Efficient Transfer Chutes - A Case Study

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Transfer chutes provide an important link between two conveyor belts and most often incorporate a change in the materials direction of flow. Many older transfer chutes were designed using the typical 'rock box' design or simple flat plating from the inlet flange to the outlet flange. This often results is a noisy and dusty transfer point that invariably causes material attrition, unpredictable chute wear, receival belt cover wear, impact damage and poor receival belt tracking. The use of modern bulk material concepts, in conjunction with advanced Computer Aided Design (CAD) software, with modern wear resistant materials enables transfer chutes to be more efficiently designed. This involves redirecting the momentum of the incoming bulk material stream to maintain the stream velocity without material degradation or receival belt difficulties. This paper will highlight some of the design aspects considered in the design of several pre-wash ROM coal transfer points located in the Hunter Valley region of New South Wales, Australia. Some qualitative post installation results of the installation will be discussed including estimation of chute life with the current design.

INTRODUCTION

The transfer chute replacement program instigated at Hunter Valley Number one coal preparation plant (HVCPP) was undertaken to reduce the plants down time due to the blockage of several key transfer chutes. The plant itself consists of the typical older design for transfer chutes where the incoming material impacts into a flat plate, from which the material is intended to fall onto the receival belt via some steel chute work. This design philosophy has several drawbacks when handling a cohesive, friable material such as ROM coal. These problems include the following:-

- Material attrition
- Adhesion of material to the impact plate and headchute areas
- High chute wear due to impact of the falling stream
- Material build up in the transfer corners due to poor design detail
- Belt mistracking due to feed material containing significant transverse momentum
- Belt wear due to the need to accelerate material in the direction of flow.

This paper explains some of the deficiencies of the older style transfer chute and the advantages of the Tunra designed chute. A section on the post installation problems indicates that there is some small improvements that can be done to further enhance the flow of material through the TBS transfer chutes which otherwise have performed well.

THE TYPICAL S^3 TRANSFER CHUTE DESIGN

The existing transfer point design used at HVCPP can be thought of as an S^3 transfer point, which is common in many plants of similar age. The S^3 transfer point means that the material is <u>Stopped</u>, allowed to <u>Spread</u>, then the material <u>Stalls</u>. In the stopping process, against a flat impact plate, the material suffers attrition as particles with momentum collide with stationary particles or directly against the impact plate. This attrition can be costly in materials were the fines content is removed, such as coal.

After the initial impact, a portion of the material will be in a stalled situation on-top of the incoming stream. There will also be material projected laterally into the corners of the head chute as there is typically no spreading constraint. This material that is projected outwards from the stream subsequently impacts into the corners of the head chute where the additional boundary friction will cause the material to adhere. The stationary material, once adhered to the surface will begin losing moisture content to the environment which, with some materials, can result in a significant increase in the materials bulk strength. The increase in strength coupled with an increasing deposition of stalled material can lead to a blocked transfer point. Blockages that are induced from material drying and setting in the transfer can require significant effort to clear.

Once the material has been stopped by the impact plate it is normally required to free fall a short distance before impacting onto the directional area of the chute. The directional part of the chute is normally intended to achieve a number of tasks. These include dust control, transferring the bulk material across to the center line of the receival belt and provide central loading. The results of a transfer point such as that shown in Figure 1 is belt mistracking, it should also be noted that with this particular transfer point their was a large amount of material segregation across the belt. The segregation problems on this belt have lead to difficulties in the washing process as one screen is fed coarse material whilst the other is fed predominantly fines.

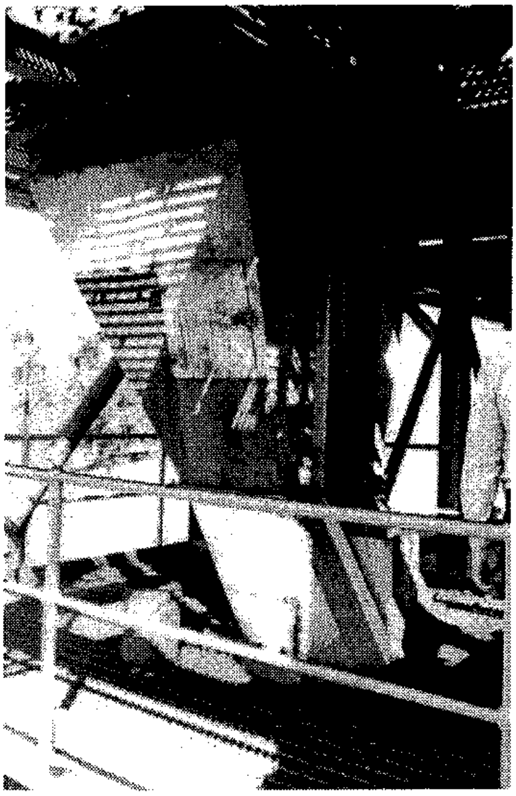

Figure 1 - Original Style transfer station

This style of transfer point is normally constructed from a mild steel material upon which patch plates can be welded once a wear hole has formed. This process results in surface imperfections upon which material build up is promoted which increases the probability of blockages.

In the figure shown the material enters from above with the feed conveyor moving from right to left. The angle of the lower section continues through the floor discharging onto a belt moving from the lower left of the page to the upper right. This results in a significant amount of mis-tracking and segregation of the material.

THE TUNRA "C^4" TRANSFER POINT PHILOSOPHY

There is increasing awareness in the Bulk Solids handling community of the benefits obtainable with careful design of transfer point both in terms of reliability of material flow and quality of the product after the transfer point. The Tunra (and others) concept is to Catch the material stream as it enters the transfer point, Curve and Concentrate the stream before loading the material Central onto the receiving belt. In short the material is controlled throughout the transfer operation. To facilitate this process a number of winged, curved plates are used throughout the transfer station. For simplicity the transfer can be broken down into two components, this process is used in the design of the transfer chutes. The first section of the transfer is the catch area, the second in the load-out area.

The first plate is used to catch the top of the incoming stream of bulk material at a low incidence angle ($<15^0$) after which, the catch plate simultaneously curves and concentrates the stream of material. The reason for the concentration of the stream in two fold. First, it provides a more compact stream to catch with the following loading spoon. Second, it is known that most bulk materials exhibit a higher wall friction angle at lower normal loads, as such, increasing the bed depth of material will reduce the effective wall friction angle. This reduction in wall friction can be used to flatten the discharge angle of the stream of material, reducing belt impact wear. Figure 2 shows a wall friction result for a cohesive bulk material on a typical wall material, it can be clearly seen that as the normal load decreases, the wall friction angle increases dramatically.

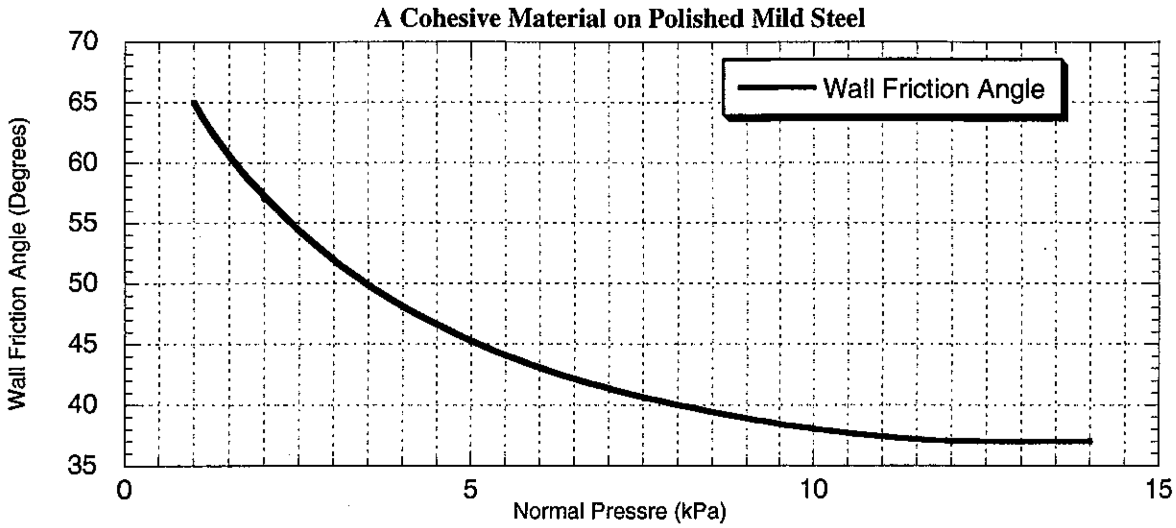

Figure 2 - Wall friction angle verses normal load

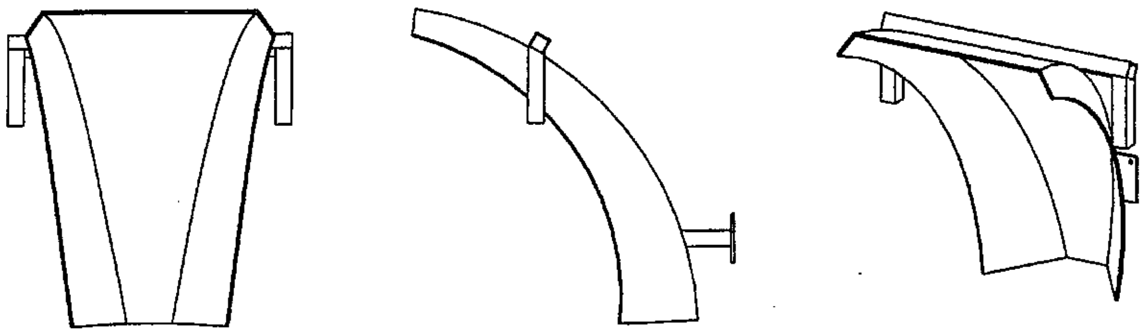

Figure 3 - Typical catch plate

After the material has been caught, concentrated and re directed, the second stage of the transfer chute is used. This stage is required to accept the incoming stream of material and accelerate it along the direction of the receival belt. At the same time as accelerating the material it is vital that the material be loaded central onto the receiving belt to optimize the tracking performance. Our terminology used for this section of the transfer station is a loading spoon, a typical loading spoon is shown as Figure 4.

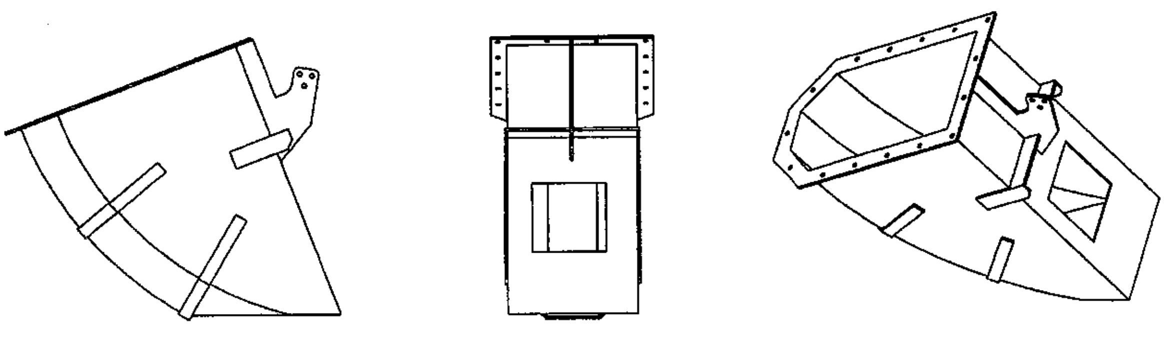

Figure 4 - Typical loading spoon

REVIEW OF THE FIRST INSTALLED TRANSFER POINT AT HVCPP.

The scope or work undertaken at HVCPP by TUNRA Bulk Solids involved the redesign of five transfer points. Three single belt to single belt transfers and two bifurcation's. The first transfer point to be modified was a single belt transfer incorporating approximately an eighty five degree angle change. The infeed material was supplied from a variable speed belt feeder withdrawing material from a 2000 tonne surge bin. The maximum velocity of the infeed material was approximately 400 mm/sec with a minimum velocity of 75 mm/sec. This represented the first design difficulty in catching the stream of material from the feed belt such that it could be concentrated. Once this stream had been captured and reduced in width, the stream drops on to the loading spoon which in this case formed the major structural element of the transfer point. It can be seen from Figure 5 that the loading spoon itself consists of a mono-directionally curved floor, in this case manufactured from 5 on 8 smooth overlay dua-plate. Adjacent to the floor is two fillets which form an angle of forty five degrees to the floor of the spoon. Atop the fillets, are vertical walls leading to flanges which were required for change out reasons. This transfer chute was originally designed with the loading spoon in one section but at the request of the HVCPP was altered to three sections. To ensure that no ledges could be possible at the joins, a taper was introduced into the individual sections such that the vertical walls were ten millimeters closer at the outlet compared to the inlet. This taper was prorated in the floor and the wing fillets. This alteration made the development of the fillets slightly more difficult to ensure that a high quality fit was obtained during manufacture.

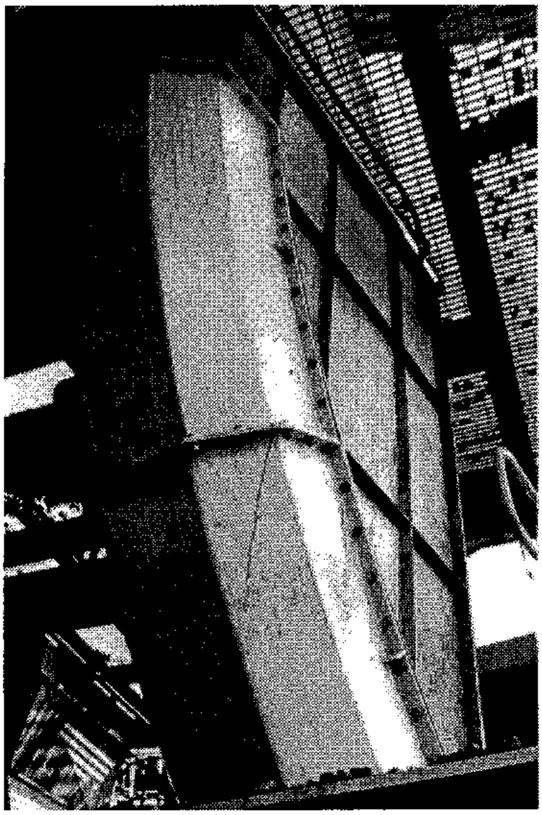

Figure 5 – Installed transfer point – as designed

Commissioning of the transfer point

There were no design flaws that could be identified at the completion of the detail design stage and the manufacture of the chutes was let to tender. The successful tender sub-let the manufacture of the loading spoons to another manufacturing group. Problems arose in communications between the principle contractor and the sub-contractor which resulted in the chutes being manufactured geometrically different to the designed items. It was later determined that the material used for the construction was also different from the design specification. These two aspects and failure to have the transfer inspected prior to installation resulted in the transfer chute blocking after only a small quantity of material had been passed. This blockage required many times the effort of the other chutes to clear.

At this stage, Tunra Bulk Solids were called to determine what had caused this chute to block, which was evident from some distance. The reader is directed to Figure 6 which shows a cad representation of the as designed and the as installed loading spoon.

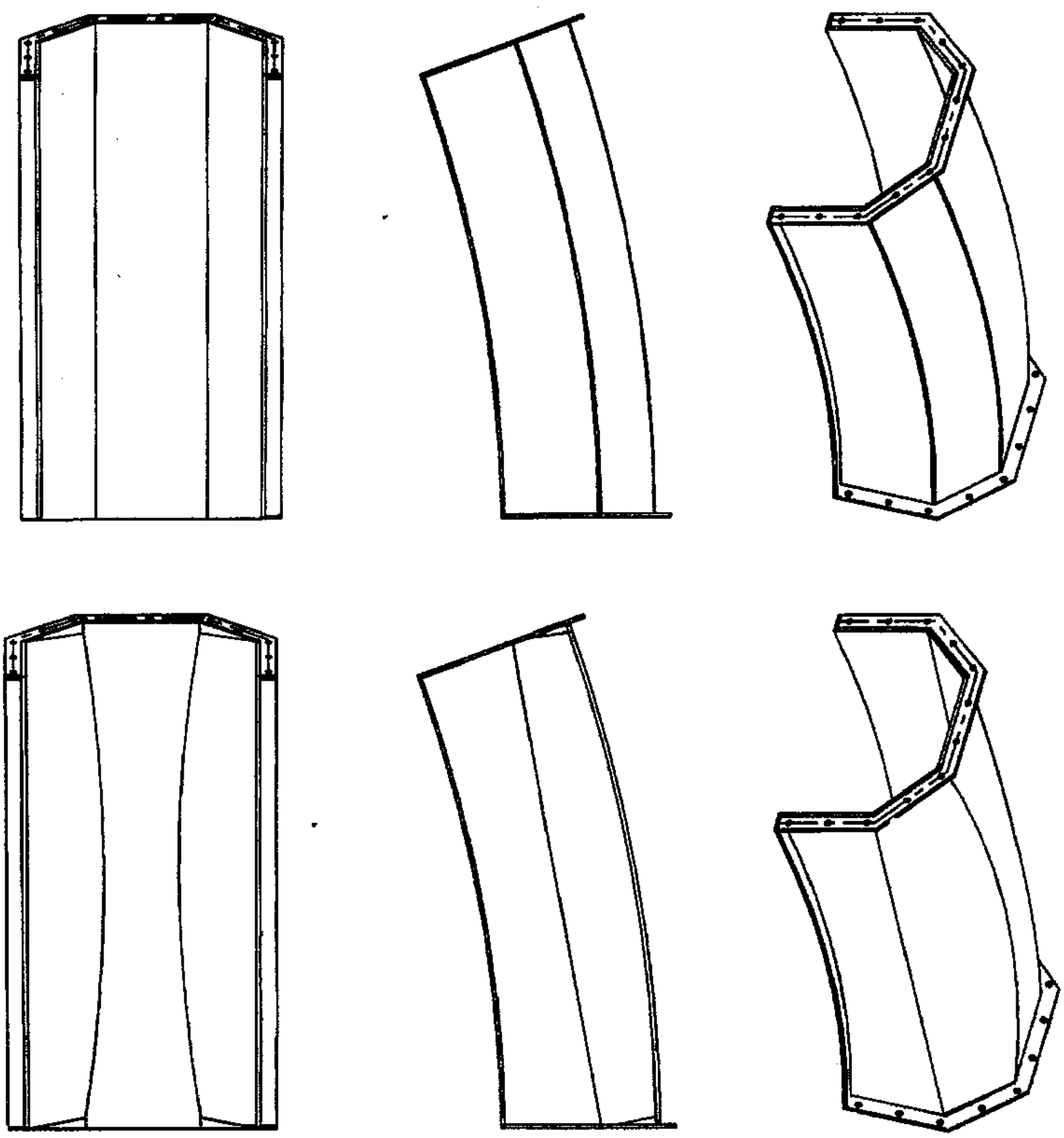

Figure 6 - As designed (Top) and as originally installed (Bottom)

With the error in manufacture identified, a second set of loading spoons was ordered which arrived again made from the incorrect grade of material. The incorrect grade of material had a surface friction far in excess of the design requirements. This resulted in a third set of spoons being ordered after some attempt had been made to polish the surface of the second set of spoons. The third set of spoons arrived manufactured from the correct grade of material and after some buffing work reached a sufficiently smooth state for installation.

The initial running of this chute resulted in a blockage after approximately three shifts of operation with a steaming coal which compared favorably to the two blockages per shift for several of the other transfer points dealing with the same material. Tunra personnel were again approached to determine what, if any, course of action was required to reduce or eliminate this remaining blockage problem. Observations from site indicated the material was impacting at a position much lower in the loading spoon than originally anticipated which was resulting in a larger than expected bow wave behind the main stream of material. This material built up, eventually blocking the flow path. Several conceptual solutions were discussed including the following:-

- A flexible rubber membrane that the material could not adhere to due to the vibrations induced from the flow of material,
- An externally mounted vibrator which was to be cycled on for short periods of time
- A water curtain to continuously wash any material from the surface and prevent the drying of stationary material.

From these, the first was discounted as a maintenance problem. The vibrator was considered and the mounts, controls etc were designed, however, concerns over structural fatigue, effectiveness and reliability when compared to the water curtain approach placed the vibrator as a second option. The water curtain method involved a solenoid controlled valve, such that the flow was able to be switched from a control center. The water was spread across the chute via a distribution pipe fitted with three 1.5mm nozzles. The addition of water to the material was not a concern as the material from this transfer was directed into the washery. The quantity of water added to the stream appears visibly negligible.

The discharge from the transfer point onto the receival belt was a centered load, which has resulted in no belt tracking difficulties. Due to the design of the transfer chute this station was able to be run without the dust boot in place with no significant dust or material spillage problems.

There was an initial high wear in the transfer which was due to the catch plate being incorrectly aligned, this was altered and the rate of wear was subsequently reduced. This highlights the need for correct setting up of the catch plate during the installation phase of this style of transfer point.

CONCLUSIONS

By designing transfer points to conserve the momentum of the incoming stream and alter the direction of flow in one plane at a time, the flow of a bulk material can be redirected with a minimum of dust, particle attrition and noise. By limiting directional change to a single plane, the tendency for a stable lateral oscillation (roping) can be eliminated. This results in a discharge stream that has a component of velocity only along the receival belt, thus reducing the mistracking of the belt to other factors. The first transfer point installed at Hunter Valley Number One Coal Preparation Plant has been in operation for some six months, passing a total in excess of 1.5 million tonnes. During this time, after the inclusion of the water jets, the overall blockage rate of this transfer point has been reduced by 85% compared to the original design.

As with most retrofit operations the largest difficulty associated with this transfer chute was the constraints imposed by the existing major structure. Several elements of the minor structure were moved or altered to facilitate this low speed transfer point. Higher speed transfers may require the head pulley to be relocated to allow enough room for the material to be caught, curved and constrained without undue wear on the catch plate. This style of transfer point should eventually become the industry standard for cohesive friable materials. For hard materials that have no cohesive strength (aggregates) the use of older style rock boxes for the transfer point is ideal.

The use of advanced computer aided design packages, such as Pro Engineer, can assist in the design of geometrically complex transfer points. Transfers in which the infeed and receival belt and not orthogonal can be readily modeled and give the designer the ability to spin the model in space in real time. This enables the designer the freedom to concentrate on obtaining good transfer chute geometry without the traditional limitations imposed by either drawing boards or 2-D drafting systems.

Authors

Mr William (Bill) McBride B.E.(mechanical 1991 with honors). Employed in the bulk materials handling field since 1990 has worked on a wide range of materials handling problems from the design of transfer chutes, reclaim optimization of self unloading ships, Plastic liner welding techniques and many other aspects of materials handling, from conceptual design to trouble shooting problematic installations. A part time Ph.D. candidate since 1995 working on stockpile mechanics as they relate to the mining industry of which this paper forms part of the ongoing research program.