

Cane preparation - optimised technology[†]

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abstract

Fives Cail has developed and improved its cane preparation technology to meet the requests of modern cane sugar and ethanol factories who either want to upgrade their factories or build new ones; the major concerns being investment, performance, energy and operation. Fives Cail now has more than 30 installations of the in-line shredder in Africa, Asia and the Americas, and has continually improved and developed the design to extend the range up to a capacity of 825 tonnes cane crushed per hour, while at the same time simplifying the original designs of feed drum, rotor, hammers and anvil plate and increasing the capacity for a given carrier width. The in-line shredder technology consists of two main pieces of equipment; a cane leveller (or carding drum) and the shredder assembly, which allows for a very simple and uncomplicated installation that can be either incorporated into an existing cane carrier or installed in a new one. Its construction is modular with a small footprint. The in-line shredder will process either whole stick or billeted (short) cane or any combination of the two, and can operate in all possible conditions including the preparation of washed cane, and also cane containing a high quantity of sand or rocks. All results shown have been obtained directly from the factories, either through official channels or from personal visits by Fives Cail personnel. As with all results collected under non-laboratory conditions, some approximation may be assumed; however, they tend to show fairly consistent figures. It can therefore be concluded that after several years of continual development and improvement, research and results show there are several genuine benefits, both direct and indirect, to be gained from incorporating the in-line shredder technology into a factory in order to upgrade the cane preparation performance. Benefits can be seen in terms of reduced installation costs, reduced maintenance costs, and reduced overall power consumption over more conventional cane preparation equipment.

Keywords: **cane, in-line, preparation, shredder**

Preparación de caña - tecnología optimizada

Fives Cail ha desarrollado y mejorado su tecnología de preparación de caña para satisfacer los requerimientos de fábricas modernas de azúcar y etanol que buscan mejorar las fábricas o construir nuevas, siendo las mayores preocupaciones la inversión, desempeño, energía y operación. Fives Cail tiene a la fecha más de 30 desfibradoras en línea instaladas en África, Asia y las Américas, y ha mejorado y desarrollado continuamente el diseño para extender el rango de operación hasta una capacidad de 825 toneladas de caña por hora simplificando al mismo tiempo los diseños originales del tambor alimentador, rotor, martillos y yunque e incrementando la capacidad para un ancho de conductor determinado. La tecnología de la desfibradora en línea consiste de dos piezas principales de equipo: un nivelador de caña (o tambor peinador) y el conjunto de la desfibradora lo que permite una instalación simple y descomplicada que puede ser incorporada a un conductor existente o instalada sobre uno nuevo. Su construcción es modular con pocos requerimientos de espacio. La desfibradora en línea procesa caña entera o caña trozada o cualquier combinación de las dos, y puede operar en todas las condiciones posibles incluyendo la preparación de caña lavada o que contenga cantidades importantes de arena o piedras. Todos los resultados presentados han sido obtenidos directamente de las fábricas, bien a través de canales oficiales o a partir de visitas de personal de Fives Cail. Como sucede con todos los datos obtenidos bajo condiciones fabriles y no de laboratorio deben suponerse algunas aproximaciones; sin embargo tienden a mostrar cifras bastante consistentes. Por lo tanto se puede concluir que después de varios años de continuo mejoramiento y desarrollo, la investigación y los resultados muestran que hay varios beneficios genuinos, tanto directos como indirectos, que pueden ser obtenidos incorporando la tecnología de desfibrado en línea en una fábrica para mejorar la preparación de caña. Los beneficios respecto a equipo más convencional se observan en términos de costos reducidos de instalación, menores costos de mantenimiento y menores consumos de potencia.

Vorbereitung von Zuckerrohr - optimierte Technologie

Fives Cail hat seine Technologie zur Vorbereitung von Zuckerrohr entwickelt und verbessert, um den Anforderungen moderner Rohrzucker- und

Ethanolabriken zu entsprechen, die entweder ihre Fabriken aufrüsten oder neue bauen möchten, wobei das Augenmerk vor allem auf Investment, Leistung, Energie und Betrieb liegt. Fives Cail hat jetzt in Afrika, Asien und Amerika mehr als 30 In-Line-Schredder installiert und verbessert und entwickelt ihr Design ständig weiter, um die Reihe bis zu einer Kapazität von 825 Tonnen Zuckerrohrzerkleinerung zu steigern und gleichzeitig das ursprüngliche Design der Vorschubtrommel, des Rotors, der Hämmer und der Ambosplatte zu vereinfachen und die Kapazität für eine gegebene Trägerbreite zu steigern. Die In-Line-Schredder-Technologie besteht aus zwei Hauptbestandteilen – einem Zuckerrohr-Planierer (bzw. einer Kardiertrommel) und der Schredder-Baugruppe – und kann auf unkomplizierte Art und Weise in einen bestehenden Zuckerrohr-Beförderer inkorporiert oder in einen neuen eingebaut werden. Die Konstruktion ist modular und hat eine kleine Standfläche. Der In-Line-Schredder wird entweder ganze Stäbe oder zu Billets geschnittene (kurze) Rohre oder eine Kombination der beiden verarbeiten. Er kann unter allen Betriebsbedingungen arbeiten, inkl. bei der Vorbereitung von gewaschenem Rohr, und auch mit Rohr, das hohe Mengen von Sand oder Steinen enthält. Alle gezeigten Resultate wurden direkt von den Fabriken eingeholt, entweder durch offizielle Kanäle oder durch persönliche Besuche von Fives Cail-Mitarbeitern. Wie bei allen unter Nicht-Labor-Bedingungen gesammelten Resultaten kann eine gewisse Approximation angenommen werden, doch wurden insgesamt recht gleichförmige Zahlen festgestellt. Es lässt sich daher folgern, dass die Forschungen und Ergebnisse nach mehreren Jahren fortgesetzter Entwicklung und Verbesserung zeigen, dass mehrere (direkte wie indirekte) echte Vorteile entstehen, wenn die In-Line-Schredder-Technologie in eine Fabrik inkorporiert wird, um die Leistung der Zuckerrohr-Vorbereitung zu verbessern. Zu sehende Vorteile gegenüber herkömmlicherer Zuckerrohr-Vorbereitungsausrüstung sind reduzierte Installationskosten, reduzierte Wartungskosten und reduzierter genereller Energieverbrauch.

Preparação da cana - tecnologia otimizada

A Fives Cail desenvolveu e melhorou sua tecnologia de preparação da cana para atender às necessidades das fábricas modernas de cana-de-açúcar e etanol que desejam atualizar suas instalações ou construir instalações novas, tendo como principais preocupações o investimento, desempenho, energia e operação. Hoje a Fives Cail tem na África, Ásia e Américas mais de 30 instalações do seu desfibrador em série, tendo continuamente melhorado e desenvolvido seu design com o intuito de aumentar seu alcance para uma capacidade de até 825 t de cana esmagada por hora. A empresa tem, ao mesmo tempo, simplificado o design original do tambor de alimentação, rotor, martelos e placa da bigorna, e aumentado a capacidade para uma dada largura de carregamento. A tecnologia desfibrador em série consiste em dois equipamentos principais, um nivelador de cana (ou tambor de cardagem) e a montagem do desfibrador, que permitem uma instalação muito simples e descomplicada, podendo ser incorporados tanto dentro de um transportador de cana já existente quanto instalados em um novo. Sua construção é modular e ocupa pouco espaço. O desfibrador em série processará tanto a cana inteira, quanto a cana atroçada (pedaços pequenos), ou qualquer combinação das duas, podendo operar em todas as condições possíveis, inclusive na preparação de cana lavada e também cana com alta quantidade de areia ou pedra. Todos os resultados mostrados foram obtidos diretamente das fábricas, tanto através de canais oficiais, quanto a partir de visitas pessoais do pessoal do Fives Cail. Como com todo resultado coletado sob condições não-laboratoriais, pode-se presumir que existam aproximações, no entanto, as cifras obtidas mostram uma tendência razoavelmente uniforme. Portanto, pode-se concluir que após vários anos de desenvolvimento e melhorias contínuos, pesquisas e resultados mostram que existem vários benefícios genuínos, tanto diretos quanto indiretos, a serem obtidos com a incorporação da tecnologia desfibrador em série em uma fábrica que procura atualizar o desempenho de preparação da cana. Os benefícios podem ser observados em termos de redução de custos de instalação, redução de custos de manutenção e redução geral do consumo de energia em comparação aos equipamentos de preparação de cana mais convencionais.

Introduction

Cane preparation is often overlooked in a factory's quest for general improvement in efficiency and performance when in actual fact, in the factory environment, it is probably one of the most important factors in achieving both of these. In terms of improving and increasing overall factory output, it is very probably one of the cheapest ways to do so. By improving the cane preparation from say a preparation of 75% to a preparation index above 90%, the increase in throughput, overall extraction and reduction in pol % bagasse is similar to the figure that would be expected when adding an extra mill to the crushing line, at approximately 60% of the equipment price (more if civils and drives are taken into account).

Historical

There have been few major developments in cane preparation since the introduction of the heavy duty gravity-fed shredders in the late 1960s. In order to achieve a preparation index above 90%, a typical cane preparation station for long cane comprises the following:

- 1 × leveller (1st) knife set (50 mm pitch)
- 1 × heavy duty (2nd) knife set (25 mm pitch)
- 1 × cane kicker
- 1 × gravity shredder

The cane knives are required to prepare and more importantly chop the whole-stick cane to a suitable condition to feed into a gravity shredder in order to avoid choking.

A typical installation drawing is shown in Figure 1.

To obtain consistent preparation, the 1st knives would be positioned on an auxiliary carrier approximately 250 mm from the surface of the slats to prepare the top half of the cane bed. The part-prepared cane would be tumbled onto a 2nd (main) carrier passing through a set of heavy duty knives preparing the remaining cane to a preparation index of around 65%, before feeding into a heavy duty shredder from a height of 6 m to 7 m.

The shredded cane would then be transported to the 1st mill. The Fives Cail recommended installed powers in order to guarantee a preparation index of over 90% with this specification would be as follows:

Figure 1. A typical whole-stick cane preparation station with gravity-fed shredder

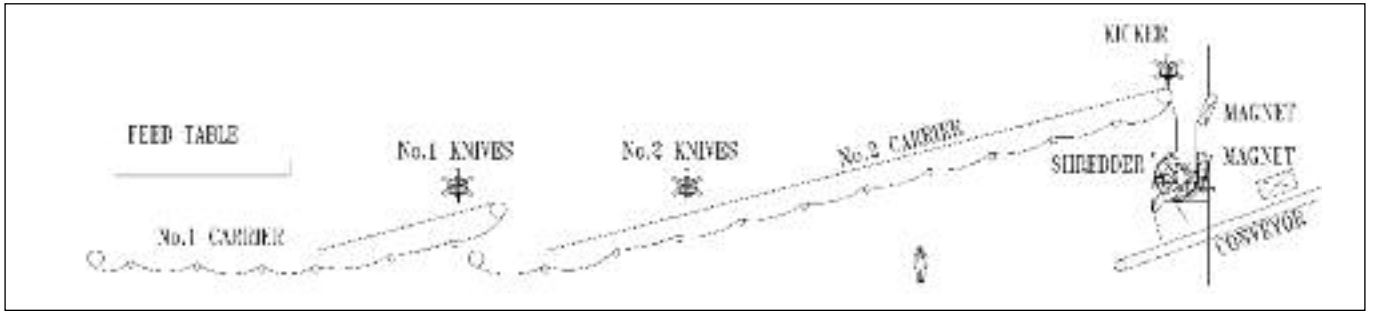
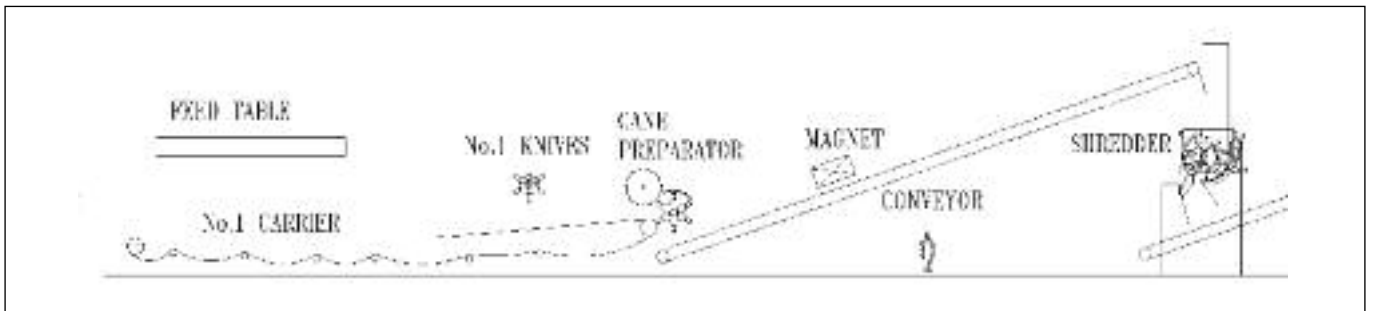


Figure 2. An alternative cane preparation station with contra-rotating knives



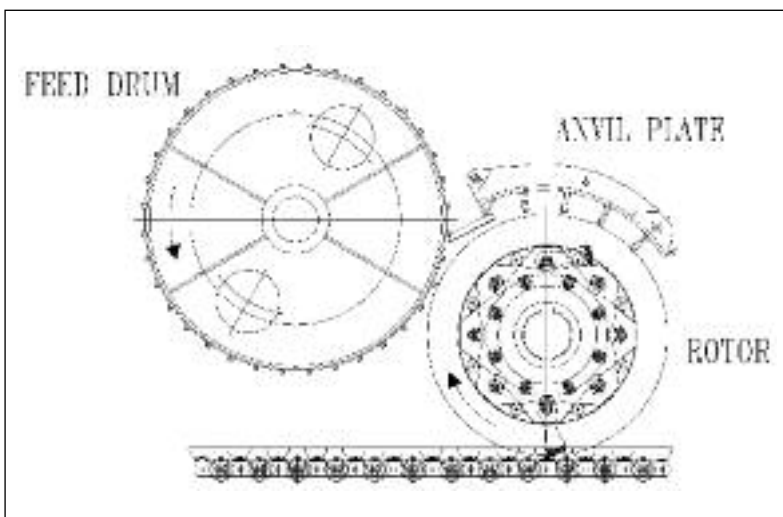
No.1 knives	11 kW.h/t fibre
No. 2 knives	14 kW.h/t fibre
Cane kicker	30 kW
Gravity shredder	45 kW.h/t fibre

So, typically for a 2135 mm wide carrier and considering a cane rate of 400 t/h at 15% fibre content, the total installed preparation power would be 4230 kW.

Contra-rotating knives

Several manufacturers produce contra-rotating cane preparation devices, fitted with either swivelling hammers or fixed knives, and operated with a washboard. These devices can be fitted in place of the No.2 knife set to reduce the installation requirements in terms of the number of carriers required and hence overall space.

Figure 3. The in-line shredder



Contra-rotating knives are especially useful in areas with rock problems as they tend to chip away the rocks. However, the installed power does increase as shown below.

No.1 knives	11 kW.h/t fibre
Cane preparator	25 kW.h/t fibre
Gravity shredder	45 kW.h/t fibre

Again, for a 2135 mm wide carrier and considering a cane rate of 400 t/h at 15% fibre content, the total installed preparation power would be 4860 kW and the configuration is shown in Figure 2.

The requirements of a modern sugar and ethanol factory

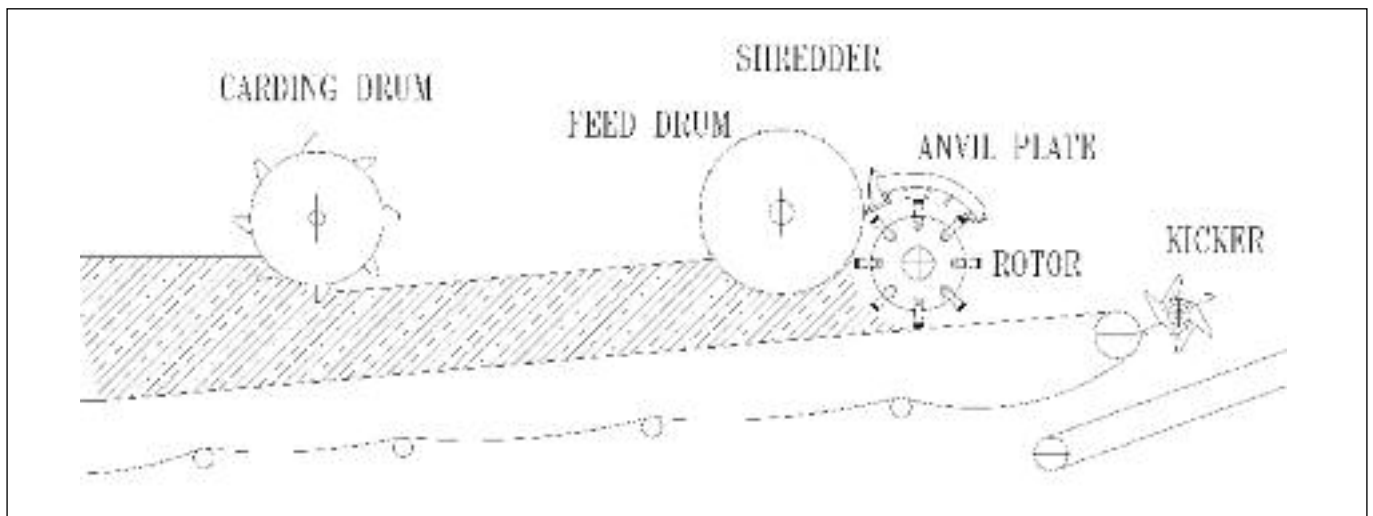
Increasingly for the front end, clients are looking for the following advantages:

- Reduction in overall energy consumed
- Increased productivity and throughput
- Reduction in downtime
- Reduced maintenance periods and costs
- Increase in factory performance
- Cost effective changes

In-line shredder

Fives Cail developed and installed some of the first in-line shredders in the 1990s, and these designs have been constantly updated, re-designed and further developed into the present range of shredders.

The in-line shredder has been designed to process either long or short cane (in any ratio) and without the need for pre-preparation, so no cane knives are required prior to the shredder.

Figure 4. A typical in-line shredder installation

The shredder assembly consists of three main components, the feed drum, the shredder rotor and the anvil plate (Figure 3). In addition to these, two auxiliary pieces of equipment are required to ensure consistent feed of cane to both the shredder and No.1 mill; a carding drum and a shredded cane kicker (see Figure 4).

Carding drum

The carding drum contra-rotates against the cane flow and is responsible for two operations

- **Metering flow:** The carding drum acts as a metering device, holding back excessive amounts of cane in the carrier and 'filling-in' sparse areas, therefore providing a consistent flow of cane at the calculated carrier speed and cane density to maintain a consistent crush rate.
- **Increasing compaction:** The density of long cane fed into a carrier normally averages between 125 kg/m³ and 150 kg/m³. The carding drum is designed to be set at a specific height, based on carrier speed and cane throughput, to achieve the required cane compaction after the drum. The resulting cane mat is therefore at a consistent density which ensures the correct approach angle can be achieved of the cane mat relative to the feed drum. For 100% short cane, the carding drum would be used to 'wipe-off' the cane bed to achieve the correct calculated height for the capacity required. No additional compaction would take place.

Only one carding drum is normally required to obtain the required compaction for installation on carriers from 0 to 10 degrees. Two carding drums are recommended at angles in excess of 10 degrees and also in situations where the cane feeding is difficult to control, for instance if substantial manual and unmonitored cane feeding is allowed after the feed tables.

Feed drum

The feed drum co-rotates with the cane flow and is responsible for providing positive feed of the cane mat into the rotor and also increasing the compaction of the cane to avoid the whole stalk being swept into the anvil. The drum 'traps' the mat of cane against the carrier slats, increasing the compaction of cane to between 280

kg/m³ to 350 kg/m³, thus allowing the rotating hammers to 'wipe-off' a section of cane from the long stalks. It is most important to keep the cane entry to the drum at a good angle, to maximise throughput while keeping the carrier speed as low as possible for the required capacity. Excessive entry angles can create cane feed problems and results in drum judder which would ultimately cause increased peak loads on both drives and bearings, leading to premature failure. The peripheral speed of the feed drum is set higher than the linear speed of the carrier to provide positive feed of cane to the hammers.

Rotor

These shredders are available with two types of rotor design, either six-row or eight-row; both types incorporate alternately staggered profiled plates. The six-row design has a swept hammer diameter of 1680 mm while the eight-row swept hammer diameter is 1900 mm. Figure 6 shows capacities for both types of rotor. All the rotors should have in excess of 100% full coverage of the hammers and ideally use high grade stainless steel tie rods and hammer bars for extended life expectancy and strength. The tie rods should be tightened to specific torque ratings using hydraulic tensioning devices.

Hammers

Hammers are manufactured from 55 mm or 60 mm thick high strength, low alloy structural steel plate preferably cut along the grain of the steel. Hard facing is applied to the hammer extremities to a minimum 3 mm thickness on the facings to give a wear resistant layer of material. The specification for the weld deposit is dependent on the operating conditions expected at site; (excessive sand or rocks would dictate different materials). Normal weight for the hammers on a Fives Cail shredder is 22 kg and life expectancy is dependent on many things, but normally 14 days between hammer changes is a reasonable expectation.

Anvil plate

The entry distance between the rotor and anvil is normally fixed at around 40 mm, with adjustment at the exit side of the anvil plate being possible as required. The anvil plate adjustment bars are also

Figure 5. A typical cane preparation station with in-line shredder

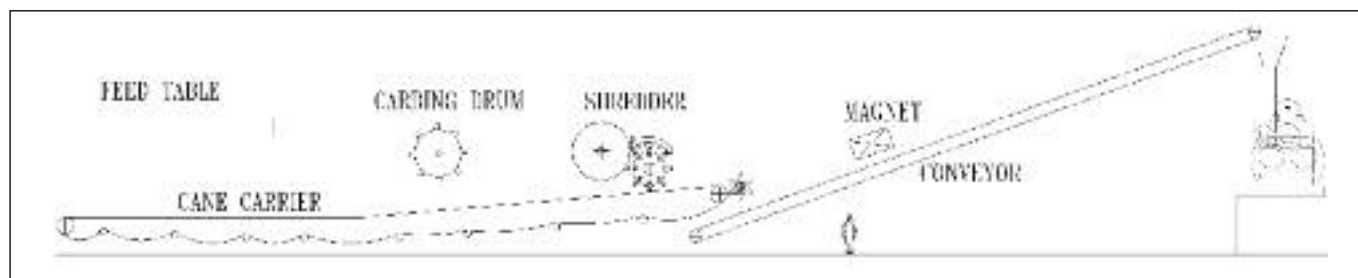


Figure 6. Theoretical capacity of in-line shredders

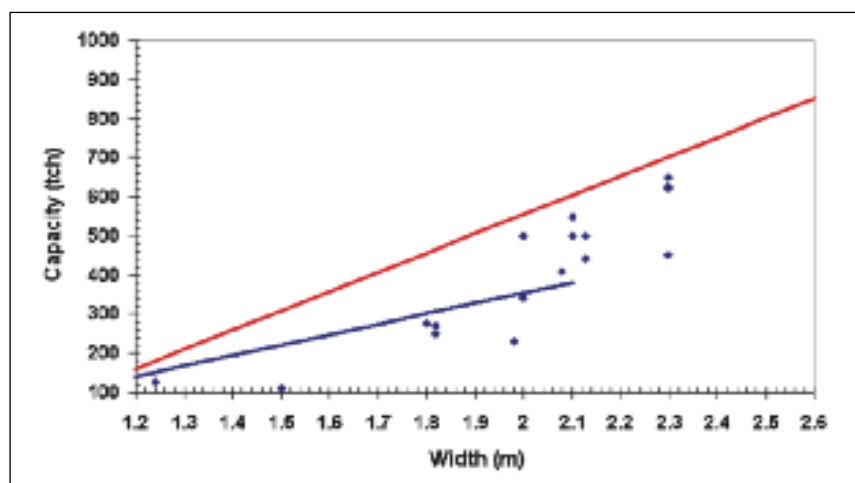


Table 1. Installations of Fives Cail in-line shredders

Country	Factory	Width m	Diameter m	Capacity TCH
Pakistan	Al Abbas	1.8	1.68	275
Guadeloupe	Marie Galante	1.5	1.68	110
Senegal	Richard Toll	2.0	1.68	260
Colombia	Riopaila	2.08	1.68	410
Guadeloupe	Gardel	1.82	1.68	250
Brazil	Olimpia	2.3	1.9	620
Peru	Paramonga	1.98	1.68	230
Brazil	Itumbiara	2.1	1.9	500
Brazil	Ituiutaba	2.1	1.9	500
Brazil	Interlagos	2.1	1.9	550
Brazil	Usina Tanabi	2.3	1.9	625
Brazil	Nova Europa	2	1.9	500
Colombia	Risaralda	1.82	1.68	270
Mexico	Lazaro Cardenas	1.24	1.68	130
Mexico	Benito Juarez	2.13	1.68	440
Brazil	Andradina	2.1	1.9	550
Brazil	Suzanapolis	2.3	1.9	625
Brazil	Sebastianopolis	2.3	1.9	650
Colombia	Manuelita	2.134	1.9	500
India	Karnataka	2.3	1.9	230
India	Pugalur Tamil Nadu	1.725	1.9	180
Belize	Tower Hill	2.13	1.9	450
Brazil	Patrocinio Paulista	1.82	1.9	420
Brazil	Campina Verde	2.3	1.9	550
Brazil	Santa Vitoria	2.3	1.9	550
Brazil	Paracatu	2.3	1.9	550
Brazil	Meridiano	2.6	1.9	825
Colombia	Incauca	2.13	1.9	500
Sudan	Sennar	2.13	1.9	300
Sudan	Assalaya	2.13	1.9	300

fitted with shear pins to protect the rotor and grid bars in case large objects should pass through the shredder. The angle of wrap is approximately 75 degrees.

Kicker

The shredded cane is very dense and wet when it is deposited back onto the cane carrier, and tends to stick to the slats at the head end and causing uneven feed onto the resulting conveyor or carrier. To overcome this uneven feed, the installation of a shredded cane kicker is always recommended if at all possible. This kicker breaks up the cane mat, reducing the shredded cane density, and improving the consistency feed into No.1 mill intercarrier.

A typical installation is shown in Figure 5.

Typical installed powers in order to achieve a preparation index over 90% are as follows:

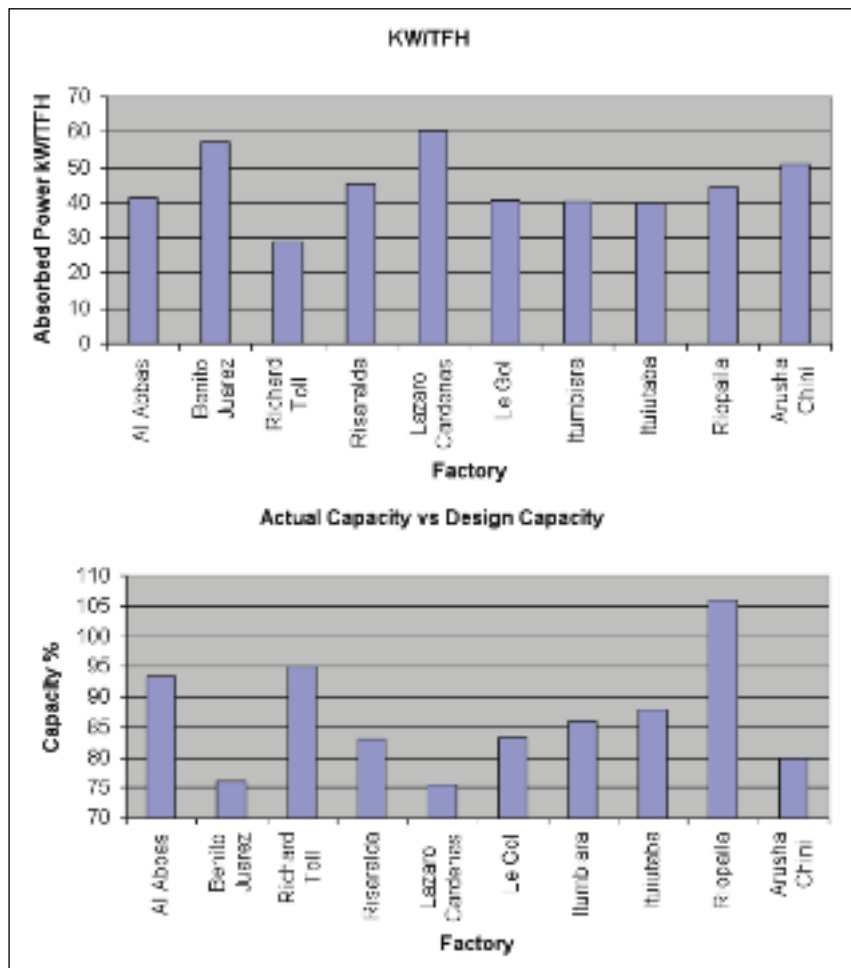
- Carding drum 75 kW
- Feed drum 75 kW
- Shredder rotor 7.5 kW/h/t cane (50 kW/h/t fibre at 15% fibre content)
- Shredded cane kicker 30 kW

Again, for a 2135 mm wide carrier and considering a cane rate of 400 t/h cane at 15% fibre content, the total installed power would be 3180 kW.

Capacity

Fives Cail manufactures in-line shredders of both six-row (1680 mm diameter) and eight-row (1900 mm diameter). Figure 6 below shows the general capacities for the two diameters of shredder when compared with the width of the cane carrier.

The blue line represents the theoretical capacity of the 1680 mm diameter shredder rotor and the red line represents the theoretical capacity of the 1900 mm. These figures are approximate and based on cane containing 15% fibre. Every proposed installation, however, should be treated on an individual basis.

Figure 7. Power consumption and capacity of installed in-line shredders

Tip speed

The calculated tip speed for the shredder is set between 88 m/s and 99 m/s, which gives a good compromise between cane preparation and hammer life.

On the 1.9 m diameter rotor, both 50 Hz and 60 Hz electric motors can operate at synchronous speed (at either 900 r/min or 1000 r/min) with no need for gear reduction.

The 1.68 m diameter rotor operates within the desired range at 60 Hz (88 m/s) and, although the tip speed is slightly slow when operating at 50 Hz (80 m/s), good results have been obtained. Turbine drives should be designed to operate with a minimum tip speed of 90 m/s.

References

Fives Cail in-line shredder installations are shown in Table 1.

Performance

Results were obtained from a random selection of factories, either sent to Fives Cail by the factory technicians or from the collection of results directly from site by Fives Cail engineers, and the results collated into the graphs shown in Figure 7.

From these graphs, it can be seen that the absorbed power for the in-line shredder is normally around 40 kW.h/t fibre. Only three

installations are operating in excess of 50 kW.h/t fibre; significantly all operate at less than 80% of their intended capacity and so it appears preferable to operate the machines and drives under load and close to their design capacities to prevent inefficiencies occurring. The drive split for the factories shown below is approximately 50/50 turbines and electric motors.

Advantages of the in-line shredder

- One-stop cane preparation: No pre-preparation is required.
- Retro fitting: A huge advantage with the in-line shredder is the ability to fit the shredder and carding drum into an existing carrier layout, (the shredders are supplied complete with all casings to match with the existing carrier sideplates). Normally, the installation can be achieved with a minimum of modification and incorporating most of the original equipment including carrier drives and drive positions, slats, etc (although the slats have to be operated in a 'reversed' direction to work successfully with the contra-rotating rotor). For factories that operate year-round, the shredder and carding drum can be positioned around existing knives and leveller equipment so that the new installation can be built and commissioned within two to three weeks.
- Space: Only 1 x carrier and 1 x conveyor are required to transport cane from the feed tables to No.1 mill.

- Simplicity: Fewer cane carriers mean there are significantly reduced costs in terms of material stocks and off crop maintenance for slats, drives, chain etc.
- Installation costs: In any project, in addition to the overall cost of the equipment, any civil works must also be considered. The in-line shredder cuts installation costs because it requires a very much smaller footprint regarding civil foundations, and a lower height requirement. The design requires a reduced quantity of machinery and with fewer drives.
- Versatility: In-line shredders will operate in almost all conditions, with washed or dry cane, in sandy areas and also in areas where rocks are a particular problem as the reverse rotation nature of the rotor means that rocks up to 300 mm diameter tend to be chipped into small pieces, thus protecting the mills.
- Long fibres: Because the shredder is processing cane that is not pre-knifed, the resulting cane fibres it produces are usually slightly longer, which tends to reduce mill slippage as the cane mat binds together better. Long fibres can also be advantageous to boiler operation.
- Increased extraction: Cane with a greater breakage of cells (i.e. more highly prepared) generally results in increased mill extraction, lower pol % bagasse figures and lower final bagasse humidity. Several suggestions have been made as to the increase in extraction possible. Moor (1974) suggests 0.045 units of extraction per 1% increase in preparation index; Edwards (1995) suggested a 0.1% increase in extraction per 1% increase in preparation index. Independent tests carried out at Tongaat Hulett in South Africa some

years ago indicated an increase of 0.83% extraction for each 1% increase in preparation index within the range of 87% to 94%.

- The shredder rotor (and carrier width) can be increased later for higher capacities or phased expansions.
- Example case: At the Benito Juarez factory, cane preparation of preparation index approximately 80% was achieved using two cane knives and a light duty shredder. Factory results for this installation over a crop period showed a reduced extraction of 94.9% with an average imbibition rate of 26.6% on cane. After the shredder installation and with no other significant changes to the extraction plant, the reduced extraction increased to 95.85% with an imbibition rate of 21.4% on cane. These results would suggest an increase in extraction of approximately 0.1% per 1% increase in preparation index. Similarly, pol % bagasse reduced from 2.3% to 1.9%. However, these improved figures should be taken as an indication only as to what might be possible rather than an expectation of results.
- Energy savings: For the examples shown earlier in the text, the installed cane preparation powers as advised by Fives Cail are as follows:

In-line shredder		= 3180 kW
Cane knives	= in-line shredder + 33%	= 4230 kW
+ gravity shredder		
Cane knives + preparator	= in-line shredder + 53%	= 4860 kW
+ gravity shredder		

The figures show that significant savings can be made regarding energy usage, allowing increased exportation to the grid where possible. For factories where energy savings are preferential to extraction, it is worth noting that a shredder can increase the overall performance by approximately the same amount as an extra mill; therefore, one existing mill could possibly be removed or bypassed, thus further increasing potential energy exportation.

Note: The figures above are a general indication of installed power only. In some areas, it is possible to install slightly lower installed power than in others. The relative percentage savings of the in-line shredder, both in terms of installed and absorbed power usually, however, remain.

- Reduced maintenance and downtime: To completely change the in-line shredder hammers takes approximately two hours and normally there is no more work required during the crop other than general adjustments. Hammer changes usually take place at either one week or two week intervals during scheduled maintenance stops. Some factories that do not have scheduled stops change only half the hammers at any one time thus allowing them to complete the task very quickly (1 to 1.5 hours). This operation is completed during unscheduled stops (general breakdowns, process house full etc), so hammer changes do not require any specific down-time. Also, fewer hammers and knives (no cane knives and fewer hammers than a gravity shredder, 144 instead of 180 on an 2135 mm, eight-row shredder) means fewer weld repair materials, reduced man hours in terms of both repair and replacement, and reduced stock levels of equipment.
- Milling operation: The addition of a carding drum and an in-line shredder will give a very consistent rate of cane feed, which improves the consistency of the whole milling operation, generally resulting in higher average milling performances.
- Mill protection: No magnet is required before the shredder, but a magnet is always recommended between the shredder and 1st

mill to remove any ferrous materials and thus protect the mill. Therefore, No.1 mill is protected from both ferrous materials and rocks, reducing tooth breakage.

Disadvantages

- Individual installed drive power for the shredder rotor is generally higher than for a gravity shredder.
- A slat carrier is normally recommended for this type of shredder.

Conclusion

Fives Cail manufactures and supplies almost every different type of cane preparation equipment; cane knives, cane preparators and both main types of heavy duty shredder, (the In-line design and the Gravity design). Therefore, the company has no particular bias to any one type of equipment over another and so a balanced overview can be assured. For either new installations or for upgrading purposes, calculating the operational and financial advantages as well as the payback period is of utmost importance and so some or all of the following arguments might be considered:

- Increased co-generation potential
- Lower overall installed power
- Reduced routine and end-of-crop maintenance
- Reduction in off-crop oil consumption due to increased bagasse stocks
- Reduced civils and installation costs
- Reduced down-time (due to simplified installation)
- Reduction in man-hours and materials for re-furbishing hammers and knives

It can be seen from the preceding arguments that for the majority of new installations and upgrades, there are genuine advantages to be gained from installing an in-line shredder, in terms of energy savings, installation and civil costs, maintenance savings and particularly co-generation benefits that will allow factories to operate at a higher level of efficiency than might previously have been possible.

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