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Comparison of Stockpile Systems: Bucket Wheel Reclaimer versus Underground Reclaimer

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Vergleich von Lagerplatz-Systemen mit Schaufelrad-Lader und Untergrund Rücklader

Die Frage nach der richtigen Lösung für ein Lagerplatz-System kann nur beantwortet werden durch Auswertung verschiedener Lösungen mit Silos, Schlitzbunker, Fallturm, Schaufelrad-Rücklader usw.

Es gibt keinen Trend in Richtung Silos, Schlitzbunker oder Schaufelrad-Rücklader und keine allgemeine Antwort, da jedes Projekt verschieden ist. Die Kenntnis der Vor- und Nachteile der verschiedenen Systeme sowie eine exakte Analyse der Bedingungen eines speziellen Projektes hilft dem Ingenieur die optimale Lösung zu finden.

Für Kohlekraftwerksanlagen mit hoher Umschlags- und Lagerplatz-Kapazität ist der Schaufelrad-Absetzer/Lader eine wirtschaftliche Lösung und wird auch in Zukunft in vielen Lagerplatz-Systemen eine Rolle spielen.

Comparaison des systèmes de stockage: Récupérateur avec roue à godets vs. transporteur tunnel

A la question sur l'outillage approprié pour le système d'emmagasinage des matériaux en vrac, on ne peut répondre que par l'évaluation de diverses solutions et par la comparaison avec des systèmes comme: silos, trémies, tour d'abaissement, récupérateur avec roue à godets etc., pour chaque projet individuellement.

Il n'y a pas d'orientation vers des silos, trémies ou récupérateur avec roue à godets. Et il n'y a pas non plus une réponse générale puisque toutes les applications et conditions sont différentes. Une compréhension des avantages et des inconvénients de divers systèmes et aussi une analyse sérieuse du paramètre d'un projet différent conduira l'ingénieur à la solution optimal.

Pour les grands centres d'énergie d'une haute capacité manoeuvrière et d'une grande capacité d'emmagasinage, l'élévateur/récupérateur avec roue à godets est une solution économique et mérite une considération de la part de l'ingénieur en cas d'évaluation téchnique. Cet appareil continuera à être l'outillage clef dans bien des grands systèmes de stockage.

Comparación de sistemas de almacenamiento de materiales con recuperador de rueda cangilones versus recuperador de tunel

A la pregunta sobre un equipo preciso para un sistema de almacenaje de materiales en gran volumen, sólo se puede contestar que por la evaluación de diferentes soluciones y por la comparación de sistemas tales como silos, tolvas, torre bajable, recuperador de rueda de cangilones, etc. para cada proyecto individual.

No hay una tendencia haqia silos, tolvas, recuperador de rueda de cangilones. No se puede dar una respuesta general porque todas las aplicaciones y condiciones son diferentes. Un entendimiento de las ventajas y desventajas de los sistemas diferentes y un análisis cuidadoso del parámetro de un projecto diferente conducirá al ingeniero a la solución óptima.

Para grandes plantas de energía eléctrica con una alta capacidad de manipuleo y grandes capacidades de almacenamiento, el acumulador/recuperador de rueda de cangilones es una solución económica y bien vale ser considerada por el ingeniero para la evaluación. El continuará siendo el equipo clave en muchos sistemas grandes de almacenamiento.

Summary

The paper highlights some of the aspects in recent developments in the basic design of open and enclosed stockpile systems in the USA.

Comparison and evaluation of solutions with different systems, such as silos, slot bins, lowering tower, bucket wheel reclaimer, etc. are described. Some applications for bucket wheel reclaimers are proposed.

For large storage capacities, the bucket wheel stacker/reclaimer will continue to be the key equipment in a stockpile system and is well worth consideration for any large future material handling facility.

1. Introduction

The recent change in the utility industry from oil to coal requires that many power plants and ports have to install new materials handling equipment.

In this paper some of the aspects and recent developments in the basic design of stockpile systems for coal-fired power stations and other applications are highlighted.

It is not possible to give the proper advice for the right type and size of the equipment because all applications are different depending on various conditions and locations. This paper may be, however, a worthwhile contribution and a helpful analysis for the engineer to compare different systems in order to approach the right solution. In other words, is the silo, the lowering tower, slot bin, the scraper-,

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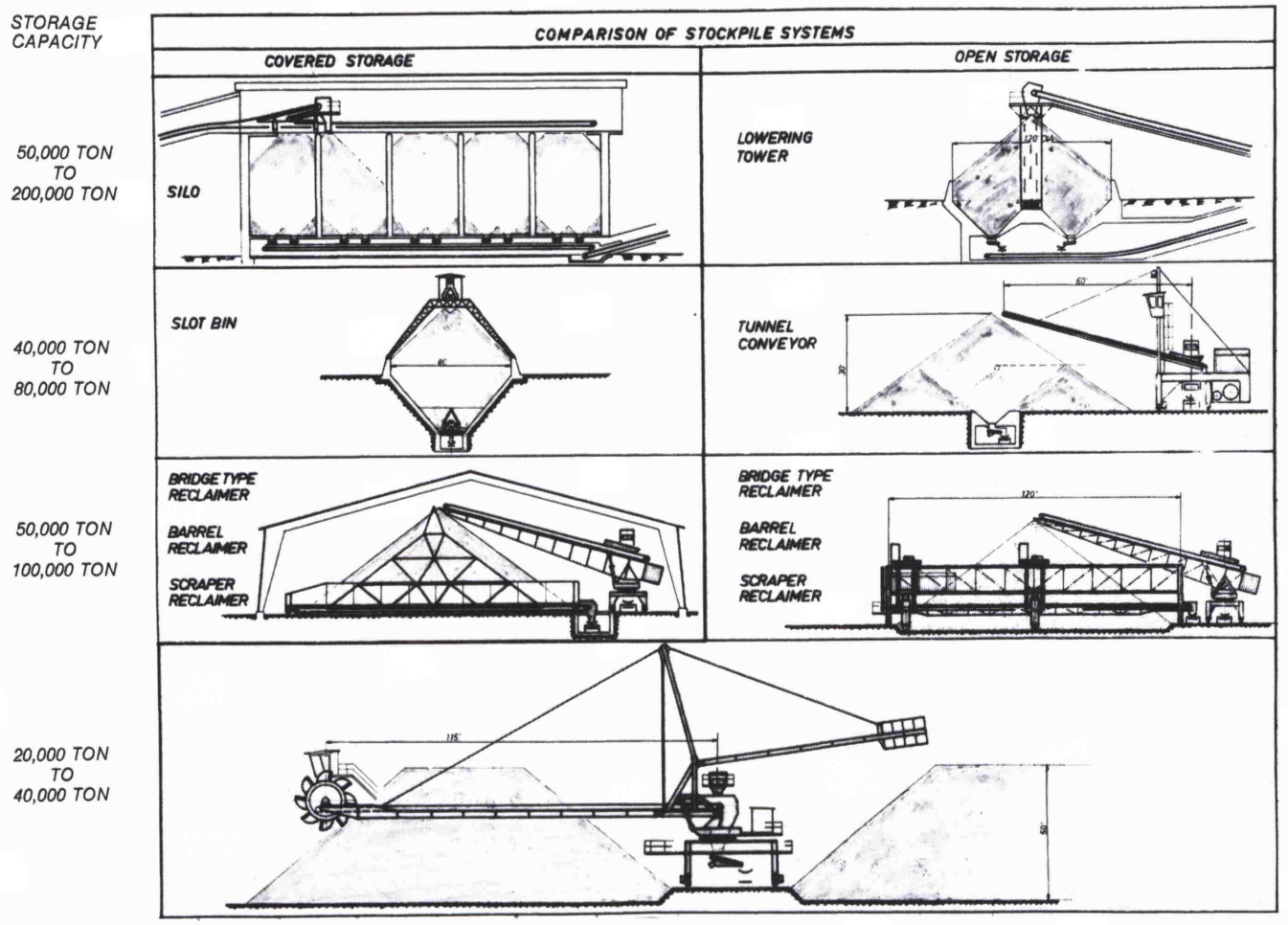


Fig. 1: Comparison of seven basic stockpile systems

barrel-, or bucket wheel reclaimer the right answer to a specific project? Open storage, covered storage, longitudinal pile, circular pile, etc., are adding a confusing variety of solutions to all the possible storage systems.

Every engineering company has to go through this evaluation exercise for each project and has to spend a lot of money and time on these studies for the comparison of different material handling schemes. And apart from the equipment performance and personal experience of the engineer, there is also a lot of emotional inclination or specific company interest for certain solutions.

The following will compare some criteria in order to find out where a silo, slot bin, or bucket wheel reclaimer is appropriate and of advantage for a certain application.

If someone reads a paper by an author from a company that builds concrete silos or underground slot bins, he may think the development goes in that direction. On the other hand, the bucket wheel reclaimer is a proven piece of equipment in hundreds of installations around the world. Therefore, all criteria for different systems have to be analyzed. Emphasis is given in this paper, however, to the bucket wheel stacker/reclaimer, especially for installation with high live storage requirements and high handling capacities.

2. Criteria for Evaluation of Storage Systems

In order to narrow down the variety of solutions, seven basic stockpile storage systems in relation to their storage capacity are shown in Fig. 1 and Table 1. Silos and slot bins — especially slot bins with the reinforced earth systems — have recently been developed for high storage capacities to tremendous sizes. Therefore, the storage capacity limits of the storage systems cannot be clearly determined. It is obvious, however, that different systems will be used for a stockpile with 20,000 or 200,000 ton storage capacity, e.g., the bucket wheel stacker/reclaimer in the area above 100,000 ton is very economical, as in order to increase the storage capacity, only the railtrack has to be extended. This is much cheaper than increasing the number of silos or length of a slot bin with all the associated civil work involved.

Table 1
Storage capacities for various stockpile systems

storage capacity (ton)	covered storage	open storage
20 — 40,000 ton	1. silo	4. lowering tower
40 — 80,000 ton	2. slot bin	5. tunnel conveyor
50 — 100,000 ton	3. bridge-type reclaimer barrel reclaimer scraper reclaimer	6. bridge-type reclaimer barrel reclaimer scraper reclaimer
50 — 200,000 ton	—	7. bucket wheel reclaimer

Due to the fact that the design and construction, as well as the material features vary, the operating costs differ greatly from one project to another. The storage capacity limits are therefore suggested border lines only.

If the engineer has to design a coal or lignite storage system, he should first evaluate the following criteria:

1. What is the purpose of the stockpile system?
   a) Storage between mine and power plant.
   b) Storage between preparation plant and ship loader.
   c) Storage between ship unloader and preparation plant.
   d) Storage and blending plant.
   e) Storage plant with majoritiy in buying or selling commodities.
   f) Storage between rail and barge facility, etc.
   g) Storage between ocean-going ship and river barge or vice versa.
2. Amount of storage for active coal, dead coal, and if additional storage can be added at a later date.
3. Handling capacity in tons per hour for stacking, reclaiming and by-passing.
4. Receiving of material by conveyor, truck, ship, rotary rail car dumper, bottom-discharge rail cars traveling on grade or on an elevated trestle, etc.
5. Capital cost and operating cost comparison for covered storage as well as for the less expensive open storage systems.
6. Reliability of the equipment and the system.
7. What are the blending requirements?
8. Is dust suppression required?
9. Coal preparation; such as dewatering, crushing, screening, and cleaning.
10. Environmental impact.
11. Fire detection.
12. Water pollution from coal piles.
13. Winter operation.
14. Other local conditions, etc.

Each parameter has a price tag. Therefore, an economical study should include three alternative solutions or basic schemes (e.g. silo, slot bins, bucket wheel reclaimer) with three alternative capacities.

Coal blending is becoming more and more important because coal may arrive from different locations or with different sulfur contents, etc. The coal can be blended on four different locations:

1. At the mine site.
2. At the preparation plant.
3. At the trans-shipment plant.
4. At the power plant.

In order to ensure that the finished blend has the optional combustion characteristics, it is important to upgrade the coal by blending. This could result in a smaller boiler size and cost saving in all auxiliary equipment for a power plant.

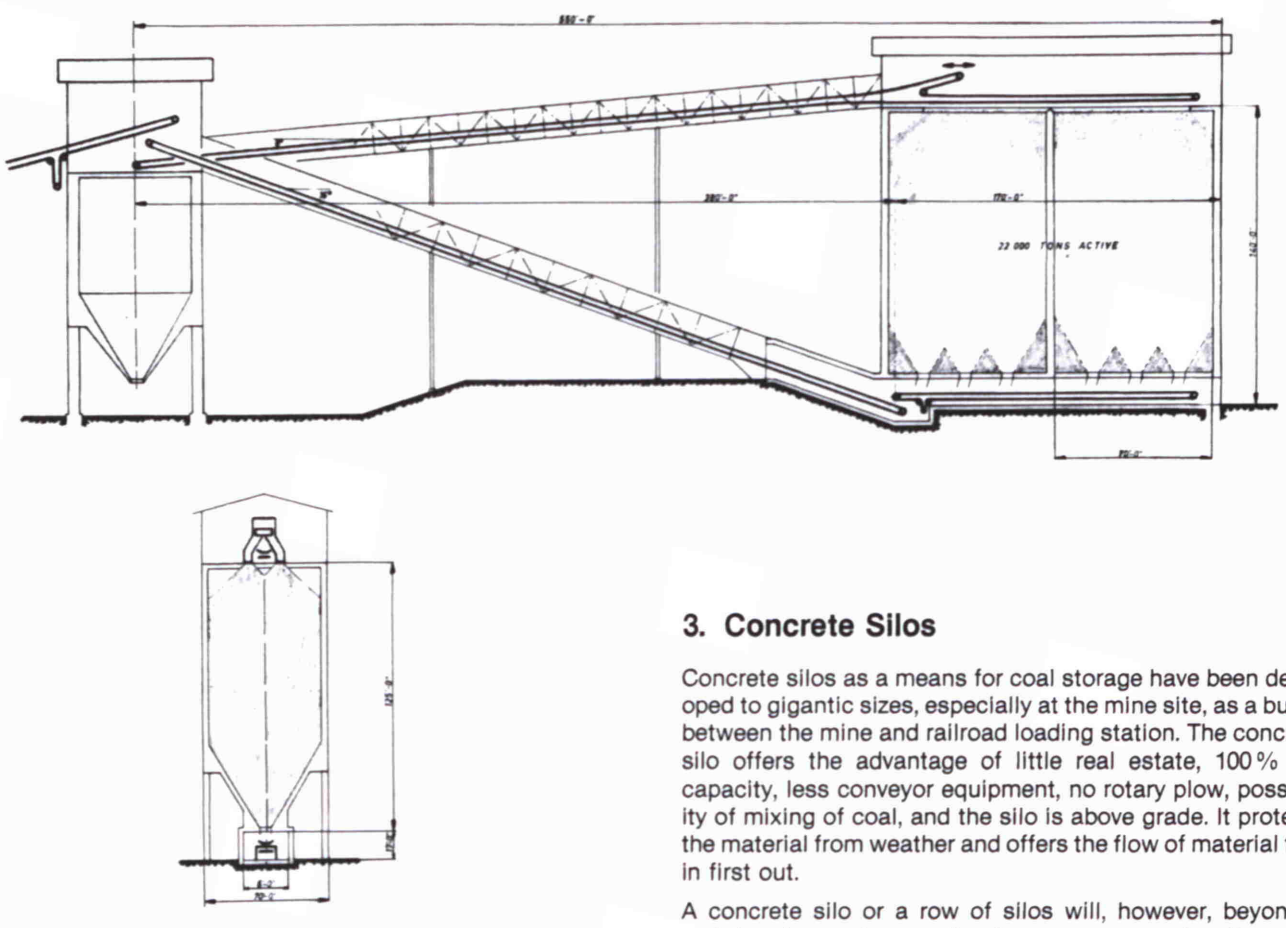


Fig. 2: Two coal storage silos with total 22,000 ton active coal

3. Concrete Silos

Concrete silos as a means for coal storage have been developed to gigantic sizes, especially at the mine site, as a buffer between the mine and railroad loading station. The concrete silo offers the advantage of little real estate, 100% life capacity, less conveyor equipment, no rotary plow, possibility of mixing of coal, and the silo is above grade. It protects the material from weather and offers the flow of material first in first out.

A concrete silo or a row of silos will, however, beyond a certain size and capacity, be more expensive than, for example, a slot bin because it is more expensive to store

coal vertically than horizontally. Silos may have problems in winter operation with frozen coal inside the silo, and silos also have limitations in certain locations due to limited ground pressure. At the mine site, silos also have to be removed after a couple of years if the mine is closed or emptied.

Fig. 2 shows a typical coal storage silo configuration with the associated feeding and reclaim conveyor system, vibratory feeders, etc. The two silos can store a total of 22,000 ton of active coal. It is easy to add more silos. However, the cost for each silo has to be added, meaning the cost increases proportionally with the storage capacity.

4. Lowering Tower

A lowering tower, or sometimes called stacking tube, is a vertical, concrete tube with several slots in the tube. Coal is dropped down from the top inside the tube and builds up an open conical pile outside the stacking tube. Reclaiming is achieved by means of vibratory feeders underneath the pile. Sometimes a common reclaim tunnel connects two lowering towers and enables blending of different materials.

A lowering tower may develop some dust problems in dry climates because big lumps are always rolling down at the outer surface of the pile to the ground. Dust suppression spray is difficult due to the fact that the total pile surface area is in motion and no telescopic chute is possible.

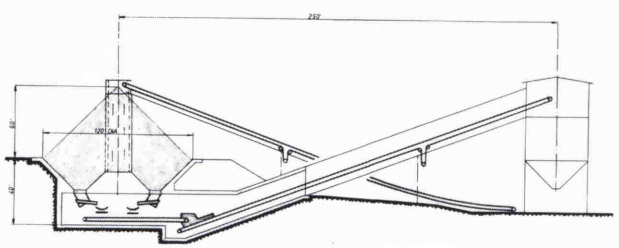


Fig. 3: Lowering tower with conical pile for 10,000 ton

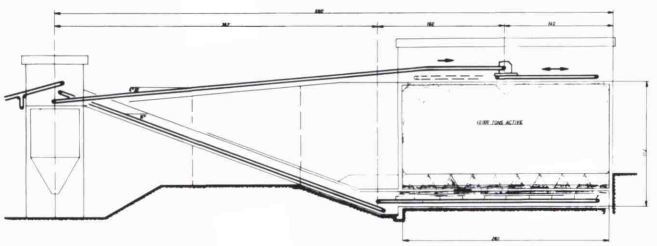
Fig. 3 shows a lowering tower for 10,000 ton of active coal. By 20,000 ton of coal the diameter would be 160 ft and the height would be 80 ft. The lowering tower has the advantage of few mechanical parts. However, in order to increase the life capacity to 80 or 100 %, the pile has to be extended into the ground with a 45° slope which requires tremendous excavation and civil work with all the associated problems involved.

Some projects have up to six vibratory feeders in a circle underneath the conical pile. This requires a lot of concrete work, underground conveyor, waterpumps, etc.

5. Slot Bins

A slot bin system is usually built as a covered storage building with a tripper conveyor mounted to the roof structure for stacking. Reclaiming is achieved by a rotary plow in the concrete reclaim tunnel, which feeds the material onto a reclaim conveyor (Fig. 4).

Recently the design of a slot bin in Montana has been increased to up to 100,000 ton storage capacity due to savings in using the reinforced earth system. This is compacted earth, and the slopes are paved with concrete plates



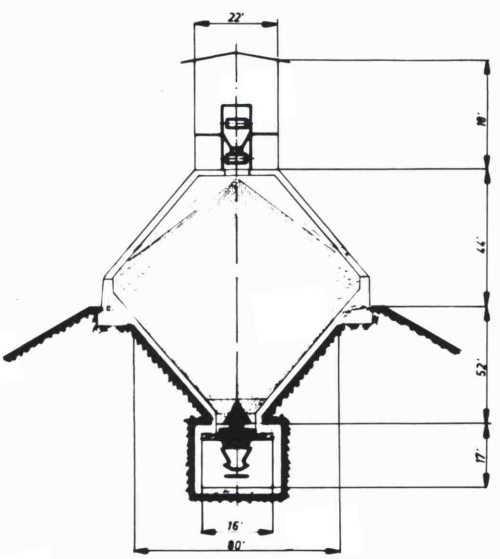


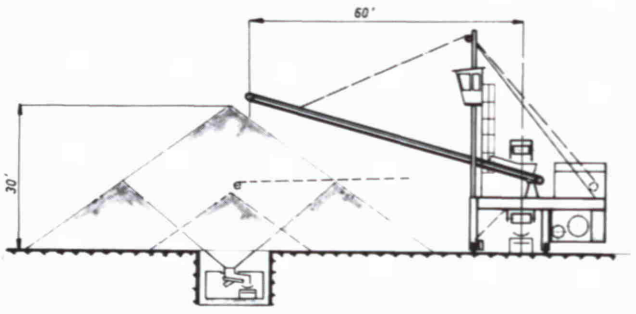
Fig. 4: Slot bin for 40,000 ton active coal

with steel anchors instead of casted concrete slopes. The foundation costs, however, may vary up to 50 % depending on ground-, water-, and local conditions. Blending and first in first out is possible. However, under certain conditions, the dropping height from the tripper to the bottom slot may result in tremendous dust development inside the building. Water sump pumps for ground and surface water have to be installed. At the mine site the building has to be removed after some years if the mine is empty or closes down after a couple of years. No concrete foundation will be allowed to remain in the ground. This may be more expensive than an above-ground storage system.

The cost of the slot bin for excavating, civil work, roof structure, tripper conveyor, rotary reclaim feeder, reclaim conveyor, etc. increases proportionally with the storage capacity of the building. Blending of two kinds of coal is possible if two bins are in line and two rotary reclaim feeders are working on one reclaim conveyor. Fig. 4 shows a typical slot bin installation for 40,000 ton of active coal with the associated conveyor system.

6. Tunnel Reclaim Conveyor

Another open storage system is the tunnel reclaim conveyor as shown in Fig. 5. Stacking is achieved by a traveling stacker with tripper trailer. The stacker usually stacks in the chevron-type stacking method. Reclaiming is achieved by vibratory feeders underneath the pile which feed the material on to a reclaim conveyor which is mounted either in a concrete tube or tunnel built of Amco steel tube sections.



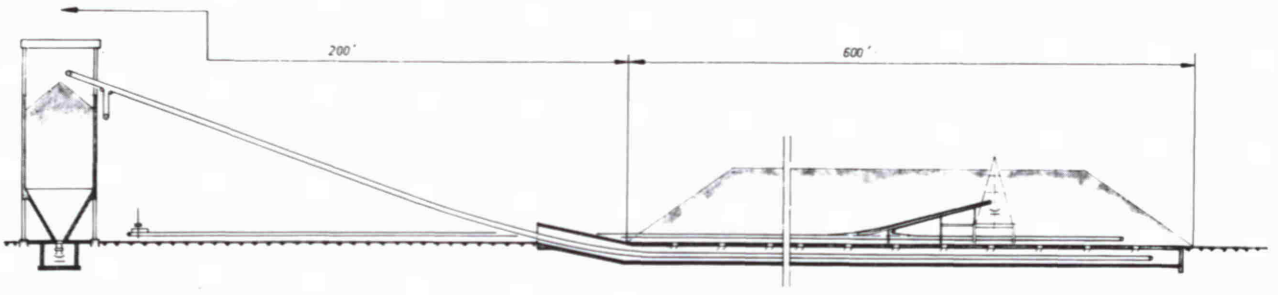


Fig. 5: Reclaim tunnel conveyor for 12,000 t

This solution seems to be simple. However, the vibratory feeder does not reclaim the pile uniformly but reclaims only a conical funnel on top of each vibratory feeder. This in turn creates some difficulty in stacking a pile with uniform pile height. The remaining dead pile can easily be moved by dozer into the vibratory feeder openings. For small storage capacities up to 30,000 ton, and with no demand on high blending effect, this system may be appropriate.

The next step, however, would be the design of a bucket wheel stacker/reclaimer with a short boom or, a so-called trench-type bucket wheel stacker/reclaimer because if the tripper trailer and stacker machinery is already there, the addition of a bucket wheel would eliminate all the vibratory feeders and the total underground reclaim conveyor.

The trench-type reclaimer and slew-type reclaimer will be described later and in more detail. Fig. 5 shows a typical tunnel reclaim conveyor system for 30,000 ton storage capacity.

7. Bridge-Type Reclaimer

As shown in Fig. 6, the bridge-type reclaimer is a typical blending machine. This system incorporates a traveling stacker which usually stacks out in the chevron-type method and a bridge-type reclaimer with one bucket wheel. In order to achieve a better blending effect, a second bucket wheel may be utilized. If the bucket wheel are designed with reversible buckets and two rakes on either side, then the bridge-type reclaimer as shown in Fig. 6 with two wheels and four rakes can work between two piles. This means one pile can be built up while the other pile can be reclaimed simultaneously. The whole system in this case is covered by an environmentally-safe storage building. The building structure is much cheaper than the roof structure of a slot bin because the roof does not carry the tripper conveyor structure for stacking. The building is a standard building structure similar to a tennis hall and independent from all mechanical equipment. Civil work is also very minimal and this environmentally-safe solution may be of major consideration for future coal-fired power plant installations.

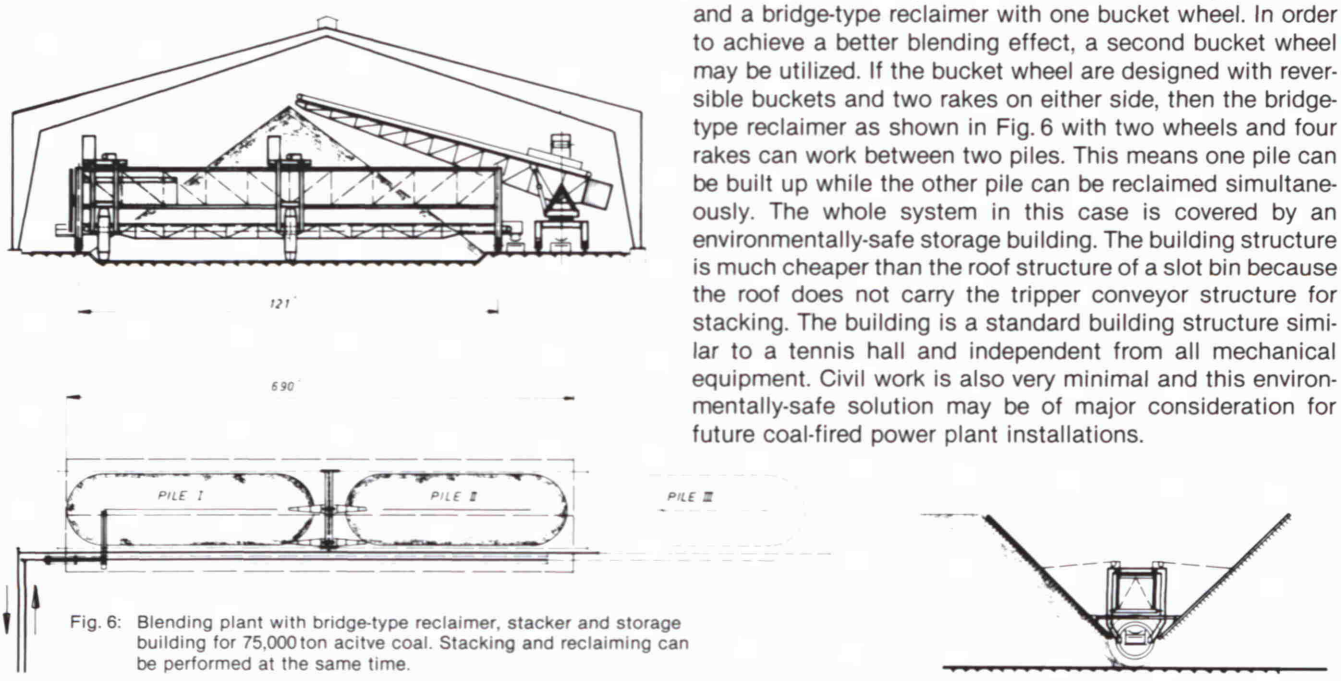


Fig. 6: Blending plant with bridge-type reclaimer, stacker and storage building for 75,000 ton acitve coal. Stacking and reclaiming can be performed at the same time.

8. Barrel Reclaimer

In case the demand for blending of material calls for the most accurate percentage figure, the barrel reclaimer comes into the picture. The barrel reclaimer works in conjunction with a traveling stacker and can also work in a storage building. The advantage of the barrel reclaimer is that the barrel really can reclaim the complete cross-section of the pile and at the same time blend the material to the highest percentage from whatever is built into the pile in the chevron or windrow stacking system. The barrel has the disadvantage of a high operating weight. Especially the weight of the rotating barrel may create guiding and welding problems. The oscillating rake covers the full stock pile cross-section which creates reaction forces on the bridge and in turn movement of the bridge which may result in guiding problems at the barrel guide rollers. The barrel reclaimer, however, is one of the most accurate blending machines available.

9. Scraper Reclaimer

Fig. 7 shows a scraper reclaimer with a stacker working in a storage building. This blending machine reclaims the complete pile cross-section at the same time. A barrel reclaimer

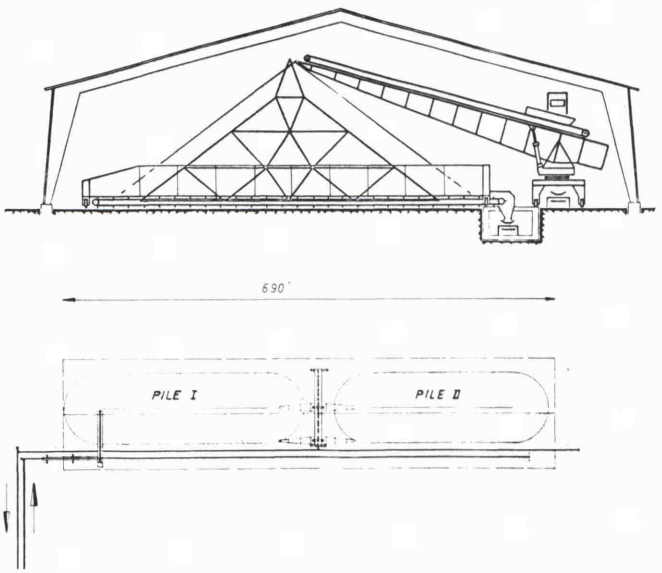


Fig. 7: Blending plant with scraper reclaimer

digs the complete bottom line of the pile cross-section by circulatory movement of the buckets while a scraper reclaimer scrapes the material in a cross movement to the side of the pile.

Scraper reclaimers are developed in various shapes and for various materials. They are also designed for circular stockpiles. This paper, however, does not go into the details for this type of machinery.

10. Bucket Wheel Stacker/Reclaimer

The bucket wheel stacker/reclaimer as shown in Fig. 8 offers the advantage of one single unit for stacking and reclaiming without underground conveyor, little civil work for the rail track, and high active storage capacity because it covers two piles on either side of the rail track. Stacker/ reclaimers are

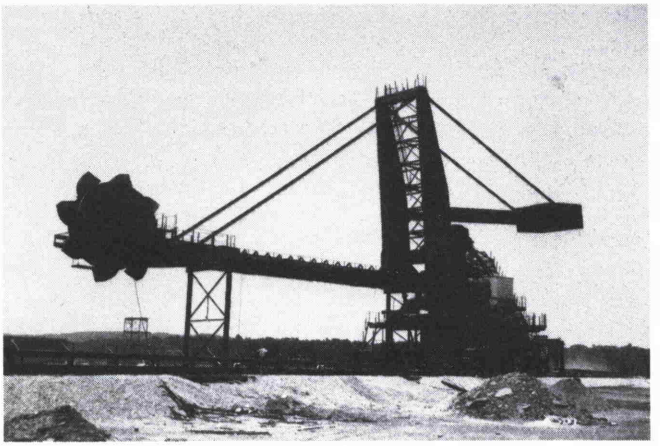


Fig. 8: Bucket wheel stacker/reclaimer for stacking 3000 ton/h and reclaiming 2500 ton/h for Alabama Power Co.

developed for automatic operation in stacking and reclaiming mode and are equipped with dust suppression systems. All types of tripper configurations are possible; i.e. tripper for material-by-passing, reversible yard conveyor, etc. Blending is achieved by stacking in windrow or chevron method and reclaiming with or without rake at the bucket wheel.

For coal piles up to 30,000 ton, a so-called trench-type reclaimer, as shown in Fig. 9, will be utilized. This machine has a

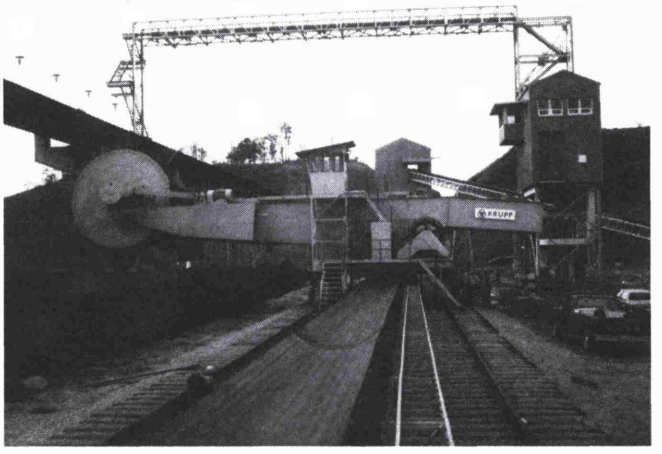


Fig. 9: Trencher-reclaimer

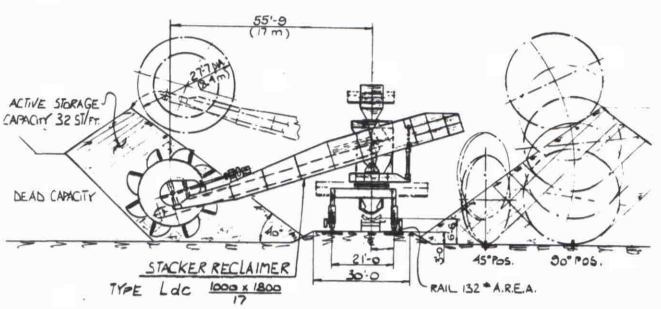


Fig. 9a: Trench-type stacker/reclaimer

short boom and does not slew by each step advance. It travels along the pile with a boom in a fixed 90° position. The constant reclaim capacity is controlled by the travel speed.

The travel drives with D.C. motors are controlled via a boom belt scale. The name trench-type reclaimer has been used because the first reclaimer of this type with a fixed boom in 90° position was designed to dig coal out of a trench 10 ft below either side of the rail track. The reclaim capacity is 20—30 short tons per linear foot. Due to the short boom, the bucket wheel is fairly large in diameter. The trench below the ground created some water problems. This, however, can be eliminated by utilizing a trench-type reclaimer with a boom position of 90° and 45° with the same or more active reclaim cross-section of 30 short tons per linear foot as shown in Fig. 9a. The name trench-type reclaimer will still remain because the machine travels along the pile in 90° or 45° boom position and digs about 10 trenches into the pile before the boom reaches the normal ground level.

For stock piles of 50,000 ton or more a slew-type stacker/reclaimer, however, is desirable. This type of reclaimer is designed for all types of application, capacities, and materials. In the following chapter two bucket wheel reclaimer systems for two recent applications are explained.

11. Bucket Wheel Reclaimer and Stacker for Blending two Kinds of Coal

Fig. 10 shows a coal blending plant for a recent project in New York State where two different types of coal arrive at different times and have to be blended.

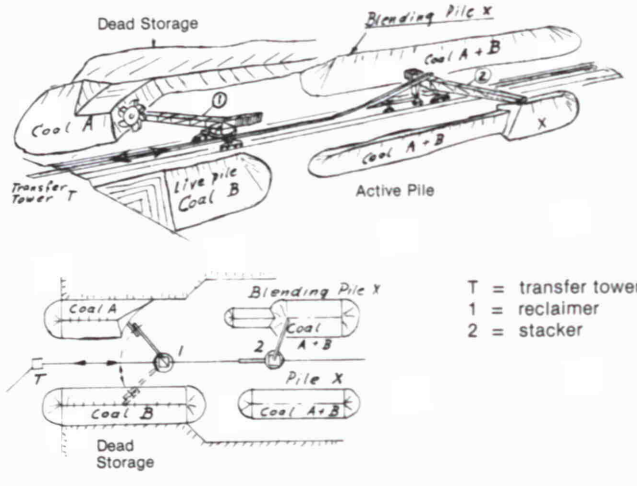


Fig. 10: Coal-blending facility with separate stacker and bucket wheel reclaimer working in line in the same reversible yard conveyor

The slew stacker can stack out coal types A and B on either side of the reversible yard conveyor, and the reclaimer can reclaim the coal piles. Blending is performed as follows: The blending piles X may be built with 50 % of coal type A coming from the transfer tower and 50 % of coal type B coming simultaneously from the reclaimer. The blending piles X can also be built by first reclaiming from pile A and stacking out one windrow or chevron type A in the blending pile X. Then the reclaimer slews to pile B and the stacker stacks out one chevron type B in a portion as requested. By reclaiming the blending pile X both types A and B coal are blended to any predetermined proportion.

Both the stacker and reclaimer are single purpose machines. They can work either in combination together or independently.

12. Bottom Discharge Rail Cars with Bucket Wheel Reclaimer — An Economical Solution

For power plant projects where coal arrives by unit cars with bottom-discharge facilities, the system shown on Fig. 11 has been approved as an economical solution.

Fig. 11: Trencher-reclaimer for Alabama Power Co.

Unit cars in slow motion are dumping coal or other minerals from an elevated rail track onto a stockpile. These minerals must be reloaded by either underground reclaim systems, such as rotary plows, vibratory feeders, or dozer.

Fig. 12 shows a solution for an above ground reclaim system which was approved and installed by Alabama Power

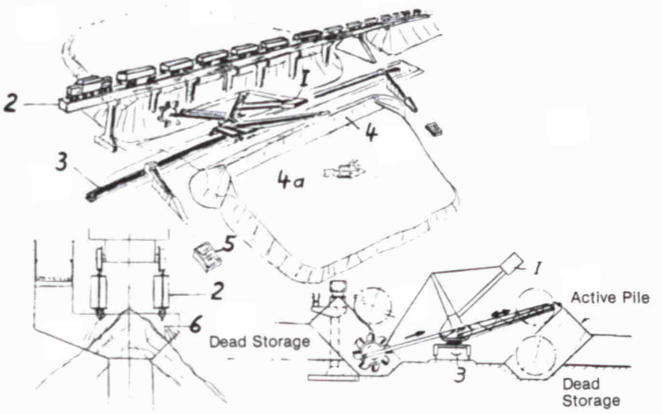


Fig. 12: Coal handling system with coal receiving by rail and reclaiming by bucket wheel

1 = reclaimer/stacker 2500 ton/h
2 = trestle
3 = yard conveyor
4 = live pile 2x36 ton/ft
4a = dead pile
5 = emergency reclaim hopper
6 = dust suppression

Company. The coal arrives by unit cars with bottom discharge facilities, traveling on an elevated trestle. The slow moving cars are unloaded one at a time and build a pile slice by slice. Dust suppression is applied for environmental protection. The material is reclaimed via a bucket wheel onto

the yard-conveyor or via a reversible stack-out boom belt onto a second storage pile in order to increase the live storage capacity.

The reclaimer can be designed for reclaiming one pile with 36 ton/ft active coal or for reclaiming two piles of 36 ton/ft on each side of the rail track as shown on Fig. 12. The machine operates in manual or automatic operation. It also can handle two different kinds of coal. By eliminating the rail car dumper, underground hopper, underground conveyors, transfer house, tripper conveyor stacker, etc., savings are substantial provided a rail trestle is feasible. This applies especially where the area is not level and an elevated rail trestle fits into the landscape without a ramp.

Fig. 13 shows a bucket wheel stacker/reclaimer for 3600 ton/h coal as installed at the Belle River Power Plant for Detroit Edison.

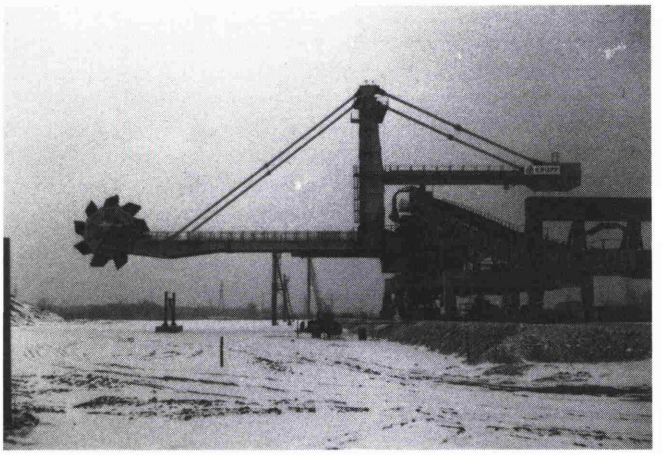


Fig. 13: Stacker/reclaimer for 4,000 ton/h stacking and 3,600 ton/h reclaiming of coal for Detroit Edison

13. Summary

The question of the right equipment for a bulk material storage system can only be answered by evaluation of different solutions and comparison with systems such as silos, slot bins, lowering tower, bucket wheel reclaimer, etc. for each individual project.

There is no trend towards silos, slot bins or bucket wheel reclaimer. No general answer can be given because all applications and conditions are different. An understanding of the advantages and disadvantages of the different systems and a careful analysis of the parameters of a different project will lead the engineer to the optimum solution.

For large power stations with a high handling capacity and large storage capacities, the bucket wheel stacker/reclaimer is an economical solution and is well worth consideration in any engineering evaluation. It will continue to be the key equipment in many large stockpile systems.