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Homogenizing/Blending Plant Applications in South Africa with Special Reference to Gencor's Hlobane and Optimum Plants

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Summary

This paper describes how an analysis of the functions, objectives and decision criteria of homogenizing/blending plants by South African metallurgists and engineers have led to a wide range of applications of this technology in South Africa over a relatively short timespan of 15 years with some interesting innovations practised at GENCOR's Hlobane and Optimum coal mines.

1. Introduction

1.1 Definitions/Functions

In a *stockpile* bulk solids are stacked to and subsequently reclaimed from a storage facility. Stockpiles link the various stages of bulk solids transportation systems to:

- bridge interruptions in sections of the system without stopping the whole system,
- act as a buffer between continuous and discontinuous sections of the system,
- collect, store and distribute bulk solids coming from or going into different flow lines, such as in the stockyard of a terminal, and
- homogenize, blend or proportion bulk raw materials for a metallurgical or chemical process.

In a *homogenizing plant* raw material such as crushed run-of-mine coal is stacked onto a bed (stockpile) and subsequently reclaimed in such a way that the inherent fluctuations in respect of quality and/or size distribution are evened out. The homogenizing effect is expressed as the ratio of the standard deviation of a given quality parameter before and after the homogenizing plant.

In a *homogenizing/blending plant* two or more grades of material are stacked onto the same bed (stockpile) to achieve a homogenized blend. The instantaneous analysis of the raw material reclaimed from such a bed will closely resemble the average value over the whole bed. Whether the average value of a fully stacked bed is sufficiently close to the desired value, depends upon:

- the storage capacity of the bed,
- the nature of the fluctuations of the incoming material, and upon
- the degree of quality control, if any, exercised over the incoming material.

If the expected quality variation from one bed to the next is too high to be compensated for by adjustment to the process, then two sets of homogenizing/blending plants are built, e.g. one for relatively high grade and one for relatively low grade material. The two homogenized/blended material grades are *proportioned*, accurately to a required composition by instantaneous adjustment of the relative reclaiming rate of the two reclaimers, the ratio being based on a reliable analysis of two homogenized grades.

The functions of bridging, buffering, storing, homogenizing, blending and proportioning may occur singly or in combination in any stockpiling facility.

1.2 Objectives of Homogenizing/Blending Plants

Homogenizing/blending plants serve to:

1.2.1 Provide an even feedstock of the required quality. From process to process, the benefits are:

- more even process operation with lower operating costs and higher product quality
- process plant is optimally sized and utilized for a given throughput rate
- product yield per unit of feedstock input is higher, therefore raw material consumption and costs are lower
- product quality remains within closer tolerances, no rejects. A more even product from one process has a cumulative benefit as an input to subsequent processes.

1.2.2 Rationalise and optimise mining, for example:

- a lower average grade of ore can be mined for a given final product quality, without risk of product rejection. This means less raw material goes to waste and unit mining costs are lower. In this way the life of the deposit is extended by better utilization of the limited raw material resources.
- there is less need for selective mining. Mining methods are simpler and mining costs are lower.

2. Selection of Machines and System Arrangements for Homogenizing/Blending Plants

The metallurgist or process engineer today has a large variety of proven stackers, reclaimers and homogenizing systems at his disposal. He can select a stacker for chevron, windrow, coneshell, stratified layer or PEHA-chevcon® stacking (Fig. 1). The stacking mode is decided in conjunction with the duty and the type of reclaimer to be used.

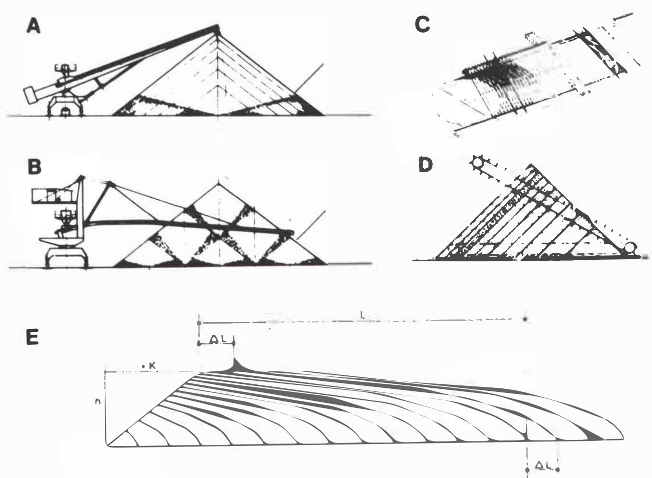


Fig. 1: Schematic view of the various stacking modes

The following reclaimer types, when used in conjunction with the appropriate stacking mode, will homogenize/blend the raw material with various degrees of success (Fig. 2):

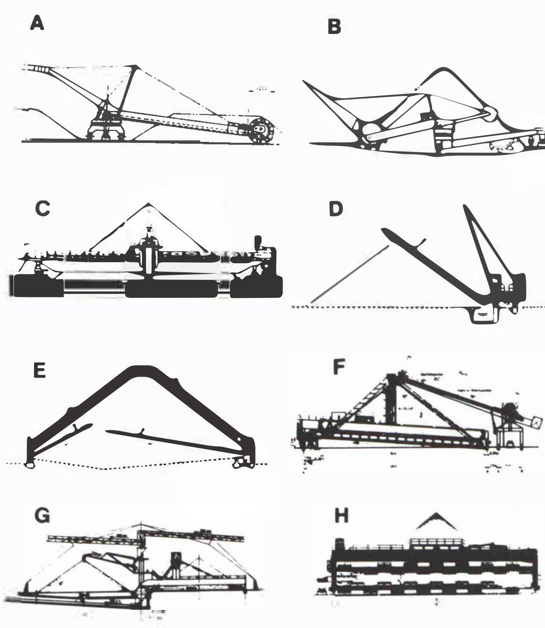


Fig. 2: Schematic view of the various reclaimer types

- Boom-type bucketwheel reclaimer working in a sickle-cut fashion off a track alongside the bed (A)
- Combined stacker/bucketwheel reclaimer working in a sickle-cut fashion off a track alongside the bed (A)
- Bridge-type bucketwheel reclaimer with:
  - Half bridge with single wheel on boom (B)
  - Full bridge with one, two or more wheels (C)

  with reclaiming from the front of the bed in a slewing or reciprocating fashion. The track partly or fully straddles the bed.
- Side-arm scraper reclaimer working off the side of the bed on a track alongside the bed (D)
- Portal scraper reclaimer working off the side of the bed on a track straddling the bed (E)
- Bridge-type scraper reclaimer
  - on a longitudinal bed with reclaiming of the entire front of the bed off a track straddling the bed (F)
  - on a circular endless bed with reclaiming of the entire front of the bed off a circular track along the outer periphery of the bed (G)
- Drum reclaimer reclaiming the entire front of the bed off a track straddling the bed (H).

The correct combination of stacker and reclaimer provides a proper homogenizing/blending system. To select the most appropriate system for a specific application a detailed analysis of the following decision criteria is essential:

2.1 The bulk raw materials to be handled:

- The number of different material types
- How the material occurs in the deposit
- By what method(s) the material is to be mined
- The physical characteristics of the material, such as bulk density, angle of repose, moisture content, size distribution, flow characteristics, abrasiveness, tendency to stick, dusting, etc.
- The variability (frequency distribution) of the main quality control parameters of the material
- The variability (frequency distribution) of the particle size distribution of the material

2.2 The need to homogenize/blend:

- The homogenizing/blending effect required in terms of quality and size distribution
- The need for separate treatment of material types

2.3 Other metallurgical and/or process requirements:

- Stacking and reclaiming flow rate ranges
- Need for constant, accurately controlled and/or variable reclaim rate
- Storage capacity required from "bridging", "buffering" and "homogenizing/blending" viewpoints
- Need to turn around the material in a given time period (ageing, combustion, drying)
- Need to avoid particle size degradation
- Need to store material under roof
- Need to stack and reclaim simultaneously
- Need to stack and/or reclaim continuously without interruption
- Need for the facility to be normally in the flow line or normally by-passed. If in line (normal with homogenizing plants), should a by-pass be provided
- Need to have access to and from an adjacent strategic reserve stockpile area

2.4 Environmental constraints:

- Prevailing wind direction
- Stormwater drainage
- Need to eliminate dust and/or noise
- Relation to other facilities such as housing, sophisticated plant, etc.

2.5 Physical contraints of the area available:

- The space available
- The shape of the area
- The topography of the area
- The soil conditions
- Situation of the area available in relation to direction of flow in and out of the facility
- The need for future expansion

2.6 Overview considerations:

- Ease of operation, degree of operating skills required
- The mechanical complexity, degree of robustness, mechanical reliability, availability, maintenance required
- The philosophy regarding standby equipment with due regard to the expected availability
- The degree of automation required and/or possible
- The capital cost, both absolute, as well as in relation to the overall project
- The operating costs in respect of operating labour, maintenance and power consumption
- Technological risk factor, proven machine design and capacity
- Time required to construct the facility.

The above decision criteria are interrelated and only by iteration a shortlist of possible machines and system arrangements can be made from all available alternatives. The final selection from the shortlist is best made by means of a Value Analysis on a points scale system as developed by Zangemeister.

3. Typical Homogenizing/Blending Plant Arrangements

Homogenizing/blending plant layouts can be basically classified as follows:

3.1 Longitudinal beds

The plant consists of at least two beds, one being stacked to and one being reclaimed from. Because, on average, one bed is half-full and the other bed half-empty the net effective storage capacity of a two-bed plant is 50% of gross storage capacity. This ratio can be improved in three and four-bed plants.

The ratio between bed width and bed length represents an interesting optimisation study. With increased bed width the capital cost of the stacker and reclaimer increases whereas the capital cost of yard conveyor belts, rail tracks, electrical reticulation and land decreases.

a) Parallel beds

The beds are located side-by-side with a slewing stacker along the middle to serve both beds. The reclaimer is transferred from one bed to another by transfer car (Fig. 3) or by means of swivel bogies and cross-rails (Fig. 4), which costs

Fig. 3: Iscor's homogenizing plant at Sishen North Plant for coarse ore (on the left) and fine ore (on the right) with the transfer car in the foreground

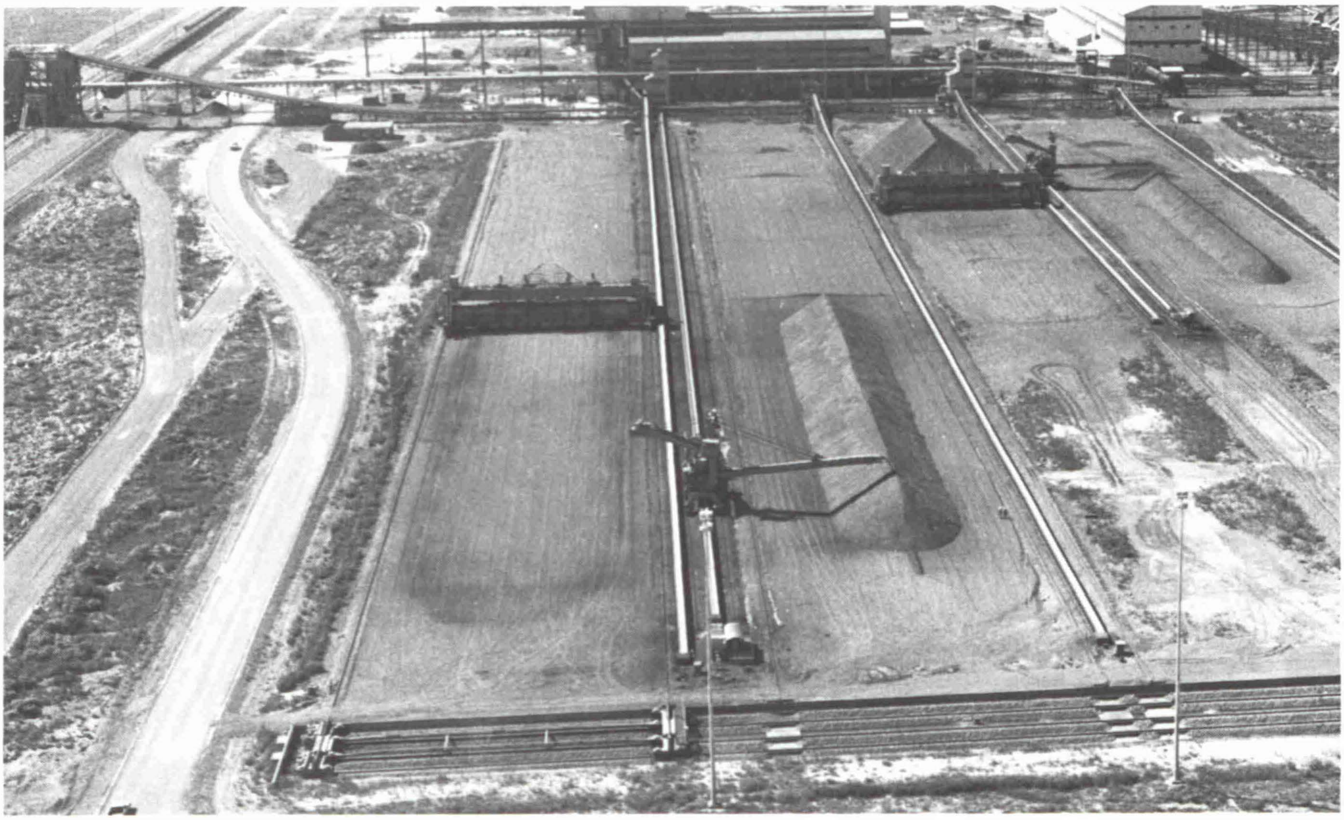


Fig. 4: Iscor's homogenizing plant at Glen Douglas for dolomite. The drum reclaimer is equipped with swivel bogies to transfer over the cross travel tracks in the foreground

less. In both cases it takes about 45 minutes to transfer the reclaimer from finishing off one bed to starting the next.

Advantages of the parallel bed configuration are:

- one reclaimer can serve more than one material type
- reclaimers can be exchanged
- higher storage capacity possible if the area length is limited
- reclaimer need only work in one direction
- the storage capacity can be increased by lengthening the stockpiles.

At the coking coal stockyard of ISCOR at Vanderbijlpark a degree of homogenizing of the various types of coking coal, stored in separate beds, is achieved, with the two combined stacker/bucket wheel reclaimers by careful stacking to the windrow mode and reclaiming across these layers in sickle-cut fashion (Figs. 5,6).

One reversible yard conveyor, passing over a counterflow tripper, is used as stockpile feed and stockpile reclaim conveyor.

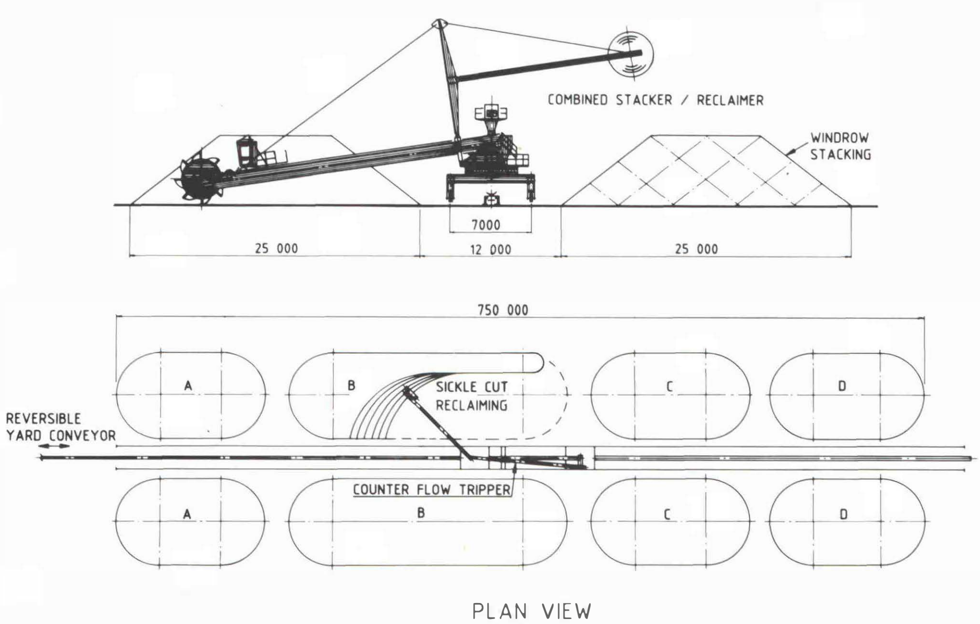


Fig. 5: Schematic view of the stockyard arrangement for coking coal at Iscor's Vanderbijlpark Works

Fig. 6: The combined stacker/bucketwheel reclaimer at Vanderbijlpark homogenizes partially by a combination of windrow stacking and sickle-cut reclaiming

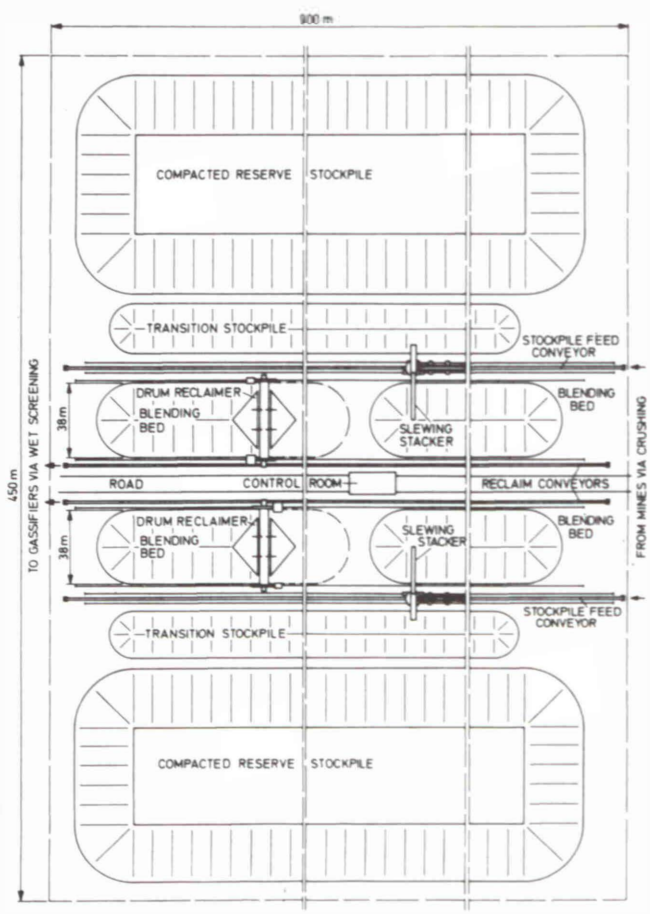


Fig. 7: Sasol 2 homogenizing plant configuration at Secunda

b) In-line beds

The beds are arranged end-on with non-slewing stacker along one side and a bi-directional reclaimer working from the mid-point, in the one or the other direction. This layout type has found wide acceptance in South Africa as:

- the bed length and storage capacity can later be increased at little marginal cost, where one end is left open
- only two belt conveyors are required and where the transport distance must be bridged in any case, the marginal cost of belt conveyors is low
- the non-slewing stacker costs less
- transfer of the reclaimer from one bed to the other takes less time
- no transfer tracks or transfer car is required, the civil work is very simple.

At SASOL 2 and SASOL 3 (Figs. 7, 8, 9) altogether 4 homogenizing plants for raw coal bridge the distance between the mines and the gasifiers. Slewing stackers were selected to transfer coal to the strategic reserve stockpiles alongside both sets of blending beds.

ANGLO ALPHA use bi-directional bridge-type scraper reclaimers for homogenizing the limestone at Dudfield (Fig. 10).

At the Kleinkopje multi-product opencast coal mine of ANGLO-AMERICAN the raw coal from nos. 2 and 4 seams is treated separately for optimal metallurgical yield in one of the world's most advanced coal washing plants. For this reason Kleinkopje installed two sets of homogenizing beds for raw coal (Figs. 11, 12). At that time, in view of the reclaim rate required, and the state of technology, the most economical solution was a half bridge boom type bucket wheel reclaimer (Fig. 13).

3.2 Circular homogenizing beds

A significant development in recent years has been the circular homogenizing plant with PEHA-chevcon® stacking to form an endless bed (Fig. 14). The slewing stacker mounted on a central column performs a continuous, combined slewing and luffing motion over a preset arc of the circle during stacking. The stacker's travel path is advanced by an adjustable increment after each slewing traverse, resulting in a constant forward development of the full stockpile cross-section. The bridge-type scraper reclaimer with triangular reciprocating rake is supported at the inner end on a slewing ring in the lower part of the same column, and at the outer end on rail mounted drive bogies. The reclaimer is therefore always confronted by a full cross-section consisting of numerous layers of material, placed over long arcs, resulting in a long-term homogenizing effect.

Since BLUE CIRCLE decided in 1981 to incorporate this concept in their current expansions at Lichtenburg (Fig. 15) further circular plants have been ordered by ANGLO ALPHA for the Simuma Cement Works and by RAND MINES for the Middelburg opencast coal mine.

Circular homogenizing beds offer the following advantages:

- The capital cost is lower than that of a comparable longitudinal bed, although the civil work costs relatively more
- The bed is endless so that the reclaimer is never repositioned and the "end-cone" effect is eliminated
- Reclaiming is always from a full cross-section with constant material stream
- The number of layers cut is higher for the same bed cross-section, stacker slewing speed, and stacking rate

Fig. 8: The first coal stacked onto the 900 m long homogenizing beds at Sasol 2

Fig. 9: The bi-directional drum reclaimers at Sasol 2 and Sasol 3 have two rakes and the buckets are designed to reclaim in either direction, without any adjustment

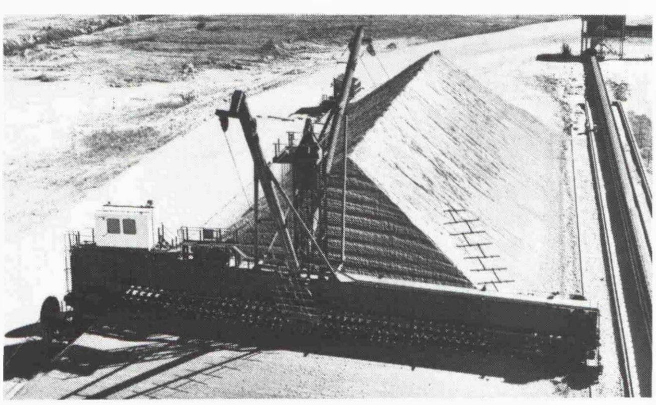
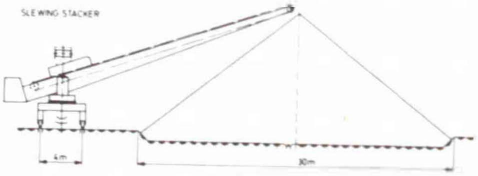
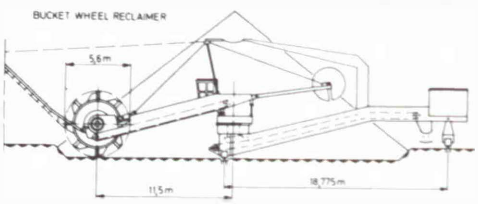


Fig. 10: The bridge-type scraper reclaimers at Anglo Alpha's Dudfield Works have dual rope-type pilesweepers for bi-directional reclaiming





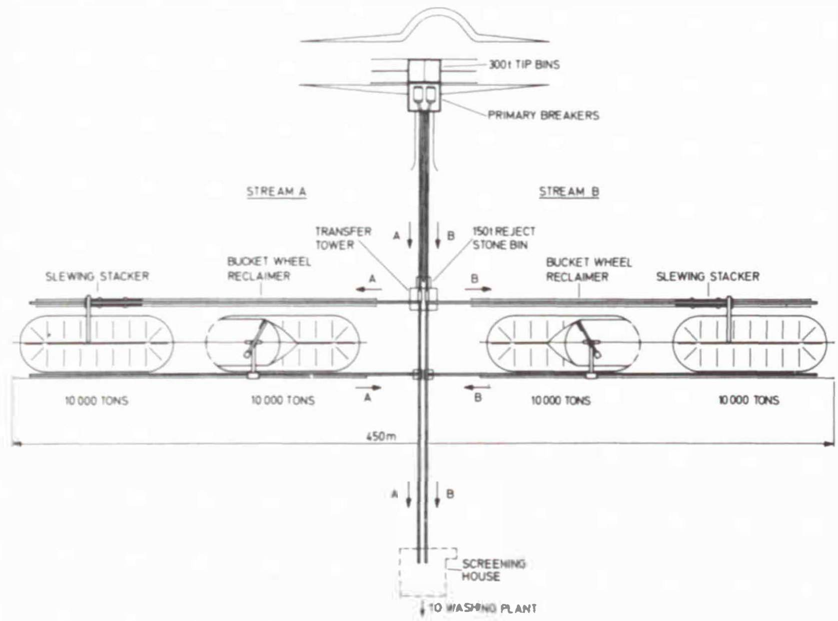
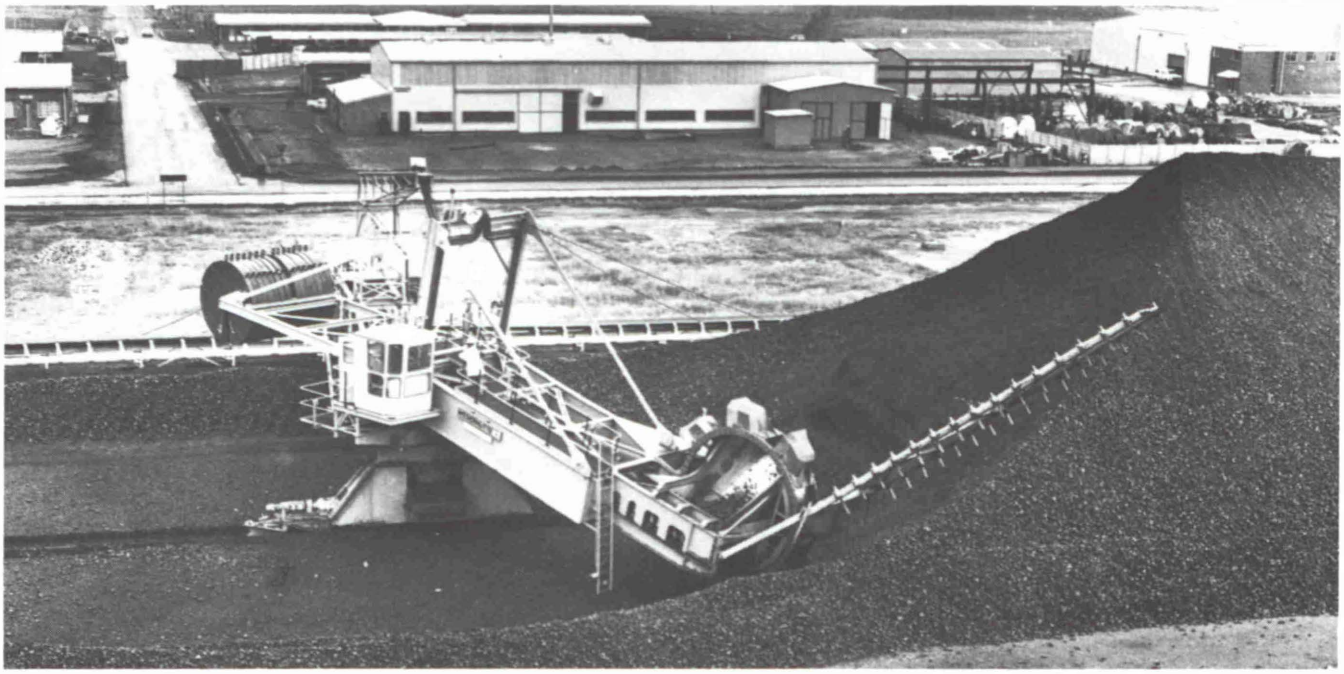


Fig. 11: Schematic view of Kleinkopje homogenizing plants for No. 2 seam (Stream A) and No. 4 seam (Stream B) raw coal

Fig. 12: Anglo-American's coal washing plant at Kleinkopje, with the homogenizing plants in the foreground. Note how easily the beds could be expanded in the future

Fig. 13: The half-bridge boom-type bucketwheel reclaimer at Kleinkopje can equally well reclaim in both directions by simply slewing the boom around



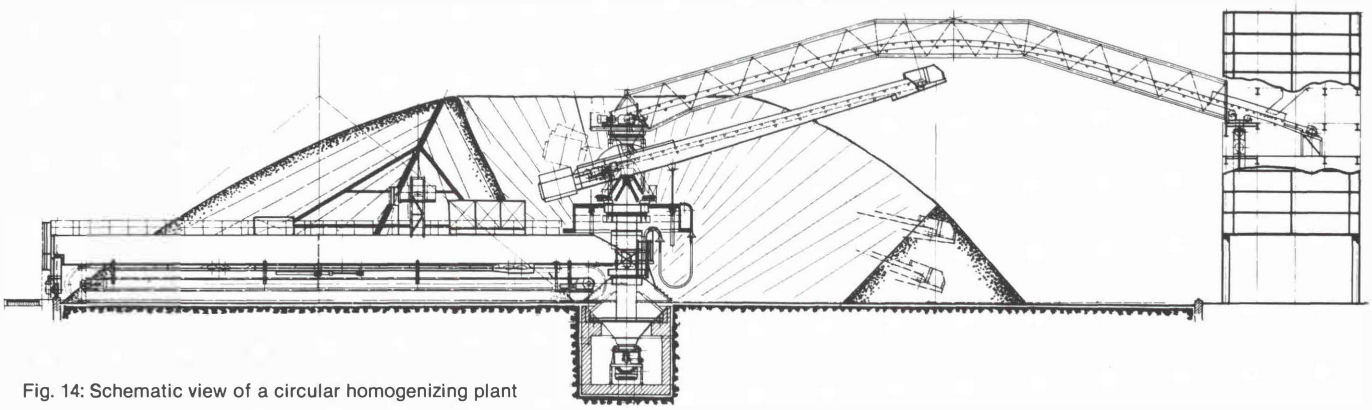


Fig. 14: Schematic view of a circular homogenizing plant

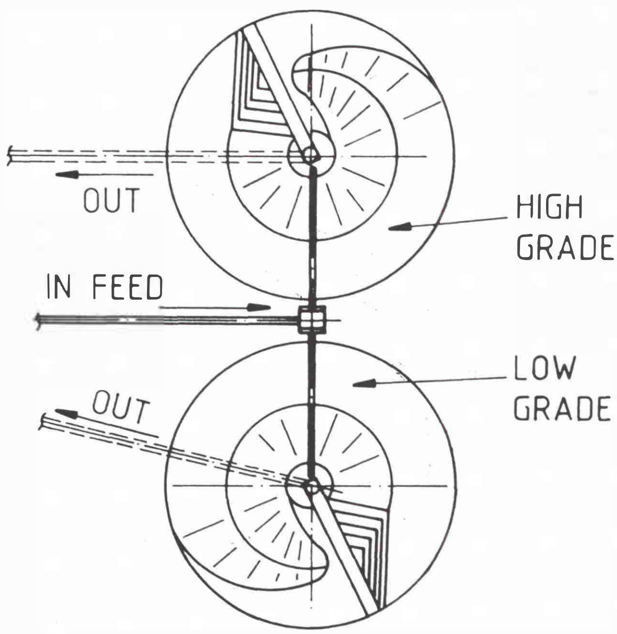


Fig. 15: Layout of the Blue Circle homogenizing/proportioning plants for high grade and low grade limestone now under construction at Lichtenburg

— Space utilization is high as net effective storage capacity is 78 % of gross storage capacity
— Maintenance and operating costs are lower because of shorter belt lengths, shorter travel distances, and lower power consumption. Most motions are on high precision, low friction, totally enclosed slewing bearings instead of wheels or rails
— Flexibility in layout design as a circle often best fits into available space and the relation between direction of inflow and outflow is infinitely variable over 360°.

Some South African engineers dislike having a reclaim conveyor in an underground concrete tunnel and the fact that the storage capacity of the circular plant is fixed and cannot be increased.

4. The Gencor Homogenizing Plant at Hlobane

Gencor's Hlobane colliery near Vryheid in Natal is one of the oldest operating coal mines in South Africa and was started around 1900. In 1980 Gencor decided to rejuvenate and expand Hlobane at a cost of R 120 million to supply two types of coking coal totalling one million tons per annum to Iscor. The two products from the washing plant, respectively produced from coal mined from the Gus seam and the Dundas seam, had to be stockpiled and homogenized separately before being dispatched in railway trucks to the Iscor Works at Newcastle and Vanderbijlpark.

The need to continuously and simultaneously stack two products and to intermittently and consecutively reclaim them, indictated the use of two separate stackers and one common reclaimer (Fig. 16). This and other topographical and ground condition factors ruled out the application of circular homogenizing plants.

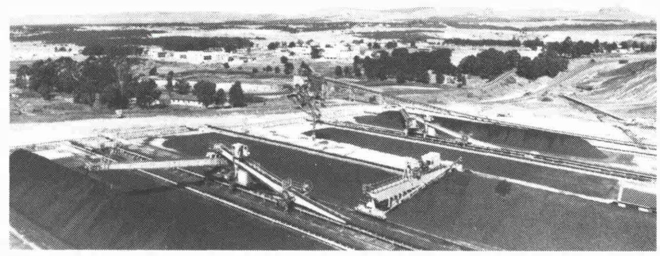


Fig. 16: Two slewing stackers and one bridge-type scraper reclaimer in operation on 4 homogenizing beds at Gencor's Hlobane coal mine

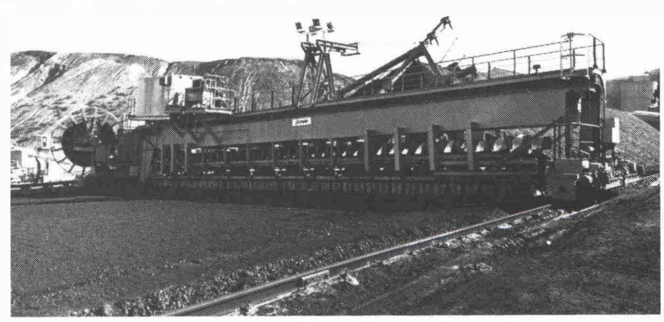


Fig. 17: The 28 m bridge-type scraper reclaimer with triangular rake at Hlobane

To reclaim the washed coal of 0—25 mm particle size at a rate of 600 t/h, it appeared that a bridge-type scraper with 28 m rail gauge would be the best reclaiming tool (Fig. 17) and this was confirmed by a preliminary value analysis.

Further special features decided on, were:

— a full triangular rake for best material flow control and homogenizing effect
— the horizontal scraper chain to bend upwards at the dis-

charge end and transport the reclaimed coal over a discharge trough, incorporated in the reclaimer, onto the yard conveyor. In this way the need for expensive concrete retaining ramps along the entire length of all four homogenizing beds was obviated.

Hlobane is situated in extremely undulating terrain, which, with three superimposed coal seams, has been widely undermined at more than one level. This presented a unique challenge in homogenizing plant layout design. The objectives were:

— to minimise capital cost in respect of machines, conveyor belts, earthworks, foundations, tracks and electrical reticulation,
— to satisfy the constraint of not exceeding 3 m of excavation at any one point due to the undermined area, in spite of the fact that contour differences of up to 17 m were present over the area envisaged, and
— to arrive at a plant layout which could be operated effectively.

The final layout arrived at (Figs. 18, 19) appears to be a straight-forward and logical solution. Nevertheless, the plant is the result of over 20 preliminary layouts of various configurations, both end-on, parallel and combinations thereof. Numerous optimisation studies were made to minimise earthworks, foundations and conveyor runs, with reclaimer transfer at near end or far end, load-out cross-conveyor at near end or far end, and combinations/permutations thereof.

For the first time a 4 bed homogenizing plant was built with each bed on a different level. In the end earthworks were further minimised by:

— having the base of the beds at an incline of 4.4° with the one reclaimer rail of each bed 2 m higher than the other
— stepping each bed downwards with a uniform inclination over each set of beds, but sharper inclination between the two sets of beds
— designing a specially articulated winch-operated transfer car to accommodate the inclination over each set of beds, but also the sharper inclination between the 2 sets of beds (Fig. 20).

The Hlobane plant is now working well and regularly supplies its target of monthly coking coal to Iscor.

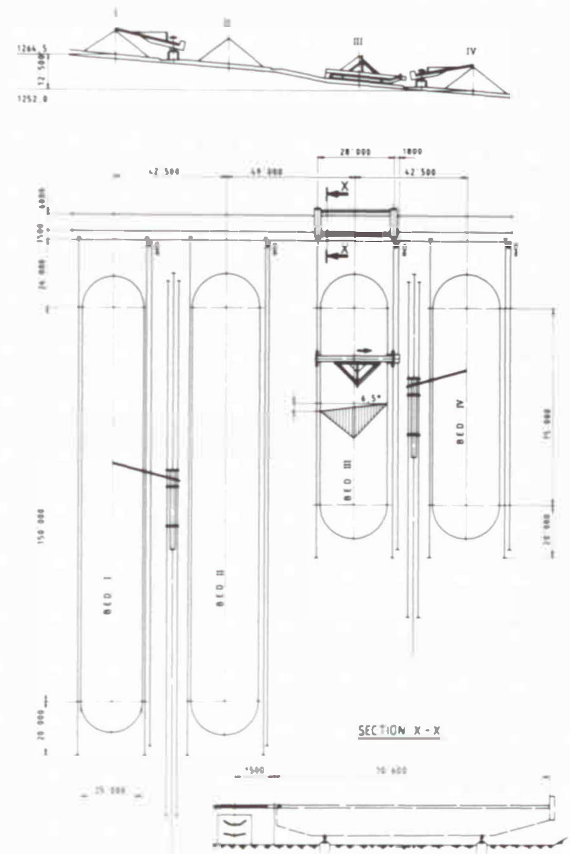


Fig. 18: Schematic view of the Hlobane homogenizing plant

Fig. 19: Aerial view of Hlobane with the washing plant in the background and the rail loading station on the right

Fig. 20: The articulated transfer car for transferring the bridge-type scraper reclaimer from one bed to the next along the inclined transfer track

5. The Gencor Homogenizing Plant at Optimum

The Optimum coal mine went into production in 1971 to supply Escom's Hendrina Power Station in the Eastern Transvaal with 6 million tons per annum of steam coal. Optimum was the first opencast coal mine in South Africa to use a walking dragline for overburden removal in a strip mining operation.

Recently Gencor decided to apply another new concept in South African coal mining, that of a tied power station colliery being converted to a multiproduct mine. Because reserves of suitable export quality coal, totalling as much as 85 million tons in situ, are in excess of Escom's requirements for the Hendrina Power Station, another 5 million tons per annum will be mined from 1983. In this way the coal reserves at Optimum will be utilized to the maximum benefit of all concerned.

To ensure a maximum yield of export coal of a consistently high quality, it was decided to install an homogenizing plant for raw coal ahead of the washing plant, with the following key requirements:

- Stacking rate 1,500 t/h to 3,000 t/h; reclaim rate 750—2,150 t/h infinitely variable
- Storage capacity of one bed equal to one week's throughput or 200,000 tons to absorb with reasonable certainty the quality fluctuations inherent in the deposit
- Maximum homogenizing effect in terms of quality and particle size distribution
- Minimum particle size degradation of the raw coal
- Maximum adaptation to incompletely filled bed
- Minimum capital and operating costs
- Minimum maintenance cost and machine complexity; maximum machine availability

A value analysis of the most likely alternatives on the points scale system according to Zangemeister showed a 12 % difference between the next best alternative and the following solution selected for Optimum:

- Two parallel homogenizing beds served by one slewing stacker and one drum reclaimer with swivel bogies for transfer from the one bed to the other over transfer rails (Figs. 21, 22, 23)

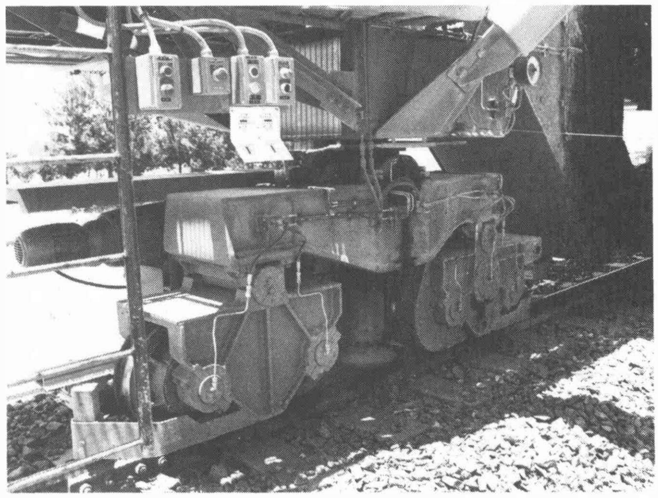


Fig. 22: The travel bogies are lifted by hydraulic cylinders and turned through 90° for cross travel transfer

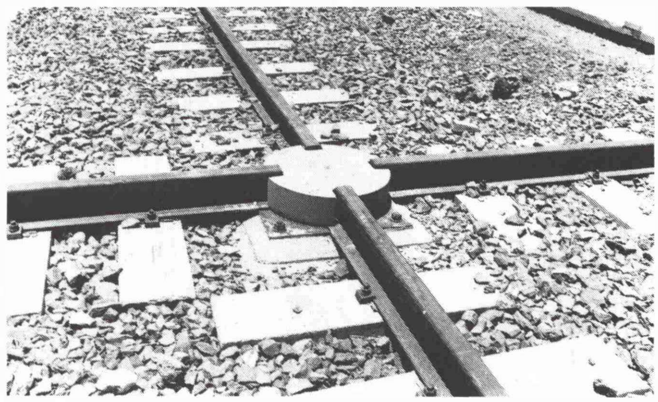
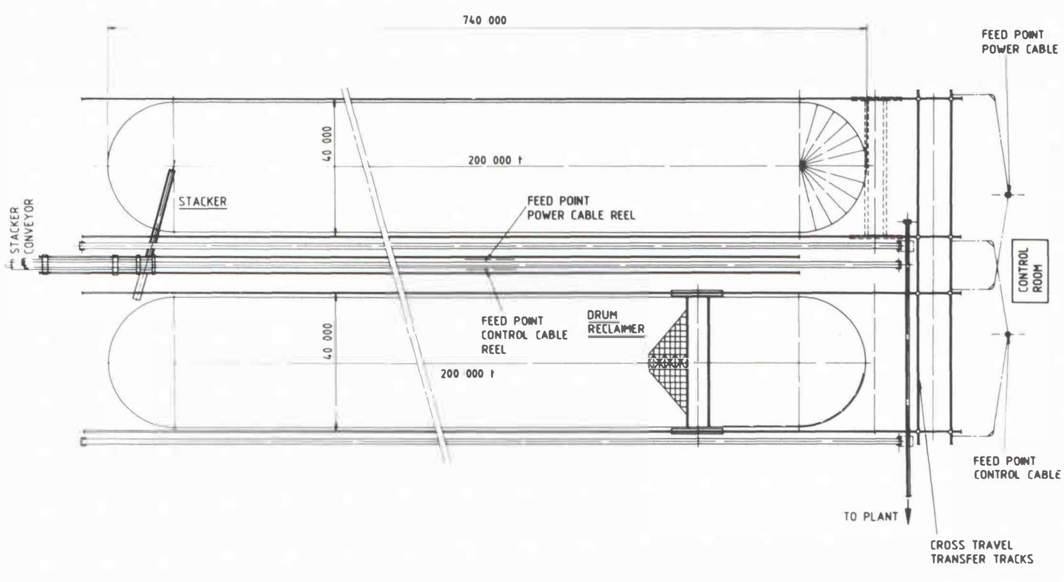


Fig. 23: Four jacking points are located at the cross travel tracks where the travel bogies are turned

- Stacking is to the chevron mode in 170 layers whilst the drum simultaneously reclaims the full cross-section (Fig. 24). The homogenizing effect based on the average stacking rate is 13:1 and occurs over one full week's timespan
- The instantaneous homogenizing effect and evenness of the reclaiming rate is illustrated in Fig. 25

Fig. 21: Schematic view of Optimum layout



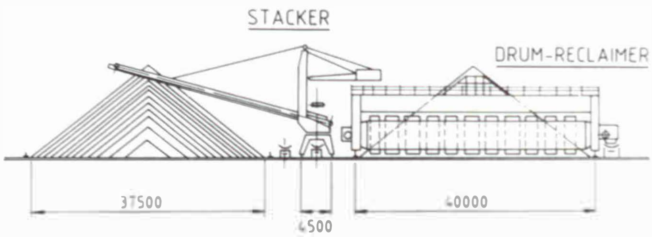


Fig. 24: Schematic cross-section of Optimum homogenizing plant

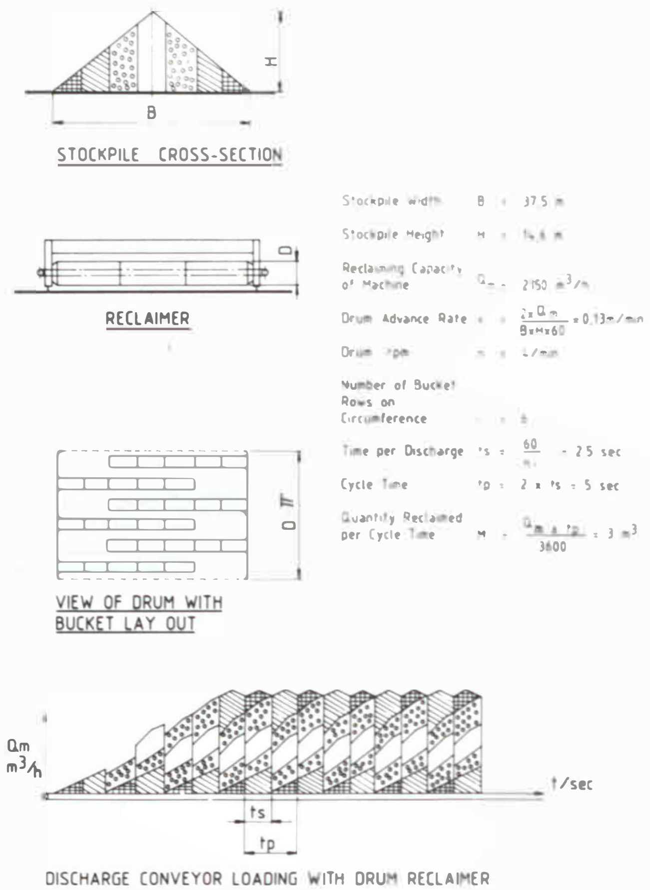


Fig. 25: Diagram illustrating the homogenizing effect at Optimum

The homogenizing plant at Optimum will go into production during the first half of 1983 and will make a significant contribution to washing plant utilization and yield. More importantly, it will herald a new high in quality consistency, something which South African coals have become known for in the international marketplace.

6. Conclusion

The first homogenizing/blending plant was built in South Africa in 1968 for blast furnace iron ore for Amcor at Newcastle. Since that time the concept has taken root and to date, 48 homogenizing plants have been built, or are under construction.

Today no metallurgical or chemical plant which consumes significant quantities of bulk raw material, is planned or built in South Africa without serious consideration being given to homogenizing and/or blending of the feedstock and/or the product.

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