

Research on Lean Production Management Model of XZ Coal Mine

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Abstract: This paper introduces the lean production management mode of coal, and discusses the problems existing in the mining of XZ coal mine area iii based on the actual cases. Part of working procedures of fully mechanized mining face in the third mining area are analyzed, improvement plans are put forward, and the four principles of 5W1H questioning method and ECRS are applied for process improvement. By carrying out lean management of coal mine, reasonably matching personnel, reducing waste of time and resources, and reducing invalid labor time, the utilization rate of equipment can be improved to achieve the improvement purpose of "4M1E".

Keywords: coal mine; lean production; optimization scheme

I INTRODUCTION

Coal is main energy in our country and basic industries, by the party and government attach great importance to for a long time, but the coal enterprise management has always been a kind of extensive management pattern, mainly by increasing resource inputs (e.g., increase investment, update equipment, the introduction of technology, increase the intensity of labor) to improve productivity, and do not take the economic benefits, the company would lose competitiveness [1]. And due to the particularity of the coal industry, coal is a kind of "straight" products, do not need the production cost of spending too much, at the same time, security issues have been occupying the highest position in coal production activities, managers will focus mainly on the safety in production, so there is a tremendous waste, in coal mining production cost is high, mostly exist in the process of mining production coal wait for transportation time is too long, the workers work activity multifarious, cause high cost of coal enterprise production, low efficiency, seriously restrict the development of coal enterprises. In order to ensure the sustainable development of coal mining enterprises, the problems of waste and low efficiency in coal

mining activities should be studied in depth, and the enterprises should make full use of their own human, material and financial resources to take the road of conical development.

II LEAN PRODUCTION AND THE CHARACTERISTICS OF COAL MINE PRODUCTION

A Lean Production

Lean production is a kind of production mode with the main objective of minimizing the resources occupied by enterprise production and reducing the cost of enterprise management and operation. It combines the advantages of single-piece production and mass production, avoiding both the high cost of the former and the rigidity of the latter. It has the following characteristics:

- The sales department is the starting point of the production process of coal enterprises;
- Concurrent engineering method and main inspection system are adopted in production to ensure high quality and low cost, shorten production cycle and meet user needs;
- Pull-on production on time in the production and manufacturing process, and eliminate all advanced and excessive production [8];
- Take "people" as the center, fully mobilize people's potential and enthusiasm, and transfer the task and responsibility to the workers who directly add value to the products;
- Pursue non-waste products, zero inventory, zero failure and so on, reduce product costs and ensure product diversification;
- Take appropriate automation to improve the flexibility of the system;
- Continuous improvement with the ultimate goal of perfection.

The supporting technologies of lean production are as follows: (1) JIT [9], that is to say, enterprises need time to

produce the required products with the required quantity; (2) flexible production system to improve the system's ability to integrated design of product design and related processes (including manufacturing process and support process).

B Coal Mine Production

Coal production refers to the production activities of providing coal products for the society, mainly coal mining and processing. Coal production has the following characteristics [4]:

- Material needed in coal production can not constitute the use value of the final product. Because coal mining is mostly mine work, and mining requires certain equipment and materials, these materials will not produce. But in the process of mining has to consume materials and use part of the equipment for production.
- Coal production in our country is mainly underground operation. The geological environment in the process of mining fluctuates greatly. In the process of coal mining, because the shearer moves forward, the back roadway will be deformed because of the rock pressure, which makes the mining environment worse. In addition, the working environment of coal mine is narrow, ventilation and lighting are limited, and it is often threatened by water, fire, gas, coal dust and other natural disasters. Therefore, safety is the most important issue in coal mining.
- Coal production cost will be affected by coal occurrence. If the coal storage conditions are good, the use of materials will be reduced in the mining process, labor will be reduced, production progress will be accelerated, thus reducing mining costs and improving production efficiency.
- Preparatory activities that do not directly form value in coal mining activities. For the whole coal mine production system, it is necessary to dig the roadway to prepare the production system and workspace; it is necessary to provide the necessary air for the underground staff to survive, and it is also necessary to remove harmful gases such as underground gas; it is also necessary to maintain lighting, and it is also necessary to regularly explore geological conditions and coal occurrence. These works will have a direct impact on the effect of coal mining.

III PRODUCTION STATUS OF THE THIRD MINING AREA IN XZ COAL MINE

A Production overview and mining plan

(1) Production overview

The working face of 31118E is shown in "Fig. 1". It is located at the east wing of the 4-3-3 mining area of the -550 level eleven-layer coal. It is the third working face of the mining area from top to bottom. Lane, the east is the

cope with changes; (3) parallel process (CE) [3], concurrent engineering is a systematic work mode for parallel and working face, and the west is designed to stop the mining line. The 31118E working face is 800 meters long from east to west, 112 to 206 meters wide from north to south, with an average of 137 meters and an inclined area of 109,600 square meters. The working surface corresponds to the ground elevation of 171.28 meters, and the average buried depth of the coal seam is 1021.8 meters.

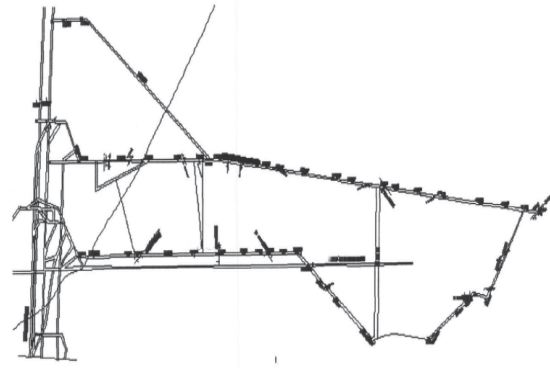


Figure 1 31118E working face ichnography

(2) Working face mining plan

Due to the influence of faults, the 31118E working face is arranged in a fold line, and the working face is unequal length mining. As the working face advances, the length will gradually increase and decrease, and it is necessary to extend (or shorten) the working face conveyor in time and increase (Withdraw) hydraulic support. The working surface is divided into four sub-block segments A, B, C and D in the form of working roadway layout.

B Workflow and Time Measurement Data of Mining Area 3 in XZ Coal Mine

(1) Pre-trade unions

Pre-union refers to a short-term meeting held between workers after work and before they leave the office. The contents include production objectives, production safety issues and so on. The average time is 15-25 minutes.

(2) Preparations before going to the mine

Preparations before going to the mine include changing clothes in the worker's walking bathhouse and taking miner's lamp in the lamp house. The whole process lasts 15-25 minutes.

(3) From mining area to working face

The following is the time measurement record from the mining area to the working face of the mine. TABLE I shows the three times measured data.

TABLE I TIME MEASUREMENT DATA

program	State	first measurement time	second measurement time	third measurement time	average time
Walk from the work area to the bus	move	11'20''	10'50''	9'40''	10'36''
Waiting for the bus to go	wait for	3'35''	4'25''	3'55''	3'54''
Take a bus to the auxiliary shaft	move	5'55''	6'45''	6'5''	6'15''
Waiting for the well to go down	wait for	8'54''	6'54''	8'10''	7'59''
Waiting in a cage	wait for	56''	35''	45''	45''
The cage runs to the bottom of the well.	move	2'55''	2'55''	3'25''	3'5''
Walking to the pedestrian waiting booth in the main lane	move	2'40''	1'48''	1'35''	2'1''
Waiting for the roadway pedestrian	wait for	free	free	13'25''	
Get on the pedestrian and wait for the bus to go.	wait for	9'56''	15'20''	11'25''	12'10''
Traffic to turnout	move	free	12'40''	free	
Waiting at the turnout (due to incoming traffic)	move	free	50''	free	50''
Garage	move	13'20''	15'10''	13'30'' (Traffic to Belt Traffic Lane)	14'
Pedestrian to Rail Pedestrian Station	move	2'20''	2'20''		2'20''
Waiting for track pedestrians	wait for	8'45''	5'4''		6'54''
Track Pedestrian Traffic	move	2'15''	4'15''		3'15''
Walk to the working face	move	19'20''	17'20''	17'30''	18'3''
Total use time		92'11''		97'3''	94'17''

By synthesizing the spatial route map of worker's arrival at the working face, using stopwatch time research method and process chart analysis method in industrial engineering

operation measurement, the detailed measurement, record and statistics of worker's arrival at the working face are carried out, and the current flow chart of the three teams of

comprehensive mining in XZ Coal Mine is obtained, as shown in “Fig. 2”.

Work Name:Flow chart before working face		Statistics			
Start: Arrive at the mine office building		project	Number of times	time	distance(m)
End:Arrive at the working face		operation	2	8'30"	
Date of study:2018.07.15		inspect	1	20'	
Review data:2018.09.25		move	11	61'25"	
		wait for	10	48'12"	
Statement of Work	time/min	Work series			
		operating ○	inspection □	mobile →	wait D
1 before the start of the class	20'				
2 walk to the bathhouse	1'30"				
3 change clothes	5'20"				
4 walk from the bathhouse to the lamp room	20"				
5 installation of miner's lamp	3'15"				
6 walk from the work area to the shuttle	10'36"				
7 waiting for the shuttle to walk	3'54"				
8 ride to the secondary shaft	6'15"				
9 waiting for the well	7'59"				
10 waiting in the cage	45"				
11 cages to the bottom of the well	3'5"				
12 walking to the alley pedestrian shelter	2'1"				
13 waiting for the alley pedestrians	13'25"				
14 sit on the pedestrian car and wait for the car to open	12'10"				
15 cars to the fork					
16Waiting at forks (due to the car)	50"				
17 car dealers	14'				
18 people to the track pedestrian station	2'20"				
19 waiting for the track pedestrian	6'54"				
20 track pedestrian train	3'15"				
21 walking to the work surface	18'3"				
Total time	138'7"				

Figure 2 Flow chart before improvement

C Analysis of problems in the production process of the third district of XZ Mine

(1) Time factor

From the flow chart of the worker to the work surface, it takes more than two hours before the worker reaches the work surface, which wastes too much work time.

(2) On-site management

First of all, XZ Coal Mine has many other coal mine enterprises to study in the field management. For example, in the auxiliary shaft waiting room, when the workers wait for the cage, the lobby will put some soothing music to ease the workers' mood. When the cage reaches the bottom of the well, some false flowers are placed in the waiting room at the bottom of the well, so that the color of the working environment is no longer monotonous, which makes the workers feel happy and helps the workers to work better. However, there are still some shortcomings in the field management. For example, the ground is too slippery, which not only affects the walking speed, but also makes it easy to fall and hurt. Moreover, the hooks of the cable hangs on both sides of the roadway are too prominent, and the worker is easily hooked to cause injury when walking.

IV XZ COAL MINE MINING DISTRICT IMPROVEMENT PLAN

A Improvement principles

According to the production characteristics of coal mine enterprises, combined with the problems existing in process flow, logistics line, field management and division of labor in the three mining areas of XZ Coal Mine, a set of improvement scheme is formed by using the theory and related technology of lean production. To reduce waste of time, reduce logistics roundabout and personnel congestion, to improve the site environment, reduce worker fatigue, improve startup rate and production efficiency. The specific improvement principles are as follows:

(1) Reduce the labor time of workers (including on the road and meeting time).

(2) Improve unit work efficiency (increased production per unit hour).

(3) Reducing the labor intensity of workers, and maintaining production balance through parallel operations and reasonable human-machine configuration.

(4) Reduce downtime (through reasonable planning and timely maintenance, reduce the factors that cause coal machine shutdown).

(5) Strengthen safety and environmental management, ensure the health of staff, clean the workplace, and avoid safety accidents.

B Process improvements

It can be seen from the process program diagram that the XZ Coal Mine Fully Mechanized Coal Mining Team is 48'12" in the inactive waiting time, waiting for up to 11 times; it takes 61'25" on the move; it takes 20 minutes before the shift starts; Workers need 138'7" before they arrive at the working face. Workers work seven hours. Before they reach the working face, they spend more than two hours, which is a waste of time. According to the "5W1H" questioning method and the "ECRS" principle in lean production, the flow chart can be analyzed to optimize the flow chart and reduce the waste of time [5]. Such as: Can the pre-class meeting be cancelled? Or at waiting time? Can workers go directly to the work area by car? Instead of walking somewhere to wait for a bus. By measuring the time and number of manned cages in a cycle, we can calculate when to arrive at the waiting area, and the waiting time is the shortest, even without waiting.

The specific optimization is: Step 6, walk from the work area to the shuttle bus, you can change the shuttle bus directly to the work area, reduce the time for workers to walk to the shuttle bus; Step 7, waiting for the drive, you can cancel or reduce the waiting time; Workers in the work area will increase the distance traveled by the shuttle bus, and the time from the shuttle bus to the auxiliary shaft will increase accordingly. It is estimated to be 2 minutes. Therefore, in step 8, the time to ride to the auxiliary shaft is 8'15". Waiting for the well can also be cancelled. If the shuttle arrives at the auxiliary shaft on time, there will be no waiting, make a reasonable time schedule. Step 13 and wait for the pedestrians in the lane; Step 14, take the pedestrian and wait for the car to open; Step 19, waiting for the track pedestrian. These steps can be canceled, or try to shorten the waiting time. "Fig. 3" shows the improved flow chart.

Job Name:Improved flow chart		Statistics			
Start: Arrive at the mine office building		project	Number of times	time	distance(m)
End:Arrive at the working face		operation	2	8'30"	
Date of study:2018.07.15		inspect	1	20'	
Review data:2018.09.25		move	10	61'25"	
		wait for	1	45"	
Statement of Work	time/min	Work series			
		operating ○	inspection □	mobile →	wait D
1 before the start of the class	20'				
2 walk to the bathhouse	1'30"				
3 change clothes	5'20"				
4 walk from the bathhouse to the lamp room	20"				
5 installation of miner's lamp	3'15"				
6 From the work area to the secondary shaft	8'15"				
Get off and walk to the cage	30"				
10 waiting in the cage	45"				
11 cages to the bottom of the well	3'5"				
12 walking to the alley pedestrian shelter	2'1"				
17 car dealers	14'				
18 people to the track pedestrian station	2'20"				
20 track pedestrian train	3'15"				
21 walking to the work surface	18'3"				
Total time	82'39"				

Figure 3 Flowchart after improvement

C Improvements in site management

(1) Implementation of 5S fixed management

Increase the 5S training for employees, enable workers to operate according to standard operating procedures, keep the production environment clean and tidy, and have a clean and finishing appearance on the work site, which

not only can improve the efficiency of work, but also ensure safe production. Through cleaning and finishing, the items on the scene are not called clearly, the scene will be orderly, and it is not easy to accident, and through the sorting, the hidden dangers at the scene will be discovered, so that timely treatment can be avoided to avoid accidents [6].

(2) Coal mining including man, machine and environment from three aspects, which are the core, through the study of the security in the mind of people, physiological, safety culture and safety technology, and other aspects of the selection and training, and constantly improve the people's safety quality, safety production skills, improve the man and his big material system of the safety of the matching between levels.

(3) Due to the complicated environment in which coal mines are produced, the working environment of workers includes temperature, humidity, air pressure, noise, lighting, etc. In the design of coal mining, these factors should be considered as much as possible, and efforts should be made to create a safe for workers. Work environment, can be on-site Kan Ban management, set up obvious signs in dangerous places to avoid casualties.

V STEPS FOR IMPLEMENTING THE LEAN MINING MANAGEMENT MODEL

(1) Using SWOT analysis methods to analyze the current situation of enterprises and find out the motives for enterprises to implement lean production changes [7].

(2) Through expert training, adopt education and training means to ensure that employees of the company establish a lean management concept. Business leaders must be able to fully grasp the lean management thinking and lead the coal mining enterprises to lead the lean enterprise. Coal mine leaders also need to educate employees about lean management concepts and corporate strategic goals based on lean management, so that all employees can realize the bright future of achieving lean management and clarify their role in corporate lean management.

(3) Start with on-site management and implement lean transformation. Through the 5S management of the production site to ensure the order and safety of the coal mining operation site, all the unsafe factors are eliminated in the bud, further simplifying the operation process and avoiding waste problems.

(4) Using value stream graph analysis technology to analyze logistics and information flow and improve it quickly.

(5) Improve the coal processing process. In accordance with the requirements of lean enterprises, improve the layout of coal enterprises, so that enterprises can organize production based on products [10].

VI SUMMARY

As resource and environmental issues have become a global strategic issue, coal companies, as an "extensive" growth model, pay little attention to issues such as waste, operational process optimization and on-site management. Through the on-site investigation and analysis of XZ coal mine, the process of workers arriving at the work surface and the site management are optimized and improved to reduce the waste of time and resources, improve the labor efficiency of workers and achieve the goal of "4M1E" improvement. Therefore, lean production, as a complete theoretical system, is also applicable to coal production.

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