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Integrated planning of the partially automated Banji coal mine in China

Becker Franz[a*], Baus-Neufang Bernhard[a], Seeliger Andreas[b]

[a]*Becker Mining Systems AG, 66299 Friedrichsthal,Germany*
[b]*RWTH-Aachen University, 52056 Aachen, Germany*

Abstract

The chinese mining company SDIC Xinji currently develops in the province of Anhui, south of Beijing, the coal mine Banji, pursuing the aim to realize an exemplary high-performance mine with the highest degree of production efficiency and a high safety standard, using state of the art technology. Remarkable with this assignment of task is the fact, that power supply technology, high voltage switch technology, automation and communication were being projected from one supplier, as an integrated complete system, based on a three- dimensional mine layout model.

Keywords: automation; integrated planning; communication; coal mine

1. Introduction

The rapidly increasing level of industrialisation in emerging nations such as Brazil, China, India and Russia has led to an increasing demand for raw materials, resulting in the rise of their prices. In order to ensure supplies to domestic markets, it is necessary to open mines and to excavate the raw material deposits in one’s own country. This reduces the dependability on raw materials obtained from the world market. In contrary to the well-established underground German coal mining, there are no over decades developed mine structures in the above mentioned countries, in which innovations can only be incorporated as isolated applications. Newly established mines give the planner the possibility to develop comprehensive automation and communication concepts, tailored to the mine and deposit targeted.

In the report, the methodology of the planning of automation sub-processes in underground coal mining, as well as the upcoming modern IT-technology to be employed is presented, using the example of the Chinese coal mine Banji.

2. Mining company SDIC Xinji and the Banji mine

The mining company SDIC Xinji (Fig. 1) is part of the State Development and Investment Corporation (SDIC) of the coal rich Chinese province of Anhui.

The SDIC-group was formed by merging companies of the energy producing, mining and communication indus-

Corresponding author. Tel.: +49-241-809 38 44.
E-mail address: seeliger@ibh.rwth-aachen.de.

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try as well as other industrial sectors.

SDIC Xinji was founded in 1989. Organisationally, it belongs to the mining sector of the corporation and is currently running four active mines with an annual production rate of 10.5 M tons of coal.

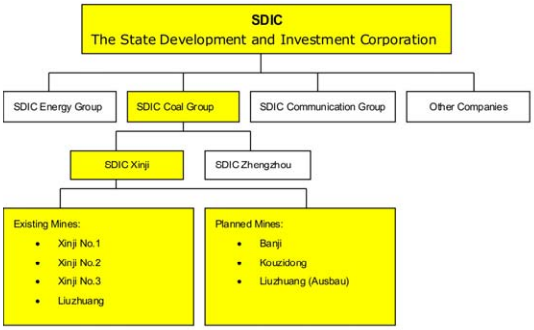

Fig.1. Structure of the mining company SDIC

Two mines (Banji and Kouzidong) are currently being opened up, while one already operating mine (Liuzhuang) is being expanded.

The SDIC Xinji claims a total area of 1092 km² and proven coal resources of over more than 10 billion tons. The annual production rate is planned to be raised up to approx. 36 M tons.

The Banji mine is located about. 920 km south of Beijing (Fig. 2), close to the city of Huainan, where the head office of SDIC Xinji is situated.

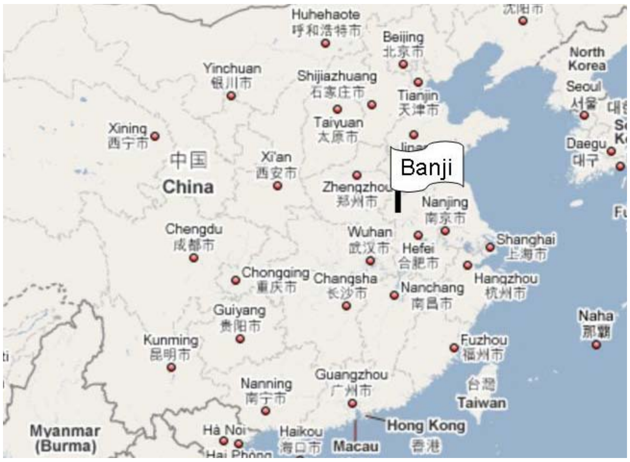

Fig. 2. Location of the Banji mine

The seam-bearing carbon strata extends as a flat bedded basin fold over 5 km × 6 km in a depth range of about 650 to 800 m under ground surface. The thicknesses of the exploitable coal seams range from 1.1 to 6.1 m. The coal is a power station coal with low sulphur content (0,1 – 0,4 %). The expected total annual production at full operation of the mine is around 3 M tons.

The panel is being operated up from the ground surface by three shafts:

- Main and hoisting shaft (5.8 m Ø) with a multi-rope hoist (4700 kW) and a double skip unit (payload: 32 t).
- Secondary shaft (7.0 m Ø) for material and man haulage with a multi-rope hoist (2100 kW) and a four level hoisting cage

- Ventilation shaft with an auxiliary man haulage construction.

It is scheduled to start the extraction in the year 2009 with a plough face (seam thickness approx. 1.1 m). A second working face, a shearer face, shall be started in 2010 (seam thickness approx. 2.2 m). Here an Eickhoff shearer loader (Type: SL 300) is planned to be employed.

The extraction operations are to be operated with the retreating longwall method. Currently the parallel headings are constructed by blasting. The transportation of raw coal will be done by conveyor belt systems, which are connected to the upward hauling main conveyor belt, conveying the material to a bunker near the main shaft.

Parallel to the belt road, additional drifts for the ventilation and for trackbound (Locomotive) haulage will be driven. The operating company SDIC Xinji aims to develop an exemplary high-performance mine with maximum production efficiency and high safety standards. This requires the introduction of the latest automation and communication technologies, which are optimally customized to the mine layout, the plant above and underground and the equipment in the planning phase.

The following work presents the integrated planning approach and the applied procedures in two main planning steps.

3. Phase 1 of the integrated planning

The first planning phase consisted of the description of the essential areas of the mine, with particular focus on the ascertainment of technical control and information technology processes. At the same time, a model of the mine layout using the software MineView [1] was developed (Fig. 3).

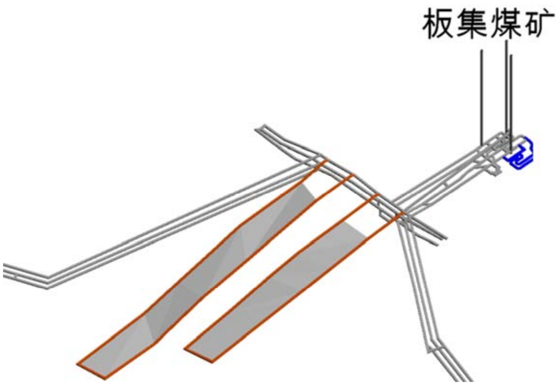

Fig. 3. Mine layout designed with MineView

Figure 3 shows the three mentioned shafts, the main and side drifts, as well as the ventilation drifts and the two coal faces with their parallel headings.

On basis of the computer supported visualised mine layout and the requirements catalogue of the mining company, individual substructures of the mine were examined under the aspect of the required IT-infrastructure. The examined substructures are: conveyor systems, energy management, central mine control station, communication, refrigerating plant, coal faces, drivage, transport infrastructure, surface compressed air supply, mine drainage and ventilation facilities.

Firstly, analysis of these substructures in their structural configuration was carried out to obtain an overview of the main components of the mine's subsystems and to determine information about their automation potential. From this analysis, a modularly built specification chart was derived which differentiated every main component (e.g. shearer, face conveyor, gate conveyor, self-advancing support, etc.) according to the following:

- Monitoring or control units
- Energy supply under specification of voltage level
- Required periphery (sensors, actuators, field and remote bus systems)
- Definition of the required information scope for each control level (process, sector, central mine control station).

The setting of the system boundaries and the modularisation of the system components are essential intermediate steps within the frame work of the presented integrated planning of partially automated mines.

4. Realisation of the concept using the example of the Banji mine

Based on the 3D dataset of the mine layout, information of the subsystems of the mine were inserted into the model and made accessible through icons.

Figure 4 is an illustration of the results of these proceedings using the example of the conveyor belt system of the mine.

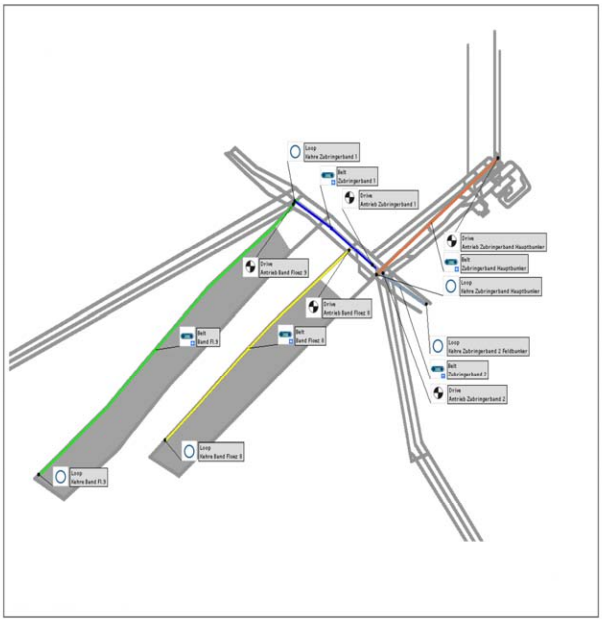

Fig. 4. Conveyor belt system of the Banji mine

One can recognise drives and return ends of the coal haulage conveyors located in the parallel headings further on in the feeder conveyors and in the upward hauling main conveyor belts leading to the main bunker. By clicking on the icons, associated information (belt quality, configuration of the drive, technical data sheets) can be retrieved [2].

By applying the above described steps, the first phase of the planning was completed. Henceforth there was a detailed record of the subsystems and components available. Furthermore, operation resources related models taking into consideration the mine layout structure were generated. These models were used in the second phase of the integrated planning. They helped in the development of the continuous automation concept that was planned for the mine (System PROMOS PLUS), as well as the required IT-infrastructure (field and remote bus, system components, periphery units, IT-backbone fibre optic cable).

5. Phase 2 of the integrated planning

Due to the specification charts and operation resources based models of the mine layout, which were obtained in the first planning phase, the components of the product line of the automation system PROMOS PLUS could be easily compiled in the second phase of the planning. Some locations were illustrated in 2D-view derived from the original 3D-dataset.

Figure 5 shows an example of this planning stage. It emphasizes the automation concept of the upward hauling main conveyor belt.

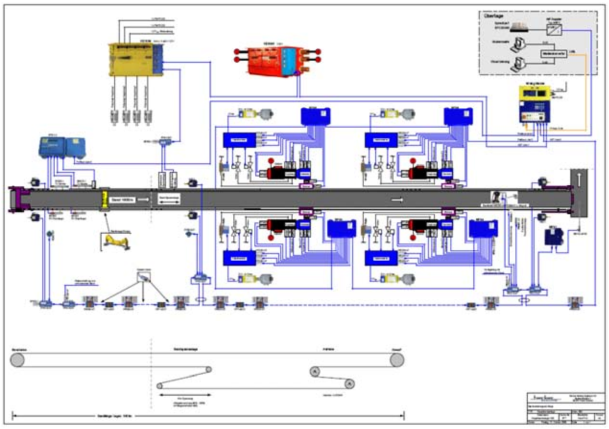

Fig. 5. Automation concept of the main conveyor belt

The conveyor belt is driven through two drums, each with two 630 kW constant speed motors, which transfer their power via fill-controlled, hydrodynamic speed control couplings connected to the gearbox. For the control of operating modes

- Automatic (independent start-up and information of the following conveyors)
- Individual operation of conveyor belts
- Repair service

The high-performance and explosion-proof IPC MINING MASTER is used.

The computer is embedded in the fibre optic-backbone of the mine (Ethernet) and possesses in addition to the PROMOS AST-field bus line, a supplementary PROFIBUS-line. The field bus AST establishes connections to the periphery devices (intercommunication system, emergency stop system, conveyor skewing limit switch etc.) via the intrinsically safe PROMOS field bus cable along the conveyor belt system. At the same time, the cable serves as jerk line for the activation of the emergency stop system.

An additional PROFIBUS-line transfers information from the belt rip detection and the belt weighing system to the control unit.

All information obtained from the sensor system (skewing, overfill, hydraulic pressure water supply, motor current, temperature and rotational speed, slippage monitor, malfunctions from the control or compact station, belt tension, functioning of the coupling etc.) can be visualised on the display of the control unit and transferred via fibre optic cable to the central mine control station.

Fig. 6. Mining master

Figure 6 shows the MINING MASTER, built with the pressure proof casing (above) for the display, power supply and the CPU. Furthermore, it includes an intrinsically safe room (below) with keyboard and field-bus-connectors.

The MINING MASTER comprises an open-system which is able to receive, visualise and transfer information from the different operating resources (shearer, roof support control system etc.) via interfaces [3].

The power supply on the different voltage levels is ensured by compact-stations of the ENDIS (Energy Distribution) product line-up, produced by SAIT Mining S.A.S.

6. Planned IT-infrastructure (wire-bound)

The backbone of the mine infrastructure constitutes a fibre optic cable-network which is connected via two 144-fibre shaft-cables with the central mine control station. The availability of 144 fibres accounts for the demand for fibre optic-channels in the latest extension phase of the mine.

With two individual cables and a subsurface ring-structure, the required redundancy for safe operating of the network is ensured. In the main and subsidiary drifts, the underground fibre optic-cables are with 24 fibres designated. This provides the necessary transmitting capacity for three physically separated networks (Fig. 7).

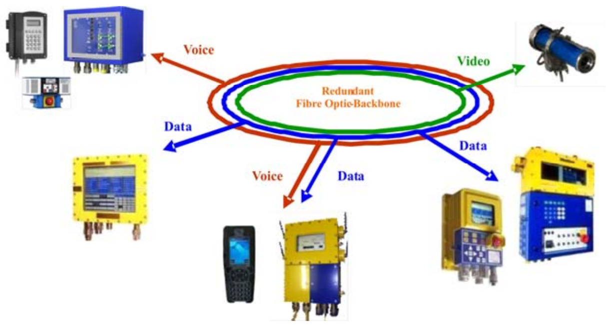

Fig. 7. Fibre Optic Cable-Network in ring topology with computer, access points and periphery units

- Inner net: multimedia network (low priority and reliability demands, availability at presence of mine gas not necessary (ib), high data volume)
- Intermediate net: automation network (high priority and demands for reliability, availability when mine gas is present is not necessary (ib), intermediate data volume)
- Outer net: voice and ventilation network (highest priority and reliability demands, availability when mine gas is present is required (ia), low to intermediate data volume)

The application of the concept of separated fibre optic cable-networks in the Banji mine on the underground mining operations, conveyor belt systems, further equipment and their interrelationship with the control room are shown in Fig. 8.

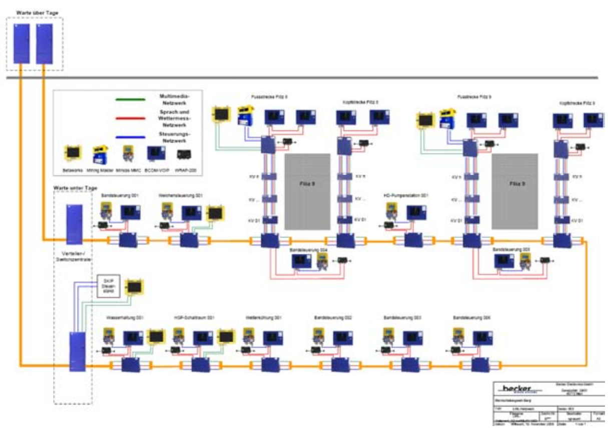

Fig. 8. Fibre Optic Cable-Networks in the Banji mine

7. Planned infrastructure (wireless)

The planned WLAN-technology is based on 2.4 GHz frequency band with bandwidth of 484 MHz (German Standard), a maximum transfer rate of 54 Mbit/s and a maximum transmission power of 100 MW within intrinsically safe area.

Explosion-proof access points (Fig. 9) distributed in the mine layout constitute the interface for the wireless data transfer to PDA's and the voice communication via WLAN-mobile phones, this establishes a network-like structure of so called hotspots. Those locations define areas where the wireless communication and the availability of electronic documentation provide a great advantage. This can be the case when for example a repair of the conveyor belts drives has to be carried out and the field workers have to be supplied with the necessary repair instructions either in written form or by qualified personnel on the surface.

Fig. 9. Explosion proof access point for the connection of WLAN und Fibre Optic-Backbone

Using the connections provided by the access points of the fibre optic cable-net, and over the existing Ethernet network, digital voice transmission using WLAN mobile phones can be realised via internet protocols (Voice over IP, VoIP). Existing telephones and intercoms in the mine will also be included into the ring network of the mine over the intrinsically safe BCOM VoIP.

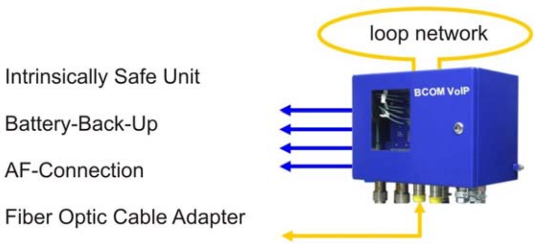

Fig. 10. Communication module BCOM-VoIP

Figure 11 is an illustration of the Ethernet based, wire-bound and wireless communication network of the mine in the latest extension phase.

The tagging and tracking system represents a possible upgrading of the communication network. It contains a remote warning system in case of danger and offers the possibility to determine the whereabouts of people. The system is based on active RFID-Technology.

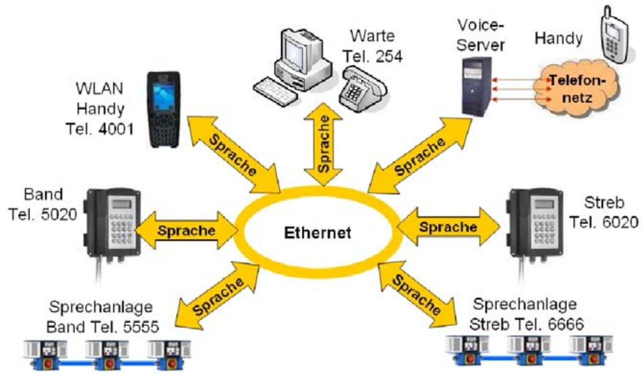

Fig. 11. Communication network of the mine

Furthermore, the placement of leaky feeders in subareas and their coupling with the VoIP-network over the already mentioned communication converters, offers the possibility to enhance the coverage of the mine using radiowaves [4].

References

[1] D. Buttgereit and R. Hünefeld, MineView – Webbasiertes 3D-Infrastruktur- und Informationsmanagement für den Bergbau; Vortrag anlässlich des fünften internationalen Kolloquiums High Performance Mining, 2009.

[2] T. Küpper and M. Hünefeld, Software nach Maß für die Rohstoffindustrie; Glückauf. 144 (2008) 285-289.

[3] F. Becker, Leistungsfähige Systembausteine zur Erfüllung der Kommunikationsanforderungen des Bergbaus; Glückauf. 142 (2006) 494-498.

[4] F. Becker and W. Jakoby, The Significance of Communications Technology for efficient, networked Mining Operations; Vorträge anlässlich des vierten internationalen Kolloqiums High-Performance Mine Production, 2007.