

Modern Mining Technology and its Application within RAG Coal International AG

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ABSTRACT; Today's structure of the RAG group of companies represents years of change in converting from purely a coal mining company to an energy and technology corporate group. Coal mining within RAG is separately organized, in Germany with Deutsche Steinkohle AG (DSK) and internationally with RAG Coal International AG, which was founded in 1999 after a larger US acquisition. Declining production in Germany gives much more importance to the international coal trade. Access to international coal resources is important to staying successful in business. As a new concept under RAG Coal International AG, we have organized international coal production, coal trade and sales, and the mining equipment manufacturing side, trying to use synergies to the greatest possible extent. In principle, all coal mining producers receive benefits from extremely operationally proven and market-orientated equipment availability. Recent developments have largely focused on improving longwall equipment. The trend of improvement is in principle towards:

- much more resistant and stronger AFCs,
- 2-m-wide roof support shields,
- electrohydraulic system control and integrated computerized operation.

In particular, system integration is in constant focus through Deutsche BergbauTechnik (DBT), and recent developments have shown great success in international application. The productivity records of longwalls have always been set with DBT equipment over the past decade. There are a variety of applications worldwide where DBT longwall equipment has shown its reliability, the extended material life of its individual components, and functional and operational advantages through system integration.

1 INTRODUCTION

RAG Coal International's role in the world of international coal mining, modern mining technology, and within our own company is very significant.

In this paper, firstly, a brief introduction to the corporate structure of the RAG group of companies will be given. Afterwards, the worldwide mining and trading activities of RAG Coal International will be briefly introduced. Finally, the latest developments in German mining technology and their international application will be presented.

2 STRUCTURE OF RAG GROUP OF COMPANIES

Today's structure of the RAG group of companies represents years of change. From its origin in 1969 as a single coal company tied to the Ruhr-Mining Region in the west of Germany, RAG has developed

into an energy and technology group operating worldwide.

RAG Holding concentrates on the strategic leadership of its six divisions, of which two are coal-related.

Deutsche Steinkohle AG (DSK), founded in 1998, is responsible for all domestic (German) hard coal mines and coking plants. DSK is the only hard coal producer in Germany. The company employs some 60,000 people (2000).

RAG's largest unit is a portfolio of energy and technology holdings:

Our company RAG Coal International AG is within that portfolio. We are focused on overseas coal production, coal trading, coal sales and mining equipment manufacturing.

The other divisions are:

- RAG Immobilien AG, which is RAG's real estate, wholesale trading and distribution company;
- STEAG, with business activities in power generation, international IPP projects and electronic systems;

- the RUTGERS group of companies, a manufacturer of chemicals and plastics;
- the Saarberg Group, with diversified activities in the field of oil products, trading, rubber products manufacturing, environmental technology and energy.

In addition, three RAG-owned service companies provide the corporation with vocational training, information technology systems and insurance.

3 RAG'S COAL ACTIVITIES

3.1 *German coal mining*

As mentioned above, DSK is the only hard coal producer in Germany. The company operates twelve deep mines and two coking plants. In 2000, DSK produced 34 Mt (metric) of coal.

In Germany, the production of hard coal is subsidized. These subsidies are based on an agreement between the hard coal industry, DSK, and the German Federal Government.

The agreement, reached in March 1997, defines a financial framework for the years from 1998 to 2005. It provides the German hard coal industry with a perspective to retain a substantial size and, therefore, guarantees long-term access to national coal resources. Nevertheless, the coal subsidies will be almost halved over the 1998-2005 timespan.

Only nine or ten mines will remain in operation in the long term. The adjustment process will result in the closure or merger of mines. Correspondingly, coal production will decline from 40 Mt (1999) to 26 Mt (2005). The number of employees at DSK is to be reduced, from 72,000 in 1999 to 36,000 in 2005. Last year, the adjustment process at DSK was extremely painful. The number of personnel was reduced by almost 12,000 and production has already declined by 6 mt.

3.2 *International coal mining*

Analogous to the trend of global concentration of larger and competent coal producers, RAG acquired the Cyprus Amax Coal Company in the USA in 1999. As a result of this acquisition, RAG Coal International was founded in April 1999 in order to concentrate RAG's international coal business under one company holding.

RAG Coal International AG is an international coal producer and is also involved in international coal trading, German coal sales, and the manufacturing of mining equipment. This amalgamation of different businesses under one umbrella is part of RAG's new concept.

In 2000, RAG Coal International's turnover reached 4 bn. USD. The corporation employs some 6,000 people and maintains sales, service, and mining locations in all five continents.

Our international coal mining subsidiaries operate in the US under RAG American Coal Holding, in Australia under RAG Australia Coal Pty., and in Venezuela under Carbones del Guasare.

The main emphasis of RAG Coal International's mining activities lies in the US. From 14 mines in six US states, RAG American Coal Holding expects production of around 60 Mt in 2000. With mines operating in the Powder River Basin, Colorado, the Midwest, Pennsylvania and West Virginia, RAG American Coal Holding is one of the few US domestic coal producers which are able to ship coal of varied quality in terms of heat content, ash, moisture and sulfur levels, allowing customers to meet their diverse quality needs.

Looking at annual coal production, RAG American Coal Holding ranks 5th amongst the 10 big coal producers in the United States. Above it are Peabody, Arch Coal, Kennecott and Consol.

In Australia, RAG Australia Coal's operations include the German Creek, Burton and North Goonyella mines, all located in Queensland. In total, our Australian coal production will reach some 6 Mt.

In Venezuela, we own a minority interest in the Paso Diablo Mine through Carbones del Guasare; the mine produces about 7 Mt of steam and PCI coal annually.

Our trading activities are growing. Last year, we traded some 24 Mt internationally, which places us third of the major international coal traders, behind Glencore and American Metals & Coal International Inc. (AMCI). About 10 Mt of coal was imported into Germany last year in order to compensate for declining German production and to enable us to serve our customers with the coal quality they are used to.

The internationally based DBT Deutsche Bergbau-Technik engineers and manufactures underground mining equipment and is the fourth column of RAG Coal International. The company is the world leader in underground raining technology. As a specialist in longwall, transport and system control technology, DBT sells systems solutions that have been tested and proven under the extreme conditions of German mining.

DBT's manufacturing and sales centers are located in all the important underground coal mining regions and markets of the world.

DBT's longwall equipment is known for its reliability and efficient use in nearly every coal mining region in the world. The main focus of this paper is to explain why this is a fact and how it has developed.

4 MINING TECHNOLOGY AND RECENT DEVELOPMENTS

Not only in Germany, but also in the US and other advanced coal mining nations, there have been major influences on the development of longwall equipment. For example, the US market is extremely competitive and only those underground longwall mines which produce coal at the same or lower cost than surface mines or room and pillar operations remain. The general trend has been towards the production of more and more coal from ever fewer longwalls in operation. Similar developments are reported from Australia. The international coal mining community certainly watches new developments, especially in these countries, which are known for their high technical standards and are also referred to as trend setters with regard to coal mining.

If we take, for example, a longwall today and its different components, we find a variety of possibilities to improve individual items. However, it is the whole set of equipment which has to operate under sometimes very hard mining conditions and which has to display good operational and productivity performances.

In order to get a better picture of what the state of the art is and where developments are going, we should look more deeply into the individual components of a longwall, which are basically:

- the transport technology with armoured face conveyor (AFC),
- the drive technology,
- the roof support technology with electrohydraulic shield supports,
- the system of automation and electrohydraulic controls;

4.1 Armoured face conveyor and drive technology systems

The basic principle of the armoured face conveyor, the AFC, has remained essentially the same since its inception. The AFC not only conveys coal, but also acts as a track for the mining machine - the shearer or the plow - and serves as a reference rail for the shield supports. Modern AFCs are up to 1,342 mm wide, with an installed carrying capacity of more than 5,000 metric tons per hour. The operating voltages are up to 3,300 volts (50 Hertz) or 4,160 volts (60 Hz).

Over the years, the pan width together with the deck-plate thickness have increased significantly, and this has been the case particularly during the past 10 years. This has also been the case with the thickness of the profiles and the breaking strength of the pan connectors.

Contrary to common thought in the early 1990s, the hardest material is not the best for wear resistance. Instead, high-strength manganese-based steel shows minimum wear, especially as the production rate increases over time. This material's surface hardens as more and more coal is conveyed. As an example of maximum pan life in good conditions, some AFCs have conveyed more than 20 million tons and are still operating with the originally supplied 40-mm deck plate.

New AFC developments were initiated by coal operators who were mining in difficult conditions and conveying more rock, which is especially the case in Germany, but can also be found internationally in cases when the longwall is operated close to fault zones and/or faces with larger stone beds in the coal seam. A new development is the DBT PF 5 pan model. Compared to the older PF4 pan model, the profiles are larger and the typical deck-plate thickness has increased to 50 mm. The dog bones each have a breaking strength of more than 4,500 kN, compared to 4,000 kN for the PF4.

DBT's face conveyor systems in operation have horsepower installations of up to 3,200 kW (each drive frame is capable of 2 x 800 kW) with high AFC chain speeds of up to 1.8 m/s. The AFC system is designed for maximum carrying capacity and/or maximum face length.

An important component in maximizing the performance of high-horsepower AFCs is an intelligent drive system for soft start, load sharing, and overload protection. The Controlled Start Transmission (CST) drive system, developed especially for application with a chain conveyor, provides a user-friendly drive control unit.

4.2 Roof support technology

DBT's shield support is available for seam heights from 0.6 to 6 m, with setting and yield loads tailored to the operator's requirements and the geological conditions. Most of these shields today are of two-leg design. The support capacity, meanwhile, exceeds 1,000 t if required. The original 1.5-m shield width has grown to 1.75 m. The advantages are obvious. Fewer shields are required for the same face length, which reduces the total number of shield units and therefore the costs. Furthermore, longwall move times can be shortened using fewer shields. Recent developments indicate that shield width may grow up to 2 m; the application of this new type of shield support will certainly depend on individual condition allowances. A 2-m-wide prototype shield was exhibited by DBT at MinExpo in Las Vegas in October 2000.

Leg diameters today have grown up to 400 mm, and they are typically double-telescopic cylinders,

maximizing the support density at a given open to closed height ratio. The large diameters improve the hydraulic flow characteristics with the leg and yield quick minimum shield lowering and setting times. The maximum operating pressure may be greater than 350 bar.

4.3 Automation and electrohydraulic controls

The PM 4 electrohydraulic control system moves the operator one step closer to full automation of longwall systems. The basic concept is "in-shield intelligence". Through individual power groups, there is little or no limitation in the flexibility to run the mining sequence efficiently. A central computer can be located at either the headgate or surface (or both) for maintenance data acquisition and face monitoring.

All shield features activated by the PM 4 electrohydraulic shield control system are programmable. This provides a safe environment for longwall personnel remote, from the moving shields with all longwall mining methods.

With increasing levels of automation and the need to make installations more user-friendly, DBT has moved a PC-based system with a standard Windows platform and Pentium processor that can be used both underground and on the surface.

4.4 Mining technology development

In summary, the recent developments of modern mining technology have been largely focused on longwall equipment. Individual components have been upgraded in terms of reliability, material life, functional aspects and system integration. The trend is in principle towards:

- much more resistant and stronger AFCs with enlarged pans and profiles,
- . 2-m-wide roof support shields,
- electrohydraulic system control and integrated computerized operation.

The main reason for this development is the permanent pressure to cut costs on the operators' side. Furthermore, there is a demand for equipment which can also be used economically under deteriorated mining conditions which, as we all know, can occur anywhere and at any time.

Under RAG's group of companies, we are running the concept of the integrated development of mining equipment in Germany. Thus, there are in principle three main advantages (among others) with mining equipment of German origin:

One is that the equipment is designed to be resistant under the unique German mining conditions, which are harder than conditions

anywhere else in the world. The second is that the same equipment is applied in mines all over the world, with a lot more success and more economically than other equipment due to the integrated equipment components approach of DBT. The third advantage is that adequate maintenance through DBT's after-sales service package ensures:

- maximum system availability and high longwall productivity,
- critical spare parts management to minimize system downtimes,
- significantly longer operational use (life) of the system.

5 INTERNATIONAL APPLICATION

The chart shows the development of longwall productivity world records which were achieved with DBT equipment in the past. We achieved 850,000 tons production in one month at Twentymile mine in Colorado, US. At other mines, e.g., West Elk from Arch, world records were also set.

Longwall performance at the Twentymile mine has been nothing short of amazing. During 1989, the mine began full-scale longwall production, using DBT's AFCs and supports, and a Long-Airbox shearer. What is commonly referred to as the "superwall" started operation in April 1996. The 256-m-wide longwall face is 2.6 m thick and the panel length is up to 5,400 m. The face equipment consists of 148 1.75-m-wide DBT 2-leg shields with a capacity of 840 tons. The PM 4 electrohydraulic shield control system is used for full-face automation.

The 1,332-mm-wide PF 4 AFC runs a 42-mm twin inboard chain at a speed of 1.81 m/s. It is powered by three 740 kW drives with the intelligent CST drive system. The guaranteed carrying capacity is more than 4,500 tons per hour. The excellent load sharing allows Twentymile to easily exceed this carrying capacity and as much as 6,000 tons per hour have been recorded over the belt.

Twentymile has consistently set and broken production records, starting with 435,000 clean tons for the month of October in 1994 with old DBT longwall mining equipment. The current monthly record from a single longwall (850,000 clean tons) was set in June 1998. Longwall availability was 99 % in that month.

US Steel Mining ordered a completely new plow longwall face from DBT with the latest technology in 1999. The plow operates with 2 x 400 kW and AFC with a CST 30 drive system with 1,040 kW of installed power. With this set-up, the mine was able to extend the face length up to 319 m and to increase productivity shortly after starting the new longwall

operation As a result of one week's full operation, a new world record for thin seams (13m) was set with 22,710 clean tons per day

In Australia, at BHP's Cnnum mine and at Mini's Oaky Creek No.1 mine, new records could be achieved by using a 1,132-mm-wide PF4 AFC with CST drive from DBT (Cnnum 43,715, Oaky Creek 38,880 mtpd)

A lot of other examples can be given to show the excellent performance of DBT longwall equipment

in underground coal mining all over the world - in China, Poland, the CIS, South Africa and, of course, in Germany

The key to the future enhancement of longwall mining productivity is not only enhancement in all system components, but also an overall increased system performance DBT puts all its efforts into engineering and manufacturing the best equipment with the target of increasing productivity and giving our customers the best value

