RG TANNA COALTERMINAL EXPANSION PROJECT CASE STUDY – THE APPLICATION AND BENEFITS OF CONTROLLED FLOW TRANSFER CHUTES

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1. INTRODUCTION

To meet the ever growing demand for coal export capacity from Central Queensland in Australia, the Gladstone Ports Corporation undertook a major expansion at their largest coal terminal, the 'RG Tanna Coal Terminal'.

The Gladstone Ports Corporation (GPC) is a Company Government Owned Corporation (GOC), constituted under the provision of the Government Owned Corporations Act 1993 (GOC Act). GPC is responsible to the Queensland Treasurer and Minister for Transport, Trade, Employment and Industrial Relations. GPC is responsible for Port Alma, the Port of Gladstone and the Port of Bundaberg.

The Port of Gladstone is Queensland's largest port and the RG Tanna Coal Terminal (RGTCT) has over 65Mt per annum capacity. The RGTCT Expansion Project involved the integration of a third rail receivable station and a third shiploader into the existing plant. To put into effect this integration and to utilise the increased capacity, five new stockpiles, 16 new conveyors and a fourth berth formed part of the new construction.

The stages of the upgrade were to:

- Speed up two existing shipping streams to increase capacity from 4000 tph to 6000tph
  - Construct and tie in Shiploader 3 and associated third shipping stream conveyors
  - Construct Berth 4
  - Construct and tie in Rail Receival Station 3
  - Construct Stockpiles 19, 20 and 21 and tie in the associated reclaim conveyors.

The engineering design of the expansion project was delivered in a conventional way with multiple engineering consultancies contracted directly by the client to deliver on different functional areas of the expansion. The client then took on the role of project manager, using the technical packages developed by the various engineers to define the scope of work. These technical packages contained the plant layout and engineering design drawings, including the engineering level drawings for all conveyor transfer chute work.

Delivery of the first stage of the project failed to achieve the projected increase in capacity from 4000 tph to 6000 tph for the two existing shipping streams. Additional technical expertise was therefore sought.

This paper focuses on the application and benefits using controlled flow chute design in the upgrade, which involved:

- Replacement of chute work that failed to meet capacity
- Replacement of chute work that caused severe belt tracking problems
- Redesign of the original plant layout to remove the requirement for 18 new conveyors
- Low head room diversion systems for Stockpiles 19, 20 and 21 reclaim conveyor transfers.

2. HISTORY OF THE TECHNOLOGY

Controlled flow has become a buzz word in the coal handling industry and has been widely adopted by engineering and regulatory firms in project specifications in an attempt to adhere to Best Available Control Technology (BACT), as mandated by the environmental protection agencies around the world. It must be noted that there is no standard definition for controlled flow between the manufacturers of these systems, and there are many variations of what is considered controlled flow. As a general description, CEMA characterises controlled flow chutes as ’being able to accurately predict and control the material stream throughout the transfer process’. Although this may seem like a fairly simple statement, the nature of bulk materials severely complicates the goal of ’accurate prediction’. One of the earliest proponents of this approach, Paul Sundstrom (based in Gladstone, Queensland, Australia) approached controlled flow as a concept based on minimising energy loss in the transfer system by guiding material in a controlled way from the feeding conveyor to the discharge point (usually) on the receiving conveyor.

In order to predict the material flow through a transfer system, there needs to be some mathematical model which incorporates the fluid properties of the bulk material with the constraining geometry of the chute design. A widely used method is Discrete Element Modelling (DEM). The chutes discussed in this paper were designed from equations based on a blend of fluid dynamics and vector models to predict the material flow. The most important factor in this methodology is that the bulk material has to act as a solid body while it flows through the transfer system. In other words, as the material moves through the chute, it should not roll over itself, and the individual particle to particle interactions should be kept to a minimum. This methodology can give extremely favourable results, but like all technology, has challenging applications. Through experience, this outcome is achieved by keeping impact angles within time proven, predetermined limits to minimise energy loss and liner wear. The history of the technology used in the design of the subject case study chutes can be traced back to Paul Sundstrom who designed and developed innovative solutions in the bulk materials handling field in close cooperation with the Port of Gladstone. The development of the controlled flow technology was born out of an urgent necessity, and was started in 1984 in collaboration with GPC.

The challenge at the time was the need to load 55 m beam-width ships with a shiploader designed for 42 m beam-width ships. If ships had to be turned at the wharf to be fully loaded this would relegate the port to a second tier export terminal.

Operations superintendent Alan Huth conceptualised that if the coal stream discharging from the head of the shiploader’s boom conveyor was gently turned so as to maintain its velocity and trajectory, the seaward side of the ships’ holds could be reached. Paul Sundstrom provided the theoretical analysis of Alan Huth’s concept and developed the mathematical equations to describe the material flow path.

Central Queensland University was engaged to solve these equations. These original equations, combined with further development over the last 25 years form the foundation of the controlled flow technology used in the design of the subject chutes. The fluid dynamic/vector model methodology also relies heavily on the friction values of the material, but eliminates the effect of internal friction, or the friction of the material on itself. This method is primarily influenced by the friction of the material against the chute wall, since the material flows through the system as a solid body. This minimises the overall influence of variances in friction, thus increasing the accuracy of the model.

In 1985 a chute system was developed that allowed the shiploader to load the wider 55 m beam-width ships. The head chute of the shiploader boom conveyor was replaced with a controlled flow hood chute, which delivered the coal into a redesigned telescopic chute which included articulation capabilities for seaward, landward, forward and aft tilt. At the end of the telescopic chute was an actuated trimming/loading (spoon) chute. All the chute work weight had to be optimised so that the shiploader and boom were not overloaded by the new chute work.

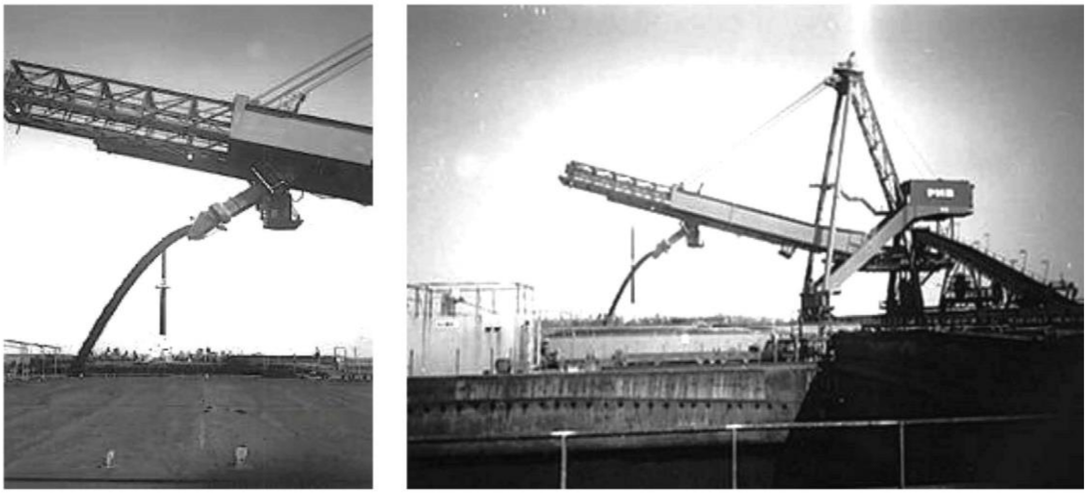

Figure 1. Shiploader 1, loading chute (circa 1985)

This chute design is still in use and has been replicated on shiploaders 2 and 3. The savings delivered by this chute design in all expansions of the RGTCT wharf runs into millions of dollars. The reason for this is that the controlled flow chutes removed the requirement of building shiploaders with longer booms. Longer booms would have meant a heavier shiploader, and a stronger and more expensive wharf structure. The controlled flow chutes allowed for Shiploaders 2 and 3 to be built to a similar lightweight design, not only saving money on the shiploaders, but allowing the wharf to be built to a compatible lightweight capacity.

The controlled flow technology is under constant improvement, again out of necessity to overcome new challenges in the bulk materials handling industry.

3. GENERIC CONTROLLED FLOW COMPONENTS - GLOSSARY OF TERMS

To allow a full understanding of this paper it is necessary to explain the terms used to describe the various controlled flow components.

3.1 Hoods

At the heart of ’controlled flow’ is the need to ’get control’ of the material stream discharging from the head pulley of the incoming conveyor as soon as possible. The name given to the component that first gets control of the material stream is the *hood* chute. The hood chute collects, concentrates and redirects the head pulley discharge stream to produce a stream of uniform shape and consistent direction at the discharge of the hood.

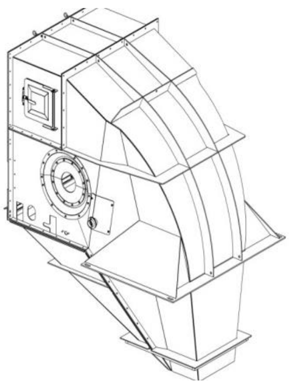

Figure 2. Typical hood

3.2 Diverters and Dividers

In modern bulk handling plants, flexibility and reliability are fundamental requirements, and it is very common for the material from the incoming conveyor to be delivered to multiple receiving conveyors, occasionally to more than one receiving conveyor at a time. The controlled flow components that provide this similar function are *diverters* and *dividers.* Diverters redirect the incoming stream to only one receiving conveyor at a time, whereas dividers can distribute the incoming stream between receiving conveyors.

In either case, diverters/dividers are designed as moving chutes as opposed to the conventional close fitting gate that moves between the walls of a chute. Diverters/dividers of this design are superior to conventional flop gate designs because there is no opportunity for build up between the moving dividing section of the chute and the side plates of the chute. As a result, diverters/dividers of this design do not suffer from the 'freezing' which is commonplace with conventional flop gates, and will freely move to the required position even when not activated for extensive periods of time.

There are over five variants of the diverters/dividers, each of which has a specific design functionality, generally related to the degree of stream realignment required and the headroom available at the transfer tower.

In properly designed controlled flow chute systems the diverter/divider chutes maintain control of the stream enabling the discharge of a stream of regular and consistent shape, moving in known directions to the next chutes.

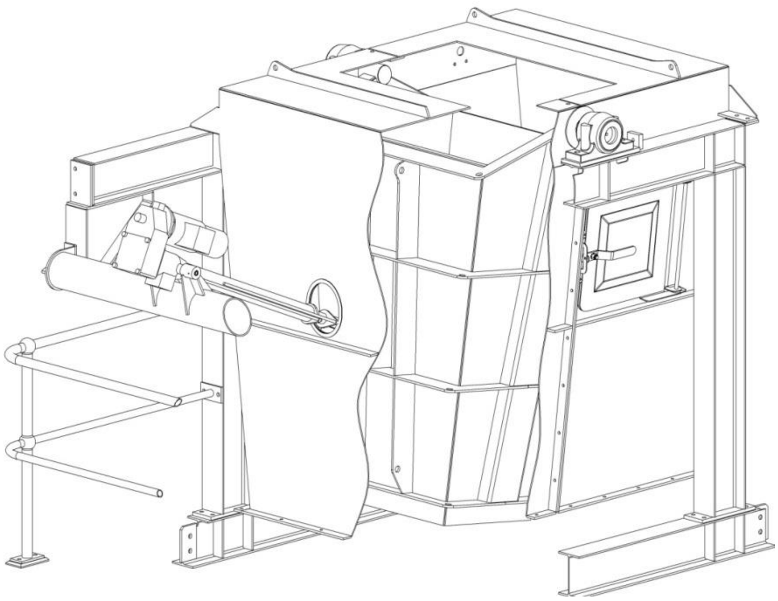

Figure 3. Typical diverter and enclosure

3.3 Intermediates

In larger transfer systems it is necessary to laterally transfer material significant distances to deliver it to the required alignment of the receiving conveyor. The name used in this paper for this chute component is the *intermediate* chute. This chute can at times be a very simple duct type chute, but more commonly it also changes the material's flow direction vector in all three directions, whilst at all times delivering discharge streams of regular and consistent shapes in known directions to the next chutes.

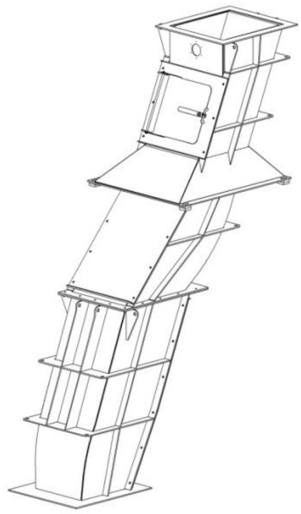

Figure 4. Typical intermediate chute

3.4 Spoons

The last component in the controlled flow transfers discussed is the *spoon* chute. The spoon chute receives the material stream from either a *hood, diverter/divider* or *intermediate* and redirects that material stream in the direction of receiving belt travel, at close to receiving belt speed, and at low impact angles. Because the spoon delivers the stream onto the receiving belt in the direction of belt travel and at close to belt speed, the re-acceleration of the stream is greatly reduced. This results in less spillage and dust and less material bounce.

The spoon chutes discussed here demonstrated via independent testing (Appendix 1) that this limited re-acceleration reduced belt cover wear by over three times compared to conventional conveyor feed chutes. Also, because the spoon discharge stream flow direction vector has no component in a direction lateral to the centre line of the receiving conveyor, the spoon discharge stream cannot steer the receiving conveyor or cause mistracking.

The low impact angles of the spoon discharge stream onto the receiving belt make it possible to load conveyors without the need for impact or close centre idlers in the loading zone. This has great application in yard machines where it is possible to load directly to the yard conveyor rather than requiring a travelling belt loading platform.

Figure 5. Typical spoon

4. SPEED UP OF TWO EXISTING SHIPPING STREAMS

The first stage of the RGTCT Expansion Project was a 'quick gain' initiative to speed up all conveyors associated with the two existing shipping streams to 5.1 m/sec, thereby lifting the capacity from 4000 tph to 6000 tph.

This capacity increase was to be achieved by replacing the existing conveyor drives and the existing chute work. It quickly became apparent during the commissioning phase that as the feed rates increased to above 4000 tph, chute blockages and poor belt loading was experienced. In fact, plant operation was so unreliable above 4000 tph that it was decided not to even try operating above 4000 tph.

After commissioning, many shutdowns were conducted in an attempt to increase throughput. The shutdowns involved modifying the newly installed chute work, which was a difficult task as the chutes were ceramic lined. This not only made the cutting and shutting of the chutes difficult, but the reinstatement of the ceramic liners in situ made it difficult to achieve good surface preparation for tile adhesion.

After months of modifications only limited improvement had been achieved. Under the circumstances, it was decided that an alternate design method was required. It had been determined that the first bottleneck in the shipping streams was at the CC5/CC6 and CC5A/CC6A transfer points which are the transfers from the jetty conveyors to the wharf conveyors. Given the significant impact on operations, it was a requirement that only minimal modifications be made to facilitate increased throughput.

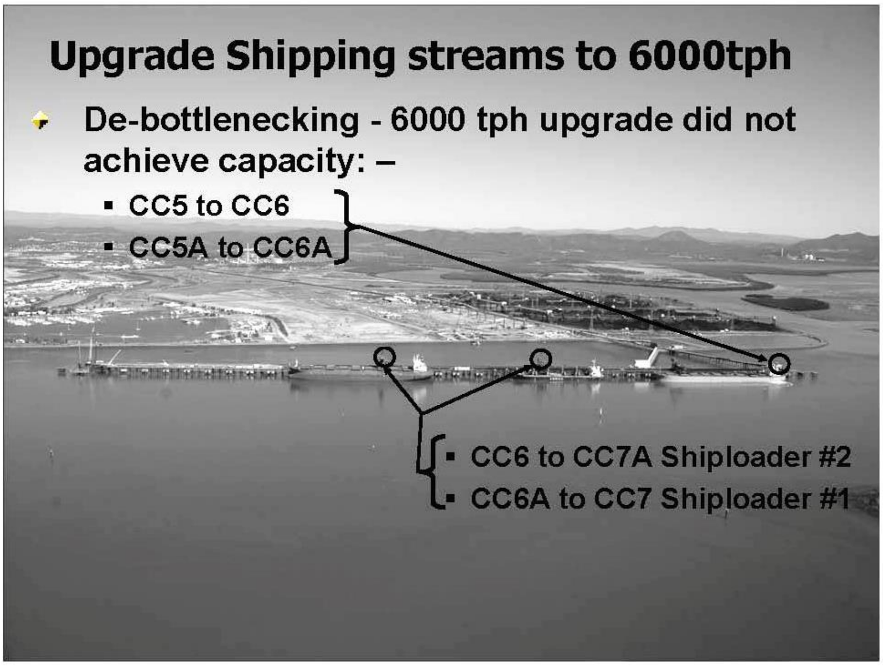

Figure 6. Upgrade of shipping streams to 6 000 tph

A review of the original hood style chute showed that it had failed to gain proper control of the coal discharge streams from the CC5 and CC5A conveyors. The discharge from those hoods had streams varying in shape, size, speed and direction. At high volumetric flow rates, any slowing of the coal stream requires a proportional increase in the cross sectional area of the stream. These hoods produced streams with large rooster tails which intersected the sides of the chute. The stream slowed further and caused blockages.

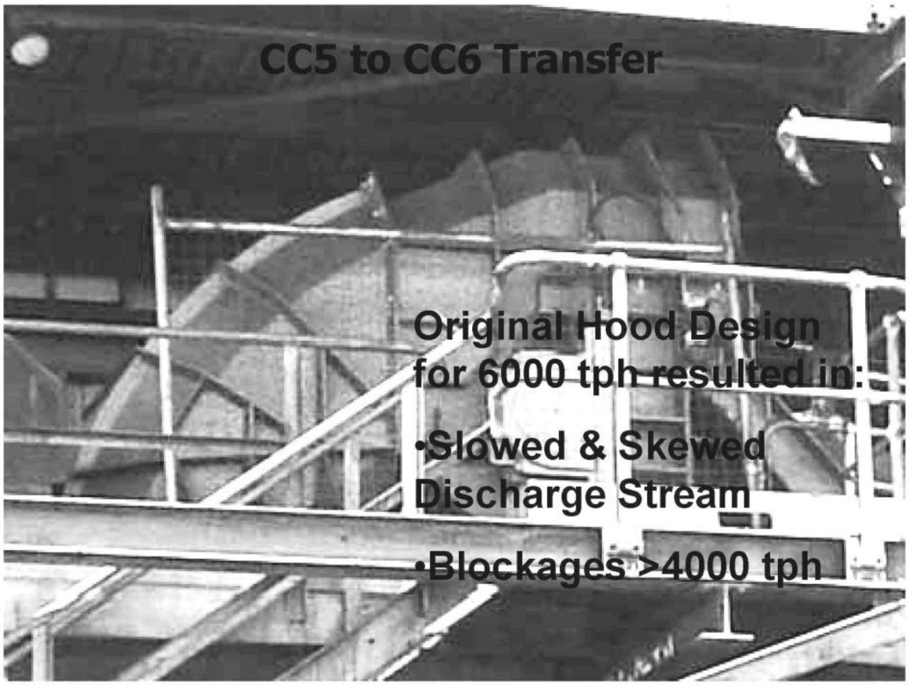

Figure 7. Original CC5 hood

The modifications made during the numerous shutdowns to the upgraded CC6 and CC6A spoons proved adequate to allow the 6000 tph throughput provided they were fed with a stream consistent in shape with a higher speed and a comparatively smaller cross sectional area. The modifications removed much of the original intended soft loading benefits, but given that time was of the essence, these benefits had to be sacrificed. By applying proper controlled flow design technology, a new hood was designed and manufactured to feed the modified spoons. As timing was critical, the CC5 and CC5A hoods were manufactured from stainless steel to avoid potential weather related delays associated with painting mild steel.

Figure 8. Redesigned CC5 hood

Within minutes of start-up after the installation of the redesigned CC5 hood, a rate of 6000 tph was achieved for the first time through this transfer. The rate was short lived because as the 6000 tph stream was delivered to the shiploader's tripper-to-boom conveyor, transfer chute blockages occurred. The bottleneck had been successfully moved to the shiploader.

Over the following weeks, step-by-step increases in the rate above 4000 tph were taken to determine if modifications could be made to the tripper-to-boom transfer so that that shiploading rates could be increased. The original designer of the upgraded CC6/CC7A and CC6A/CC7 tripper-to-boom conveyors on Shiploaders 1 and 2 fully expected that there would be problems at this transfer, particularly in relation to boom conveyor belt tracking.

In an attempt to manage the expected belt tracking problem, the chute designer had fitted an actuator to the curved deflector plate in the tripper head chute. The shiploader operator had remote controls for this actuator in the cabin so that belt mistracking could be corrected by steering the stream to the left or to the right side of the boom conveyor.

This technique was ineffective and prone to erratic positioning by the operator. As the rate changed on the plant, the operator constantly had to vary the deflector to compensate for the change in rate. If the rate increased quickly the deflector plate became an obstruction to flow and resulted in blockages.

Figure 9. Shiploader, original tripper to boom

It was ultimately decided this transfer also needed to be replaced. This was a relatively difficult transfer because of the low headroom and the increased belt speed.

The tripper head pulley's offset from the conveyor's intersection point (IP) and belt separation had not changed from its original lower belt speed position. There were several reasons for this. The higher belt speed and resulting increased trajectory from the tripper head pulley logically required that the offset to the IP be increased. If this were done in the low headroom location, the fines collection chute from the secondary and tertiary belt cleaners would be too shallow to have any chance of flowing.

If the fines collection chute valley angles were to be improved, then the tripper head pulley needed to be raised. Raising the tripper head pulley would necessitate a longer tripper to achieve the increased height, which is undesirable given the costs of wharf construction.

This compromise between tripper height/lengths and wharf or stockyard length is played out on every yard machine or shiploader around the world. To apply controlled flow technology and gain the soft loading benefits at a transfer, the material stream is essentially turned through nearly 180 degrees. The stream's direction vector discharging from the tripper head pulley needs to be turned from a below horizontal angle to a vertical direction and then this vertical stream needs to be turned to near horizontal to softly load onto the boom conveyor. This has to be done within the limits of allowable stream-to-chute wall impact angles so that the stream is not overly slowed. These issues drive demand for IP offset and belt separation.

To meet these separation demands at this transfer, the redesign incorporated a launch pulley as a way of creating the additional IP offset and belt separation without moving the existing tripper head pulley. The launch pulley was positioned before and above the existing tripper head pulley. A high percentage of launch pulley applications are at tripper-to-boom conveyor transfers.

The launch pulley causes the coal stream to separate from the conveyor before it reaches the head pulley and begins to turn naturally through the air before impacting the surface of the hood. This reduces the impact on the hood and also creates more headroom for the transfer. The use of the launch pulley also keeps the belt cleaners as close as possible to the receiving conveyor which maximises the fines chute valley angles. In other applications there has been a reduction of the head pulley IP offset to maximise fines chute valley angles.

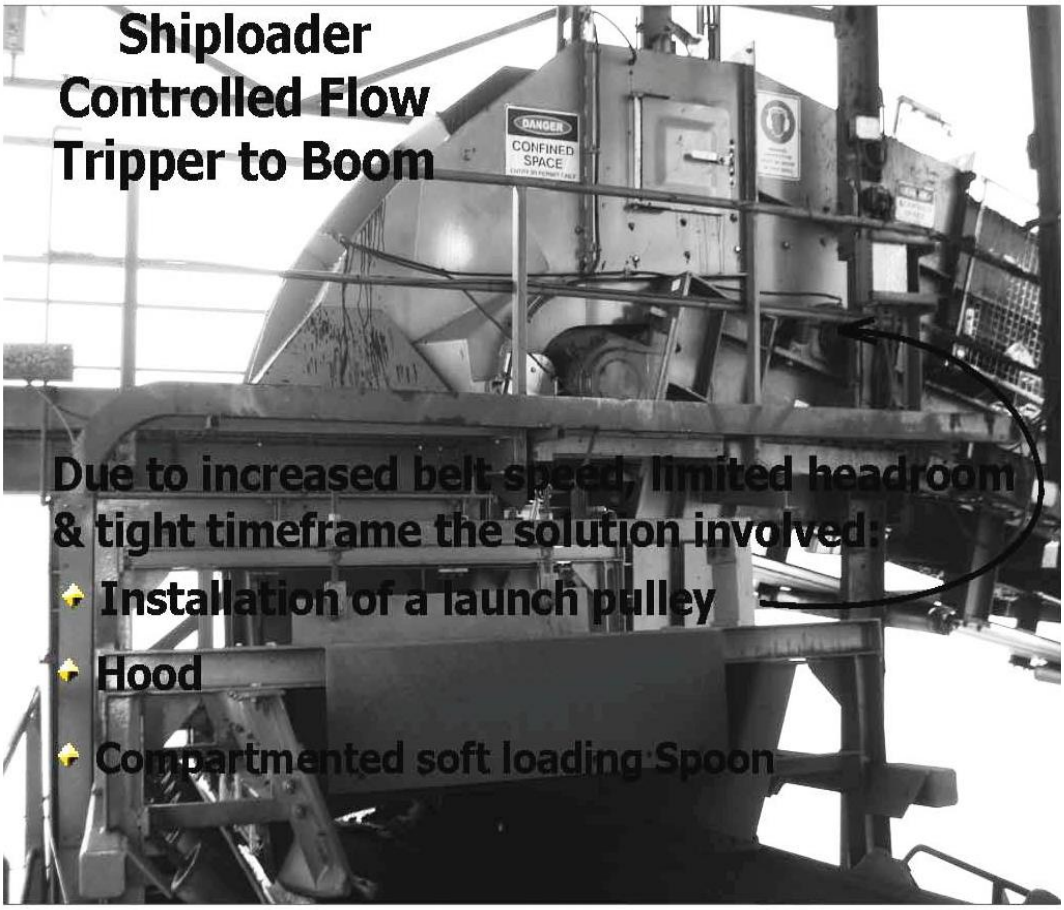

Figure 10. Shiploader, controlled flow, tripper to boom

After the installation of the controlled flow solution the rate was immediately stepped up to 6000 tph. This resulted in a reliable 6000 tph throughput rate coupled with central and soft loading of the boom conveyor, thus eliminating the boom conveyor tracking problems. The chute systems were replicated on both existing shipping streams so that the 6000 tph capacity upgrade of the existing shipping streams was reached.

5. THIRD SHIPLOADER AND ASSOCIATED THIRD SHIPPING STREAM CONVEYORS

5.1 Third Shipping Stream Conveyors

There was concern that the other transfer system designs might also be defective and not meet the performance requirements. A specialist consultant in materials handling and plant optimisation was engaged, who had extensive experience in controlled flow chute application to review the transfer chute designs.

To maximise shipping flexibility, each stockpile reclaim conveyor had to be able to deliver to any of the three shipping streams. Before the third shipping stream this was a relatively simple system which comprised a hood feeding a two way pivoting diverter which in turn fed intermediate and spoon chutes.

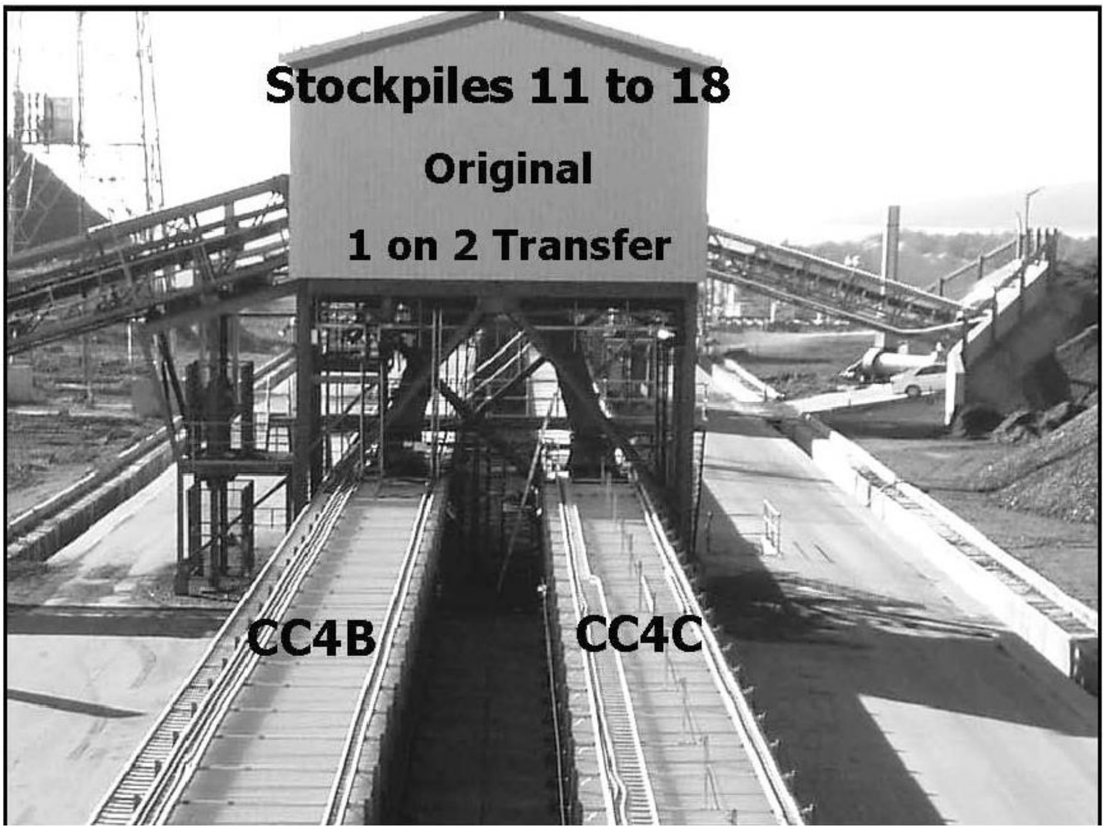

Figure 11. Typical reclaim conveyor to Shipping streams 1 and 2 yard conveyors (typical of Stockpiles 11 to 18/Stockpiles 1 to10 similar)

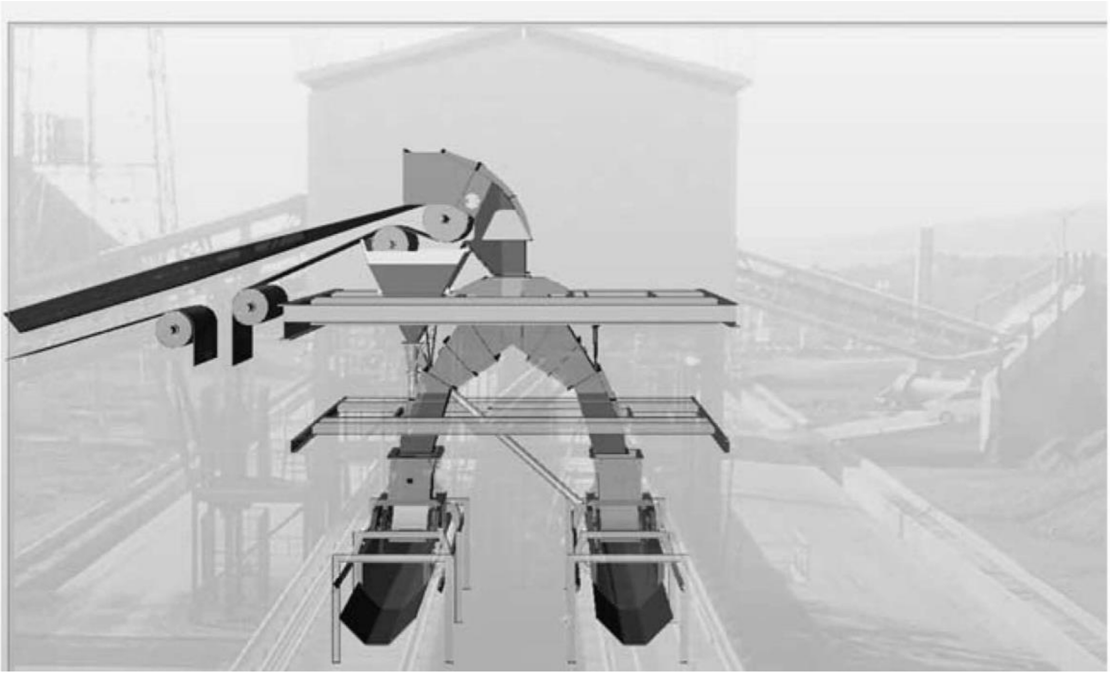

Figure 12. Typical reclaim conveyor to Shipping streams 1 and 2 yard conveyors, chute details

Of great concern was the design of the third shipping stream conveyors which had to be integrated alongside the two existing shipping streams that serviced Stockpiles 1 to 18. The RGTCT is different from most other coal terminals in Australia because its customers pay not only for cargo handling, but also dedicated stockpile capacity. As a result, there are a large number of stockpiles, each with its own underground reclaim system and conveyor. Each stockpile reclaim conveyor rises from underground at 90 degrees to the yard shipping stream conveyors. Each yard shipping stream conveyor is dedicated to a particular shiploader.

During the design stage it was decided that the third shipping stream yard conveyors be located on the roadway next to one of the two existing conveyors. However, in this location the chute angles from the head of the existing stockpile reclaim conveyors to the third shipping stream yard conveyor were too shallow to transfer the coal.

The solution was to provide a short slew conveyor with its pivot point under the discharge of the stockpile reclaim conveyor hood. Due to the limited space between the columns of the existing transfer towers, the slew conveyors had to be narrow to provide the necessary slew angles to reach across all three shipping stream yard conveyors. CC4D is the third shipping stream conveyor servicing Stockpiles 1 to 10 and CC4E is the third shipping stream conveyor servicing Stockpiles 11 to 18. In all, 18 slew conveyors were required.

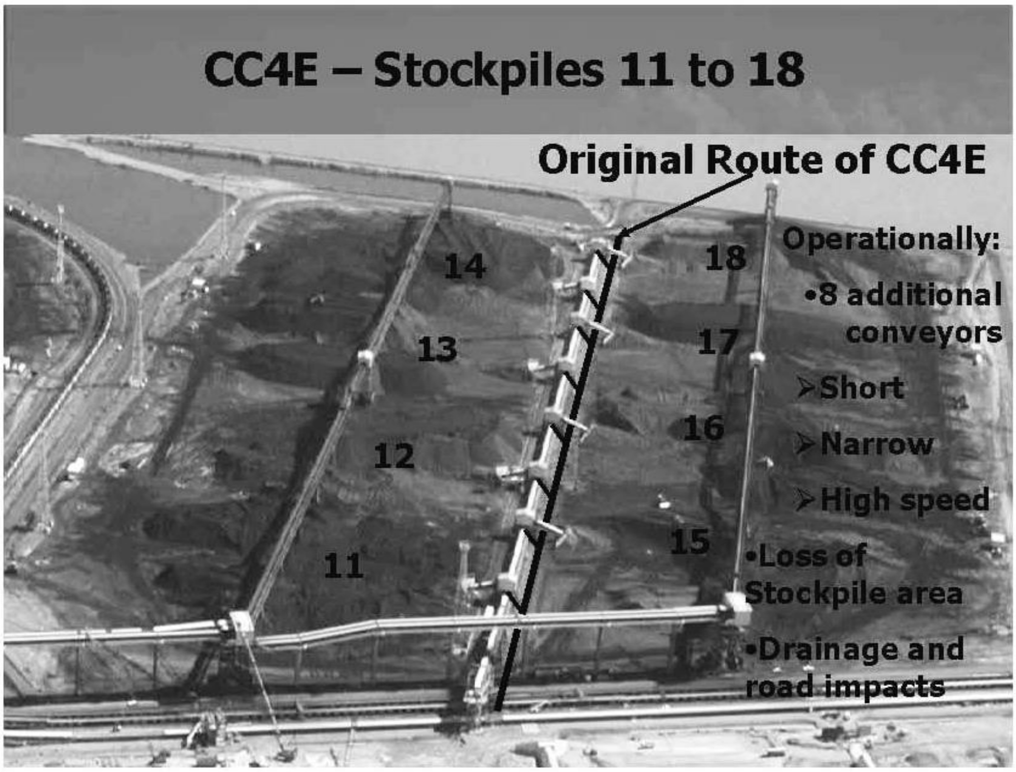

Figure 13. Third shipping stream CC4E - proposed location for Stockpiles 11 to18 (CC4D for Stockpiles 1 to10 similar)

This solution created many operational problems. Firstly, to convey the required tonnage rates on 1 500 mm wide slew conveyors meant that they would be running at high speed. Secondly, the slew conveyors were relatively short, so there would be a high on-going belt replacement regime. Thirdly, the slew conveyors were not completely rigid and relocation from one shipping stream to the next would likely result in some distortion during the slew process, probably creating alignment problems that would exasperate the expected belt tracking problems of short high speed conveyors. Furthermore, these operational issues would be repeated 18 times.

Operationally, once a new vehicle access roadway was constructed beside CC4D/CC4E, the existing drainage system would have to be rebuilt, which would then encroach the stockpile pads thus reducing the highly valuable commodity of stockpile capacity.

During the specialist consultant's review of the proposed design, an alternate route was identified, the viability of which was assessed. This then placed the third shipping stream yard conveyors above and between the two existing shipping stream yard conveyors. The review of this alternate route confirmed that a viable controlled flow solution could be provided.

To confirm the feasibility of constructing the alternative third shipping stream yard conveyor routes, it was necessary to develop conveyor structural and mechanical design.

The specialist materials handling consultant worked with an Australian-based multidisciplinary engineering firm that specialises in materials handling machines and structural integrity. At the completion of all reviews it was confirmed that the proposed alternate routes were viable from all design disciplines. At this stage however, the following had already been completed:

- Detailed design of the original CC4D and CC4E routes
- Foundations poured for the 18 slew conveyors
- All long lead items ordered (MCCs, drive units, pulleys) for the 18 slew conveyors
- The first slew conveyor to stockpile 18 installed

- $3million committed to the original concept.

The structural design of the new third stream conveyor galleries picked up on the foundations that had been poured for the slew conveyors to minimise the in-ground construction and to minimise any further foundation costs.

The alternate routes were reviewed in detail with the project director, explaining the benefits of the alternate routes. There was however, a major drawback in that the alternate routes would take longer to deliver than the original concept which had been approved and was progressing well.

Taking the correct and long-term view, the alternate routes for CC4D and CC4E were approved. In doing so, this:

- Saved in excess of $7 million compared to the original design
- Made 18 slew conveyors redundant
- Negated the maintenance and operational issues associated with the slew conveyors
- Maintained stockpile capacity
- Left existing road and drainage systems in place.

Figure 14. Third shipping stream CC4E, alternate location for Stockpiles 11 to18

For this space-constricted transfer system to work, a rotating spoon diverter was used, allowing coal stream discharging from the stockpile reclaim conveyors' hoods to be directed into any of the three shipping streams. Due to the no-contact design of these diverters, this rotating spoon diverter is driven by a 0.55 kW gear motor.

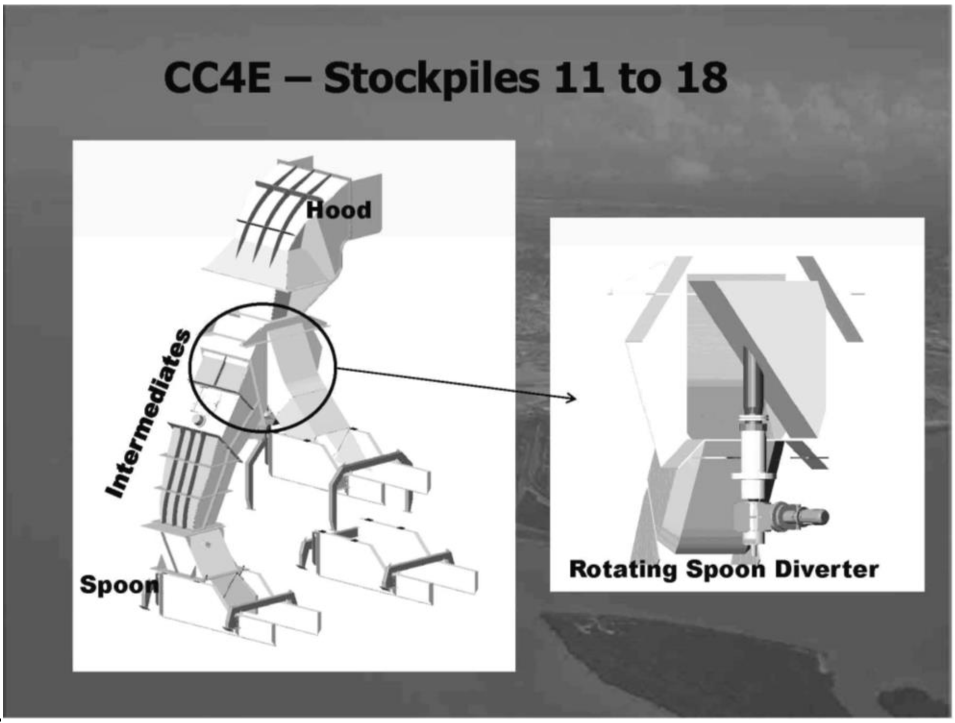

Figure 15. Third shipping stream CC4E, alternate location rotating diverter

Figure 16. Typical third shipping stream CC4E transfer tower

5.2 Third Shiploader

After the issues experienced on the 6000 tph upgrades to the two existing shiploaders, a redesign of the elevator to boom transfer for Shiploader 3 was requested. This transfer was different to Shiploaders 1 and 2 in a number of ways.

Firstly, Shiploader 3 was designed with an elevator conveyor instead of a tripper to the wharf conveyor. This created a number of additional design difficulties. The elevator conveyor was wider and slower than the wharf conveyor. Being independent from the wharf conveyor with a significant lift, the elevator conveyor would stop more quickly than the longer, faster lower lift wharf conveyor. As a result of this, the elevator conveyor had to be driven on during loaded stop events as there was insufficient height available at the wharf-to-elevator transfer to provide sufficient capacity to store the differential stopping time volume. This in turn meant that this differential stopping time volume had to be delivered to the elevator-to-boom transfer.

Secondly, given the span of the shiploader superstructure, the elevator was an independent structure with no physical linkage to the shiploader superstructure. The measurement and control systems between the elevator and the shiploader superstructure could result in a misalignment of approximately 200 mm.

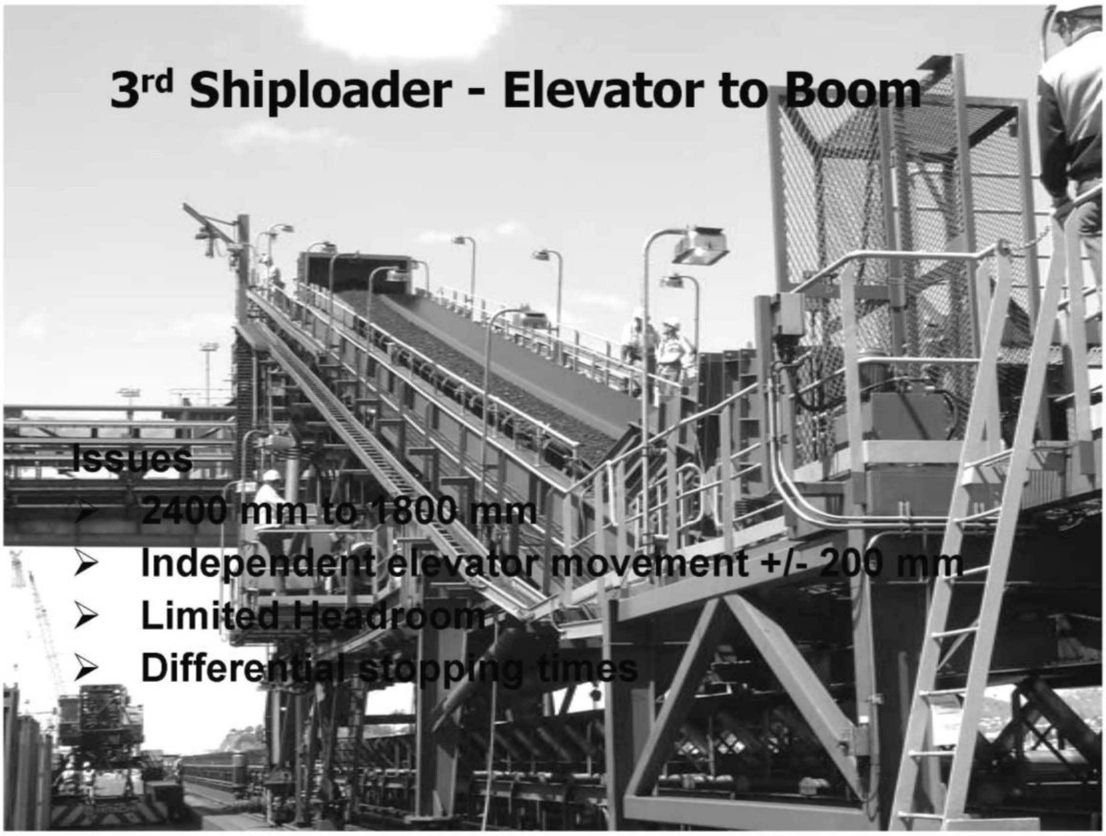

Figure 17. Third shiploader, elevator to boom

Again, at this transfer, a launch pulley was used to provide the benefits as described for Shiploaders 1 and 2. The differential stopping time volume that needed to be catered for at the elevator-to-boom transfer was 18 m^3. This volume of coal created significant concern, not only in how to provide the volume that would self-fill to contain it, but also the profiling of this contained material on start-up, and the loads applied to the boom conveyor.

The designed solution included a surge box with transitional/stepped profile plates that would roll the contained coal on itself whilst the lower section of the contained coal was profiled to the belt capacity profile so that it did not spill from the boom conveyor on its way to the loading chute.

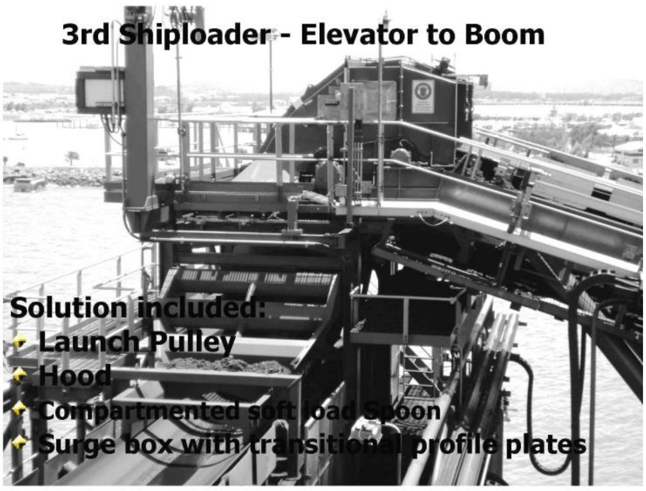

Figure 18. Shiploader 3, elevator to boom transfer

The surge box was deliberately left open to prevent the coal wedging and placing additional loads on the boom conveyor drive. The transfer was successful and the trailing of the surge box was a precise commissioning activity where it was manually filled by driving the elevator onto a stopped boom conveyor. The transfer system provided central and soft loading of the boom conveyor and performed reliably in service.

Figure 19. Shiploader 3, elevator to boom CAD Image

6. STOCKPILES 19, 20 AND 21 RECLAIM

The next area of the expansion that required review was the reclaim conveyors from the yet-to-be-constructed Stockpiles 19, 20 and 21. The stockpile earthwork foundations were all but complete when the chute design review was conducted. Like the other stockpiles on site, there was an elevating underground reclaim conveyor for each stockpile. This time however, these new stockpiles were adjacent to the three shipping stream jetty conveyors and not the yard conveyors. As such, these new stockpiles would load directly onto the shipping stream jetty conveyors. It had been decided that a service/wharf access road would be positioned between the second and third stream jetty conveyors which resulted in 15.3 metres between the centres of the second and third jetty conveyors. This made a one-on-three diversion system impractical. It had already been determined by the engineers that a fixed trip would be positioned in the reclaim conveyor that would either deliver coal to the third stream jetty conveyor or back onto itself for transfer to a head chute over the top of Streams 1 and 2 jetty conveyors.

Figure 20. View of Stockpiles 19 to 21 reclaim towers from service road

The review of the engineer's layout identified that insufficient height had been provided at the transfers to allow for simple controlled flow diversion systems to be used, and that the receiving shipping stream jetty conveyors would have high impact loads and minimal stream speed in the direction of belt travel. It was confirmed that a controlled flow design solution was required for these stockpiles' reclaim conveyors. Two ways to achieve this were to increase the reclaim conveyor incline angles to 18 degrees, or to move the stockpile further away from the jetty conveyors.

Neither of these options was desirable given the advanced state and cost of stockpile earthworks and reclaim tunnel design. The solution was to utilise its lowest head height requirement diverter, the rotating hood diverter, along with increasing the reclaim conveyor inclination angle from 15 degrees to 16 degrees. This meant that the stockpile could remain as originally situated, and the existing tunnel design could accommodate the 16 degree inclination.

The rotating hood diverter was the lowest head height requirement diverter as the diversion starts immediately the stream discharges from the incoming head pulley.

Figure 21. Typical Stockpile 19 to 21 fixed trip rotating hood diversion transfer

Figure 22. Rotating hood diverter

The rotating hood diverter (Figure 22) delivers the coal stream onto the third stream jetty conveyor shown in the foreground of the photograph. When the fixed trip rotating hood is actuated forward it delivers the coal stream back onto itself via the through loading spoon for transfer to Tower A located above Stream 1 and 2 jetty conveyors.

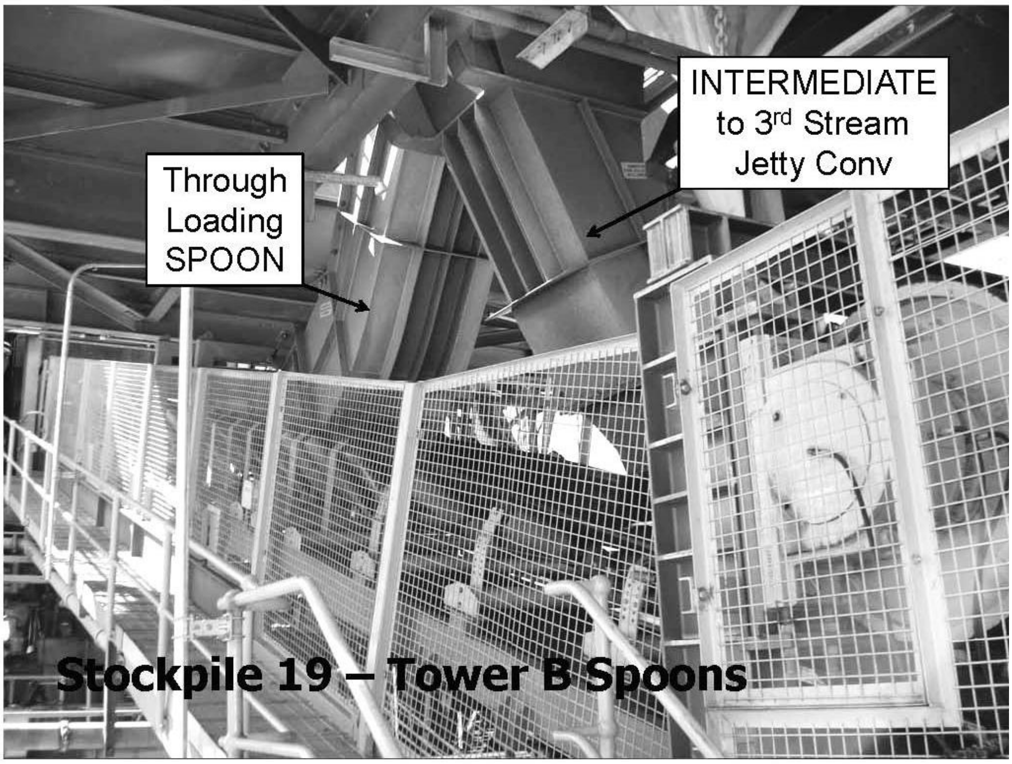

Figure 23. Stockpile 19, Tower B spoons

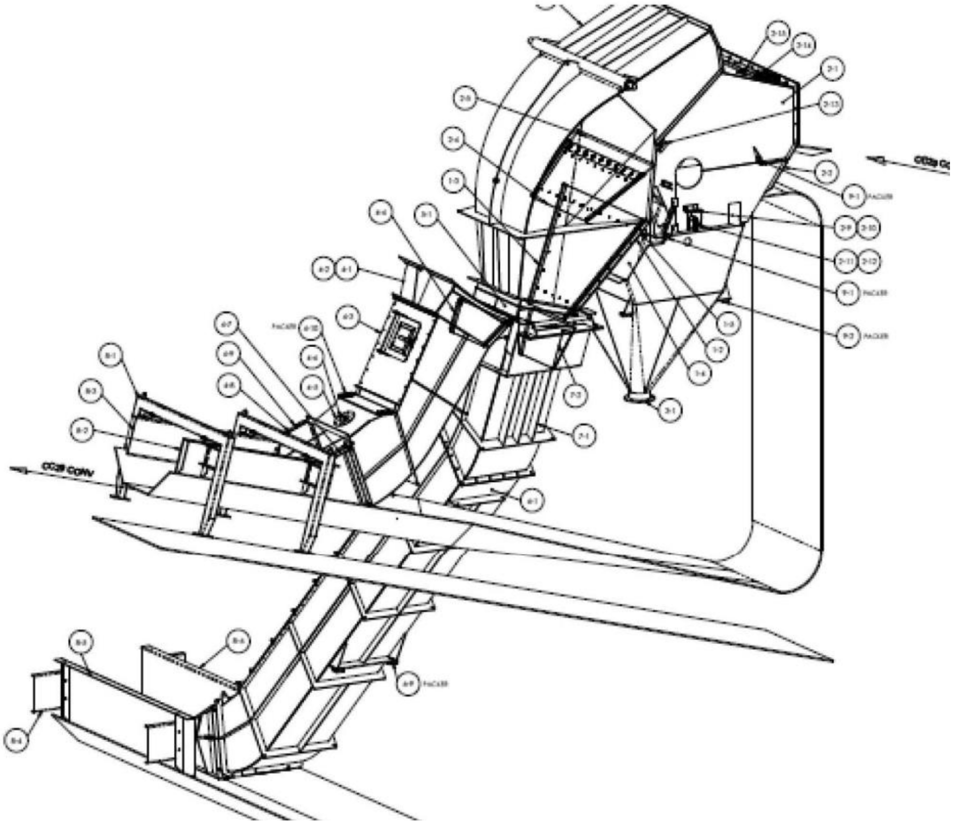

Figure 24. Tower B, rotating hood diverter, fixed trip

At the drive head of the reclaim conveyor is another rotating hood diverter that delivers the coal stream to either the Stream 1 or the Stream 2 jetty conveyors.

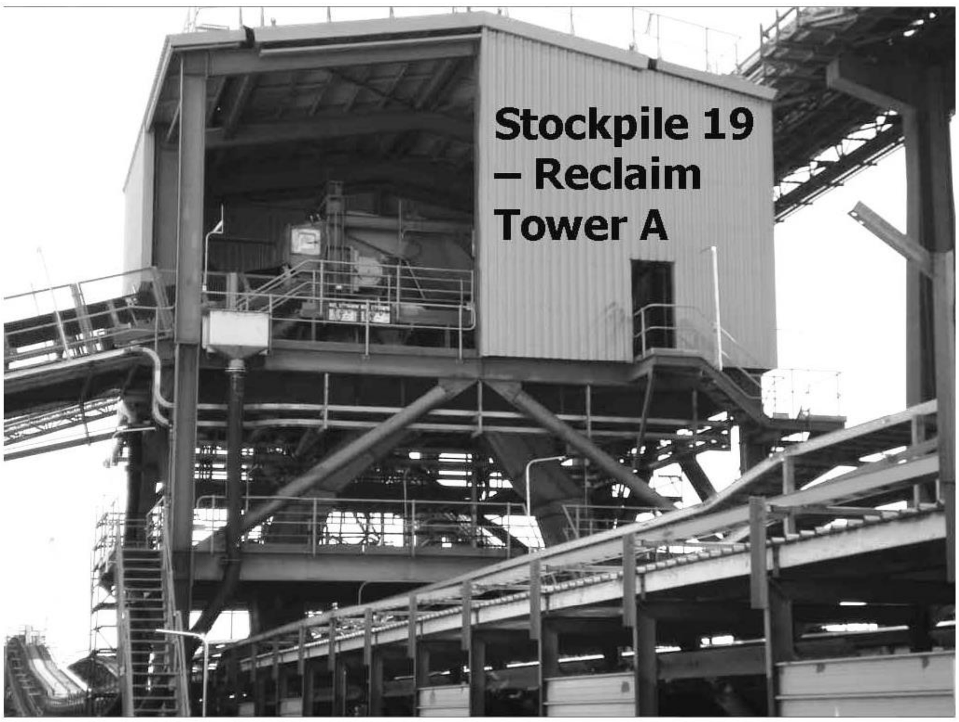

Figure 25. Stockpile 19, reclaim tower

At Tower A the rotating hood diverter delivers the coal firstly to intermediate chutes which transfer the coal streams to their respective spoon chutes which in turn load the jetty conveyors.

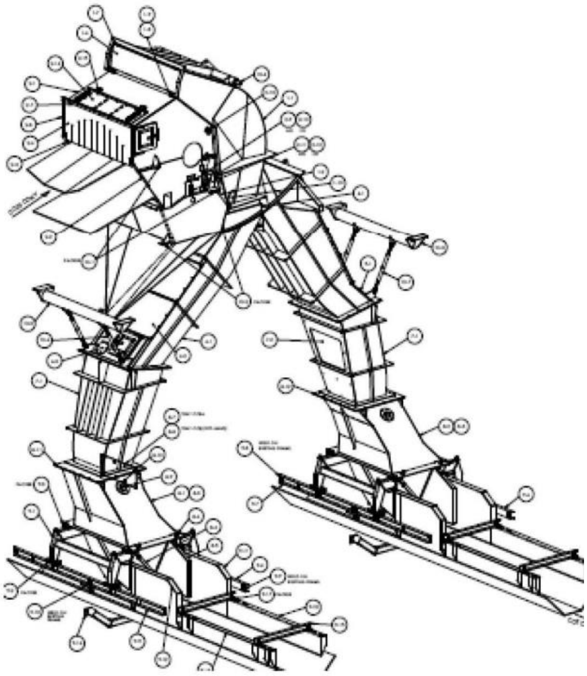

Figure 26. Tower A, rotating hood diverter, drive head

7. STOCKPILES 19, 20 AND 21 INLOADING

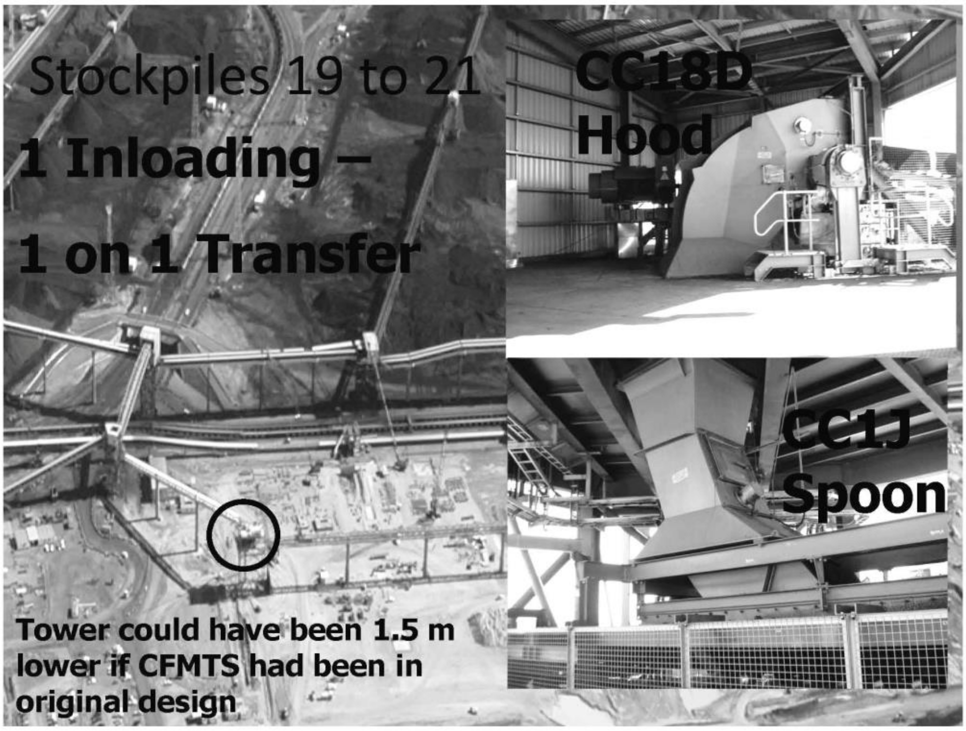

Figure 27. CC18D to CC1J transfer

In the review of this simple one-on-one transfer, a properly designed controlled flow transfer could have easily been installed with 1.5 metres less head room than provided for by the engineers. Construction was well advanced so this saving could not be realised. This in isolation is not a major issue, but if this over-provision occurs across the whole plant then substantial and on-going energy costs and carbon footprint issues exist. In one greenfield coal terminal review, the application of the controlled flow technology yielded a net 27 metre lift height reduction. For a 60-plus million tonne per annum plant not having to unnecessarily lift 60-plus million tonnes of material 27 metres each year is a substantial cost saving.

8. APPLYING CONTROLLED FLOW TECHNOLOGY

In the application of the technology, a consistent staged approach is followed. The fundamental step in any design process is the gathering of data necessary to process through to an output. Data is entered either via an input screen or directly into the 3D CAD package which is bi-directionally linked to the design program. This creates a 3D environment for the designer to work within and the necessary inputs for the design logic to proceed. All transfers start from a launch point, be it the head pulley, crusher rolls or feeder discharge. The trajectory path is plotted and there is then a known moving material stream to collect. The input fields are basic conveyor information as well as the set out difference between the feeding conveyor and receiving conveyor/s and/or equipment.

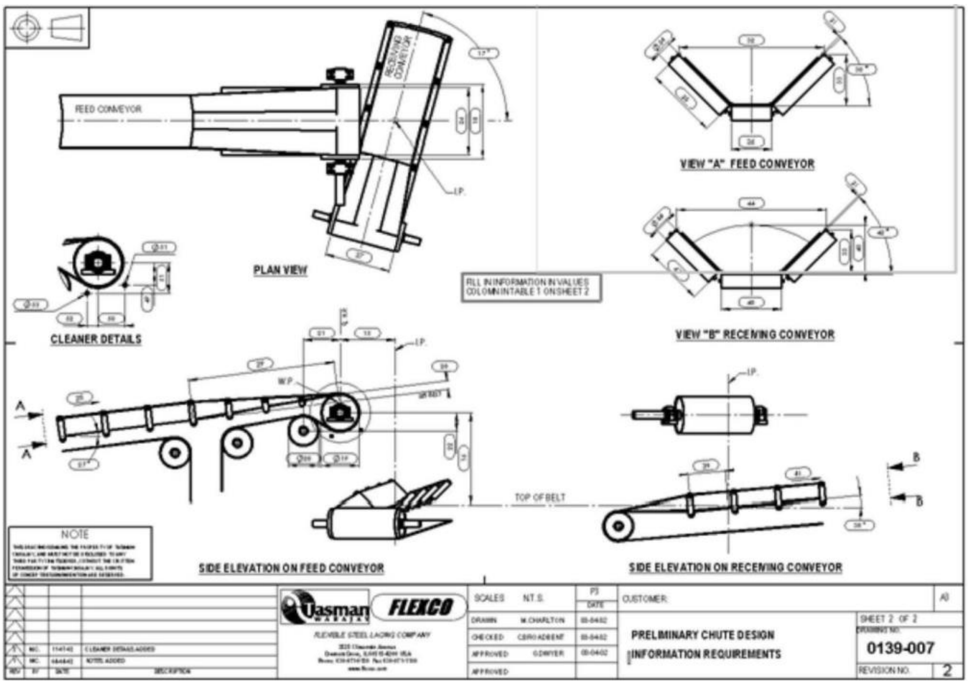

Figure 28. Typical data sheet specifing input geometry

After the data is input, the conveyor model is generated. At this stage the prime concern is the relationship between the conveyors and equipment.

Figure 29. Typical conveyor model

Using an internally developed variation of the CEMA trajectory equations, a 3D material trajectory model is generated.

Figure 30. A 3D material trajectory model

The objective of the controlled flow design process is to collect the stream as soon as practical and guide the material through low impacts to the desired discharge point. The design process maintains a suitable stream velocity that is neither too low nor too high. Low stream velocities risk stalling and causing the transfer system to block. Too high a stream velocity can lead to premature liner wear, material degradation or dust generation. Generally the point of discharge is a receiving conveyor, but may be a surge bin, ship hold, stockpile, crusher, screen and so forth.

The controlled flow design is fundamentally a set of rules and logic which determines the optimal result within the constraints of the project geometry. Several software packages are used in this process including our own software package which was developed from a desire to increase speed and reduce potential errors. Utilising this software affords the opportunity to optimise designs to a level that would previously have been impractical due to the amount of iteration required. This also allows for more complex designs to be analysed and developed with confidence.

The designer then returns to the physical environment to firm up on some of the constraints that may affect the design of the transfer system. The approach is to first identify the best material flow path without being constrained by structural concerns. After determining the best material flow path, any barriers to implementing this flow path are identified.

It is generally felt that in a materials handling plant, it should be the materials handling requirements that drive the structural design. In existing plants, after identifying the constraints, the feasability of structural modification to allow the preferred flow path to be implemented is investigated. It is only after all practical opportunities are exhausted that the material flow path design is reworked to fit around the structure.

Once the final 3D material flow path is confirmed, work commences on the detailed design of the liners and supporting platework and its integration with the mechanical equipment. This results in a total 3D model of the transfer system from which platework details and other manufacturing data is developed.

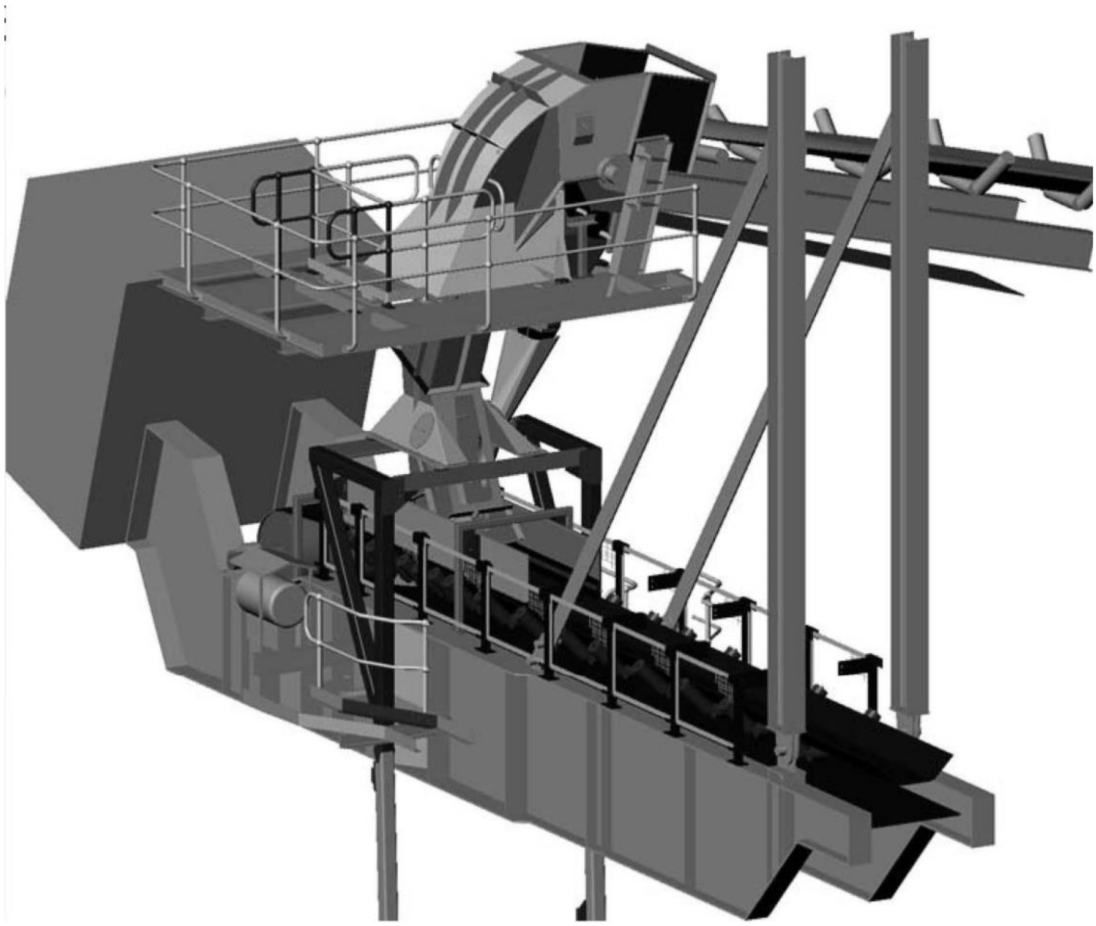

Figure 31. Typical complete 3D model of tripper-to-boom transfer

9. CONTROLLED FLOW TECHNOLOGY RESULTS

Over the 25 years of the application of controlled flow technology, some impressive and quantitative results have been recorded. The following results have been demonstrated in actual installations.

9.1 Belt Cover Wear Reduced by 3.6 Times - RGTCT

In this case study, one of two identical shiploaders had its tripper-to-boom transfer chute replaced with a properly designed hood and spoon. After 60 million tonnes through the transfer, the belt cover wear rates between the two shiploaders were compared and it was determined that the wear rate on the properly designed controlled flow transfer was 3.6 times less than that of the conventional transfer. (Appendix 1).

9.2 No Reported Chute Maintenance and Tile Wear <1 mm after Nine Years

In this case study, the 1CP to 7AP transfer was replaced after nine years of operation because of a plant upgrade. The spoon chute was returned for testing and a tile wear of less than 1 mm on average was recorded. No record of chute maintenance could be provided from the site's maintenance management system, and from the appearance of the chute no maintenance had been performed. The site advised that approximately 130 million tonnes of coal had been transferred by this chute during the nine years of use. (Appendix 2).

9.3 <2.1dB(A) Average Noise Increase from Empty to Loaded

A client requested data on noise generated by controlled flow transfer chutes as noise was an operational concern. To provide this data a NATA registered company was commissioned to conduct tests on an overhead tripper transfer. The tripper transfer was selected because it did not have an associated drive which would add to any noise generated by the chute itself. The noise levels adjacent to the chute were measured with the transfer running empty and at 6000 tph. An average noise increase of <2.1dB(A) was recorded with a maximum increase of 2.4dB(A). (Appendix 3).

10. CONCLUSION

This case study of the RG Tanna Coal Terminal expansion demonstrates that the application of advanced controlled flow technology delivered many benefits to the operator:

- Increased throughput
- Increased reliability via the utilisation of chutes instead of multiple conveyors
- Improved plant layout and operability
- A significantly less complicated plant with 18 less conveyors than original design
- Capital savings of over $7 million
- Reduced on-going maintenance.

It has been observed that general engineering design practices either don't provide appropriate belt separation or IP set outs to allow for reliable controlled flow transfers to be fitted, or build in far more height than necessary to ensure that a transfer can be made to work.

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After graduating as a mechanical engineer, Bernie worked in a range of project, maintenance and operational roles at Collinsville, Curragh, Gordonstone and Gregory coal mines with most of this time spent involved with the coal handling and preparation plants.

In 1998 he joined Queensland Sugar as their Engineering Manager for the seven bulk sugar terminals, later adding the operational management responsibilities for Bundaberg and Brisbane bulk sugar terminals to this role. During his time with Queensland Sugar he was responsible for delivering the Mackay Shiploader Project and the 400,000 tonne storage shed at Townsville.

After working as Unloading Maintenance Superintendent at RG Tanna Coal Terminal, Bernie joined Tasman-Warajay as Managing Director in 2005.

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