

**MINISTRY OF EDUCATION AND TRAINING
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**RESEARCH ON DETERMINING THE REASONABLE
PRODUCTION ORGANIZATION STRUCTURE IN ORDER TO
IMPROVE THE EFFICIENCY OF MECHANIZED LONGWALL
MINING IN SOME UNDERGROUND COAL MINES IN
QUANG NINH**

**Major: Mining
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SUMMARY OF DOCTOR THESIS

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INTRODUCTION

1. Rationale

Nowadays, along with the growth of the economy, the demand for energy is large, of which coal has a significant proportion of 18.2%. The output of commercial coal produced in the whole industry is expected to reach between 47 and 50 million tons by 2020; between 51 and 54 million tons by 2025; and between 55 and 57 million tons by 2030. For the purpose of ensuring sustainable development, one of the important factors is to increase labor productivity and minimize the number of workers directly working in the pit. In the context of increasing requirements for underground coal mining, the number of underground mining workers tends to decline due to shifting to other types of economy. Therefore, the mechanization investment in coal mining is the inevitable destination, which guarantees the long-term strategic development of the coal industry. Although the mechanized mining has achieved several achievements, the annual coal mining output is still not high, specifically reaching 73.8, 51.3%, 61.4% according to the plan respectively for the years of 2013, 2014 and 2015. A total of mechanized lines have been invested and applied in Vietnam National Coal – Mineral Industries Holding Corporation Limited, but there are only six lines in operation until at this time.

For five recent years, when the mining industry has accumulated a lot of experience in using mechanization technology, it is found that the potential factors causing production interruption have resulted in the effectiveness of these longwalls not achieved as expected. Summary of advantages, difficulties and unsuccessful implementation of mechanization technology in the condition of Quang Ninh mine area has shown a big gap in production organization that should be specifically studies.

Therefore, the topic *“Research on determining the reasonable production organization structure in order to improve the efficiency of mechanized longwall mining in some underground coal mines in Quang Ninh”* is really essential to provide tools for leaders, operators, supervisors of the production organization in the mechanized longwall and to meet the requirements for sustainable development of coal mining industry in Quang Ninh, practically serving the development planning of Vietnam’s coal industry by 2020, with prospects to 2030.

2. Research objectives

- To find out the method to build a production organization structure to satisfy the requirements of improving the continuity in the production process in accordance with the specific conditions of the mechanized longwall mining in Quang Ninh.

- To rationalize the production organization structure to establish a periodic organization chart close to practical conditions in an effective way.

3. Research object and scope

- *Research object*: Basic components of the production organization structure of the mechanized longwall.

- *Research scope*: Fully mechanized longwall with ceiling lowering and without ceiling lowering in Quang Ninh area.

4. Research contents

- Study on some organizational models of production in the country and in the world;

- Study on the production organization structure of the mechanized longwall in geological – technical - technological conditions of mines;

- Study on developing a spatial model of exploitation stages and determining the effective working time of the production organization structure of the mechanized longwall;

- Optimizing the production organization structure for some mechanized longwalls in Quang Ninh.

5. Research approaches

The Thesis has applied a combination of the following research methods:

- Method of theoretical research: Researching and applying reliability theory, string theory, inductive method, deductive method, etc.

- Method of synthesizing field statistics: Through data obtained during observation, direct statistics at the mechanized longwall patterns, thereby synthesizing data and comparing with theoretical results;

- Method of block diagram and graph method;

- Fuzzy Synthetic Evaluation Approach.

6. Theoretical and practical significance

- *Scientific significance of the project*: Scientific and logical methodology connects different discrete production tasks into a continuous and flexible production structure, consistent with the actual conditions of mechanized longwall mining in Quang Ninh.

- *Practical significance of the project*: The production organization chart for the mechanized longwall in specific conditions is quickly set up; The research results of the project are good management and monitoring tools for space, time, and working components in the process of mechanized longwall production, so that technical managers may quickly establish production organization charts for the mechanized longwall in specific conditions, determining the causes of manual and flexible craftsmanship in changing the working status of the longwall.

7. New contributions of the Thesis

1. The longwall state under the impact of technical and technological conditions, geological conditions of mines is determined through 16 time parameters. In particular, shear intensity and time standard deviation coefficient K_{LC} are important indicators reflecting the compatibility of the production organization structure with the fluctuation of geological and technical factors of the mine. They allow to regulate the working speed of equipment assemblies in the longwall, specifically at Ha Lam coal mine, $K_{LC} = 0.87$ at seam 11; $K_{LC} = 0.88$

at seam 7; while $K_{LC} = 0.78$ at seam 11 of Duong Huy coal mine.

2. It has established a model of changing the working status of the production organization structure and a production organization chart for the conditions of longwall with stone pillars, foundation subsidence in the actual longwall mining in Quang Ninh.

8. Scientific arguments

- Natural conditions are unchangeable objective elements, so the selected technical and technological conditions should be compatible with the geological conditions of the mine. The level of complexity of mine geology and the operability of the longwall equipment combination determine the appearance of the production organization structure. When the level of complexity exceeds the self-adjustment capacity of the organizational structure, repair and recovery solutions should be activated to bring the longwall to the normal working status.

- Shear intensity in the longwall and time standard deviation are important indicators reflecting the compatibility of the production organization structure with the fluctuation of geological and technical factors of the mine.

9. Structure of the Thesis

The Thesis consists of Introduction, four chapters of content, Conclusion - Recommendations, along with lists encompassing 65 References and Appendices presented on 188 pages of A4 paper, including 09 tables and 97 figures.

CHAPTER 1. AN OVERVIEW OF RESEARCH ON THE PRODUCTION ORGANIZATION STRUCTURE OF THE FULLY MECHANIZED LONGWALL

1.1 An overview of some production organization models of the fully mechanized longwall

The production organization structure reflects the rationality in terms of space and time, the ability to coordinate among people with the operating system and equipment. The production organization structure of the mechanized longwall depends heavily on the type of technology being used. Currently, according to the technology used for longwall mining, it can be divided into two basic groups: a group of longwall with lowering the roof coal ceiling and another group of longwall without ceiling lowering.

The model of production organization for the mechanized longwall is divided into two types including four shifts per day-night and three shifts per day-night.

Typically, the organizational model of four shifts per day-night usually focuses on producing in the first three shifts, while the fourth shift is used to inspect, repair and maintain equipment (see Figure 1.1).

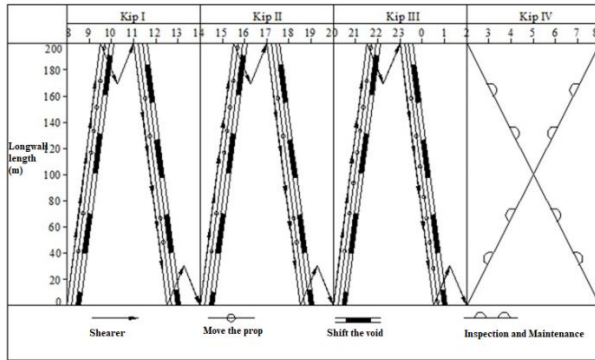


Figure 1.1. Production organization chart of 04 shifts/day-night

Equipment inspection and maintenance does not necessarily occur at the last shift every day. This work depends on the actual situation of the mine, mainly related to the operational status of the equipment and the number of labor assigned.

For the mechanized longwall with ceiling lowering for coal recovery, the organizational model of 3 shifts/day-night is applied, in which the production is usually arranged in the first 2 shifts, while the third shift is used for inspection and maintenance (see Figure 1.24). In some cases, the lowering of the coal ceiling can be performed separately in the third shift in addition to equipment maintenance.

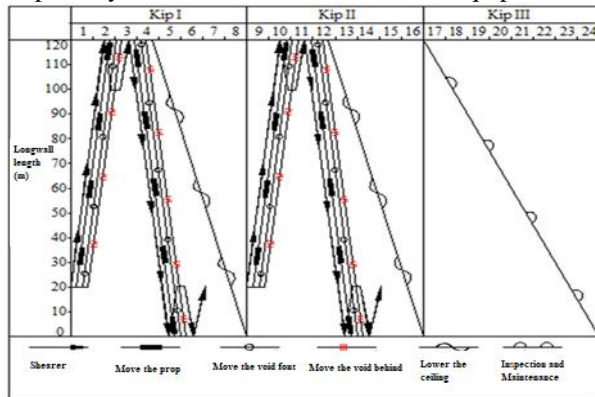


Figure 1.24. Organizational chart of the longwall cycle 8402 at Xishui coal mine, China

Due to the geological characteristics of coal mines in Vietnam, the planning of production organization in each shift depends on the actual production conditions in the area of the mechanized longwall. The workload in each shift may be similar or different. Equipment inspection and maintenance may be arranged at the end of the cycle or at the beginning of each production shift.

1.2 An overview of research on the production organization structure of the mechanized longwall

In Vietnam, for describing a production cycle in the longwall and the number of manpower needed to serve that area, organizations and businesses are currently using two common methods: forward calculation method and reverse calculation method. In the world, there are also 02 most popular methods to evaluate the possibility of applying mechanized mining technology diagrams in underground mines: Method of scoring and method of general assessment of coal reserves and geological characteristics - mining techniques. The research methods of production organization have certain advantages, depending on the conditions that can be used, resulting in relatively reliable results. In general, however, these production organization methods, in one way or another, have not yet comprehensively assessed the influencing factors (inputs). Thus, the production organization according to the plan always maintains a certain difference compared to the reality, especially with the specific conditions in the underground mines in Vietnam.

1.3 Conclusion of Chapter 1

1. The production organization models in the mechanized longwall are basically geared towards continuity in the production line. There are two models of working arrangement encompassing a model of working three shifts per day-night and another model of working four shifts per day-night. In the world the two models may be interchangeable or they themselves will improve continuous operation in many shifts and maintenance pushed back to the next shift, while the model of three shifts per day-night is arranged in Vietnam.

2. The deviation between the design and the actual construction of the mechanized longwall in Quang Ninh shows that the potential risk of production interruption has not been properly assessed in accordance with the level of influence. Especially, unexplored geological conditions and mining techniques are the main causes affecting the unsuccessful mechanized longwalls in our country.

3. The role of the organizational structure of mechanized longwall production is to regulate the exploitation activities in accordance with the specific conditions. There is no specific work in the world and in the country to study and establish the organizational structure of mechanized longwall production in Quang Ninh, which is also a space for the Thesis to develop its research.

CHAPTER 2. RESEARCH ON THE IMPACT OF MINING GEOLOGY AND TECHNOLOGY TECHNIQUES ON THE ORGANIZATIONAL STRUCTURE OF MECHANIZED LONGWALL PRODUCTION

2.1 Impact of mining geology on mechanization technology for underground coal mining

The Thesis has applied Fuzzy evaluation method to develop the dependent functions of geological factors impacting on the mechanized longwall mine, depicting the influence of these factors on the mining work. The geological

factors are divided into 3 basic groups encompassing a group directly related to the coal seam, a group related to the rock surrounding the seam and another group related to technical factors.

Table 2.1. Summary of the value of the factors affecting the mechanized longwall mining

No.	Factors	Total value in normal mechanization	Total value in lower-ceiling mechanization	Factors	Normal mechanization	Lower-ceiling mechanization
1	Complexity of structural geology	0.2076	0.1968	1. Effect of interruption	0.1428	0.1503
				2. Effect of folds	0.0648	0.0465
2	Degree of stability of coal seam	0.2387	0.2418	1. Mining capacity of coal seam	0.1098	0.1012
				2. Fluctuation of thickness	0.0862	0.0028
				3. Coefficient of hard rock content	0.0427	0.1378
3	Seam thickness	0.0937	0.1045	Depth of the coal seam mining	0.0937	0.1043
4	Seam slope angle	0.1049	0.1321	Steep angle of coal seam	0.1049	0.1321
5	Seam strength	0.0211	0.1436	Seam strength	0.0211	0.1436
6	Conditions of stone panel	0.2135	0.0867	1. Stability of direct panel	0.1008	0.0307
				2. Reciprocity of basic panel	0.0792	0.0322
				3. Effect of fake panel	0.0091	0.0034
				4. Impact of pillar	0.0244	0.0204
7	Longwall speed	0.1205	0.0945	1. Longwall length	0.0646	0.0536
				2. Length in the direction	0.0659	0.0409
8	Total	1.000	1.000	Total	1.000	1.000

Determining the influence of mining geology on the mechanized longwall mine helps to develop an algorithm diagram to select the appropriate equipment according to geological and technical conditions (Figure 2.14).

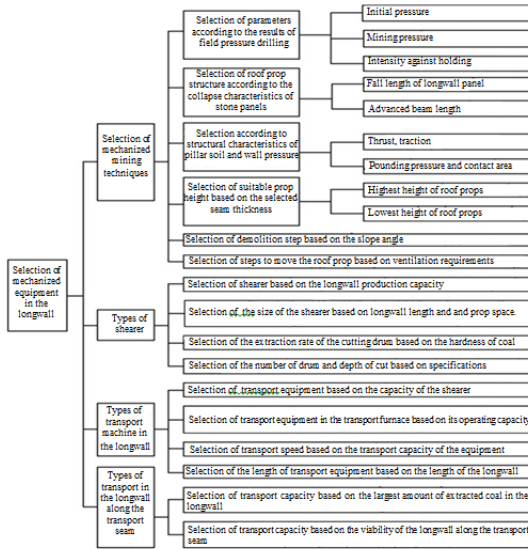


Figure 2.14. Block diagram of selecting a combination of equipment suitable to geological and technical conditions

The first factor to consider whether the production structure can be operated is the suitability of the mechanized longwall equipment combination with the natural conditions of the mining area.

2.2 Analysis of the impact of mining technical conditions on the production organization structure

The compatibility relationship of equipment combination in the longwall space includes shearer – void – prop, while the relationship between the production capacity of the mechanized longway and equipment serving outside the longway plays an especially important role in forming the production organization structure suitable for longwall mines. The ability to operate continuously and the compatibility between the combination of longwall equipment are critical to the working efficiency of the organizational structure of mechanized longwall production.

2.3 Working status of the production organization structure when taking into account adverse impacts from mining geological and technical conditions

There are n factors that may cause production interruption. State 0 is considered that all factors affecting the mechanized longwall do not negatively affect, and the organizational structure operates normally. State j is the j^{th} part which is in a state of adverse effect on the structure. At that time, the diagram will change from the status to be restored and corrected to the normal operating state as shown in Figure 2.18.

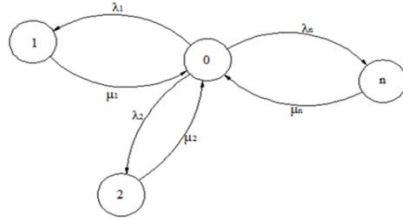


Figure 2.18. . Diagram of the change in the state of the production organization structure when it has a negative impact

Where: λ_j – Frequency of malfunction of the j^{th} part;
 μ_j – Ability to repair and restore the j^{th} error to state 0;

The probability of transitioning from state j to state 0 depends on the fixed-state orientation parameter $\pi=(\pi_0, \pi_1, \dots, \pi_n)$, when turning negative states into a normal operating state, it means that:

$$\begin{cases} -\lambda_0 \cdot \pi_0 + \mu_1 \cdot \pi_1 + \dots + \mu_n \cdot \pi_n = 0 \\ \lambda_1 \cdot \pi_0 - \mu_1 \cdot \pi_1 = 0 \\ \dots \\ \lambda_n \cdot \pi_0 - \mu_n \cdot \pi_n = 0 \end{cases}$$

The above expression shows that in order to return to the normal operating state (state 0), the multivariate functions of the risk of interruption must be zero.

2.4 Conclusion of Chapter 2

1. The natural conditions (mining geological conditions) are unchangeable objective. The technical specifications, technology, preparation system, ancillary others... of the mechanized longwall mine should be built on the basis of suitability with the geological conditions of the mine. It was found that the geological conditions determine, directly or indirectly, the operational mode of the production organization structure of the mechanized longwall.

2. The ability to operate continuously and the compatibility between the combination of longwall equipment is critical to the working efficiency of the production organization structure of the mechanized longwall.

3. Space, time, performance and continuity of the production organization structure are affected by unidentifiable underlying factors. When the underlying factors appear and cause negative effects as disrupted production, it is necessary to activate the recovery mode μ_j . Waiting time for transitioning from interruption to normal operation is called work-time loss.

CHAPTER 3. RESEARCH ON DEVELOPING THE PRODUCTION ORGANIZATION STRUCTURE OF THE MECHANIZED LONGWALL

3.1 Operational modes of longwall equipment combination

The operational mode of the longwall equipment combination is divided into two main equipment groups: extraction equipment group and support equipment group.

For the longwall with lowering the ceiling for roof coal recovery, the effectiveness of the aforementioned combination of operating equipment is highly dependent on the ceiling lowering distance and the way to lower the coal ceiling. Experiments show that the application of the method of two-stream extraction with ceiling lowering in multiple turns for the mechanized longwall mining, brings the highest percentage of roof coal recovery.

3.2 Modeling production structure according to space and working time of the mechanized longwall

The production organization structure of the mechanized longwall depends heavily on coal extraction, different types of coal extraction will lead to the arrangement of different stages of production.

- 1/ Two-way extraction, opening the stream at the top of the longwall;
- 2/ One-way extraction, opening the stream at the top of the longwall, leaving the triangular coal corner;
- 3/ Extraction is cross from the middle of the longwall.

In favorable conditions, the operating speed of the production organization structure depends on the speed of the lowest work. In unfavorable conditions that production disruption occur, the operating speed of the production organization structure depends on the speed of recovery and repair to bring the faulty state back to the normal operating state.

3.3 Research on establishing an organizational structure of producing a mechanized longwall

Production in mines is currently divided into several separate blocks such as ground block, transport block, electromechanical block, etc. The goal of the blocks is for efficient production, but there are times when conflicts cause production bottlenecks. Therefore, the role of the production organization is to regulate the smooth operation of these blocks. In the mechanized longwall, based on the characteristics of production such as mine geological conditions, ability to provide raw materials, ability to transport, etc., the production structure will play a role in regulating production activities. On such basis, the Thesis has established a block diagram of logic relationship among production stages, which is also the foundation for developing the in-depth study of production structure in the mechanized longwall.

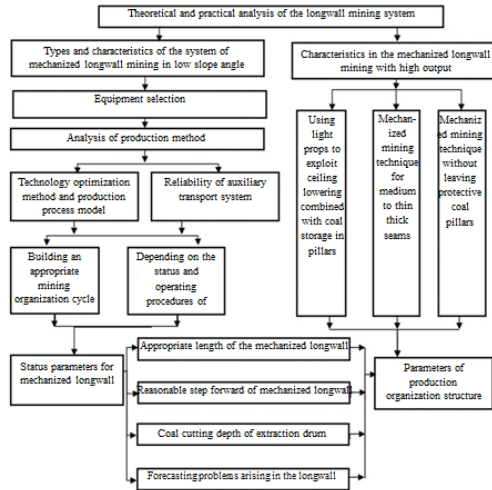


Figure 3.6. Block diagram of logical relationship among research contents

If each stage of coal production operates individually in the production structure, the working sequence will operate on a discrete chain when connecting each production stage to form “nodes”. At the end of each node is a production state. Connecting these nodes into a network of nodes will simulate the entire workflow process of production. This process is repeated at the beginning, called complete production cycle.

The work in the mechanized longwall space depends on types and size of seams, operational form of equipment combination, and work arrangement, etc. From the model of “Network of nodes”, it is possible to determine the location, level, time of interruption and working time of each equipment combination in the production structure of the mechanized longwall. In particular, each “node” describes the work to be completed in a production cycle:

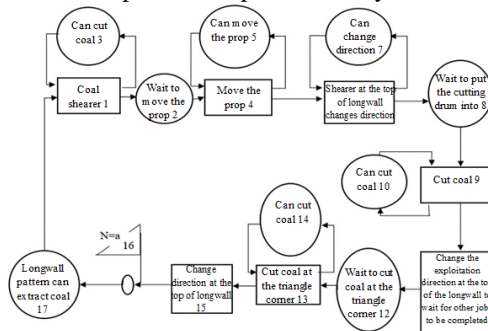


Figure 3.9. Diagram of a network of “circulatory nodes” when the extraction has no ceiling lowering

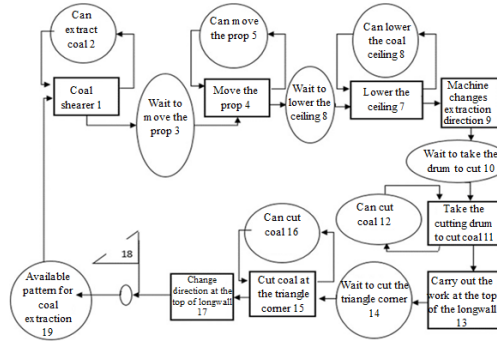


Figure 3.12. Diagram of a network of “circulatory nodes” when the extraction has ceiling lowering for roof coal recovery

3.4 Working status of the organizational structure of mechanized longwall production

Mining is the process of working with potential factors, affecting the production organization structure. The working space of the production organization structure is shown in Figure 3.13. It is divided into 3 groups of influence: Group of geological conditions, group of technical conditions and group of technological conditions.

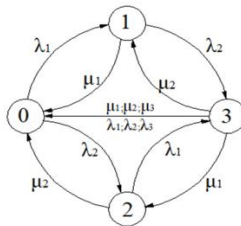


Figure 3.13. Status system of the production organization structure

Considering these 3 groups as 3 parts affecting the production organization structure, Interrupted time is to recover incidents from faulty states (states 1, 2 or 3) to the normal operation state, usually 0. Where 1 is a part causing interruption, 2 is two parts causing interruption, 3 is all three parts causing interruption. Working time with less than 100% productivity is the time when the incident occurs but the incident does not cause production interruption.

3.5 Developing the production organization structure according to the working time of the mechanized longwall

Thus, the state of the production organization structure is affected by two main factors which are inefficient working time and interrupted working time.

In order to evaluate the effective working time of the longwall, it is necessary to specify in detail the applicable conditions and the technology used in

the longwall. Developing a system of factors affecting the effective working time of the longwall helps operators, managers and direct workers to grasp their meanings, thereby proposing practical production measures to increase the effective working time mentioned above.

For each type of different mining technology, there will be different methods of assessing the effect of the effective working time of the longwall on the longwall mining output. The basic algorithm models for calculating the effective time in mining as shown in Figure 3.15.

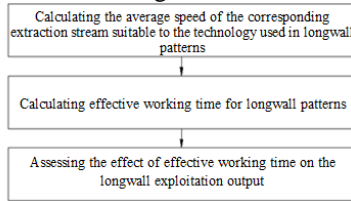


Figure 3.15. Basic algorithm diagram of the calculation of effective mining time

The effective working time in a production cycle is calculated as follows:

$$T_{LV} = \sum_{i=1}^{14} t_i \quad , \text{ minute(s)}$$

Where:

t_i – time to carry out the i^{th} stage in the production cycle, minute(s);

14 – total number of component stages in a production cycle, minute(s).

The time of stages in the calculation includes:

+ t_1 – time for the shearer to extract and examine the foot area in the upward direction;

+ t_2 – time from when the machine stops to redirect until it finishes moving the void to examine the foot area;

+ t_3 – time for the shearer to finish examining the foot area in the downward direction;

+ t_4 – time from when the shearer stops to change the direction until it finishes moving the support for the foot examination area;

+ t_5 – time for the shearer to move without load at the foot examination area in the upward direction;

+ t_6 – time for the shearer to clear longwall streams in the upward direction;

+ t_7 – time to wait for machinery navigation at the top of the longwall area, minute(s);

+ t_8 – time for the shearer to return to the first examination in the downward direction;

+ t_9 – time from when the shearer stops waiting for its navigation until it has finished moving the void for the first examination area;

+ t_{10} – time for the shearer to complete the first examination in the upward direction;

+ t_{11} – time from when the shearer stops waiting for its navigation until it has finished moving the support for the first examination area;

+ t_{12} – time for the shearer to move without load at the first examination area in the downward direction;

+ t_{13} – time for the shearer to clear longwall streams in the downward direction;

+ t_{14} – time for the shearer to stop waiting for its navigation at the foot of the longwall, minute(s).

The actual working time of a production cycle is:

$$T_{CK} = T_{LV} + t_{15} + t_{16} \quad , \text{ minute(s)}$$

Where

t_{15} – time to maintain and repair equipment, minute(s);

t_{16} – time to handle arising problems, minute(s).

Standard deviation of working time coefficient:

$$K_{LC} = \frac{\sum_{i=1}^{15} t_i}{\sum_{i=1}^{16} t_i} = \frac{T_{LV} + t_{15}}{T_{LV} + t_{15} + t_{16}}$$

The standard deviation coefficient is determined by the total working time plus periodic maintenance time on the total cycle time (including the time for troubleshooting to bring the longwall to work in normal condition. The closer K_{LC} coefficient is to 1 (100%), the more effective the production structure is.

Extraction density coefficient denotes the overall exploitation capacity of the production organization structure under specific conditions. The greater the extraction intensity is, the higher the operational efficiency of the production organization structure is, and vice versa:

$$f_K = \frac{L_{LC} \cdot r \cdot k_{KH} \cdot n_{KH} \cdot \gamma \cdot (m_{KH} + (M - m_{KH}) \cdot k_{TH}}{\sum_{i=1}^{16} t_i} \quad , \text{ T/phút}$$

Where

L_{LC} – longwall length, m;

m_{KH} – shearer height, m;

r – cutting depth (extraction step), m;

k_{KH} – extraction coefficient;

n_{KH} – extraction streams in a cycle;

γ – coal density, T/m³;

M – seam thickness, m;

m_{TH} – recovery height, normally $m_{TH} = M - m_{KH}$

k_{TH} – coal recovery coefficient

3.6 Conclusion of Chapter 3

1. In favorable conditions, the deployment capacity of the production organization structure depends on the speed of the slowest work. In unfavorable conditions where production disruptions occur, the speed of operation of the

production organization structure depends on the speed of recovery and repair to bring the faulty state back to the normal operating state.

2. The network model of “*circulatory nodes*” is a simplified product of the working cycle in the longwall. Each node describes a stage that must be completed during production. In the case of normal operation, the distance between the nodes is the *time amplitude* of each production stage. At the same time, when stopping the machine, the distance between the nodes is the time of interruption which needs to be restored to the normal working state.

3. Effective working time is when the production structure of the organization deploys its exploitation activities without stopping production incidents. The time when equipment assemblies operate at the designed capacity, is considered to be an effective working time. The status model of the structure is described and calculated to the detrimental factors, causing production interruptions. In particular, all time errors and interruptions will be converged to the time parameter t_{16} . The distance and size of t_{16} depend on the complexity of the component failures and the resilience to return to the normal operating state of the production organization structure.

4. Time standard deviation is the ratio between the effective working time and the actual working time. The closer the K_{LC} coefficient is to 1 (100%), the higher the efficiency of the production organization structure is. It means that the mining operation is in favorable conditions and vice versa.

5. Extraction intensity indicates the capacity to deploy the overall mining operation of the production organization structure under specific conditions. In particular, it takes into account adverse factors in production. The greater the extraction intensity is, the more effective the production organization structure is, and vice versa.

CHAPTER 4. OPTIMIZING THE PRODUCTION ORGANIZATION STRUCTURE FOR SOME MECHANIZED LONGWALLS IN QUANG NINH

4.1 Actual design status and actual production organization at Duong Huy coal mine

Summary of actual results has been collected for the mechanized longwall seam 11 at Duong Huy coal mine:

- Pattern height: $H = 3,4$ m;
- Longwall length: $L = 122$ m;
- Cutting depth (extraction step): $z = 0.63$ m;
- Coal density: $\gamma = 1.63$ T/m³;
- Extraction coefficient: $\rho = 1.0$;
- Examination length: $x_p = 25$ m.
- Shearer length: $d_k = 15$ m;
- Moving speed of the shearer in no-load status: $V_{cz} = 10$ m/min;
- Moving speed of the shearer during extraction: $V_r = 5$ m/min;

- Moving speed of the shearer during examination: $V_z = 2$ m/min;
- Average number of workers for a day-night: 121 people.

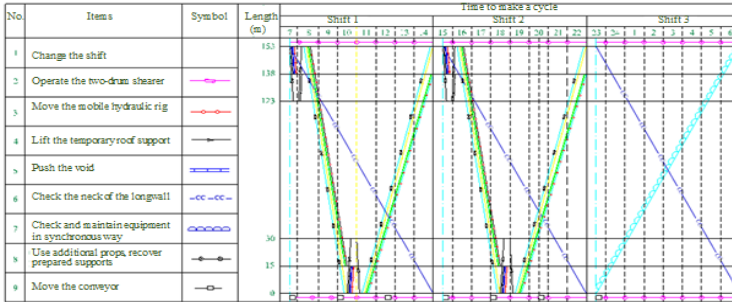
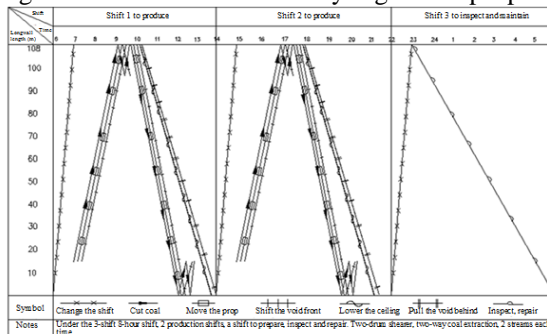


Figure 4.4. Organizational chart of actual exploitation at Duong Huy coal mine
The actual output of the mechanized longwall seam 11 at Duong Huy coal mine in 2018 reached **402,794** tons.

4.2 Actual design status and actual production organization at Ha Lam coal mine

Summary of actual results was collected for longwall CGH 11-1-16 at Ha Lam coal mine:

- Pattern length: $H = 2.6$ m;
- Longwall length: $L = 118$ m;
- Cutting depth (extraction step): $z = 0.63$ m;
- Coal density: $\gamma = 1.63$ T/m³;
- Extraction coefficient: $\rho = 0.95$;
- Examination length $x_p = 15$ m;
- Shearer length: $d_k = 11$ m;
- Moving speed of the shearer in no-load status: $V_{cz} = 0,7 \div 5$ m/min;
- Moving speed of the shearer during extraction: $V_r = 2 \div 4$ m/min;
- Moving speed of the shearer during examination: $V_z = 1,5 \div 2,5$ m/min;
- Average number of workers in a day-night: 102 people.



Hình 4.6. Figure 4.6. Actual diagram of production organization at Ha Lam coal mine, seam 11

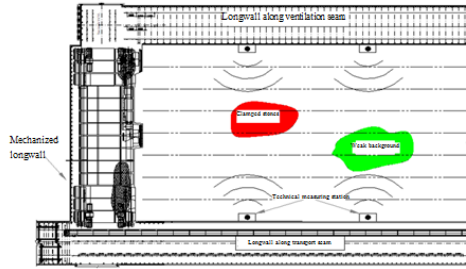
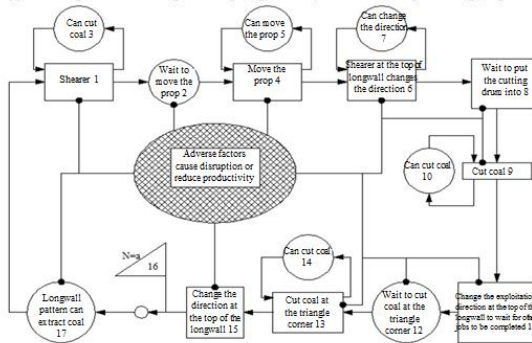


Figure 4.15. Simulating locations of measuring stations to detect potential risks in the mechanized longwall mining

When the coal seam conditions are known in advance, attaching them to the production schedule will allow the regulation of specific methods.

4.4 Developing an optimized calculation model for some mechanized longwalls in Quang Ninh

Factors affecting the production organization structure of the mechanized longwall include 03 groups: a group of geological elements of coal seams, a group of surrounding geotechnical factors and another group of technological factors. The calculation model is built through the model of “circulatory nodes” which builds the production organization structure when taking into account the possible disadvantages, this model is built differently for the two types of longwalls: no ceiling lowering (Figure 4.16) and roof ceiling lowering (Figure 4.17).



Hình 4.16. Figure 4.16. Production organization structure model when taking into account the disadvantages in mechanized longwall without ceiling lowering

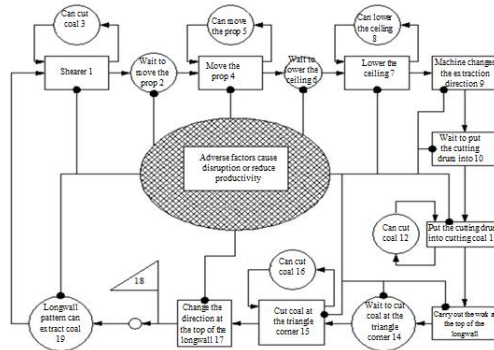


Figure 4.17. Production organization structure model when taking into account the disadvantages in mechanized longwall with ceiling lowering

From the models of the production organization structure built above, it can be seen that there is a risk of production disruption at any time, at any position of work.

4.5 Optimizing working time, organization production for some mechanized longwall mines in Quang Ninh

On the basis of specific exploitation conditions in Quang Ninh region combined with models, algorithms built, the Thesis has solved the problems of working status and optimizing the production organization structure. For seam 11 of Duong Huy coal mine and two seams 7 and 11 of Ha Lam coal mine, the optimal results are as follows:

- + For CGH 11-7 longwall, Duong Huy coal company:
 - Time standard deviation coefficient: $KLC = 0.87$;
 - Extraction intensity: $fK = 2.28$ T/min;
 - Annual output calculated: $AN = 666,634$ T / $600,000$ T = 1.11.
- + For CGH 11-1.16 longwall, Ha Lam coal company:
 - Time standard deviation coefficient: $KLC = 0.88$;
 - Extraction intensity: $fK = 3.93$ T/min;
 - Annual output calculated: $AN = 737,482$ T / $600,000$ T = 1.23.
- + For CGH 7-3.1 longwall, Ha Lam coal company:
 - Time standard deviation coefficient: $KLC = 0.78$;
 - Extraction intensity: $fK = 2.06$ T/min;
 - Annual output calculated: $AN = 1,269,412$ T / $1,200,000$ T = 1.06.

* Comments on calculation results:

Calculation results are based on actual data used at CGH 11-7 longwall oven (Duong Huy coal company), 11-1.16 longwall and 7-3.1 longwall (Ha Lam coal company) for the calculated output to exceed $6 \div 23\%$ compared to the original design output. The core of the calculations for this outstanding metric is:

- The application of geotechnical solutions to predict the risks of machine shutdown due to the geological condition of the mine, thereby allowing

the conversion of the production organization chart in a proactive and flexible manner.

- Equipment should be synchronized in the direction of regulating the speed of the complexes in the mechanized longwall according to the slowest production stage. Thereby the adverse conflicts that come from different geological conditions and technical conditions should be minimized.

4.6 Conclusion of Chapter 4

1. The adverse factors causing production interruptions can be divided into the following groups:

- The group of geological conditions include panels, pillars, intrinsic nature of coal seams, hydrogeology, clamped stones, faults, demolition, thickness fluctuations, slope angles, ...

- The group of technical conditions includes: Longwall length changing in the direction of elongation and shortening; the pattern dropped down; platform base sinking to the ground, initial resistance and anti-rated force; drops distorted, etc.

- The group of technological conditions includes: Problems of shearers, voids, props, coordination between devices in the longwall, coordination between longwall and peripheral equipment, other mechanical and electrical problems, etc.

2. The orientation of perfecting the organizational structure in the direction of equipment synchronization by compatible operating time synchronization method will lead to greater working efficiency of the structure than for the equipment to operate discrete freely. Accordingly, it is necessary to improve the efficiency and the speed of the slowest stage in production.

3. When a predictive tool clarifies potential risks from the geological condition of the mine, it will improve the continuity of the production organization structure in the mechanized longwall.

CONCLUSION AND RECOMMENDATIONS

1. Conclusion

1. The production organization model in the world mainly applied is 3 shifts/day-night and 4 shifts/day-night. In Quang Ninh province, the production organization model of 3 shifts/day-night is mainly practised. Impacts on the organizational structure of mechanized longwall production are mainly geological conditions and mining techniques, in which the determinants of longwall production capacity are the hidden factors that have not been clarified.

2. All stages of production in the mechanized longwall contain potential risks, causing the machine to stop and be repaired and recovered to return to normal operation. To simplify the working cycle by the node network space diagram, the distance between the nodes is the time to complete the production stage, expressed by 16 time parameters representing the working status of the mechanized longwall in geological and technical conditions.

3. Shear intensity in the longwall and time standard deviation are important indicators reflecting the compatibility of the production organization structure with the fluctuation of geological factors and mining techniques. The intensity of coal pulverization allows to regulate the working speed of equipment assemblies in the longwall. The time standard deviation K_{LC} reflects the effectiveness of the production organization structure. Specifically, at Ha Lam coal mine, $K_{LC} = 0.87$ at seam 11; $K_{LC} = 0.88$ at seam 7; while $K_{LC} = 0.78$ at the longwall seam 11 of Duong Huy coal mine.

2. Recommendations

Other studies should be undertaken to solve the operational state problem of the mechanized longwall that the framework of the thesis has not done yet.

It is suggested that Vietnam National Coal – Mineral Industries Holding Corporation Limited (Vinacomin), Dong Bac Corporation, research institutes, universities, etc., should apply the research results, developing software for more efficient production.

LIST OF SCIENTIFIC WORKS PUBLISHED BY AUTHORS

I. Works in SCOPUS/ISI indexed list (03)

1. **Nguyen Van Dung**, Nguyen Phi Hung, Tan Do (2019), *Numerical study of pile reinforced slope-A case at Khe Cham coal preparation construction site project (Vietnam)*, Book series “Lecture Notes in Civil Engineering” published by Springer and indexed in Scopus (sciencesconf.org:cigos2019:242346). (Accepted).

2. Nguyen Phi Hung, **Nguyen Van Dung**, Tando (2019), *Dynamic properties of loose sand using numerical analysis-A case at Hong Thai Tay coal transportation road project (Vietnam)*, Book series “Lecture Notes in Civil Engineering” published by Springer and indexed in Scopus (sciencesconf.org:cigos2019:236693). (Accepted).

3. **Nguyen Van Dung**, Nguyen Phi Hung, Tan Do, *Experimental study on the efficiency of water infusion for 2 underground mining of a coal seam*, Civil Engineering ISI chi số IF 2.77 (Indexed by the Science Citation Index Expanded (In reviews)).

II. Works in international scientific conferences (03)

1. Nguyen Van Thinh, Nguyen Phi Hung, Nguyen Van Quang, **Nguyen Van Dung**, Tran Bao Ngoc (2016), *Improving exploitation technology by efficient solution with conditions of thick and steep seams at Mao Khe coal mine*, International Conference on Advances in Mining and Tunneling, Hanoi, Vietnam. P 218-221.

2. Nguyen Phi Hung, Bui Manh Tung, Nguyen Cao Khai, **Nguyen Van Dung** (2017), *Research for waste material utilization to increase the life of support*, International Conference on Geo-spatial Technologies and Earth Resources, Hanoi, Vietnam. P 373 -376.

3. Nguyen Phi Hung, Bui Manh Tung, Nguyen Cao Khai, **Nguyen Van Dung**, Pham Manh Tung, Tran Dai Nghia (2017), *Research in producing block brick from wates of disposal area of Thong Nhat coal mine*, International Conference on Geo-spatial Technologies and Earth Resources, Hanoi, Vietnam. P 493 – 498.

III. Works in the national scientific conference (03)

1. **Nguyen Van Dung**, Nguyen Phi Hung, Nguyen Cao Khai, Dang Phuong Thao, Le Duy Khanh (2018), *Study on developing the mining process of mechanized longwall hold with 2ANSH platform for Hong Thai - Mao Khe mineral area*, National Conference on Earth Science and Natural Resources for Sustainable Development, Hanoi, Vietnam. P 41 – 47.

2. Nguyen Phi Hung, Nguyen Cao Khai, Bui Manh Tung, Tran Van Thanh, **Nguyen Van Dung** (2018), *Research on some causes and solutions to solve problems during the mechanized longwall mining*, National Conference on Earth Science and Natural Resources for Sustainable Development, Hanoi, Vietnam. P 84 – 90.

3. Nguyen Phi Hung, Bui Manh Tung, Nguyen Cao Khai, Tran Bao Ngoc, **Nguyen Van Dung** (2016), *Determining the thickness of the lower coal grade in the exploitation of thick and steep seam at 7 West seam of Mao Khe coal mine*, The 15th National Conference on Mining Science and Technology, Quang Ninh, Vietnam. P 246 – 248.

IV. Scientific works on the industry magazine (04)

1. Nong Viet Hung, **Nguyen Van Dung**, Phung Manh Dac (2016), *Study on the interaction relationship between rock block and platform in the lower mechanized longwall in underground mines in Quang Ninh area*, Journal of Mining Industry, Hanoi, Vietnam. P 1-4

2. Nguyen Phi Hung, Tran Van Thanh, Bui Manh Tung, **Nguyen Van Dung**, Nguyen Vuong Minh Hung (2018), *Research on technological solutions in*

the exploitation of steep and inclined seams at Hong Thai coal mine, Science and Technology Journal of Mining - Geology, Hanoi, Vietnam. P 27 – 31.

3. **Nguyen Van Dung**, Nguyen Phi Hung, Vu Thai Tien Dung (2019), *Influencing factors and effective working time calculation method in the organizational structure of mechanized longwall production*, Science and Technology Journal of Mining - Geology, Hanoi, Vietnam. (accepted).

4. **Nguyen Van Dung**, Nguyen Phi Hung, Dao Van Chi, Bui Manh Tung (2019), *Applying conditional system model to analyze and determine the working status of the organizational structure of mechanized longwall production*. Journal of Mining Industry, Hanoi, Vietnam. P 35 – 40.

V. Works under Hanoi University of Mining and Geology (01)

1. Nguyen Phi Hung, **Nguyen Van Dung**, Vu Thai Tien Dung, Bui Manh Tung, (2019) *Study on developing solutions for organizing and operating synchronous production stages for mechanized longwall at seam 11, Duong Huy Coal Company*. (Decision No. 492/QD-MDC, project code: T 19-08).