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In-Pit Crushing and Conveying

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Summary

The author reviews the factors leading up to the selection of In-Pit Crushing and Conveying technology and discusses the currently available options in equipment selection.

1. Introduction

The enormous rise in oil prices in recent years has led to increasing interest in a technology that has been available for nearly twenty years but which has only slowly been taken up by the mining industry with its rather conservative outlook.

The technology referred to is that of the increased use of rubber belt conveyors to replace heavy trucks for the transport of mined material from hard-rock and mineral open pit mines (see Fig. 1).

Fig. 1: In-pit crushing and conveying system

In this case it is particularly the, often considerable, height difference between the working face and the treatment plant which causes the high transport costs.

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At the beginning of the 1960s the accent was clearly most heavily on the reduction in operating costs by a reduction in the number of operating personnel. Today the increased oil prices have driven companies to investigate other possibilities of reducing costs, in particular those concerned with fuel (Fig. 2).

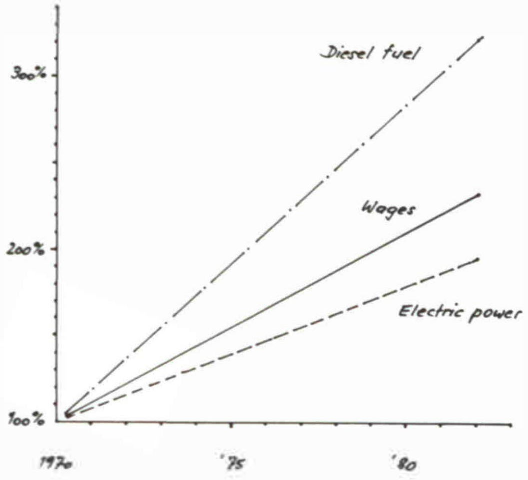

Fig. 2: Comparison of diesel fuel, electric power and wage increases since 1970

One of the major plus points of heavy truck (HT) operation which is constantly emphasised is the increased flexibility of operation and their ability to operate at reduced output (even if half the trucks are out of service the other half are still running). Data from actual operating practice with belt conveyors show an availability factor of 90%; when coupled with a mobile crusher 85%; so that these arguments can be seen to be of limited validity.

The cement industry has realised applications for conveyor belt technology in the development of marl and chalk quarries where the ground has shown such a low bearing capacity that the operation with heavy trucks was impossible because of the prohibitive costs involved in laying roads (Fig. 3).

Fig. 3: Mobile crushing unit operating on difficult ground

On the other hand in most cases a large boulder size in the excavated material is a distinct disadvantage for conveyor transport. The material must therefore be crushed to a "belt-ready" size before transport. This crushing should be carried out as near to the work face as possible so as to achieve with the crushing an early blending effect and to regulate the material flow rate.

The smaller the output variations can be held, the better (and hence more economically) the subsequent treatment plants can achieve the required throughput.

For the crushing of such material there are three basic types of crusher available: stationary, semi-mobile and mobile.

2. Stationary Crushers

A first step in introducing conveyor belt technology is often the placing of a fixed crushing plant in the mine. This is usually positioned so as not to inconvenience the extension of the mining operations, i.e., on the edge of the deposit. This often means, however, that in the course of operations the haulage distances become longer and when mining deep-seated deposits steep gradients will have to be negotiated.

The face output and the seam dimensions are the important factors in siting a crushing facility in open pit mines. It is important that, as far as possible, steep trails are avoided, and when unavoidable that they be negotiated with empty trucks.

3. Semi-Mobile Crushers

When operating a number of mining faces concurrently or alternately, a stationary crusher is not to be recommended. In this case a semi-mobile crusher is the better solution. This can be built as a complete unit or in several sub-units and is placed in the main working area. The haulage distances are kept short and the unit can be moved, following the work face, once the haulage distances have become too long. A further advantage of the semi-mobile equipment over fixed equipment is that usually only minimal foundations are required, or even none at all. Thus when the equipment is moved no costs involved in foundation work are lost. Units which are dependent on each other, e.g., feed hopper with feed apron-conveyor or crusher with power unit, can be transported as a single unit thus not requiring extensive set-up and testing procedures (Fig. 4).

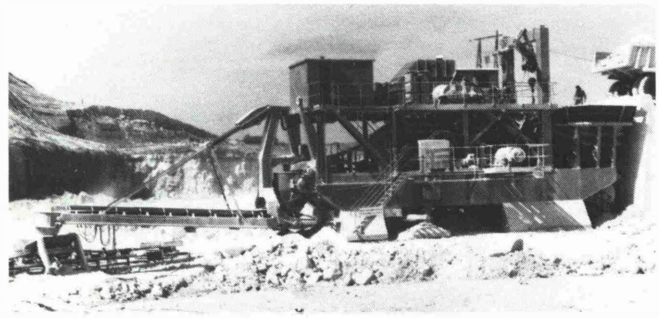

Fig. 4: Semi-mobile crushing unit

Once the new site is prepared the move of the semi-mobile plant can be carried out in only a few hours with comparatively minor effort.

For the transport between sites one can use various techniques depending on the plant-layout, the ground conditions and not least the distance involved. The following vehicle types are used:

— Connectable wheeled (tires) vehicle
— Connectable rail vehicle
— Fork-lift car or Piggyback transporter (Fig. 5)
— Crawler-mounted transporter (Fig. 6)

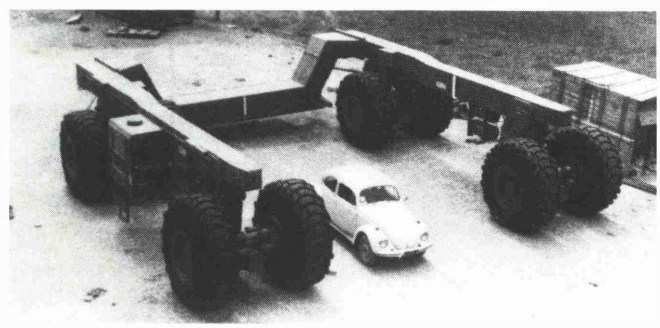

Fig. 5: Connectable wheeled (tires) transport vehicle

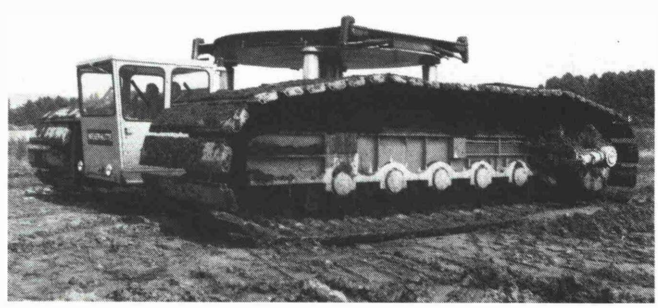

Fig. 6: Transport crawler

4. Mobile Crushers

The use of a mobile crusher is indicated where a wandering seam is mined and the loading machinery loads the mined material directly into the crusher, without any intermediate transport. Mobile crusher and loader work as a unit (Fig. 7). Variations in grade which can be controlled by selective mining in the methods above cannot be dealt with here and where necessary a blending pile must be used between workface and processing plant.

Fig. 7: Mobile crusher and shovel working as a unit (see Fig. 1)

This is particularly true when using a dipper shovel for loading operations. The shovel must load that material which is within reach of its shovel. However, due to the permanent availability of the loading point (feed hopper of the mobile crusher) its loading capacity can increase by up to 40 % as compared with heavy truck loading.

A blending effect can be achieved, albeit a comparatively minor one, when the mobile crusher is fed by a wheel loader. This can bridge distances of up to 70 m between feed point and the mobile crusher without any significant loss in throughput. Even with an action radius of 120 m, 60 % of the maximum feed rate is possible (Fig. 8).

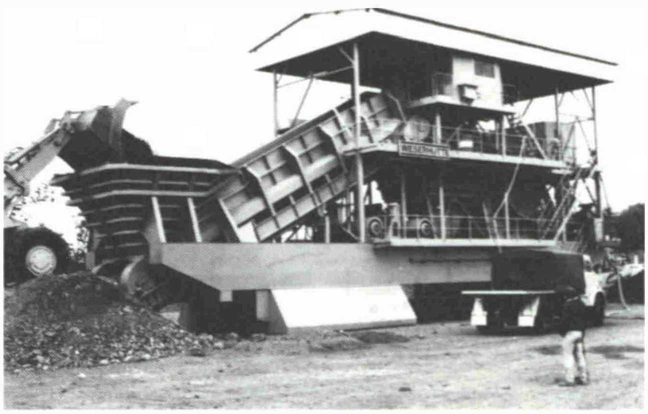

Fig. 8: Wheel loader feeding mobile crushing unit

While the type of machinery used (dipper shovel, wheel loader or trucks) decides the layout of the feed assembly, the choice of crusher is governed by the feed boulder size, feed characteristics, required throughput and ground pressures. Mobile crushers are in action with a throughput of up to 3,000 t/h and a service weight of 1,000 t. Projects for throughputs of 6,000 t/h are in progress (Figs. 9, 10).

The soil characteristics and the proposed mining system determine the choice of transporting mechanism. The most useful are:

— Hydraulic walking mechanisms (pads) (Fig. 11)
— Crawler tracked chassis
— Wheeled (rubber tires) chassis (Fig. 12)
— Rail mounted chassis.

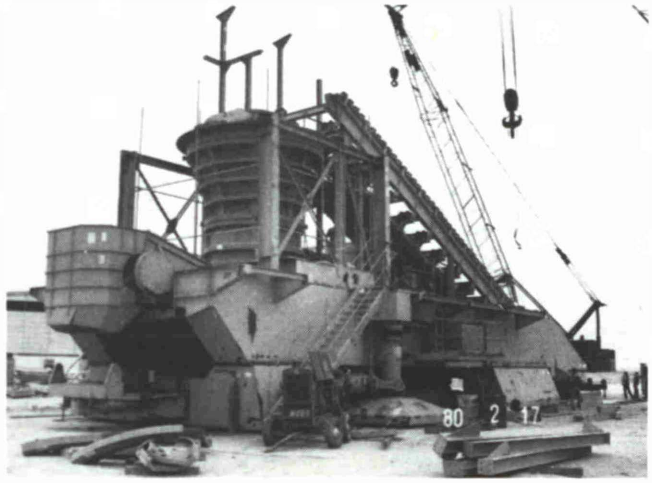

Fig. 9: Large mobile crushing unit during erection on site

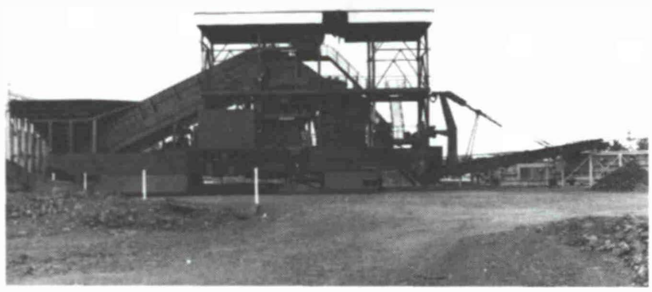

Fig. 10: Mobile crusher after erection

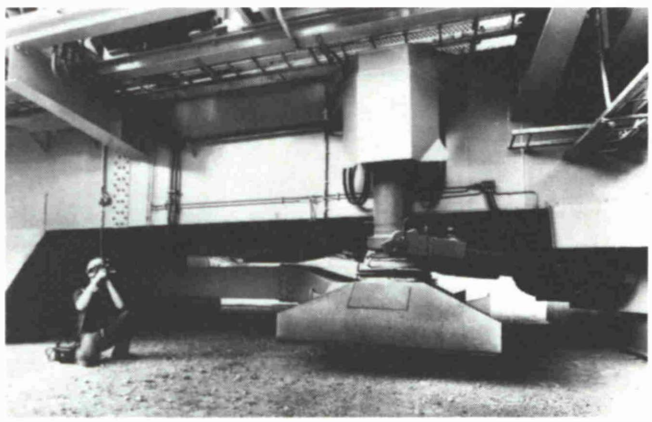

Fig. 11: Hydraulic walking mechanism

Fig. 12: Wheel mounted mobile crusher

The speeds of travel vary between 2.0 m/min and 30 m/min. Ground pressures of between 60 kPa and 500 kPa are possible.

5. Conclusion

Up to now approximately 80 mobile or semi-mobile crushing units are in operation worldwide. Cost analyses have clearly demonstrated that savings in operating costs of up to 40 % compared to conventional heavy truck operation are possible.

A typical installation of such machinery manufactured by PHB Weserhütte is shown in Figs. 13 and 14. The Phosphate Development Corporation (Foskor) Phalaborwa deposit in the Northeast Transvaal, South Africa, represents one of the most up to date applications of in-pit crushing and conveying technology available.

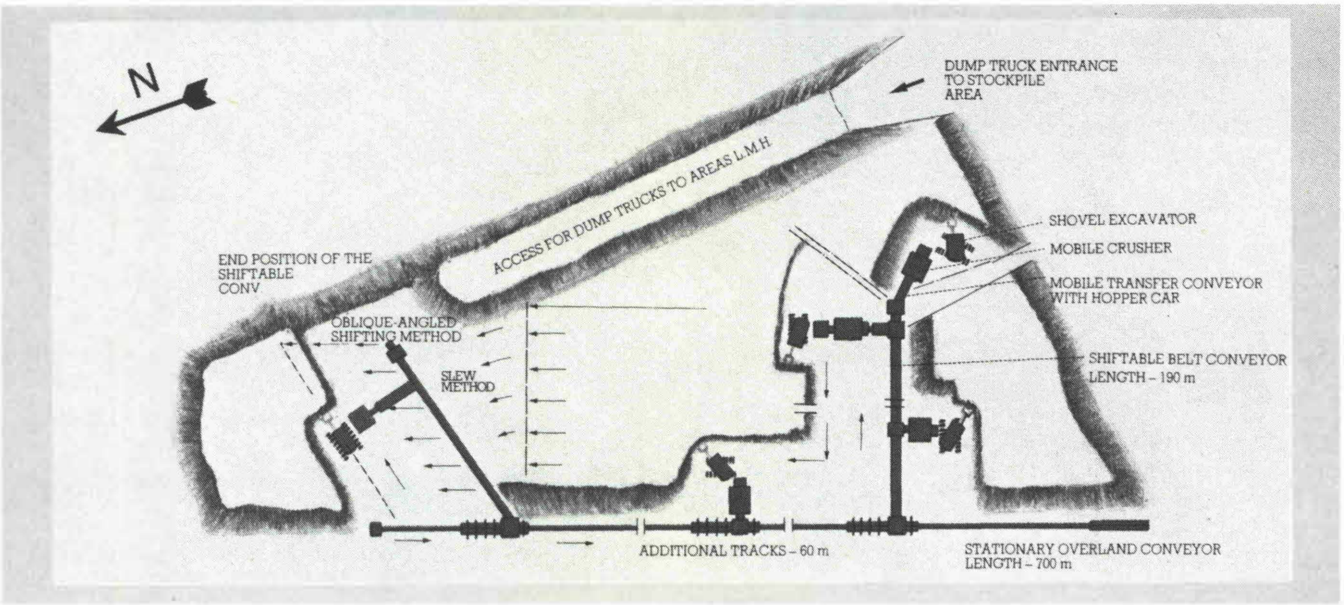

Fig. 13: Foskor Phalaborwa complex, South Africa

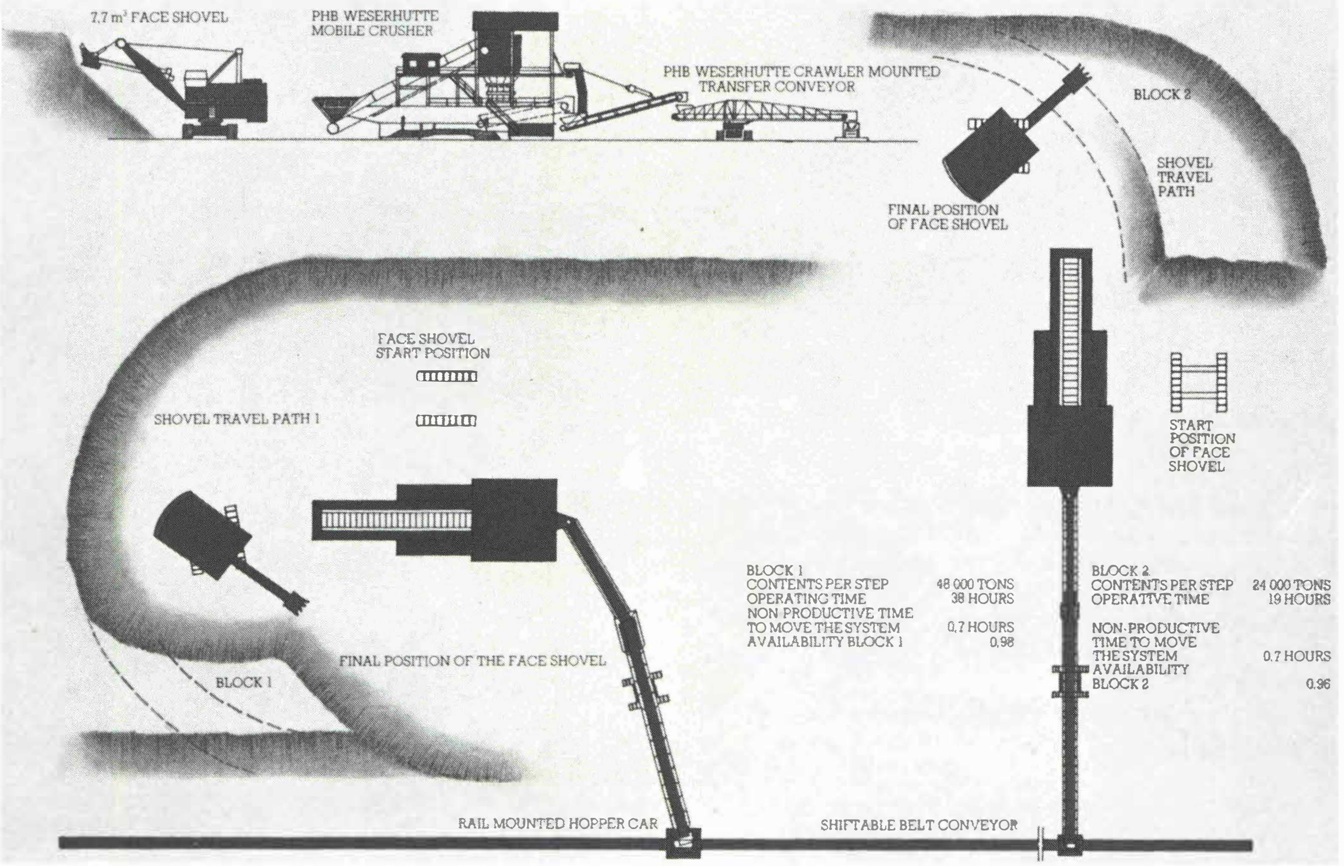

Fig. 14: Foskor Phalaborwa material handling plan