REVIEW OF CANE SHREDDING

B St C MOOR

Tongaat-Hulett Sugar Limited, Maidstone

Abstract

The evolution of cane shredding practice is reviewed, leading up to modern "90 + preparation" for both milling and diffusion. Features of modern heavy duty shredders are described. Particular aspects covered are shredder size, power requirements, rotor construction, hammers and the grid plate. Comments are made on some aspects of operation and maintenance.

Historical

The equipment now generally used after knifing (or sometimes billeting) to complete the preparation of cane for the extraction plant is the shredder But this has only been so over the past 20 to 50 years in most cane sugar industries. Previously, initial knifing was followed by a heavy "crusher" to break up the cane further. These devices usually comprised two rollers, often with complex, coarse, non-circumferential grooving, such as on the Kradewski Crusher (Figure 1). Other coarse crusher designs included those of Craig, Cail, Fulton and Stewart.

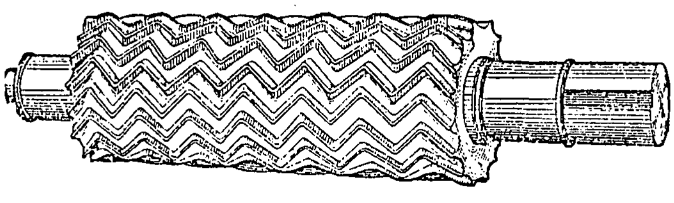


FIGURE 1 Kradewski crusher roll

These crushers extracted some juice and discharged the cane in compressed lumps. To break up these lumps, so as to enable an even feed to subsequent mills, a device called a "Maxwell Shredder" (Figure 2) was fitted at the exit from some crushers. This was no more than a "teaser" or rotary carding comb – a far cry from the modern shredder concept. However, it did serve to provide the idea of further high-speed cane disintegration and spawned a number of devices for this purpose.

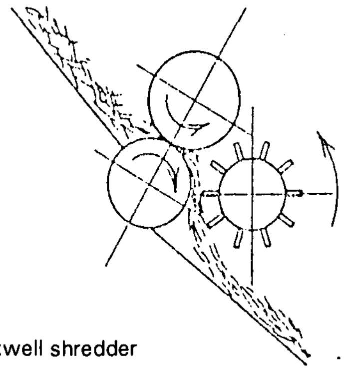


FIGURE 2 Maxwell shredder

Early shredders

The National and Searby shredders (Figure 3) had light swing hammers with an open-spaced set of anvil bars.

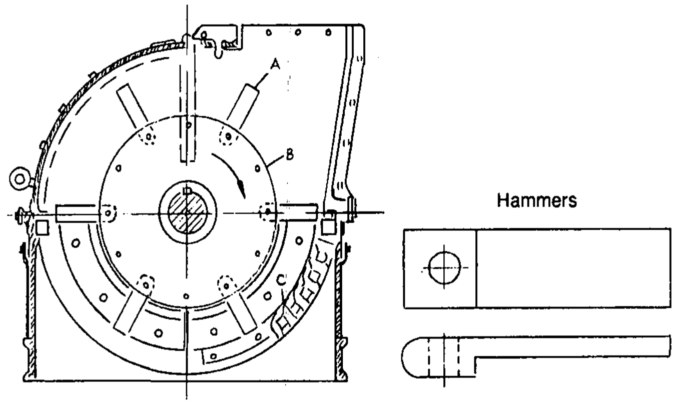


FIGURE 3 Searby shredder

The Gruendler shredder (Figure 4) had heavier, profiled hammers and featured a serrated "washboard" type grid.

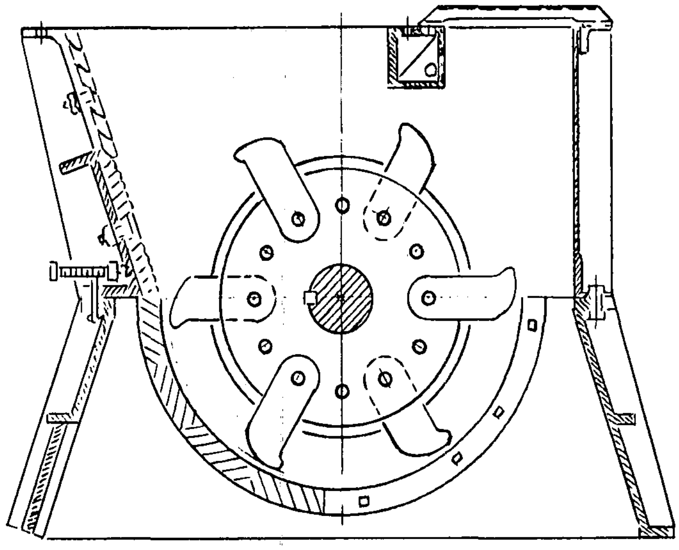


FIGURE 4 Gruendler shredder

All these shredders were initially designed to follow a traditional crusher unit. They were characterised by hammer tip speeds of 60 to 65 m/sec. With hammer masses of 3 to 7 kg, this tip speed resulted in considerable hammer swing and heavy wear of both hammer bars and hammers. Installed power was generally around 10 kW/t fibre/h and at best a Preparation Index (PI) of 85 - 87 was achieved, with a significant proportion of chunks of cane remaining unshredded. (PI is not a reliable measure of preparation where large pieces of cane remain undisintegrated, as these are often discarded from the samples).

Modern heavy duty shredders

Various technologists thereafter logically decided to reposition the shredder ahead of the "crusher" or first milling stage. More powerful units were also introduced.

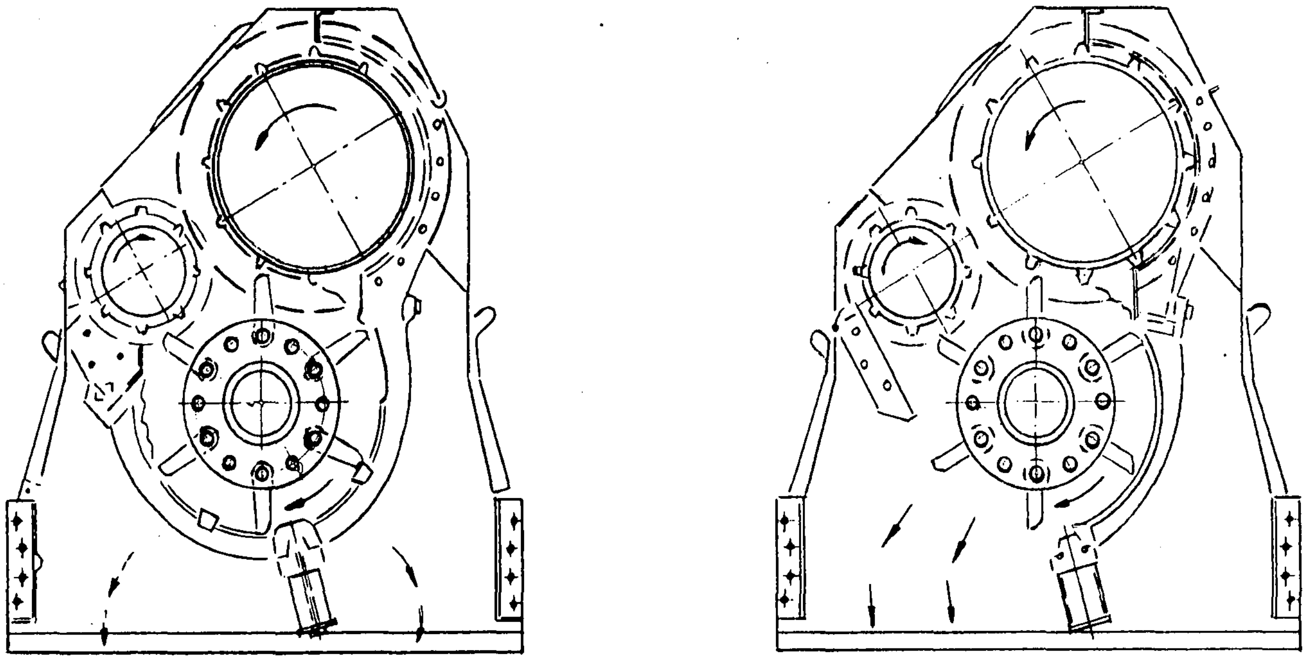


FIGURE 5 Buster and Fibersizer

In Hawaii, John Payne and the Silver Equipment Company revisited the cane diffusion concept. They identified the importance of extensive cane disintegration for successful diffusion (Payne,1968). Their solution was to provide an initial knifing followed by two powerful shredding devices, which they called a "Buster" and a "Fiberizer" (Figure 5).

As far as is known, these were the first devices to produce "90 + preparation" consistently- whether measured by % open cells, displaceability index or preparation index.

The Australians followed closely behind. Their Walkers company initially produced shredders of the Gruendler type, but working closely with the Sugar Research Institute and Queensland University, progressed to their own heavy duty design. Hammer tip speeds were increased to 90 - 110 m/sec and the hammer mass to 15 kg or more, and the washboard was changed to a pocketed design. However, the rotor remained of conventional disc-and-spacer construction.

South African heavy duty shredders

South African technologists took note of the comments of Payne (1968) regarding the effect of preparation on diffusion efficiencies. They also noted Australian experience as reported, *inter alia*, by Clarke and McCulloch, (1970), Cameron (1970) and Murry (1971). These showed the considerable potential for improved milling extraction - of the order of 1% - from improved shredding. Subsequent South African experience confirmed these figures for long milling trains but found substantially greater extraction benefits for shorter trains (Moor, 1974).

The quest for improved extraction prompted several mills to upgrade their shredding equipment. It also led to the development of the Tongaat Shredder (Figure 6), which was described by Moor (1973). The most radical feature of the Tongaat design was its rotor incorporating alternately staggered profiled plates instead of the traditional disc-and-spacer construction. This novelty provided important benefits, particularly

- reduced mechanical stresses in rotor plates, hammer bars and hammers,
- full-width hammer coverage without the use of costly "club head" hammers, and
- a more rigid rotor construction.

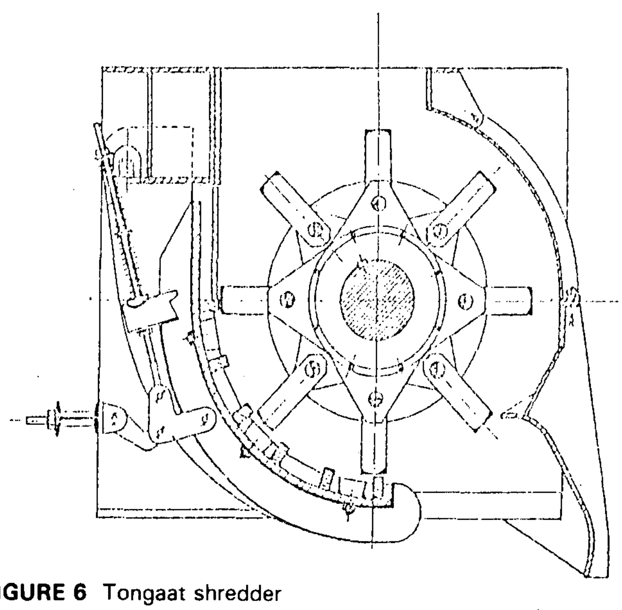


FIGURE 6 Tongaat shredder

The majority of shredders in the Southern African industry are now of the Tongaat type but there are also a number of heavy duty units of the conventional disc-and-spacer type.

Technical Features of Heavy Duty Shredders

In selecting, installing or operating a modern shredder, several features need to be considered. Among the more important are:

Shredder size

Most South African shredders are 2 130 mm wide (some are wider) with a swept diameter of either 1 525 mm or

1 780 mm. Most have eight rows of hammers although some of the 1 780 diameter units have ten rows.

The 1 525 mm units will provide 90 + PI on throughputs up to 40 or 45 tons fibre per hour. For higher rates, the larger diameter (and possibly width) is recommended.

Preparation quality is more critical for diffusion than for milling, and this can affect a decision on marginal sizing of the shredder and its drive.

Power requirements

Surveys reported by Renton (1974), Jones (1991) and Reid (1994) indicate installed powers in the range 40 to 65 kw/t fibre/h on successful preparation lines.

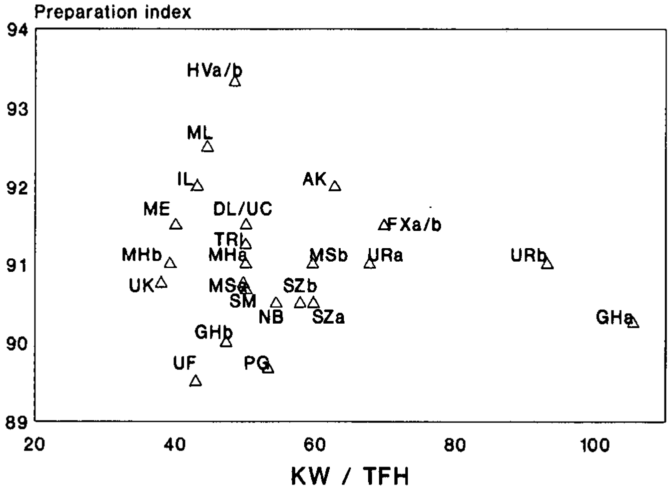


FIGURE 7 Shredder installed power survey (Jones, 1991)

Of these, only Renton systematically attempted to measure the power *absorbed,* but less than half the shredders then tested were achieving 90 + PI. Measurements on those installations indicate average power absorbed of 25 - 45 kw/t fibre/h. Somewhat higher figures (up to 55 kw/t fibre/h) have been measured with blunted hammer tips or poor feed conditions. It is also necessary to cater for surges and short term peaks, which justifies the higher installed powers.

Of critical importance to surge-free operation and consistently good preparation is to ensure a steady cane feed to the shredder. This can be achieved either by the use of feeder rolls (which can themselves prove troublesome) or by ensuring an even feed projected into the "nip" as the shredder hammers approach the grid. The rotational mass of the rotor plus hammers of a heavy duty shredder is sufficient to make a flywheel unnecessary. Additional power in pre-preparation (knifing) will at best only partially reflect in reduced shredder power. Care must be taken to avoid excessively fine knifing as this tends to cause short fibre lengths and "pulping", which detracts from feeding in mills and impedes percolation in diffusers.

The choice of drive unit – whether turbine or electric motor – is covered in a paper to be presented by Boshoff (1994) at this Congress.

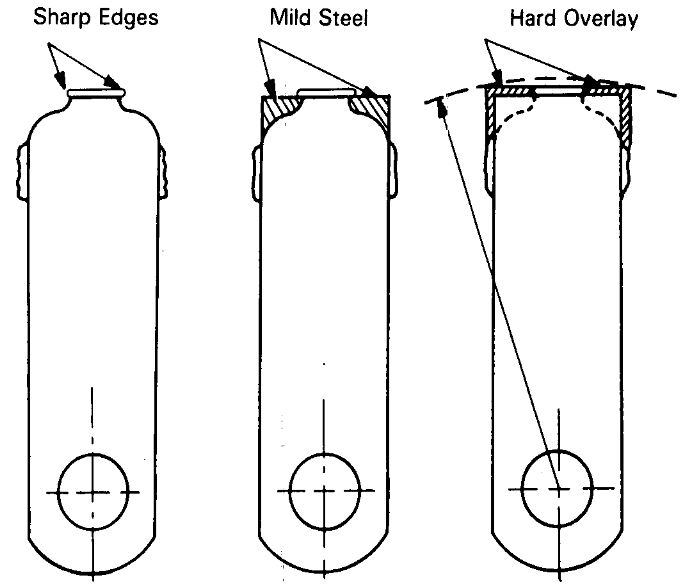
Shredder hammers

For optimum preparation, it is important that hammer coverage be provided across the full width of the shredder to avoid "short circuiting" of chunks of cane. The Tongaat rotor design automatically provides full coverage, but with disc-and-spacer type rotors, club head hammers are necessary.

Most heavy duty shredders use hammers of more than 15 kg. Under normal operating conditions, the kinetic energy of the hammers and their natural periodicity are such that a very small angle of swing occurs (Crawford, 1969; Moor, 1973 and Cullen and McGinn, 1974). As a result, wear rates on hammer bars of suitable material should be low and Maidstone have achieved an average of 2,5 m tons cane per set of hammer bars (Moor, 1991). The small angle of swing also means that the cost of replaceable bushes in hammers cannot generally be justified. Maidstone's experience showed 1,5 - 2,0 mm ovality in hammer pivot holes after 1,5 m tons cane, by which stage it was felt that the general condition of the hammers warranted their replacement.

Rate of wear of the hammer faces appears to be more dependent on extraneous matter (particularly sand) than cane variety. Some engineers state that extremely tight grid plate settings (tip-to-tip) tend to increase hammer wear rates.

Most South African mills protect the working face of their shredder hammers by applying a hard welded overlay. Provided this hard cover is not too thick, (preferably not more than 8 mm) it retains a sharp leading edge as the hammer wears, with the softer base material being undercut as it wears more rapidly. The resulting "hook" provides ideal preparation over the full period between hammer changes (see Figure 8).



(a) Both sides worn. (b) Mild steel rebuilt. (c) Hard overlay to gauge.

FIGURE 8 Rebuilding worn hammer

In welding to refurbish worn hammers, it is desirable to work with jigs. These ensure a constant length from pivot hole to longest extremity and also a reasonably consistent mass for each hammer. All hammers do not need to be of identical mass, but it is essential that hammers are replaced in dynamically balanced sets.

In order to reduce hammer maintenance costs, various replaceable hard-wearing hammer tips have been tried. Experiments at Amatikulu and elsewhere with very hard tungsten carbide failed because the replaceable tips shattered on impact with extraneous matter (rocks and tramp iron).

Less hard but tougher materials have proved more successful but suffer from the same problem as heavily applied chrome carbide hard facing: over time, the leading edge wears to a rounded profile which then "pulps" the cane rather than shredding it. This results in poor preparation and excessive power consumption and can also impair shredder feeding.

Following research by Mason (1977), the Australian industry uses "Duo blocks" which comprise a very hard high chromium white iron block measuring approximately 75 × 75 × 10 mm, brazed to a mild steel backing plate. These blocks are indexed and mounted on the hammers with high tensile bolts. With far less extraneous matter from their chopper harvested cane, shattering does not appear to be a problem but they also wear to a rounded leading edge. Both Maidstone and Felixton recently imported Duo block tips for testing.

Other proposals have included an s g iron block with a chill hardened surface which would perhaps retain a sharp edge when partially worn. New surface hardening and surface alloying techniques currently under development could well produce a satisfactory and cost effective replaceable hammer tip in the near future.

Grid plate

The grid plates of most modern shredders cover a working arc of 90 degrees although South African (and Australian) shredders range from 80 to 120 degrees. This latter is probably the limit for a single pivoted grid plate assembly as it is of importance that the setting of the grid plate can be adjusted over the entire working area. This is normally done by checking the gap between extended hammers and the working surfaces of the grid across the width of the shredder at both the inlet (first grid bar) and outlet (final grid bar). Setting is carried out by adjusting the hinge points at both sides of the shredder and then adjusting whatever devices are used to control the pivoting about these hinges.

Mill Engineers hold various theories regarding the desirability of converging, parallel or diverging settings around the working zone but it is universally accepted that the range of settings at all points should be between 0 (i.e. tip to tip) and 20 mm maximum. Any larger gaps allow unacceptable quantities of unshredded cane to pass out from the shredder.

Greenwood (1971) showed that pocketed type grids were more effective than the serrated washboard type. He also concluded that the pockets should be not less than 200 mm wide by 40 mm deep. This results in a grid comprising five to seven grid bars. High speed photography at the University of Queensland subsequently confirmed the effectiveness of this type of grid construction (Cullen and McGinn, 1974). In recent years, some shredders have been fitted with extra deep "pigeon hole" pockets (150 - 200 mm deep). There does not appear to be any published evidence that these perform better than, say, 70 mm deep channel pockets.

They may well have advantages in greater structural rigidity (depending on construction) and in sound deadening properties through the thicker mattress of cane within the pockets. However, most sound emission occurs through various openings such as the shredder discharge and end covers around the shaft. The pigeon holes are also reported to collect small items of tramp (bolts, etc.).

The mechanism of shredding in a pocketed grid appears to be that a mattress of fibrous cane packs within each pocket. The cane being impacted and pulled through the shredder by the rotating hammers is then stripped against the surface of this fibrous mattress. The compacted mattress slowly "flows" through the pockets and most of the shredding occurs against this constantly renewed fibrous surface. This explains why the leading edges of the grid bars do not wear nearly as fast as do the hammers. It is however important to keep reasonably sharp edges on the grid bars to ensure that the fibrous mattress is retained within the pockets.

The grid plate can be rigidly secured but most Engineers prefer to allow for some fail-safe mechanism in the event of large tramp iron or an excessive surge of cane. Mechanisms to allow the grid plate to move rapidly away from the rotor under such circumstances include pneumatic, hydraulic or spring loading against adjustable stops (all of which are self re-setting) or shear pins (which require a stop for replacement if sheared).

Conclusions

The modern heavy-duty shredder constitutes the single most important part of cane preparation. The basic equipment parameters and maintenance requirements are well established. Complying with these is essential for acceptable extraction rates, whether from a milling train or a diffuser. It is therefore appropriate to conclude with a checklist provided by Reid (1994) for improving performance and/or simplifying shredder operation:

- Check the concentricity of the grid plate regularly.
- Check grid bar clearances frequently.
- Keep control of hammer lengths and masses (use of jigs).
- Consider building a spare grid plate assembly, if none exists.
- Particularly for diffuser operation, limit knifing to just enough to prevent shredder chokes.

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