DEVELOPMENT OF CLEATED BELT BAGASSE CONVEYORS

By

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Abstract

THE INTERMEDIATE carriers used in most Australian sugar factories are either drag conveyors or conventional, smooth rubber belts. Drag conveyors are generally high cost in terms of both capital expenditure and maintenance. Smooth rubber belts offer low cost but are restricted to operating at relatively shallow angles of elevation. The shallow angle necessary with smooth belts increases the footprint and so the cost of new factory layouts and means that such belts cannot be retrofitted in place of steep drag conveyors. A rubber belt fitted with deep, transverse cleats to allow operation at high angles combines the advantages of traditional drag conveyors and smooth rubber belts. A prototype, cleated belt for conveying bagasse was run at Bundaberg Sugar's Fairymead mill during the 2000 season. Testing and development of the prototype lead to the first Australian commercial installations in 2001. Six cleated belt conveyors have been installed in Australian sugar mills and single units have been supplied to mills in Fiji and Mauritius. The paper describes the testing done with the original prototype and subsequent operational experiences leading to the current design.

Background

The intermediate carriers presently used by the Australian sugar industry are almost exclusively either drag conveyors (Figure 1) or smooth rubber conveyor belts. Drag conveyors are generally high cost items in terms of both capital and maintenance. Virtually all the industry's drag conveyors operate at angles of elevation in the range 20–60^0.

Smooth rubber conveyor belts typically incur lower capital and maintenance costs than drag conveyors but they are restricted to operating at relatively low angles up to about 20^0 for reliable operation with bagasse if no maceration liquid is applied to the belt.

Some smooth rubber bagasse belts in the industry run a little steeper than 25^0 but operation at such angles is marginal.

The limitations of conveying angle mean smooth rubber conveyor belts cannot usually replace existing drag conveyors directly. In the case of new factories, the large footprint necessitated by the shallow conveying angles of smooth rubber conveyor belts increases costs.

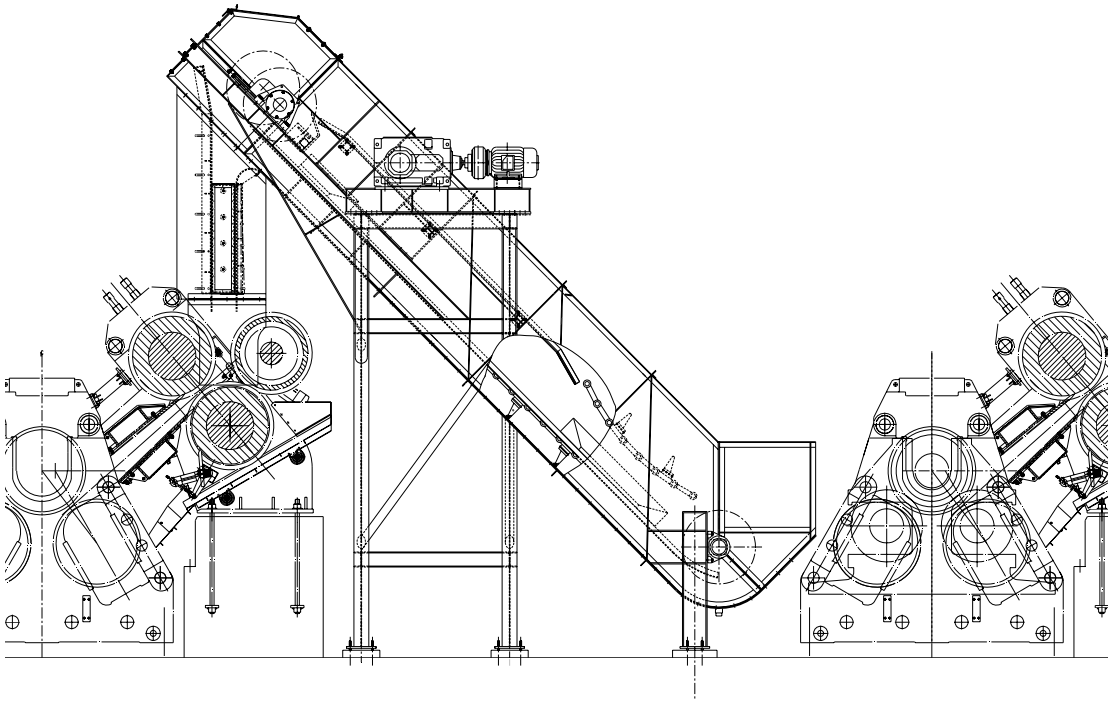

Fig. 1—A traditional intermediate carrier.

A rubber belt capable of conveying bagasse at a steep angle could offer the small footprint of a steep drag conveyor combined with the lower costs of a rubber belt conveyor.

Steep angle, rubber conveyors

There are five classes of steep angle, rubber conveyors (CEMA, 1997). These are:

- Moulded cleat belts with transverse, chevron or 'U' shaped ribs in the range 5–40 mm high. These belts are capable of running on conventional, troughed idlers on the loaded side and flat idlers on the return trace. CEMA (1997) indicates that moulded cleat belts are capable of conveying bagasse at angles up to 30^0. This is not steep enough for many sugar mill applications.
- Belts with large (deep) cleats bonded or mechanically fastened to the top cover after manufacture of the belting. Depending on the design and application, the cleats may be continuous or segmented and the belt may run in either a troughed or a flat geometry. Figure 2 shows a conveyor with segmented cleats running conventional troughed idlers on the loaded side and special disk idlers on the return side. An advantage of these belts is that many standard conveyor belt components are used. Disadvantages are that the cleats can be susceptible to damage, good tracking is usually essential, special return idlers may be required and belt cleaning is difficult. Use of deep cleated belts is thus normally restricted to short conveyors with few or no return idlers and applications where the material does not stick to the belt or where carry back is acceptable.

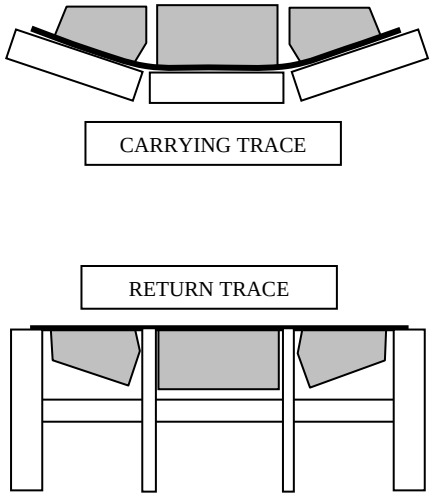

Fig. 2—Large cleated type belt (after CEMA, 1997).

- Pocket belts extend the large cleat approach by adding corrugated sidewalls to the belt. Pocket belts use a special cross-rigid belt that prevents bowing or sagging between idlers. The range of cross-rigid belting tends to be limited. It is relatively expensive and availability can be poor.
- Totally enclosed belts are also known as pipe or tube conveyors. These conveyors wrap the burden in a belt whose edges seal together after loading to form a tube. These conveyors have the advantage of good dust control, ability to negotiate tight curves and steep angles. However, these belts need to be fed steadily and kept full to prevent the material sliding back. This, cost, complexity, and the need to accept the feed from the full width of a mill could be problematic in the case of intermediate carriers.
- Sandwich belts clamp the burden between two smooth belts. Much of the hardware is conventional conveyor equipment and the belts run at normal conveyor belts speeds. Sealing and belt cleaning is relatively simple. Cost and complexity are undesirable features.

Of these five types, the deep cleated belt seems the most attractive for conveying bagasse at steep angles between milling units.

Prototype cleated belt conveyor

A prototype, deep cleated belt conveyor was installed after the 'B' train de-watering mill at Fairymead Mill for the 2000 season. The prototype was installed above the existing smooth belt out of the de-watering mill. The prototype conveyor accepted material from the de-watering mill, conveyed it up at 60^0 and deposited the material back onto the smooth belt. Figure 3 shows the general geometry.

Table 1 records the details of the prototype conveyor.

The processing rate through the Fairymead 'B' train in 2000 was around 130 t cane/h. Still and video photography were used to observe and document operation of the prototype conveyor. Belt speed was varied. The addition of maceration liquid at a rate of 200% on fibre was simulated with water at ambient temperature.

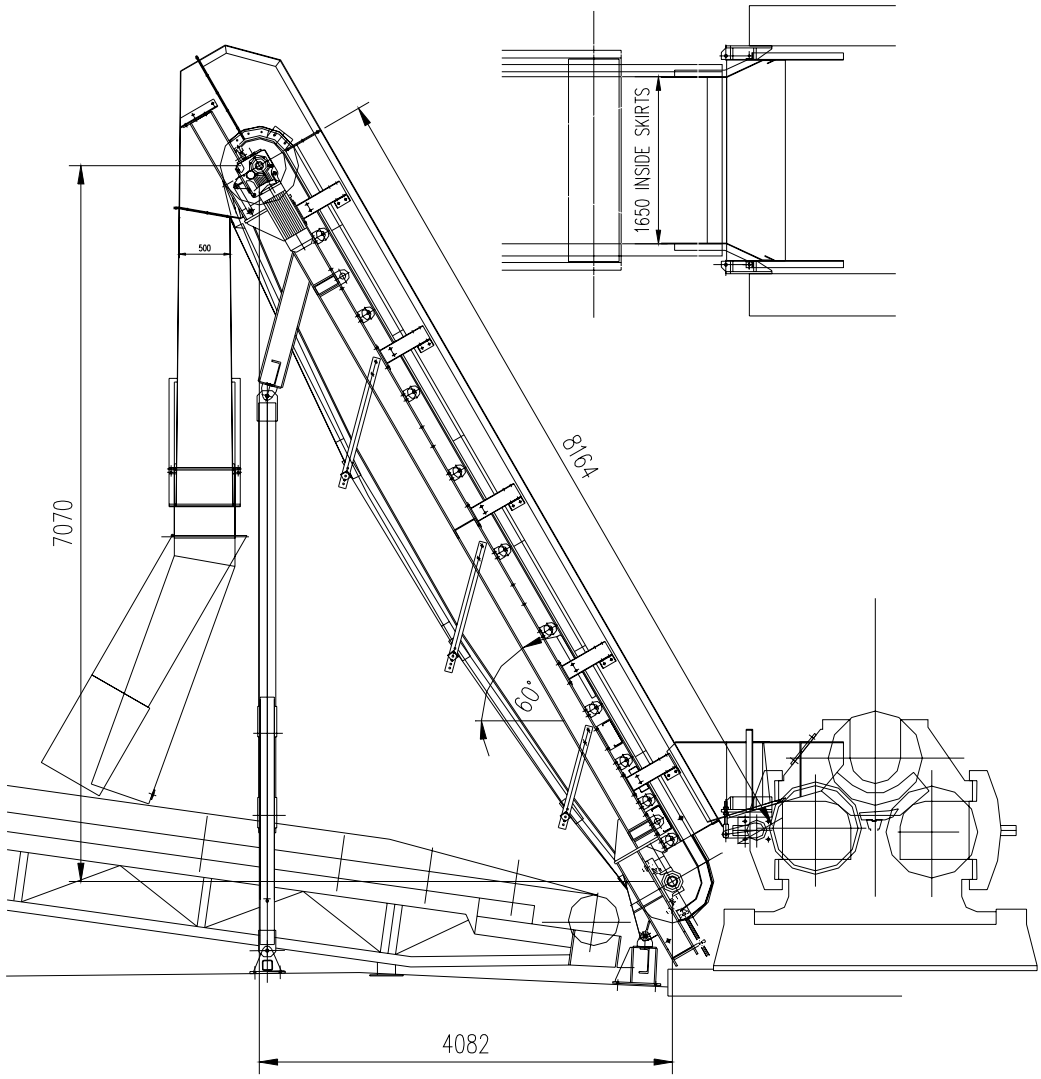

Fig. 3—Arrangement of prototype cleated belt conveyor installation in 2000.

Table 1—Details of the prototype cleated belt conveyor.

BELT		CLEATS	
Width	1.8 m	Type	T
Fabric	3 plies of PN150	Height	110 mm
Cover thickness	5 mm and 1.5 mm	Length	1.6 m
Cover grade	AS-N		
Endless method	Goro V6 fasteners		

The prototype cleated belt rubber conveyor operated the entire 2000 season at Fairymead without major difficulty. Sealing was the main problem with the installation. The escape of bagasse caused problems with belt tracking and created an on-going requirement for housekeeping. The main causes of bagasse escape were identified as:

- the absence of maceration liquid applied at the base of the conveyor (the installation was on final bagasse)
- the installation being open to the elements (no enclosing building)
- the tall transfer from the cleated belt conveyor back onto the smooth rubber conveyor
- the mechanical splice which wore a gap under the skirt seals
- sagging of the belt between the idlers which allowed material to escape underneath the skirt seals (Figure 4).

Power measurements on the prototype cleated belt conveyor suggested a worthwhile power saving compared with drag conveyors operating at other factories.

Design guidelines for belt width, belt speed, cleat type, cleat height, cleat spacing, drive power and conveyor discharge trajectory were formulated from investigations done using the prototype conveyor. Operational experience with the prototype gave rise to recommendations to improve sealing and tracking.

Commercial installations

The first commercial installations of cleated belt intermediate carriers in Australia were in 2001. One unit was installed at Bingera Mill and three were installed at Rocky Point Mill. The main design change to these conveyors relative to the prototype was smooth slides supporting the edge of the belt to prevent sag between idlers (Figure 5).

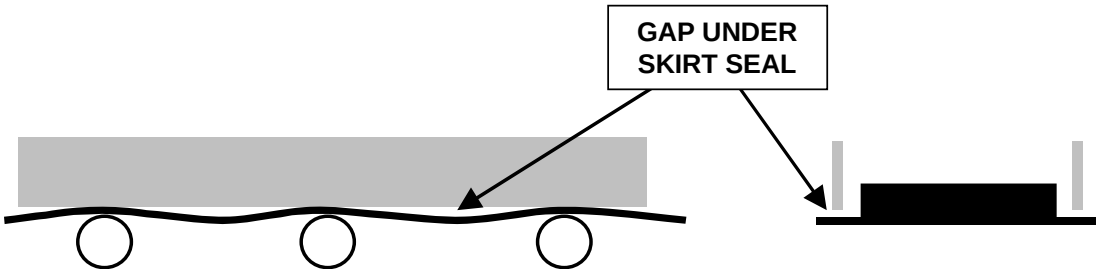

Fig. 4—Points of escape on the prototype cleated belt conveyor.

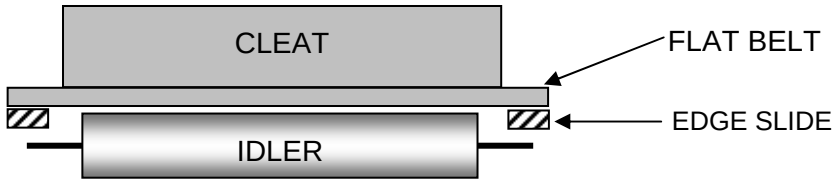

Fig. 5—Slides to support the edge of the belt and prevent escape of material.

Bingera Mill, Australia

The cleated belt conveyor installed at Bingera Mill for the 2001 season comprised a belt 2.2 m wide with transverse cleats 2.0 m long and 100 mm high. The cleats were cold bonded to the belt. The nominal crushing rate of the tandem was 400 t cane/h.

The conveyor operated at an angle of 45^0. The drive for the cleated belt conveyor was by a 37 kW electric motor to a shaft mounted gearbox via V-belts. The return trace of the cleated belt ran in a segmented tray.

The concept was that this tray would support and guide the return trace of the conveyor and capture any material that carried round.

Figure 6 shows a general arrangement of the Bingera installation. Excepted as noted, the conveyor gave trouble free service for six seasons with little maintenance.

The motor power was selected as the same as that used on the old drag conveyor to avoid any possibility of problems on this unit. As expected, the motor was substantially over-sized. It drew about 45% of full load current during operation.

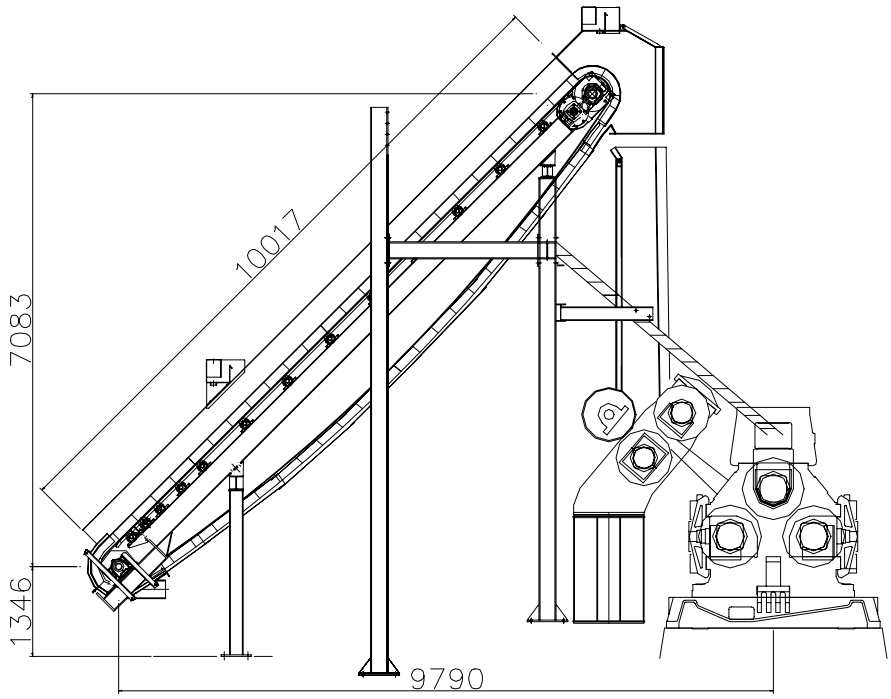

Fig. 6—The cleated belt conveyor at Bingera Mill.

During its life, the Bingera Mill conveyor withstood tens of occurrences operating with the head box of the Donnelly chute of the following mill choked with bagasse and one occurrence of a severe tracking problem which resulted in the cleats jamming up under the skirt seal. Not a single cleat came off or even started to lift despite this treatment.

The capacity of the boot of a cleated belt conveyor is small relative the boot of a conventional intermediate carrier.

There was resultant uncertainty over the practicality of applying maceration liquid at the tail of the conveyor as traditionally practiced in Australia. A system was installed which allowed the maceration liquid to be applied near the tail of the conveyor or near the head of the conveyor as a safeguard. In practice, no difficulties were experienced applying maceration near the tail of the conveyor. In fact, the cleated belt proved reasonably able to convey liquid away from its tail up to the head.

A set of nine paired trials found no significant difference in the retents extraction of the mill following the conveyor due to the point of application of the maceration liquid (head or tail). The relatively high speed of the conveyor and the associated short transport time mean the result was not unexpected. A problem found with applying maceration at the head of the conveyor was that the liquid entering the Donnelly chute could give a false indication of chute height.

The edge slides were originally bare stainless steel. After two months service, the bottom cover of the belt showed signs of wear, heating and some tearing off of the cover where it ran on the slides. The edge slides were faced with low friction plastic in response to this problem. No further difficulties were experienced.

Problems were experienced with the idler bearings after about four years of service. The bearings were found contaminated with water and in a very poor state. This was considered a result of hosing down to clean the conveyor and the lack of monitoring and preventive maintenance because the sides of the conveyor were inaccessible.

The problem was overcome by running lubrication lines back to an accessible, central point and instituting a programme of regular greasing. The original cleated belt conveyor at Bingera served for the 2001 through 2006 seasons inclusive. Eventually, the skirt seals wore into the top cover of the belt causing strips to come away at the edges of the belt. The belt completed the 2006 season with some patches and reinforcing strips.

Rocky Point Mill, Australia

Three cleated belt conveyors were supplied to Rocky Point Mill for their 2001 season. These conveyors were intermediate carriers between the number 1 and number 2, number 2 and number 3, and number 3 and number 4 mills. The conveyors comprised belts 1.8 m wide with cleats 1.52 m wide. Drive was by 30 kW geared motors. Maceration was applied at the bottom of the conveyors.

The tail pulleys of these belts had inboard bearings to overcome a space limitation. This arrangement proved problematic in terms of access for monitoring and maintenance.

The cleats on one of the belts dis-bonded soon after it was put into service. The problem of the cleats coming away was traced ultimately to a change in the cleat material and use of an incompatible bonding technique (refer Lautoka Mill experience below). This belt was replaced by a more robust belt with more plies after two years of service. The relatively short life was a result of the dis-bonding of the cleats and early operational problems. Of the other two belts, one was replaced after five seasons and one after six seasons of service.

Lautoka Mill, Fiji

A cleated belt conveyor was installed between the two mills dewatering diffuser bagasse at Lautoka Mill, Fiji for their 2002 season. This cleated belt conveyor was 13.6 m between the head and tail pulley centres at an angle of 36^0. The width of the conveyor was

1.96 m between the side plates. The cleat spacing was 0.4 m. The nominal crushing rate of the tandem was about 350 t cane/h. Some maceration water was applied near the tail of the conveyor. The drive was by a 30 kW, shaft mounted, geared motor.

The Lautoka conveyor had problems with the cleats dis-bonding from the belt cover after only a few days of service. This was overcome at the time by bolting a variety of metal tabs and lengths of light angle onto the belt. The belt ran the remainder of the season successfully with the metal attachments.

Subsequent investigation discovered that a supplier had changed the specification of the cleat material during 2001 and the new material was not compatible with the cold bond attachment method used successfully on the prototype belt and the first belts installed at Bingera and Rocky Point mills. A replacement, hot bonded belt was supplied to Lautoka for their 2003 season. This conveyor operated for four seasons without major difficulty. Ultimately, the skirt seals wearing through the belt, as occurred at Bingera Mill, determined the life of the conveyor. The shorter life (four seasons at Lautoka as opposed to six seasons at Bingera) is thought to be due to greater pressure between the skirt seal and the belt.

FUEL Mill , Mauritius

A cleated belt conveyor was installed between two of the mills in the FUEL tandem in Mauritius for their 2002 season. This cleated belt conveyor was 8.2 m between the head and tail pulley centres at an angle of 49^0. The belt was 2.1 m wide with cleats 1.82 m long cold bonded to the top cover of the belt. The crushing rate of the tandem was around 320 t cane/h. Maceration liquid was applied near the tail of the conveyor. The drive was by a 30 kW, shaft mounted, geared motor.

FUEL's experience matched that of Lautoka. The first cleats started to come away from the belt within days of commencing operation. There were numerous attempts to re-bond the cleats using various methods of preparation and gluing by several different contractors. Replacement adhesive cleats were tried as was a double sided adhesive sheet. Some cleats were reattached by bolting them to the belt along their leading and trailing edge.

The cleated belt conveyor was replaced by a mechanically spliced belt with hot bonded cleats toward the end of the 2002 season. This same rubber belt completed the 2007 season and is planned to be operated for the 2008 season as well. Operational experience at FUEL identified the clearance between the tip of the cleats and the return trays as critical to the operation of the conveyor.

Broadwater Mill, Australia

Two cleated belt conveyors were installed at Broadwater mill for the 2007 season between the first and second mills and between the second and third mills of the tandem. Both conveyors were 2.22 m wide between the side plates, operating at an angle of 42^0. Crushing rate for the season averaged 270 t cane/h.

These conveyors had hot bonded cleats and a new style of double skirt seal. The intention of the new skirt seal was to provide:

- better sealing with lower sealing pressure due to the double seal arrangement
- easier adjustment of the skirt seal so there was less temptation to adjust the seals down hard in an attempt to reduce the frequency with which adjustment was required.

This implementation of a seal arrangement was not successful. Bagasse getting past the first seal became trapped between the first and second seals and seemed to force the belt down onto the edge slides. Difficulties were experienced feeding the first intermediate carrier due to a lack of space. This was overcome by installing a kicker at the discharge of the number one mill. The timing of the application of maceration was also a challenge but successfully addressed successfully by fine tuning the control system.

Conclusions

Investigations done with the prototype conveyor combined with practical field experience from commercial installations means cleated belt conveyors can be sized accurately for the required duty. Development of the original prototype conveyor into a commercial product has required several detail design changes based on operational experience gained across several installations over a number of years. Cleated belt conveyors are now a practical, direct replacement for traditional, drag style intermediate carriers. Cleated belt conveyors can accept maceration at the tail of the conveyor and feeding directly off the apron plate of a mill without the need for a kicker where there is sufficient room.

The capital cost of a cleated belt conveyor is typically lower than that of a drag conveyor. The case for replacing existing drag conveyors in reasonable condition with a cleated belt conveyor is more marginal. In suitable installations, it can be possible to remove a cleated belt conveyor as a unit for maintenance in a workshop or for ease of access to other plant. The smaller diameter head pulley means that a taller Donnelly chute is often possible with a cleated belt conveyor. There is considered to be a moderate power saving associated with using cleated belt conveyors but the evidence to date is that the saving is not as great as the 50% originally envisaged.

The small boot capacity of cleated belt conveyors means consideration has to be given to the timing of the application of maceration liquids. The shorter duration of transport on the conveyor means there is less opportunity for mixing / diffusion between milling units but the significance of this has not been noticeable on existing installations.

Almost by definition, a rubber conveyor will be more susceptible to damage by operational extremes such as tramp iron. However, the same applies to the other rubber conveyors used for billet cane, prepared cane, intermediate carriers and final bagasse at numerous factories. Operational experience has been that cleated belt conveyors are more maintainable than one might imagine.

Factory experience has identified tracking and sealing as the keys to achieving long, trouble free life from cleated belt conveyors. Typically, cleated belt conveyors have required less day to day maintenance and less annual maintenance than traditional drag conveyors.

The life of existing cleated belt conveyors has basically been determined by wear due to the action of the skirt seals. This will be the focus of on-going refinement in 2008.

Acknowledgements

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REFERENCE

CEMA (1997) 'Belt conveyors for bulk materials'. 5th edn (Conveyor Equipment Manufacturers Association: USA).