic technological processes of the tunnel cycle. It is possible to achieve this by dividing the bottomhole zone into two separate zones, in each of which various operations of a sinking cycle are made. That is, while conducting work on cutting and extracting rock mass in one zone, simultaneous work on securing the workings in the other. With the step-by-step anchoring of the mine workings, the rate of sinking is increased by approximately 25 %, compared with the standard technology of tunneling and fixing the mine workings. The daily machine work time of the combine machine increases to 0.2-0.5, and the speed of the workings increases by 20-30 %.

Keyword: anchor, mining, rock massif, mine workings, coal mine, rocks deformation, lining erection, sinking cycle, tunneling

Information about authors: Karaganda State Technical University (KarGTU), Karaganda, Kazakhstan
Demin Vladimir Fedorovich, Doctor of Technical Sciences, Professor of the RMPI Chair,. vladfdemin@mail.ru
Musin Ravil Altavovich, art. Lecturer RMBI, https://orcid.org/0000-0002-1206-6889 R.A.Mussin@mail.ru
Ikonopisceva Ekaterina Olegovna, student of the department of the RMIP, kat10-10@mail.ru
Khalikova Elvira Ravilovna, doctoral PhD, RMPI chair, https://orcid.org/0000-0003-1501-8492 salyahova_e@mail.ru
Burak Yulia Sergeevna, a student of the RMPI Department, uliaburak@mail.ru

*ДЕМИН В. Ф., МУСИН Р. А. *, ИКОНОПИСЦЕВА Е. О., ХАЛИКОВА Э. Р., БУРАК Ю. С.*
*Қарағанды мемлекеттік техникалық университеті, Қарағанды, Қазақстан, *e-mail: R.A.Mussin@mail.ru*

ТАУ ҚАЗБАЛАРЫН КЕЗЕҢ-КЕЗЕҢІМЕН АНКЕРЛІК БЕКІТУІҢ ҰЙЫМДАСТЫРУ

Түйіндеме. Бұл жұмыста тау-кен қазбаларын кезең-кезеңімен анкерлік бекіту технологиясы, тау-кен техникалық және технологиялық параметрлерге байланысты қазындыны күтіп ұстау шарттары зерттелген. Зерттеулер тау-кен қазбаларын ұстап тұру үшін анкерлік бекітуді пайдаланудың тиімді сызбаларын жасауға мүмкіндік берді. Бекітпені тұрғызу үрдісі, қазындыларды анкерлермен бекіткеннің өзінде, қазу (үнгілеу) циклінің 40-тан 70 % құрайды, бұл кезде жоғары сапалы және қымбат үңгілеу қондырғылары жұмыс уақытының 40 %-нан артық бөлігінде босқа тұрады. Осылайша, қазіргі уақытта пайдаланылатын жер асты қазбаларын қазу және бекіту жұмыстарының технологиялық сызбалары (схемалары), көмір шахталарындағы жабдықтарды және жұмыс уақытын пайдаланудың заманауи талаптарына сай келмейді, осының салдарынан еңбек өнімділігінің артуына ықпал етпейді. Комбайнның жұмыс істеу уақытын ұлғайту және жер асты әзірлеу жұмыстарының жылдамдығын арттыру, сондай-ақ тіреуіштерді күшейту жұмыстары кезең-кезеңімен анкерлеу технологиясы арқылы жүзеге асырылуы мүмкін. Кезең-кезеңімен анкерлеу технологиясы пайдаланылғанда жерасты жұмыстарының қарқыны тек үңгілеу комбайндарының өнімділігін арттыру арқылы ғана емес, сонымен қатар қазу (үңгілеу) циклінің негізгі технологиялық үрдістерін біріктіру арқылы арттырылады. Бұл қабаттың кенжар аймағын екі бөлек аймақтарға бөлу арқылы жүзеге асырылады, олардың әрқайсысында қазу циклінің әртүрлі операциялары орындалады. Яғни, бір аймақта тау массасын үңгілеу және шығару жұмысы жүргізілсе, басқа аймақта тау қазбаларын бекіту жұмыстары жүргізіледі. Тау-кен қазбаларын кезең-кезеңмен бекіткен кезде, ұңғылау жұмыстарының жылдамдығы стандартты технологиямен салыстырғанда 25 %-ға артады,

ал комбайнның күнделікті машинаны пайдалану уақытының тәуліктік коэффициенті 0,2-0,5 дейін, ал қазба жұмыстарының жылдамдығы 20-30 % артады.
Түйін сөздер: анкер, тау-кен қазбалары, көмір шахтасы, тау жыныстарының деформациясы, бекітпені тұрғызу, үңгілеу циклы

ДЕМИН В. Ф., МУСИН Р. А., ИКОНОПИСЦЕВА Е. О., ХАЛИКОВА Э. Р., БУРАК Ю. С.*
*Карагандинский государственный технический университет, Караганда, Казахстан, *e-mail: R.A.Mussin@mail.ru*

ОРГАНИЗАЦИЯ ПОЭТАПНОГО АНКЕРНОГО КРЕПЛЕНИЯ ГОРНЫХ ВЫРАБОТОК

Резюме. Исследованы технология поэтапного анкерного крепления горных выработок, условия их поддержания в зависимости от горнотехнических и технологических параметров. Исследования позволили разработать эффективные схемы применения анкерного крепления горных выработок. Процесс возведения крепи, даже при креплении выработок анкерами, составляет от 40 до 70 % проходческого цикла, из этого следует, что высокопроизводительное и дорогостоящее проходческое оборудование имеет простои более 40 % своего рабочего времени. Таким образом, технологические схемы проведения и крепления подземных выработок, применяемые в настоящее время, не соответствуют современным требованиям угольных шахт по использованию оборудования и времени проведения выработок, и соответственно они не способствуют повышению производительности труда. Повысить время работы комбайна и увеличить скорость проведения подземных подготовительных выработок, а также усилить крепление возможно за счет технологии поэтапного анкерного крепления. Технология поэтапного анкерного крепления позволяет увеличить темпы проведения подземных выработок не только за счет увеличения производительности проходческих комбайнов, но и за счет совмещения основных технологических процессов проходческого цикла. Это возможно достичь путем разделения призабойной зоны на две отдельные зоны, в каждой из которых производятся различные операции проходческого цикла. То есть при ведении работ по зарубке и извлечению горной массы в одной зоне, осуществлять одновременное ведение работ по креплению выработки в другой. При поэтапном анкерном креплении горной выработки увеличивается скорость проходки примерно на 25 % по сравнению со стандартной технологией проведения и крепления горной выработки, а также увеличиваются суточный коэффициент работы машинного времени комбайна до 0,2-0,5 и скорость проведения выработок на 20-30 %.
Ключевые слова: анкер, горная выработка, угольная шахта, деформация горных пород, возведение крепи, проходческий цикл

Introduction. Recently, the mines of the Karaganda coal basin have undergone changes in the mining and technical conditions of development. With an increase in the depth of development, in more scale reserves with complicated mining and geological conditions are developed. Increasing the depth of mining contributes to the growth of the gas-richness of the seams, their outburst danger and the change in the stress-strain state of the rock massif around the conducted excavations.

In connection with these complicating factors, the pace of mine workings began to drastically lag behind the time of advancement of the working faces, which leads to delays in the commissioning of mechanized lavas, that is, ensuring the necessary front of clearing operations [1].

To assess the complexity, disturbance and methods of influence on the rock massif, Figure 1 shows the types of difficult conditions, the characteristics of the massif, the nature of the manifestation of complexity, and the nature of the manifestation of deformations [2-5].

In the mines of the Karaganda coal basin, according to the fastening passports, 15 % of the underground workings are fixed by anchoring, 45 % – of the mixed type by metal arch support (MAS) and anchor support and 40 % – metal-arch support. An analysis of the exploitation of underground pits in the mines of the Karaganda coal basin in various mine-geological and mine-technological conditions has shown following. The reason for the low penetration rate is an increase in the time required to fasten the workings due to the increase in the cross-sectional area and the support parameters (the anchorage density, the length of the anchors, etc.).

Experimental Part. The technology of stage-by-stage anchoring of the preparatory work with the use of composite anchors. Figure 2 is a graph of the organization of the preparatory works of the mine "Kazakhstan" of the Karaganda coal basin. Preparatory workings have been completed in a pure form with the use of an anchorage. The distance between the rows of anchors is 0.5 m. The distance between the strips is 1 m.

From the schedule of work organization it is evident that during the work of the site in the technological shift, the construction of the anchor support takes 55 minutes, which is 50 % of the time of the break-through cycle. For a single technological shift, the group of workers performs 3 cycles, with the passage of workings for a length of 1.5 m.

Experience has shown that, in difficult mining and geological conditions, a secondary anchorage is used to strengthen the standard anchorage using deep-seated anchors with a high bearing capacity.

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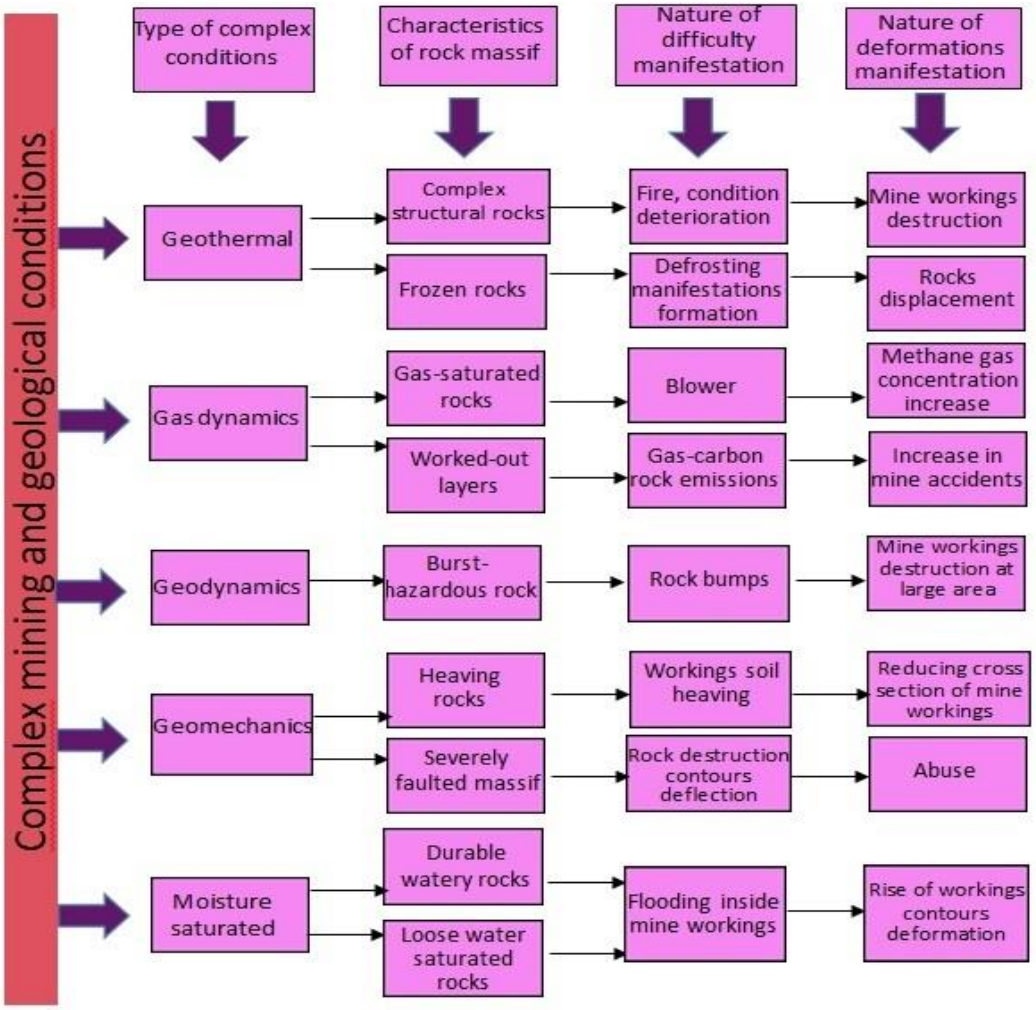

Figure 1 – Assessment of manifestations of deformations taking into account mining and geological conditions of development

The name of the operation	Workers number, person	1 cycle duration, minutes	Shift 1						Shift 2, 3, 4.					
			Shift hours						Shift hours					
			1	2	3	4	5	6	1	2	3	4	5	6
The work of the combine	1	55												
Loading of rock mass	1	55												
Construction of anchorage	3	55												
Build-up of ventilation pipeline	3	30												
Other support works	3	55												
The inspection of the machines	1	360												
Shipping materials, growing the fireproof and air column	7	360												

Figure 2 – Schedule of organization of works of the preparatory site of the mine "Kazakhstan"

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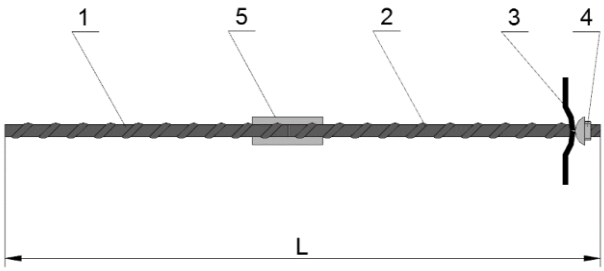
The use of composite anchors leads to the sustained maintenance of preparatory workings adjacent to the purifying bottomhole. [6,7]. When moving the lava and getting the workings in the zone of bearing (increased) rock pressure, composite anchors allow increasing the safety of work and maintaining the necessary parameters for the entire lifetime of this production. The construction of the composite anchor AVPK 22 is shown in Figure 3.



1 – reinforcing rod L1; 2 – reinforcing rod L2;
3 – support plate washer; 4 – screw nut hemispherical;
5 – coupler

Figure 3 – Construction of an anchor composite AVPK 22

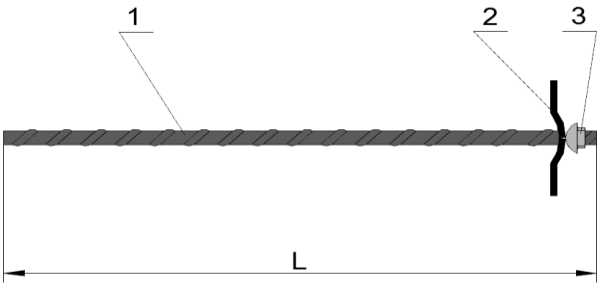
Brief technical characteristics of the composite anchor AVPK 22. Anchor fasteners AVPK is designed for fastening underground workings in coal mines with the chemical method of fastening steel rods in wells with a diameter of 27-30 mm, drilled in coal and rock with a compressive strength of at least 10 MPa for coal and 25 MPa for rocks. The main parameters are shown in Table 1.

Table 1 – Basic parameters of composite anchor AVPK 22

Basic parameters	Composite Anchor AVPK 22
Load-bearing capacity, kH, not less than	240
Length of the anchor rod (L1, L2), mm	1500-3000
Length of composite anchor with coupling (L), mm	3200-6200

Step-by-step anchoring provides for the first stage to install a minimum number of KAS anchors using the strips necessary for the stability of the bottomhole formation part. The design of the KAS anchor is shown in Figure 4.

Brief technical specification of the KAS anchor. Anchor support KAS is designed for fixing the roof of underground workings in coal mines with the strength of coal and rock for compression, respectively, 10 and 25 MPa and the sides of the excavations with the strength of coal and rock for compression, respectively, 6 and 20 MPa. The main parameters are shown in Table 2.



1 – reinforcing rod L; 2 – support plate washer;
3 – helical hemispherical nut

Figure 4 – Construction of the KAS anchor

Table 2 – Basic parameters of the KAS anchor

Basic parameters	Steel anchor KAS
Diameter of the rod, mm, min / max	21,6/25
Load-bearing capacity, kH, not less than	223
Length of the anchor (L), mm	1500-3000

After installed in the first stage of the anchors KAS with strips, in the second stage, the installation of composite anchors is made and the fastening is fixed to the passport value, at some distance from the face (Figure 5). Installation of composite anchors in the second stage of fastening is provided in such a way as to make up the tightness of the anchorage, including the steel anchors to make the support beam above the workings roof. It is important to note that the anchors installed at the sides and the anchor against the heaving, at the side of the future lava, must made from fiberglass.

The fastening of the support to the passport value at the second stage of fastening can be made in the repair and preparation shift, and also during the removal of the mass behind the combine in the technological shift or during the forced downtime of the combine. To ensure safety in the conduct of work using a phased anchorage, it is necessary to conduct constant monitoring of the displacement of the roofing of the mine workings, as well as the deformation of the anchorage support at each stage of the fastening.

If necessary, to adopt operational decisions to strengthen the fastening of the mine workings.

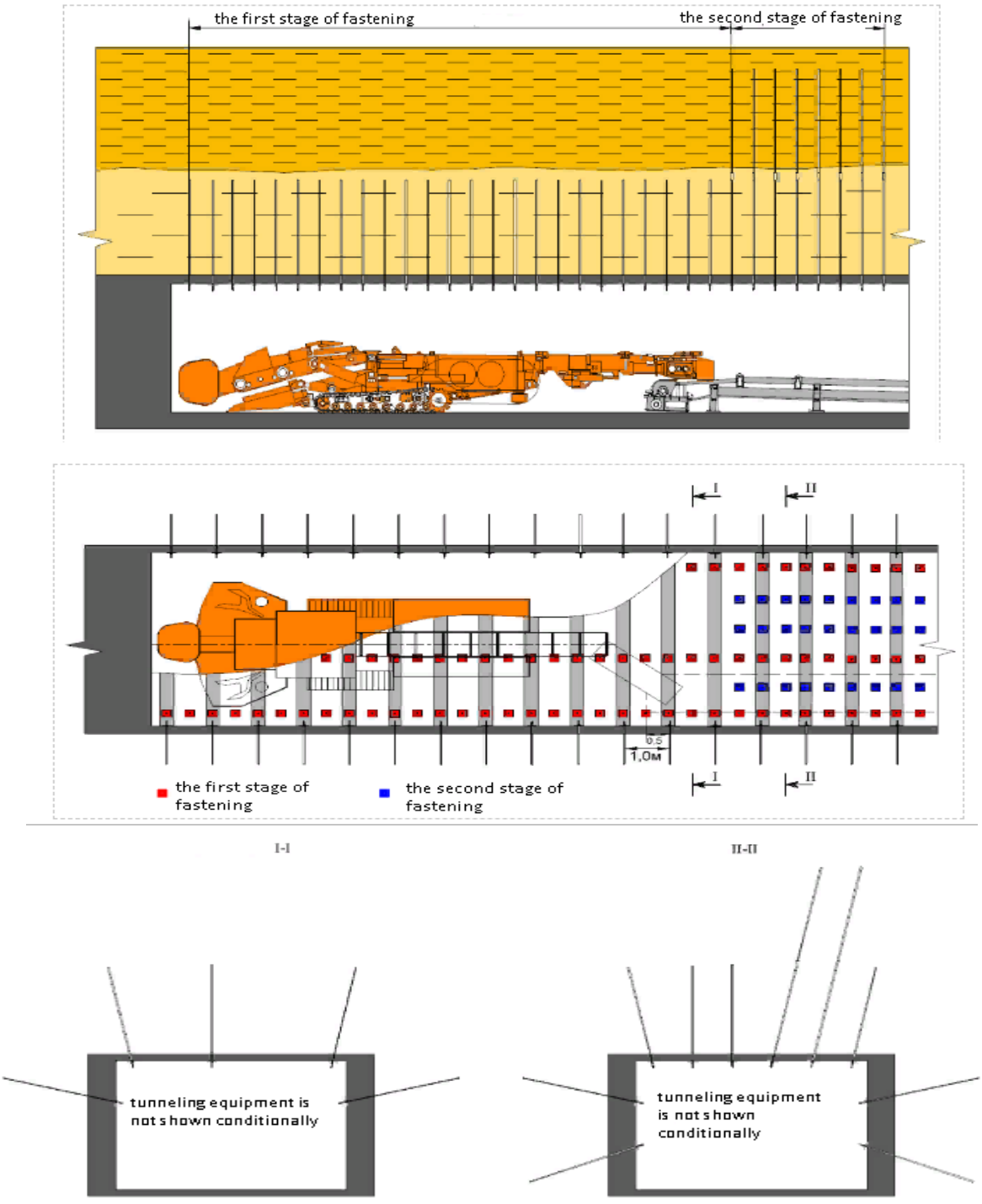


Figure 5 – Technology of stage-by-stage anchoring of the preparatory working

With the use of a phased fixing, the schedule of work organization, when carrying out the preparatory workings out, takes on the following form (Figure 6).

Results and discussion. The use of the phased anchoring technology allowed to increase the performance of work by a link of workers in the technological shift up to 4 cycles, i.e. the production per working shift was 2 m, which is 25 % more than the production in the standard way [8, 9].

The technology of stage-by-stage attachment of the mixed type in the preparatory work.

Work organization schedule

The name of the operation	Workers number, person	1 cycle duration, minutes	Shift 1						Shift 2,3,4.					
			Shift hours						Shift hours					
			1	2	3	4	5	6	1	2	3	4	5	6
The work of the combine	1	55												
Loading of rock mass	1	56												
Construction of anchorage	3	27												
Build-up of ventilation pipeline	3	30												
Other supporting work	3	55												
The inspection of the machines	1	360												
Shipping materials, growing the fireproof and air column	7	360												

Figure 6 – Schedule of work organization using the technology of phased anchorage

In the Karaganda coal basin, the share of mounts of preparatory workings by a mixed type accounts for about 45 % of all underground workings.

Mounting of mixed type implies the joint use of MAC and anchor bolts.

This combination ensures a high load-bearing capacity and a stable maintenance of the preparatory work. Figure 7 shows the schedule for the organization of the preparatory works of the mine "Kazakhstan". The preparatory work was completed with a mixed type of attachment.

Work organization schedule

The name of the operation	Workers number, person	1 cycle duration, minutes	Shift 1						Shift 2, 3, 4.					
			Shift hours						Shift hours					
			1	2	3	4	5	6	1	2	3	4	5	6
The work of the combine	1	90												
Loading of rock mass	1	90												
Erection of MAK	3	40												
The erection of the anchor support	3	45												
Build-up of ventilation pipeline	3	25												
Other support works	1	90												
The inspection of the machines	1	360												
Shipping materials, growing the fireproof and air column	7	360												

Figure 7 – Schedule of organization of works of the preparatory site of the mine "Kazakhstan

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The schedule of work organization shows that during the work of the site, in the technological shift the construction of the anchor support takes 45 minutes, which is 25 % of the time of the sinking cycle. For a single technological shift, the link of workers fulfills two cycles, with the passage of mine workings to a length of 1.5 m. During a day, the working is 4.5 m.

The technology of stage-by-stage fixing of the preparatory work with the use of a mixed-type fastening provides for the first stage of the MAC installation to ensure a stable support of the bottomhole part of mine working. At the second stage the steel anchors are installed and the fastening fixed up to the passport value, at some distance from the bottom (Figure 8). It should be noted that the distance between the MAC frames installed in the first stage in this case increases by 20-30 %, and the steel anchors installed outside the bottomhole zone (in the second stage) increase the mine workings contours stability to ensure the required fixing installation density.

The fastening of the support up to the passport value at the second stage of fastening can be made in the repair and preparation shift and, during the removal of the mass behind the combine in the technological shift or during the forced downtime of the combine [10–13].

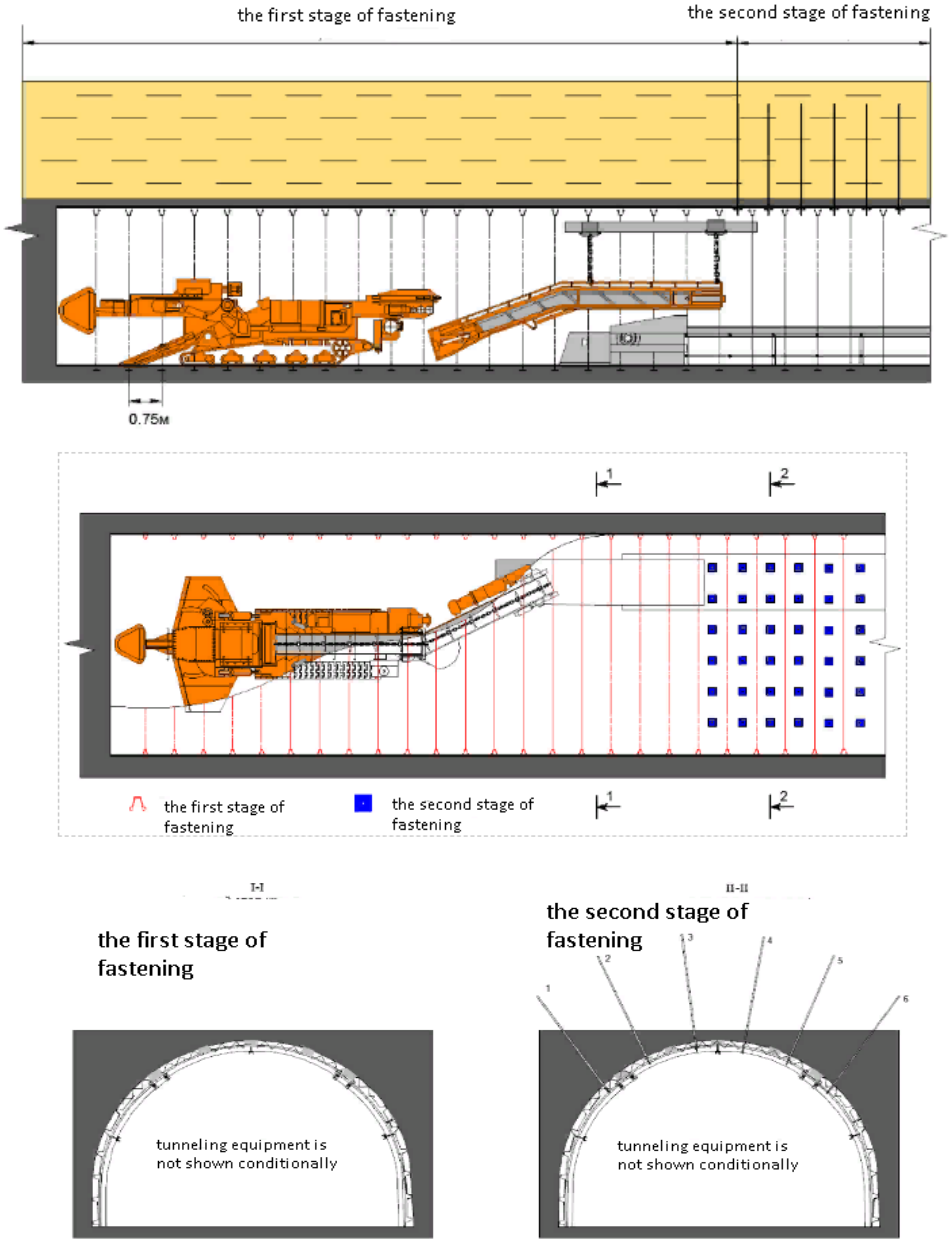

Figure 8 – Technology of stage-by-stage attachment of a mixed type of preparatory work

Work organization schedule

The name of the operation	Workers number, person	1 cycle duration, minutes	Shift 1						Shift 2,3,4.					
			Shift hours						Shift hours					
			1	2	3	4	5	6	1	2	3	4	5	6
The work of the combine	1	90												
Loading of rock mass	1	90												
Erection MAK	3	40												
The erection of the anchor support	3	45												
Build-up of ventilation pipeline	3	25												
Other support works	1	90												
The inspection of the machines	1	360												
Shipping materials, growing the fireproof and air column	7	360												

Figure 9 – Schedule of work organization using the phased attachment technology

With the use of a step-by-step fastening, the schedule of work organization, while carrying out the preparatory work with the fixing of the mixed type, takes on the following form (Figure 9).

Application of stage-by-stage technology allowed increasing the work of the combine and the loading of rock mass for 90 minutes per one technological shift, which is 25 % more than the working conduction by the standard way. The output per day was 6 m. [8, 9, 14–16]

Conclusions. The analysis showed that the use of stage-by-stage fastening of underground mining excavations allows increasing the daily coefficient of combine's machine time up to 0.2-0.5. Also, carrying out the mine workings with the technology of stage-by-stage fastening allows to reduce the time of the sinking cycle by 25-50 % and, accordingly, to increase the speed of the workings by 20-30 %. Thus, the expediency of using this technology is obvious.

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