bulk solids handling Volume 2, Number 1, March 1982

New Developments in Continuous Mining and Materials Handling

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Summary

Bulk mining and handling technologies have been affected in two ways by the soaring cost of oil and oil products in recent years.

Firstly, the substitution of oil by coal, oil sands and oil shale demands the development of high-capacity mining and handling equipment, and secondly, the rising fuel costs favour a trend away from cost-intensive heavy truck transport.

To cope with the growing volumes of material in mining and handling, larger equipment units have to be designed. This tendency becomes apparent from the examples of the Hambach open pit mine in Germany.

A combination of the flexibility of heavy truck transport and the cost advantages of belt conveyors is achieved by the system of semi-mobile crushing installations described in this paper.

1. Causes of New Development Trends in Mining and Handling Technology

Bulk mining and handling technologies have been affected in two ways by the growing scarcity of low-cost energy resources in recent years.

In the first instance, the increasing cost of oil and natural gas led to intensive efforts throughout the world to develop fossil fuel resources for energy generation.

To open up new coal, oil shale and oil sand deposits, adequate equipment has to be created for mining and handling such materials.

Since especially the more accessible coal and lignite deposits are exhausted, it is necessary to turn to deposits with less favourable overburden/coal ratio and less easy stripping conditions: higher overburden/coal ratios in turn mean handling of greater overburden volumes for production of a given quantity of coal.

The increasing share of coal in world energy supply thus leads to an over-proportional increase in mining and handling volumes which can only be attained by mining and handling equipment designed for higher capacity. This development is illustrated below by some examples.

A second aspect influencing the present development in mining and handling technology is the enormous rise in cost of gasoline and diesel fuel, causing a change from expensive heavy truck transport in the pits to cheaper continuous flow of materials by means of belt conveyors.

While the continuous-flow system of bucket wheel excavators, shiftable conveyors, and boom stackers for spoil disposal, has already been firmly established in open pits with non-compact overburden, it is only lately that a system has been developed for hard rock open pits by means of heavy truck transport in the pit, a semi-mobile crusher, and subsequent conveyor haulage; this combines the flexibility of truck transport for the mining advance with the cost advantages of conveyor transport. The concept, too, is described by an example as follows.

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2. Open Pit System with a Daily Output of 240,000 bank m³

2.1 Reasons for Development of the System

The lignite district of the Rhineland extends over an area of about 2,500 km² west of the Rhine, between the cities of Cologne, Bonn, Aachen and Mönchengladbach. With a total lignite reserve of 55,000 million tons, of which 35,000 million tons are profitably mineable by today's standards of technology, this is the largest developed lignite deposit in Europe [1, 2]. About one quarter of the West German electricity supply is based on lignite from this district in the Rhineland.

Industrial utilization of these lignite deposits began around the turn of the last century, mostly in the southern part of the district where seams of up to 100 m thick were found under a shallow overburden cover. Since 1955, these extremely favourable reserves have been exhausted. In order to meet the growing power demand nevertheless by sufficient coal production, it was necessary to open up deep-going lignite pits, with higher overburden/coal ratios.

The latest example of this new development is the Hambach mine. Rheinische Braunkohlewerke AG, which also owns and runs the opencast mine in Hambach, is the sole mining company operating in the Rhenish lignite field. Initially, operations will begin in the Hambach I coalfield where reserves amount to 2,400 million tons.

In its final stage around the middle of the 1990s the Hambach I open pit is scheduled for a coal plus overburden volume of $350 \cdot 10^6 m^3$ per year. If this output rate had to be achieved with equipment of the maximum dimensions existing until now, then so many equipment groups, each comprising a bucket wheel excavator, conveyor system and spoil stacker, would be required that difficulties in operation management would have arisen. Therefore a new equipment generation was developed for Hambach with an output capacity of 240,000 m³ per day.

2.2 Description of the 240,000 m³/day Equipment

2.2.1 Bucket wheel excavators

Bucket wheel excavators with a daily capacity of 240,000 bank m³ are the largest earthmoving units existing in the world today (Fig. 1).

Their design is characterized by the tripartite arrangement of the overall plant, — the actual excavator, a connecting conveyor bridge, and separate mobile loading unit — which has been introduced for all high-capacity bucket wheel excavators. The connecting bridge is a telescopic structure, its ends resting on the excavator and loading unit. The arrangement represents a considerably improved serviceability of the excavator plant; for instance, the face conveyor and loading unit may be placed 14 m higher or 16 m lower than the excavator part; set-up movements of the excavator in partial block digging may proceed without having to move the loading unit. From one bench level, in high and deep cut and intermediate high and deep steps the bucket wheel can then dig a total face height of 98 m.

Among the technical data of the bucket wheel excavator plant, particularly impressive figures are the total length of about 200 m, a height of 87 m, bucket wheel diameter of 21.6 m, and bucket wheel drive rating of 3360 kW, as well as the total weight of the plant in operating order which is 13,400 tons [3].

2.2.2 Conveyors

All belt conveyors in the open pits are shiftable, so that they can follow the advance of mining without major loss of time.

At the Hambach mine, the belt width in the shiftable conveyors is 2.8 m and the belt speed is 7.5 m/sec. A conveyor may be equipped with up to six 2000 kW drives at the head and tail terminal, and its handling rate may be up to 37,500 t/h. [4].

Drive terminals weigh approximately 700 tons; return terminals weigh from 80 tons up to 220 tons depending on the installed equipment (Fig. 2).

Fig. 1: Bucket-wheel excavator with a capacity of 240,000 bank m³/day

Head and tail terminals, as well as the transition trusses of the drive terminals, can be shifted or transported over longer distances by transport crawler units.

The transport crawler system was originally developed by Krupp Industrie- und Stahlbau for conveyor systems of 3 m belt width, but is meanwhile being used also for smaller conveyors and semi-mobile crushers.

2.2.3 Boom stacker

The stacker of the 240,000 m³/day equipment generation is a three-conveyor design. It has a feeding conveyor whose one end rests on a crawler-mounted supporting carriage while the other end is mounted in the slew center of the stacker, followed by an acceleration belt and the actual discharge conveyor (Fig. 3). Overburden is transferred from the dump conveyor to the stacker feeding conveyor by a crawler-mounted tripper car with integrated slewing belt.

Among the technical data of the boom stacker, the most noteworthy are a discharge boom length of 100 m, feeding boom length of 80 m, and more than 60 m total height of the machine. Belts of the feeding and accelerating conveyor are 3.2 m wide and run at a speed of 5.2 m/sec, while the discharge belt is 3 m wide and has a speed of 7.8 m/sec. The working weight of the stacker is about 5,700 tons [3].

3. Semi-Mobile Crushing Plant

3.1 Development of the Semi-Mobile Crusher System

In today's open pit hard rock workings, overburden and pay minerals are blasted from the mining face and loaded onto dump trucks by power shovels or wheel loaders. The trucks take the overburden to the dump and deliver the mineral to the processing plant.

Truck haulage in open pits provides great flexibility for the mining operations. Trucks can collect different grades of mineral from various points of the mine and deliver them to the processing plant in such a way that the mixture is uniform at all times.

On the other hand, truck transport is much more costly than conveyor transport, and the comparison between the two systems has recently shifted even more in favour of conveyors due to the soaring fuel costs. Operating costs of a truck fleet tend to increase especially if steep gradients have to be negotiated on the exit route from the pit.

One possibility of combining the flexibility advantage of dump truck transport with the low cost of conveyor systems is the use of semi-mobile crushers followed by conveyors for onward haulage [5, 6].

In this system, too, overburden and pay mineral are blasted from the face. The material is then loaded onto trucks by

Fig. 2: A 4 x 2,000 kW conveyor drive unit being moved by a crawler-mounte

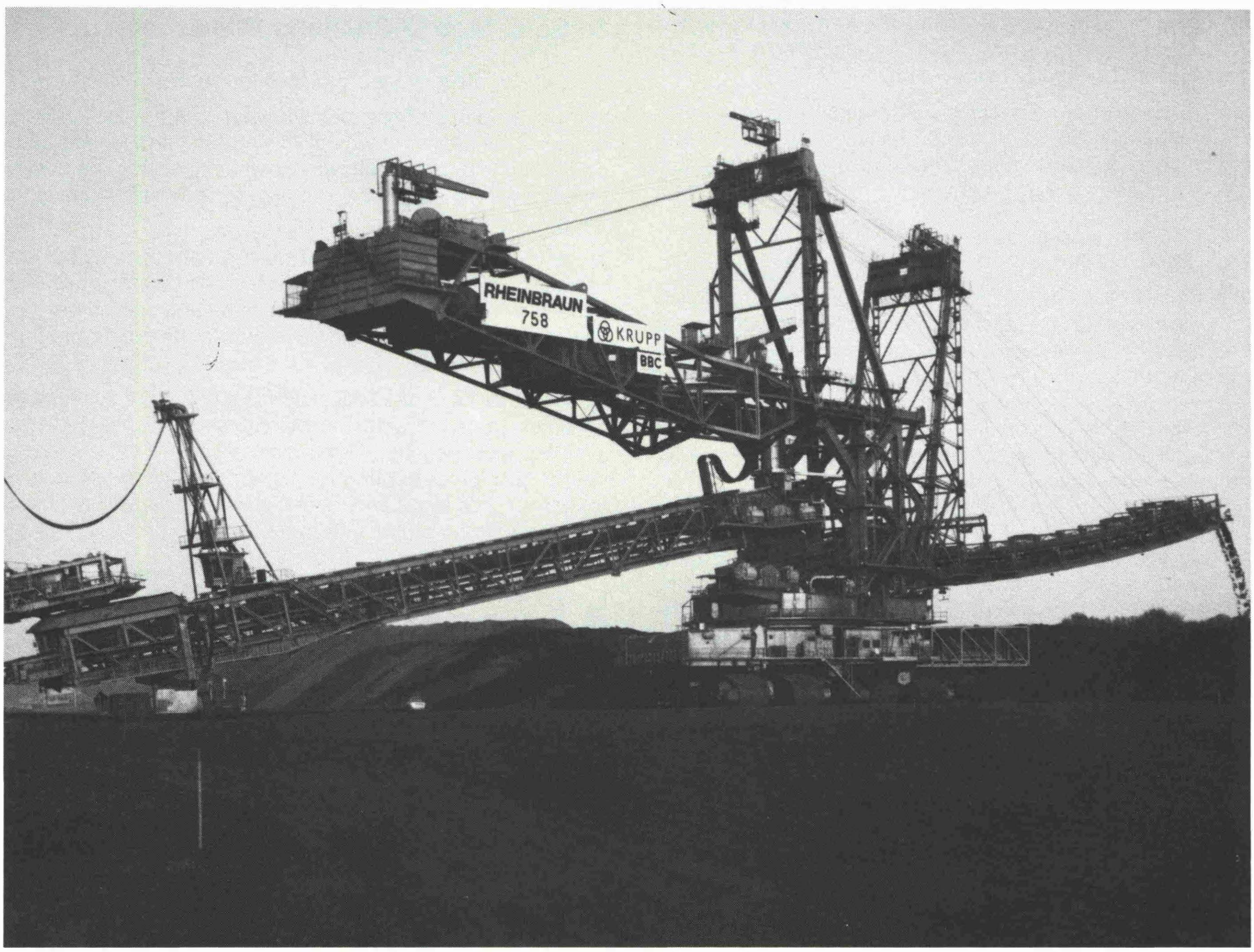

Fig. 3: Boom stacker with a capacity of 240,000 bank m³/day

shovels or wheel loader. The trucks take the material to the semi-mobile crusher set up in a central location within the pit, so that no great gradients occur on the truck route.

In the crusher, the material is sized down sufficiently for conveyor transport, and delivery to the conveyor system for onward haulage to the dump sites outside the pit, or to the processing facilities.

The semi-mobile crushers are relocated from time to time to follow the advance of mining; the new site is chosen so as to provide optimum truck access.

This concept maintains the flexibility of truck transport; pay minerals can be collected from the different mining points and taken to the processing plant in the grades momentarily required for the beneficiation process. It also makes use of the cost advantages of conveyor transport, especially where major differences in level have to be overcome to take the material out of the pit to surface.

Depending on the pit layout and mining advance, the crusher has to be relocated only every six months to two years. These time intervals make it expedient to use a semi-mobile crushing plant which is relocated by a transport crawler.

While in operation, this crushing plant is set on two or three pontoon bases spaced with sufficient clearance between them for entry of the transport crawler. For relocation of the crusher, the transport crawler lifts the crushing plant by means of its built-in jacking system, and carries it to the new site.

3.2 Application Example: An Open Pit Lignite Mine in Spain

The Meirama lignite deposit is located in a narrow valley near La Coruna in north-western Spain. Its overburden is partly interspersed with granite boulders and shale horizons; in addition, solid granite strata occur at the edges of the deposit, some of which has to be removed along with the mining operation.

The ordinary overburden is stripped by bucket wheel excavators, and taken to the dump site by conveyors. The granite and shale are broken up by blasting, the lumps are loaded onto trucks by power shovels, and delivered to the semi-mobile crushing plant. The sized-down overburden is discharged from the crusher onto the overburden conveyor system and taken to the dump site together with the ordinary overburden.

The core of the crushing plant is a Krupp jaw-type gyratory crusher No. 135—190, Type Esch, with lateral enlarged feed opening for a throughput rate of 600 t/h; maximum feed size is 1,800 mm x 1,250 mm x 1,000 mm, product size is 0 to

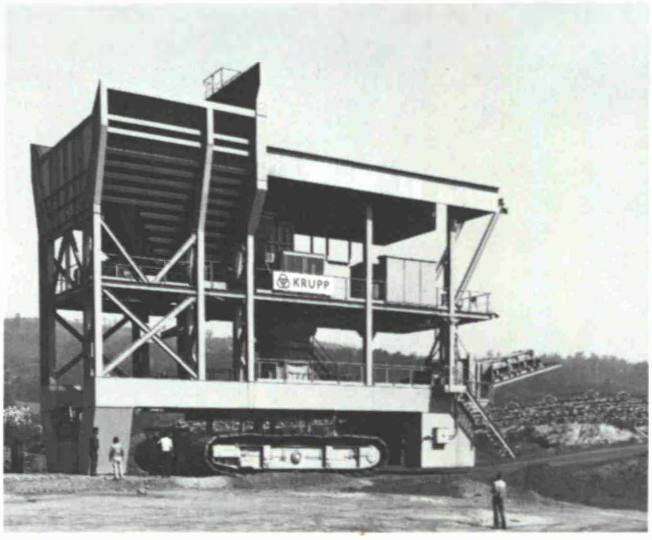

Fig. 4: Transfer of a semi-mobile crushing plant by a crawler-mounted transporter

250 mm. Material is fed to the crusher by a reciprocating plate feeder from a bin into which the heavy trucks dump the material.

The weight of the crushing plant in ready operating order is 500 t. it is 17.6 m high, 8 m wide and 36.9 m long. The crushing plant and the ramp structure for heavy truck access to the bin are moved by a transport crawler, Type R 500.

Fig. 4 shows the crushing plant being moved by the transport crawler to its new destination. According to present plans the crushing plant is scheduled to be moved every one to three years.

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