

The Development Course of Fully Mechanized Mining Electromechanical Equipment and Its Exploration of Technological Innovation in Datong Coal Mine Group Company

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Abstract: The paper introduces the development course of fully mechanized mining electromechanical equipment in Datong Coal Mine Group Company, and expounds the technology approach and research direction of improving reliability of complete set of fully mechanized mining equipment in the manufacture and application of the equipments, and probes into production and scientific research direction of fully mechanized mining equipment manufacturing in future.

Keywords: fully mechanized mining equipment; development; innovation

Datong Coal Mine has gradually developed into an extra large coal electricity energy group from factory system after development of 57 years. The development history of Datong Coal Mine could be said the history of the gradual introduction and absorption of the fully mechanized mining electromechanical equipment, the history of constantly overcoming technology difficulties and innovating, the history of promoting coal technology to progress. The history evolution of fully mechanized mining electromechanical equipment and the exploration in practice and innovation in Datong Coal Mine Group Company are introduced for a rough in below five parts.

1. The development course of fully mechanized mining electromechanical equipment

Datong Coal Mine and Taiyuan Coal Academy Branch started the design and development on Chinese first set of hydraulic support in the 1960s. Chinese first integrated complete set of fully mechanized mining electromechanical equipment that Datong Mining Bureau and Taiyuan Coal Research Institute together researched had been tried in Datong Coal Mine and a success had been obtained on November 28, 1970. From then, the fully mechanized mining equipment of Datong Coal

Mine were from scratch, from the exploration, import, digestion to the development, improvement, innovation and application and gradually embarked on a sustained, steady and healthy development track.

Recalling the history of fully mechanized mining of Datong Coal Mine, the development course of fully mechanized mining electromechanical equipment can be divided into five stages on the whole.

The first phase: It is a phase of exploration, development and test. It was also a start phase of Datong and even China Coal Mine to develop fully mechanized mining from 1970 to 1974.

Chinese first set of TZ-1 type of chock support had been tried in the thin seam face of Meiyukou mine of Datong Mining Bureau in November 1970. This mining face had been matched with MLQ-180 type of hydraulic haulage drum shearer, SGW-150 type of face conveyor and WRB-100 type of hydraulic pump station at the same time. 67,800 tons of coal had been mined in 1971, 6814 tons every month on average. Mining face efficiency is 3.48 tons/(d-man). The prelude of Chinese comprehensive mechanization mining had been opened.

The second phase: It is a phase of introduction of complete sets of fully mechanized mining

equipment abroad and for digestion and absorption from 1974 to 1980.

Our country introduced 43 sets of fully mechanized mining technical equipment from the advanced mining countries such as Britain, Germany, Poland the first time in 1974, among which there were 5 sets used in Datong Coal Mine production in practice.

Our country introduced 100 sets of fully mechanized mining equipment from DT and Jialike company of UK, Eickhoff company of Germany and Mitsumiike company of Japan in the second batch, among which there were 18 sets used in Datong Coal Mine. Compared with the first batch of introduced equipment, the second batch were focused more on increasing power of hydraulic traction shearer and the traffic of the mining face conveyor and the working resistance of hydraulic support.

In this phase, through the use and digestion of the introduced fully mechanized mining electromechanical equipment, we cultivated a technical team who master the fully mechanized mining technology and the use of introduced equipment, laying the foundation for the further development of the fully mechanized mining technology.

The third phase: It is a phase of digestion, absorption, consolidation and development from 1980 to 1985.

Through the application of imported equipment and a wide range of technical exchanges with advanced foreign enterprises, we accelerated the tackling and development of fully mechanized mining equipment, pushing the fully mechanized mining production to develop forward continuously.

Zongsi team and Zongyi team of the Yongding mine of the Datong Coal Mine both made a breakthrough of annual output of more than 1 million tons in China the first time in 1981. During this period, the Datong Coal Mine had successively applied and digested EDW-170-L type of shearer technology of the Federal Republic of Germany,

together developed and applied a series of domestic equipment such as the EDW-170-L type of shearer and the hydraulic support imitating DT of UK, achieving good results.

The fourth phase: It is a phase of common fully mechanized mining electromechanical equipment to be domestic from 1986 to 1993.

Through the application, digestion, absorption, development and improvement of the introduced common fully mechanized mining equipment, we achieved a variety of fully mechanized mining equipment to be domestic and filled the gaps, basically meeting the needs of ordinary fully mechanized mining production. Furthermore, the installed capacity and production capacity of developed equipment were larger and larger, the reliability were higher and higher, so the fully mechanized mining production had been developed by leaps and bounds.

In this phase, we mainly used the MLS₃, MG, MXA and AM500 types of hydraulic traction shearers. This four series of hydraulic traction shearers all had made good results in the actual practice in 1.5-4.5m middle hardness of coal seam.

The first electrical haulage MG344-PWD type of thin climbing coal seam shearer developed by China and Poland were used in 0.9-1.6m middle hardness of coal seam in Datong Coal Mine, starting a new way of Chinese electrical haulage shearer.

Mining face conveyor experienced from open bottom type to bottom sealing type, chain arrangement form gradually experienced from single medium chain to double center chain last. Transport capacity of scraper conveyor could reach to 700-1000t/h, transport capacity of a whole machine could reach to 1-2 million tons. Joint strength could reach to 1500KN between grooves.

According to the characteristics of Datong Coal Mine Seam, we developed and applied a series of different supports summing to about 20 species of which high degree of support were 0.7-3.7m and the highest working resistance could reach to 10000KN, including a special series types such as economic type, roof caving type, large inclined angle type.

This several series of hydraulic supports could be basically suitable for the conditions of Datong Coal Mining Area and the characteristics of mine pressure, having made a good result.

The fifth phase: It is a phase of development of high yield and high efficiency fully mechanized mining from 1994 to now

Aiming at the advanced target of international and domestic high yield and high efficiency, Datong Coal Mine mainly developed and researched new technology, new materials, new technique, new achievement at high power, high strength, high transport capacity, high reliability and high-tech combining with national conditions, local conditions and all professional shearer manufacturers, getting on a new stage at research on complete set of equipment of fully mechanized mining technology and mining, achieving significant economic benefit.

Tackling development of shearer and conveying machinery was emphasized on the aspect of single machine. Different specification series and grade of fully mechanized mining matching equipment were formed by developing and researching on matching equipment and special mining technique aiming at different mining condition in thin, thick, special thick seam besides perfecting and improving equipment using in gently inclined middle and thick coal seam on matching aspect. Some technical level reached or approached to the international level.

Datong Coal Mine respectively introduced a set of equipment of daily output reaching to 10,000 tons and a set of equipment of daily output reaching to 7,000 tons from September 1994 to May 1995. The two sets of fully mechanized mining equipment were respectively used in Yazishan mine and Majiliang mine. Daily output and monthly output of Yazishan mine "double high" face created a national highest record of longwall mining, daily output of Majiliang mine "double high" face also created a national highest record of the low coal seam mining. The two mines were both named as "double high" mine by Ministry of Coal. A new millennium of mechanization development of our

bureau fully mechanized mining mechanization was opened.

Large mining height mining face went into production in October 2002, using SL-500 shearer made in Eickhoff Company of Germany, conveyor made in Zhangjiakou Coal Mining Machinery Company and hydraulic support made in Beijing and Zhengzhou Factory. The sets of equipment had advantages of a high degree of mechanization, power, advanced equipment, reliable performance and high technical content. Good achievements continuously were created in various indexes after commissioning of the mining face, refreshing 3 history records of Datong Coal Mine Group. The average mining efficiency could reach to 122.6 tons/(d·man). After exploiting the total reserves of 12 million tons, large mining height fully mechanized mining produced 3 million tons of coal more than the ordinary fully mechanized mining. The coal resources recovery rate had been increased by 37 percent. Large mining height fully mechanized mining really realized high yield and high efficiency and high resource recovery rate, creating significant economic and social benefits. "The key technology research on large mining height fully mechanized mining under the 'two hard' conditions" project was rated as one of the top ten scientific and technological achievements. The technology opened up a precedent of coal mining technology under the 'two hard' conditions in China, achieving the advanced level of the international mining industry.

Datong Coal Mine equipped with Jinhuaogong plough in the mining face in July, 2005. The mining face was matching with plough system made in DBT Company of Germany and two-leg shield hydraulic support made in Beijing Coal Mining Machinery Factory. The maximum daily output could reach to 6000 tons and the maximum monthly output could reach to 90,000 tons. Resources recovery of the low coal seams was increased.

2. Science and technology innovation conditions of Datong Coal Mine fully mechanized mining equipment in recent years

In recent years, to meet the requirement of high yield and high efficiency of the modern fully mechanized mining production, Datong Coal Mine actively organized scientific research for tackling, digested, absorbed and introduced technology, increased the joint development level with the professional manufacturers, accelerate the step of key equipment to be domestic especially the full use of electrical haulage shearer, large traffic conveyor in mining face, electro-hydraulic control system of hydraulic support, 3.3KV power supply system of fully mechanized mining, monitoring and control and fault diagnosis technology. Our unit is one of the leading units in the same trade in our country in technical content and advancement of equipment, achieving significant economic and social benefit.

According to the conditions of complex geological condition, hard coal seam, hard roof and high mining difficulty in Datong Coalfield, Datong Coal Mine devoted to optimization design, reasonable selection and scientific research for tackling. A breakthrough has been made. Complete sets of fully mechanized mining equipment of large inclined angle, short arm, light top-coal drawing, low-position top-caving, large mining height have been applied successively. We have developed and applied advanced equipment being at the first-class level at home and aboard, making a lot of firsts:

The first MG344-PWD type of thin coal seam off-pan electrical haulage shearer developed by China and Poland was tried in Yanya mine of Datong Coal Mine Administration in February 1992, opening a new way of Chinese electrical haulage shearer.

The first electrical haulage shearer using in middle and thick coal seam was applied in Jinhuaogong mine in 1996.

The first MG250/300-NWD type of short-wall electric-driven shearer was applied in mining face of Sitai mine in 2002.

In 2002, Chinese first set of high power, long conveying distance, high reliability, SGZ1000/1050 type of crossing side unloading mining face

conveyor developed with Zhangjiakou Coal Mining Machinery Factory and Chinese first set of ZZ9900/29.5/50 type of hydraulic support developed with Beijing Coal Mining Machinery Factory were applied in once mining and complete high mining face of Silaogou mine.

We successively jointly developed MG750/1910-GWD 、 MG750/1815-WD 、 MG800/2040-WD、 MGTY750/1800-3.3D types of shearers with professional manufacturers in Xi'an, Shanghai, Jixi which were respectively their first super-high-power, thick seam (5 ~ 5.5 m) electric-driven shearer from 2004 to 2005, so the electric-driven shearer technology had been made substantial breakthrough.

The first light top-coal drawing ZF4600/19/30 type of hydraulic support was applied in Meiyukou mine in 2003.

The first domestic 3300V voltage thin and medium thick electric-driven MG300/701-AWD shearer was applied in Sitai mine fully mechanized mining face in 2003.

The first set of 500L BRW500/31.5 type of emulsion pump station of large flow, liquid supplied in ring shaped was applied in once mining and complete high mining face of Silaogou mine in 2004.

As is emphasized, through the introducing of SL-500 shearer made in Eickhoff of Germany, anterior and posterior conveyor, ZF10000/25/38 support made in DBT company of Germany and actively increasing the intensity of independent innovation, Tashan mine can be expected soon to achieve an design objective of annual output of 15 million tons.

As mentioned above, fully mechanized mining high yield and high efficiency mining face equipment of Datong Coal Mine have the following characteristics of development in recent years:

□ Shearer

First, gradually increase the power and capacity. Second, the electric-driven shearer has

become the leading model. Third, increase the traction force and haulage speed, improve the chainless traction mechanism. Fourth, the layout of the machinery has a new development. Fifth, innovate and improve the cutting drums on increasing the depth-web, decreasing the coal dust, increasing the lump coal rate and increasing the service life. Sixth, use the microelectronics technology to achieve the condition monitoring, data collection, fault diagnosis and automatic control of the integration of electrical and mechanical. Seventh, improve the reliability and easy maintenance of the shearer, shorten the time for replacement parts underground, extend the overhaul cycle and the service life, improve the operating rate.

□ **Scraper Conveyor on Mining Face**

Scraper conveyor develops into heavy-industrialization in order to meet the growing needs of the production capacity of high-power shearer. First, continuously develop into large volume, long distance, high-power. Second, the conveyor chute develops into heavy-industrialization cast welding chute. Third, use the new transmissions such as two-speed motor and soft-start. Fourth, the chain components are made continue to improving anti-impact toughness and enhancing the fatigue life. Fifth, mainly use the crossing side unloading at machine head and tail devices in order to decrease height, enhance the intension and service life of frame and sprocket.

□ **Hydraulic Support**

Four pillars chock-shield and two-leg shield are generally used in hydraulic support. Control technology of hydraulic support has been changed greatly. Electro-hydraulic control technology tends to be perfect and mature, being promoted to application.

□ **Auxiliary Equipment**

Investment in science and technology also constantly increases in auxiliary equipment such as pump station for fluid supply, extensible belt conveyor, power supply for fully mechanized mining, meeting needs of the main equipment.

3. Technical means and research direction for improving reliability of complete sets of fully mechanized mining equipment

Datong Coal Mine has made remarkable social and economic benefits in the application of new technology, new equipment in recent years. The technical level of equipment has yet to be further enhanced and improved after careful analysis of the status quo. As has been proved in practice, only reliable equipment can ensure high yield and high efficiency of the fully mechanized mining face. Reliability of complete sets of fully mechanized mining equipment depends on the reliability of the single machine above all. Only under the reliability of the single machine, the operating rate and utilization rate of fully mechanized mining equipment will have a foundation. Therefore the manufacture and application of three machines assortment of fully mechanized mining face should been mainly considered in the following issues:

□ **Hydraulic Support**

Hydraulic support newly developed of fully mechanized mining face of high yield and high efficiency should meet requirements of the sufficient strength, the matching speed, reliable capability, quality materials, the simple system, easy maintenance, long overhaul cycle, a short time for moving. We should ensure the manufacturing quality and properly increase the investment, so the hydraulic support can match the big introduced conveyor and high-power shearer. Only in this way the hydraulic support technology can be really on a new stage.

□ Must quickly develop and promote a new generation of valve for support. Large traffic safety valves are used to adapt to rock burst. Setting load pledged valves are used to fully play the support effect. Operating valve and various kinds of the check valve flow section are improved to meet the need of high yield on the mining face. the development of electro-hydraulic control system

was accelerated to narrow the gap with foreign countries.

□ Develop new dual-extension legs. At present, China uses the differential pressure type of dual-extension hydraulic legs of which the internal pressure of middle cylinder can be as high as 100Mpa. There are high requirements of the strength of the middle cylinder and the sealing of inner bottom valve, so the middle cylinder is easily damaged. Dual-extension hydraulic legs of constant pressure has been successfully developed abroad and used in practice, China should also apply and promote it as soon as possible.

□ Quest the new-type support to overcome the shortcomings of the four linkage mechanism. The four linkage mechanism is the rigid force transmission component at the hydraulic support and can't yield to the level load. In addition, with the weak capacity of the lateral load, the four linkage mechanism is easily deformed to damage in the bad environment.

□ Improve the anti-fatigue capacity of the hydraulic support. With the fully mechanized mining face of high yield and high efficiency lengthening and advancing faster, the number of repeated load of hydraulic support increases. The speed of putting up the support will have doubled and redoubled. So propose to increase the number of support life test from 5,000 to 10000-15000.

□ Select the high-strength materials. 16Mn welded steel structure components are often used in domestic hydraulic support of which the compressive strength is about 300-350Mpa. 500Mpa welded steel structure components are used in some supports with special requirements. New supports not only need to meet the requirement of increasing the work resistance, but also the requirement of reducing the weight of the support. Using high-strength steel as structural parts is its essence.

□ Improve the structure of the side guard plate of top beam and the thrust gear, increase the force for pulling support, ensure the shift-step and raising the waste stone exhaust performance.

□ Increase the intensity of connectivity components.

Increase the intensity of several major connectivity components such as the top beam, the former beam, the shield beam, increase the intensity of the column and the connection ear of jack in order to ensure no damage in use.

□ Improve the withhold quality of hose crimper, strengthen the research on seal and increase the service life of pipe fittings and seal.

Supply large-diameter specifications ($\phi 19$, $\phi 22$, $\phi 25$ mm, etc.) on high-pressure hose to meet the requirement of fast-shifting.

□ **Shearer**

The shearer should adapt to needs of various coal mining under requirements of modernization mine and fully mechanized mining face of high yield and high efficiency. From the current situation, we should mainly take the following measures at enhancing the reliability of shearer:

□ Eliminate the weak links in the transmission system as far as possible, enable lives of the transmission partstransmission parts such as the bevel gear, the long axis, chain drive to be fundamentally equal.

□ Select high-quality materials. For example, JOY company of USA manufactures chassis with cast alloy of $\sigma=70\text{kg/cm}^2$. Germany manufactures gears with the 17CrNiMo8 steel and seals with high-quality oil resistance rubber and so on.

□ High-pressure hydraulic transmission with the stringent environmental requirements should be used as little as possible. Hydraulic traction should be gradually replaced by electrical haulage technology.

□ Reliable and firmly loosing prevention technology such as hydraulic nut and split nut should be used between the connection of the major components.

□ CAD technology should be used to design drum and choose the best parameters, so the shearer could become stable when it is used in picking cutting in order to extend the service life.

□ Improve the pick structure, raise the technology level of cutter head alloy welding, improve the

spray system, extend the pick life and reduce the replacement time.

□ Internal support structure of rocker should be replaced by the outer support as far as possible, which is beneficial to reduce the support load, reduce the machine vibration and extend the support life.

□ Improve the diagnosis system of machine fault, facilitating looking up and treating failures.

□ An independent structure is used in the major components, so there is non-interference in handling and replacement, facilitating the rapid processing of the underground fault.

□ Supply and perfect quality test indicators and strengthen techniques of manufacturing and inspection.

□ **Scraper Conveyor**

In recent years, domestic scraper conveyors of fully mechanized mining face have been made a certain development, but being also far short of requirements of high yield and high efficiency of fully mechanized mining face. There is still a great distance with heavy-duty scraper conveyors abroad, showing as the small transport capacity and the low volume of coal flow quantity and so on. In order to satisfy the need of the development of fully mechanized mining face, improve the reliability of scraper conveyor, we should focus on solving the following issues:

□ Increase the effective power of coal transportation.

First, use bottom sealing chute, reduce friction, blocking of the central slot and the idle power. Second, use the side unloading equipment, increase unloading capacity and reduce the volume of coal reclaiming coal, effectively reduce idle power. Third, develop the hollow scraper to reduce idle power. Fourth, choose the smallest preload under the condition of ensuring the scraper conveyor normal operating.

□ Improve the overall performance

First, develop into low head structure. Second, develop into non-chain drawing and chain track. Chain track or single-toothed gears are used to

replace rack or row gears. Third, hydraulic tension chain equipment are used for achieving security, fast tension chain, effective adjustment and timely check on scraper chain.

□ Increasing the supply voltage of motors and using kilovolt-voltage motors can reduce the volume and improve the reliability of the same power motor.

□ Improve the reliability of components such as middle trough and its connecting pieces, round link chain and link chain.

4. Several suggestions for the future equipment manufacturers

Under the quality of design and manufacturing, complete sets of fully mechanized mining equipment through reasonable selection and correct matching are fully able to meet the requirements of high yield and high efficiency. Therefore it can be said that only further advance of machinery reliability can effectively reduce the loss of working hours. We also should research and develop on the following aspects at the same time.

□ Monitor the operation state of the equipments and show the permissible limits and actual value of operation with text and graphics.

□ Diagnose and predict the fault, so that operators can clearly know the point of fault that has taken place or may arise.

□ Monitor and control parameters, coordinates, speed of the equipment, so that the equipment will have the self-adjustment ability to ensure the regular work in a normal state.

□ Coordinate and control various sub-systems of complete sets of fully mechanized mining equipment with computer system.

5. Conclusion

Fully mechanized mining technology of Datong Coal Mine Group Company has developed for nearly 40 years. The mechanization degree of fully mechanized mining and fully mechanized mining winning has respectively reached to 98.03% and 54.66% by the end of 2006. At present, Datong Coal Mine Group Company is quickly constructing a coal-electricity energy base, actively promoting and

strengthening five main strategies. As one of the main industries, coal feeder industry is accelerated the pace of integration of the reorganization. We strive to complete the formation of the coal feeder company by the end of the year. We will join the domestic and foreign enterprises and scientific research institutes with advantage , actively introduce strategic partners, integrate the capital, diversify the property, upgrade the technology, adjust the structure and introduce various elements to constantly improve the capabilities of manufacturing and technology research and development of coal feeder and gradually explore a new path in the coal industry. We also welcome the relevant enterprises and people of insight for the construction and development of coal feeder industries. We will mutually benefit and together develop. As can be believed in the near future, Datong Coal Mine Group Company will make new contributions for the high-efficiency and safely mining productions and comprehensive mechanization degree of Chinese coal industry to a new level.

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