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# Development of Support Plan and Operation Scheme for Semi-mechanized Longwall Face of Coal Seam 10T, Nam Khe Tam Mine – 86 Company, Dong Bac Corporation

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**Abstract.** Support plans and operation schemes of mine faces are critical technical documents in underground coal mining management. The development and selection of a reasonable support plan and operation scheme of the face are complicated because they involve many factors. In specific mining conditions, developing and selecting an appropriate support plan and operation scheme will improve the working efficiency of equipment, increase labor productivity, and ensure workers' safety. This article researched a mining technology for the thin seams, focusing on coal seam 10T in Nam Khe Tam coal mine, 86 Coal Company. From the analysis of geo-mining conditions, the article developed and selected a reasonable support plan and operation scheme for the face in coal seam 10T. After being used in the field, the support plan and operation scheme have brought the face efficiency and safety.

**Keywords:** Mining technology, Semi-mechanized, Hydraulic prop, Box bar, Operation scheme, Support plan

## 1. Introduction

Semi-mechanized mining technology is a type of technology that uses shearer or plow with non-mechanized supports to extract raw coal block [1]. This technology has been used in many countries, especially in China [2, 3], where semi-mechanized mining techniques applied to thin coal seams with a gently sloping angle are also relatively effective. However, this technology for thin coal seams is still new for underground mines in Quang Ninh coal basin, Vietnam.

To date, Dong Bac Corporation's coal mines are managed and exploited mainly by the underground method. With a limited mining area, the annual mining output at the mines is not high. The Nam Khe Tam mine of Company 86, Dong Bac Corporation, is an exception. In Dong Bac, underground sites include Bac Quang Loi, Tay Bac Khe Cham (Company 790), Tay Bac Nga Hai, Tay Nam Khe Tam (Company 35), Dong Ri (Company 45), Nam Khe Tam (Company 86), Khe Chuoi (Company 91), Ho Thien (Company 618), Dong Quang La, and Tay Quang La (Thang Long Company) occupy total geological reserves of about 66.9 million tons.

Due to different geological conditions, Dong Bac Corporation has applied a few mining systems and supporting and mining technologies. Nowadays, the Corporation has researched and used different types of supports for each geological condition. Hydraulic props, moveable hydraulic supports, moveable frame supports, support shields “ZRY”, and recently, flexible mechanized support are being deployed at Company 35, Company 618, and Company 790. However, most faces in the Corporation are using mining technology of drilling and blasting method. The advantage of drilling and blasting technology is mobility and flexibility, applied to all geological conditions. However, the disadvantages of this technology are low safety, interruption in the technological chain, releasing harmful gases, and low productivity.

To eliminate the disadvantages of the drilling and blasting mining method, along with the determination to modernize technology in underground mining, Dong Bac Corporation has cooperated with Company 86 to find suitable areas for applying mechanized mining technology. The first problem is choosing the type of mechanization technology (semi-mechanized or fully mechanized). The second is human resources to operate the equipment because the Corporation has no experience applying such technology. Based on research results and consultation and a practical study on the application of semi-mechanized mining technology at some Chinese longwall faces for thin and gently sloping coal seams, the efficiency has been realized. Therefore, the Corporation decided to apply for the same conditions at Nam Khe Tam [3, 4].

From the above practical issues, the article has researched and proposed a design for support plan and operation scheme for longwall face in seam 10T. Nam Khe Tam mine can apply and deploy these proposal designs in actual production to improve synchronous equipment's supporting and working efficiency in the longwall face, thereby increasing mining efficiency and productivity.

## 2. Geological features and mining technology of Face № 10-2, Nam Khe Tam mine, Company 86

### 2.1 Geological characteristics of Face № 10-2

Basic geological parameters of the designed area are as follows [5, 6]:

- Name of the face: № 10-2
- Mining levels: +70/+90
- Coal seam: 10T
- Average thickness of coal seam: m = 1.3 m;
- Average seam dip angle: $\alpha = 20^{o}$;
- Volumetric weight of coal: $\gamma = 1.58$ T/m$^3$;
- Average length in dip direction: Ld = 88 m;
- Length in strike direction: Lp = 250 m;
- Immediate roof is siltstone with an average thickness of 3.3 m, hardness f of 4 ÷ 6; the main roof is sandstone with an average thickness of 8 m, Protodyakonov scale of hardness f of 6 ÷ 8;
- Immediate floor is siltstone with a thickness of 6 m, hardness f of 4 ÷ 6; the main floor is sandstone, an average thickness of 5.5 m, Protodyakonov scale of hardness f of 6 ÷ 8.

From the results of geological exploration and data collected from the preparatory excavation process, the coal in the designed area is of the semi-anthracite type, without spontaneous combustion. Coal seam has a simple structure. The roof and floor are of medium to stable stability, and the main roof is stable to very stable. With the above geological conditions, applying semi-mechanized mining technology for longwall face № 10-2 is appropriate. Seam 10T is thin and gently sloping, so selecting and applying equipment with small capacity used in the face is entirely feasible.

*+ Location of Face № 10-2*

For opening the deposit at Seam 10T, Company 86 drove an adit level +45 and drove transport drift level +70 from ventilation raise +45/+70. From collar level +195 drove ventilation raises +100/+195 and +70/+90, therefore drove ventilation drift level +90. On that basis, drove raise +90/+70 to form Face № 10-2 at Seam 10T. Figure 1. show the location of the longwall face № 10-2.

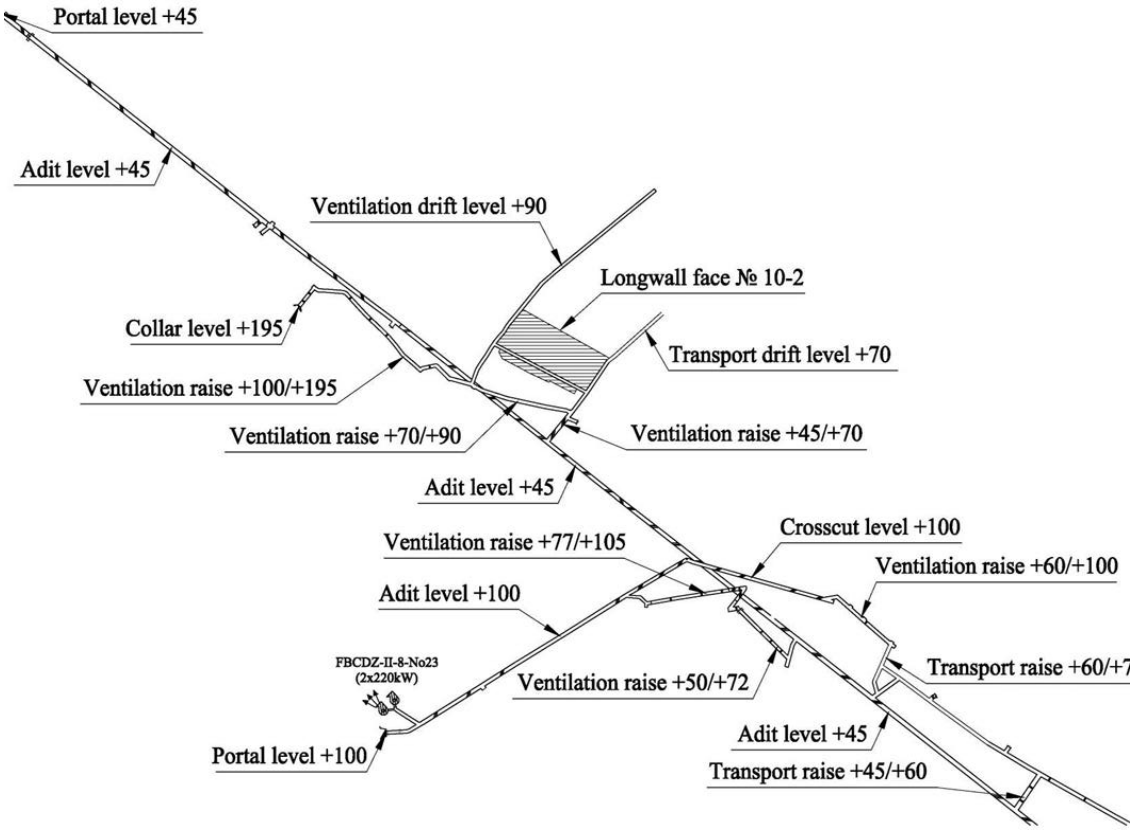


**Fig. 1.** Location of the longwall face № 10-2 at coal seam 10T, Company 86.

### 2.2 Mining technology of the longwall face № 10-2

***+ Mining technology***

The selection of coal mining technology depends on many factors in which the geological conditions of mine are the decisive factors. Coal seam 10T in Nam Khe Tam mine has an average slope angle of 20 degrees, an average thickness of 1.3 m; this is a thin and gently sloping seam. According to a preliminary assessment of geological conditions, the seam is relatively stable, and it is possible to use mechanized technology. Currently, this technology is used in many different underground mines and has shown fairly good results. The application of mechanized technology at underground coal mines of Dong Bac Corporation has been approved based on geological conditions assessment of a few mines having suitable conditions. The application of mechanization technology ensures the requirements of output, productivity, and a high level of safety [4].

***+ Main synchronized equipment at the longwall face*** [7]

Many different factors and regulations influence the selection of synchronous equipment at the longwall face. This selection is a problem of the technological system and a problem of the most optimal combination. The synchronous selection of equipment achieves the most relevant results for overall longwall face design. The equipment synchronization must be consistent with the geological conditions of the designed area and technical and economic factors of Company 86.

*- Shearer*

To extract coal in the longwall face № 10-2, Company 86 has chosen the China shearer MG125/150-WD (Fig. 2) with specifications shown in Table 1.

**Tab. 1.** Specifications of shearer MG125/150-WD.

| (№) | Parameters | Unit | Value |
|---|---|---|---|
| 1 | Cutting range | m | 0.8 ~ 2.2 |
| 2 | Cutting drum web | m | 1.0 |
| 3 | Operational Haulage speed | m/min | 0 ~ 3.5 |
| 4 | Maximum Haulage pull | KN | 150 |
| 5 | Number of cutting drum | drum | 1 |
| 6 | Cutting drum diameter | mm | 800 |
| 7 | Cutting drum speed | r/min | 82 |
| 8 | Chain type | mm | Φ18×64 |
| 9 | Operation angle of ranging arm | degree | +45 ÷ -16 |
| 10 | Coal hardness | | f ≤ 3.5 |
| 11 | Slope angle | degree | ≤ 35 |
| 12 | Speed adjustment method | | inverter |
| 13 | Maximum power installed on cutting drums | Kw | 125 |
| 14 | Supply voltage | V | 660/380 |
| 15 | Cooling method | | by water |
| 16 | Maximum power installed on haulage drive | Kw | 22 |
| 17 | Total weight | Ton | ~8 |
| 18 | Outer Dimensions (Length x Width x Height) | mm | 6500 x 1600 x 700 |

*- Roof support*

From analysis and comparison of different types of roof supports, the support selected for application at the longwall face № 10-2 is a combination of single hydraulic prop DW22-300/100 and steel box bar DFB 2800/300. Specifications of single hydraulic prop DW22-300/100 and steel bar DFB 2800/300 are shown in Tables 2 and 3.

**Fig. 2**. Shearer MG125/150-WD.

**Tab. 2.** Specifications of single hydraulic prop DW22-300/100.

| № | Parameters | Unit | Value |
|---|---|---|---|
| 1 | Rated working resistance | kN | 300 |
| 2 | Rated working pressure | MPa | 38.2 |
| 3 | Setting load | kN | 118 - 157 |
| 4 | Hydraulic pump pressure | MPa | 15 - 20 |
| 5 | Max height | mm | 2240 |
| 6 | Min height | mm | 1440 |
| 7 | Piston range | mm | 800 |
| 8 | Cylinder diameter | mm | 110 |

**Tab. 3.** Specifications of steel box bar DFB 2800/300.

| № | Parameters | Unit | Value |
|---|---|---|---|
| 1 | Bar length | mm | 2800 |
| 2 | Weight | kg | 65 |
| 3 | Allowable load of bar | kN.m | 300 |

- *Transport equipment*

The transport equipment used in the longwall face № 10-2 is a conveyor coded SGZ 630/2*90, synchronized with the shearer MG125/150-WD (see Fig. 3). Table 4 shows the technical parameters of this conveyor.

**Fig. 3.** Armored face conveyor SGZ 630/2*90.

**Tab. 4.** Specifications of conveyor SGZ 630/2*90.

| № | Parameters | Unit | Value |
|---|---|---|---|
| 1 | Transport capacity | Ton/h | 250 |
| 2 | Conveyor length | m | 150 |
| 3 | Moving speed | m/s | 0.868 |
| 4 | Electric motors | | DSB-90, 90Kw × 2 |
| | Motor speed | r/min | 1480 |
| | Voltage | V | 660 |
| 5 | Hydraulic coupling | | D450 |
| | Rated power | Kw | 90 × 2 |
| | Cooling method | | by water |
| | Coolant water flow | lit | 14 |
| 6 | Chain type | | two middle chains |
| | Chain specification | | ϕ18×64 |
| 7 | Dimensions of plate (Length × Width × Height) | mm | 1500×630×190 |

## 3. Design of support plan and operation scheme for longwall face № 10-2

Support plan and operation scheme are two closely related technical documents. They must fit together in both time and space. These documents are prepared by professionals and are used to direct the production and management of the mine [8].

### 3.1 Design of support plan for the longwall face № 10-2

The support plan is a document that shows necessary information for viewers to use to build and install the roof supports, ensuring the safety of workers and equipment. This plan offers the status of longwall face according to each extraction cycle, type of used mining technology, distance between supports, number of supports, movement of shearer and support, and pressure control method in the face. In addition, the support plan also shows the progress of moving face in one day and the procedure for creating a room placing shearer.

**+ *Design basis*** [6, 9, 10]

- Documents on the mine geology of design area; parameters on properties of the roof and floor rock;
- Mining technology in the longwall face, technical parameters of equipment;
- Hypothesis to determine mine pressure (console beam hypothesis);
- Method of creating a room for placing shearer (head or tail);
- Method of controlling mine pressure in the longwall face;
- Skill level of workers;
- Requirements of actual production;
- Technical, safety, and efficiency requirements.

***+ Support plan for the longwall face № 10-2***

According to the calculation, the length of the longwall face is 88 m, the number of single hydraulic props is 1057 pillars, and the number of steel bars is 23 units. In the longwall face, there are three rows of props. The distance between the prop rows is 0.8 m, the distance between the props in each row is 0.5-1 m (Fig. 4).

### 3.2 Design of operation scheme in the longwall face № 10-2

The operation scheme in the longwall face shows how to arrange the work in a specific space and time relationship. It also shows the required labor to complete each assignment, ensuring that the longwall face moves on schedule to reach the designed capacity. It is imperative to establish a suitable operation scheme for each different condition, which is helpful to managers because it determines the working efficiency of the selected synchronous equipment and ensures the safety of workers.

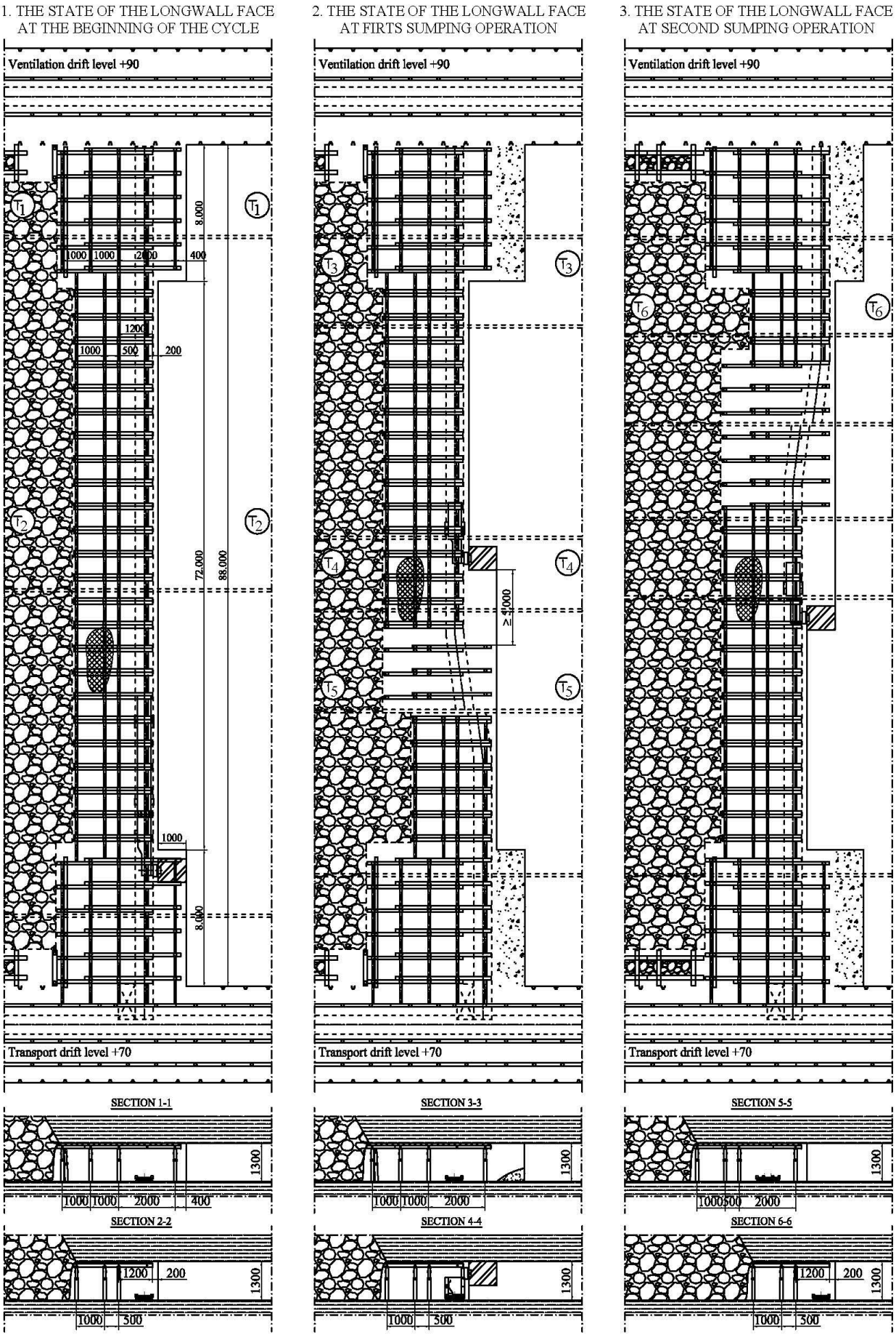


**Fig. 4**. Support plan for the longwall face № 10-2, Nam Khe Tam mine.

Detailed research and calculation based on initial geological data to establish a close relationship between technological stages are essential, aiming to maximize the working efficiency of the shearer and other equipment at the longwall face. The operating efficiency of shearer is one of the factors affecting the economic efficiency in the mining process. It is necessary to arrange a reasonable operation scheme so that shearer can promote its advantages to achieve high productivity in longwall face.

**+ *Design basis*** [1, 8, 11, 12]

- Factors regarding characteristics of geological conditions of the design area;
- Technical and technological factors;
- The parameters directly affect the productivity of the shearer;
- Movement speed of shearer;
- Tasks need to be completed in one mining cycle: cutting face, strengthening face, repairing face, operating face supports and conveyors...);
- Norms to complete each task;

***+ Operation scheme for the longwall face № 10-2***

The production tasks in the longwall face № 10-2 are organized and performed in cycles. A cycle of two web cuts is completed within two shifts, equivalent to the face moving progress of three meters per day (Fig. 5). A web cut includes the following stages: cutting face and installing supports with an advance rate of 1.0 m, recovering supports at transport, and ventilation drifts. The inspection and maintenance of equipment are carried out at the end of each shift, including maintenance, repair, and replacement of spare parts if necessary for shearer, roof supports, conveyors, electrical equipment and emulsifier pump systems, dust filter system, power supply system, water supply system, methane warning system, and pressure test of roof supports. The number of workers in the face is arranged depending on the specific work of each shift. According to calculations, the required number of workers is 29 people for the first shift and 27 people for the second shift (Fig. 6).

| № | WORK CONTENT | SIGN |
|---|---|---|
| 1 | Strengthen the longwall face | |
| 2 | Shearer operation (cutting) | |
| 3 | Coal transport | |
| 4 | Conveyor shifting | |
| 5 | Support shifting | |
| 6 | Inspection and maintenance | |
| 7 | Drilling | |
| 8 | Mine charge, blasting, ventilation | |
| 9 | Install additional supports in drifts | |
| 10 | Recover additional supports in drifts | |
| 11 | Install the supports in the area adjacent to the drifts | |
| 12 | Break time | |

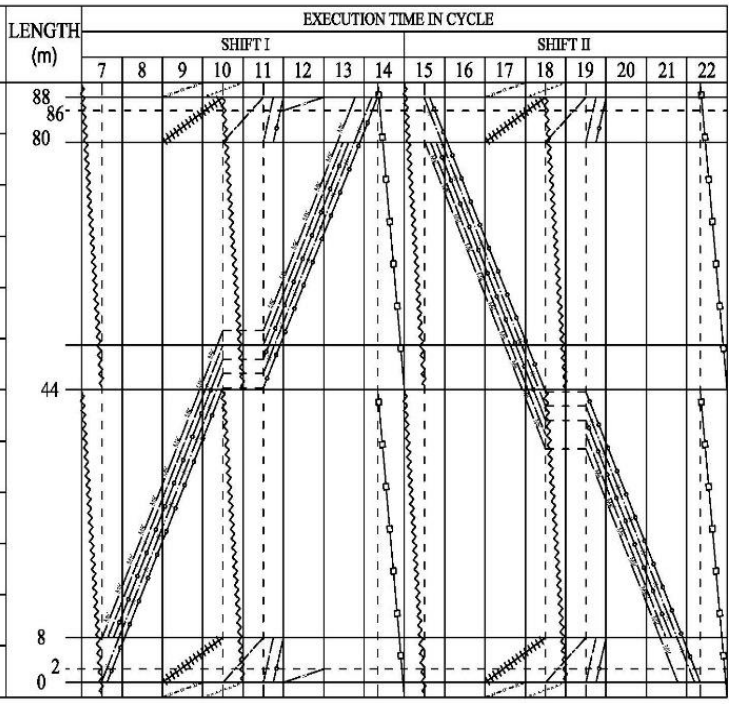


**Fig. 5.** The operation scheme in the longwall face № 10-2.

| № | WORK CONTENT | Number of people | | | EXECUTION TIME IN CYCLE | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | SHIFT I | | | | | | | | SHIFT II | | | | | | | |
| | | SHIFT I | SHIFT II | TOTAL | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| 1 | Strengthen the longwall face | (10) | (10) | (10) | | | | | | | | | | | | | | | | |
| 2 | Shearer operation (cutting) | 2 | 2 | 4 | | | | | | | | | | | | | | | | |
| 3 | Conveyor operation in longwall face | 1 | 1 | 2 | | | | | | | | | | | | | | | | |
| 4 | Conveyor operation in transport drift | 1 | 1 | 2 | | | | | | | | | | | | | | | | |
| 5 | Loading | 4 | 4 | 8 | | | | | | | | | | | | | | | | |
| 6 | Conveyor shifting | 4 | 4 | 8 | | | | | | | | | | | | | | | | |
| 7 | Support shifting | 8 | 8 | 16 | | | | | | | | | | | | | | | | |
| 8 | Inspection and maintenance | 8 | 8 | 16 | | | | | | | | | | | | | | | | |
| 9 | Drilling | 4 | - | 4 | | | | | | | | | | | | | | | | |
| 10 | Mine charge, blasting, ventilation | | | | | | | | | | | | | | | | | | | |
| 11 | Install additional supports in drifts | 2 | 2 | 4 | | | | | | | | | | | | | | | | |
| 12 | Recover additional supports in drifts | | | | | | | | | | | | | | | | | | | |
| 13 | Install the supports in the area adjacent to the drifts | - | 4 | 4 | | | | | | | | | | | | | | | | |
| 14 | Transfer materials, food | 2 | 2 | 4 | | | | | | | | | | | | | | | | |
| 15 | Control area manager | 1 | 1 | 2 | | | | | | | | | | | | | | | | |
| 16 | Electromechanical manager | 1 | 1 | 2 | | | | | | | | | | | | | | | | |
| 17 | General production manager | 1 | 1 | 2 | | | | | | | | | | | | | | | | |
| 18 | Break time | - | - | - | | | | | | | | | | | | | | | | |
| TOTAL | | 29 | 27 | 56 | | | | | | | | | | | | | | | | |

**Fig. 6**. Chart of human resource arrangement in the longwall face № 10-2.

### 3.3 Economic and technical indices

After researching and establishing a support plan and operation scheme for Face 10-2 seam 10T Nam Khe Tam mine, which is exploited by semi-mechanized technology, with the above equipment combination, the calculated main economic-technical indices are shown in Table 5.

## 4. Results and discussions

To bring the best coal cutting efficiency of shearer, we need to arrange it to work correctly. Therefore, the arrangement of shearer to work in the face is also the process of calculating and establishing the support plan and operation scheme in the longwall face. It determines the labor productivity in the longwall face and thus should be arranged to work properly.

The article has built a support plan (Fig. 4) and an operation scheme (Figs. 5, and 6) for Face 10-2 seam 10T Nam Khe Tam mine, Company 86. Based on the established support plan and the operation scheme of Face10-2, 10T seam, Nam Khe Tam mine, the authors calculate the economic-technical indices for the face. The results (Table 5) show that this technology has good efficiency, completely meets technical and economic requirements, and at the same time ensures safe conditions in exploitation.

Compared to other studies, the new point of this study is the development of a support plan and operation scheme for the semi-mechanized face (currently, Quang Ninh coalfield has nine faces, which have been used fully mechanized technology). The type of shearer used is the single-drum shearer. The cutting depth of the shearer is 1 m (the shearers currently used in nine faces in Quang Ninh are double-drums shearer, cutting depth 0.63 m) [13, 14, 15, 16, 17].

**Tab. 5.** Economic and technical indices of the longwall face № 10-2.

| № | Indices | Unit | Amount |
|---|---|---|---|
| 1 | Average thickness of coal sean | m | 1.3 |
| 2 | Average slope angle of coal sean | degree | 20 |
| 3 | Volumetric weight of coal | Ton/m³ | 1.58 |
| 5 | Strike length | m | 250 |
| 6 | Average length in dip direction | m | 88 |
| 7 | Face advance in one web cut | m | 1.0 |
| 8 | Cycle completion coefficient | - | 0.95 |
| 9 | Number of shifts in a day | shift | 3 |
| 10 | Extraction coefficient | - | 0.95 |
| 12 | Coal output of one face cut (1 shift) | ton | 171.7 |
| 13 | Coal output of a day | ton | 489.4 |
| 14 | Coal output of a month | ton | 12.724 |
| 15 | Coefficient of change in location of longwall face | - | 0.8 |
| 16 | Capacity of longwall face | T/year | 122.150 |
| 17 | Number of workers in a day | worker | 84 |
| 18 | Direct labor productivity | T/ labor | 5.8 |
| 19 | Wood consumption for 1000 tons of coal | $m^3$ | 26.5 |
| 20 | Explosive consumption for 1000 tons of coal | kg | 76.87 |
| 21 | Detonator consumption for 1000 tons of coal | unit | 128 |
| 22 | Consumption of wire mesh for 1000 tons of coal | kg | 1506.7 |
| 23 | Consumption of emulsifying oil for 1000 tons of coal | kg | 481.8 |

## 5. Conclusions

The proposed mining technology diagram has been applied at Nam Khe Tam mine, and it gradually shows the efficiency in exploiting thin and gently sloping seams. Thereby, it is recommended that Nam Khe Tam mine - Company 86 continue to report and evaluate so that this technology can be applied to other areas with similar geological conditions. At the same time, this is also a premise for Dong Bac Corporation to comprehensively evaluate other mines with thin, gently sloping seams in the Corporation to put this technology into application.

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