A REVIEW OF CANE KNIFING

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Abstract

The role of the knives in cane preparation is discussed and the few later developments which have taken place in South African mills are enumerated. Typical installations presently in existence are described and the average power provided per ton of fibre processed is given. Various types of cane knives which have become available are briefly introduced and their relative merits are evaluated. Some of the earlier work on the comparison of hard facing materials is described and some recommendations are given.

Introduction

The increasing use of diffusers in Southern Africa has placed more emphasis on the importance of shredder preparation to achieve good percolation, and the role of the cane knife has tended to be pushed into the background. This is understandable because it has become apparent that coarse knifing and fine shredding are beneficial to good percolation whereas the converse could cause serious flooding in the diffuser. The role of the cane knife has therefore become that of a device to ensure that the shredder is evenly fed and that no conditions exist that can promote choking.

The role of the cane knife

Before the advent of the shredder, the cane knife was the only means of preparation, and was perfectly adequate when the acceptable extraction was around 90%. However, when higher extraction became more important it was realised that a greater proportion of broken cells could be more effectively achieved by hitting the cane with a heavy hammer at very high speed and in the process employing greater power. The cane knife was then relegated to the role of leveller or prebreaker in order to facilitate the operation of the shredder. In fact more engineers are beginning to hold the opinion that a large shredder on its own without any previous knifing is better than one or more cane knives followed by a shredder. Of course this would only work satisfactorily if the incoming cane was either very clean and uniform, such as in the case of burnt cane, or if it was chopper harvested, or both. In some areas and in Australia in particular where all cane is chopper harvested, knives have been removed completely.

The cane knives as used in South Africa are therefore seen to have four different roles:

- Leveller mounted on the main cane carrier with a clearance of 500 to 1500 mm, mainly to facilitate feeding into the main cane knives.
- Primary knives, with a clearance of 60 to 600 mm to prepare the top layer of cane.
- Main knives, with a clearance of 10 to 40 mm, to complete the knifing operation.
- Feed knives mounted above the shredder, to break up lumps in the feed and to accelerate the cane blanket into the nip of the shredder. It also probably assists the shredder by cutting the cane slightly more than the last knife.

No mills have all four types of cane knife together, as discussed below.

Survey of cane knife installations

There are 24 cane preparation lines in South Africa and Swaziland. There is not enough information on those in Zimbabwe and Malawi to be included in this brief survey which is taken from an SMRI communication (Reid, 1992).

Twelve lines have three sets of knives. In most of these cases the first knife is a leveller and does little preparation. In nine of these lines the third knife is a shredder feed knife. It may therefore be concluded that most knifing is effectively carried out by one knife set, which may be called the "main" knife. In fourteen lines the main knife runs in "reverse" direction to the conventional. This means that it cuts upwards into the advancing cane blanket, and usually cuts against a fixed or rotating anvil, throwing the cane down onto the next conveyor in a shallow trajectory.

Each of the lines at Felixton has two "billeters", one each for rail and road deliveries which are 20 and 14 m wide respectively. These were designed to chop the cane into short billets to facilitate conveying on a rubber belt and feeding at a controlled rate into the shredder. The original idea was based on slow speed cutting of evenly presented cane with a sharp knife but the shape of knife and design of its attachment were no match for the high sand, rock and tramp iron content of FX cane. After much experimentation the attachment has been modified so that the knife pivots on a polyurethane bush and the knife shape has been changed to put a more even load on the attachment. The material of the knife is now a cast alloy which is refurbished by abrasive sharpening several times per season.

The first of the objectives of the billeters has been achieved but not as effectively as was intended. The billetted cane is not cut into neat short lengths like chopper harvested cane

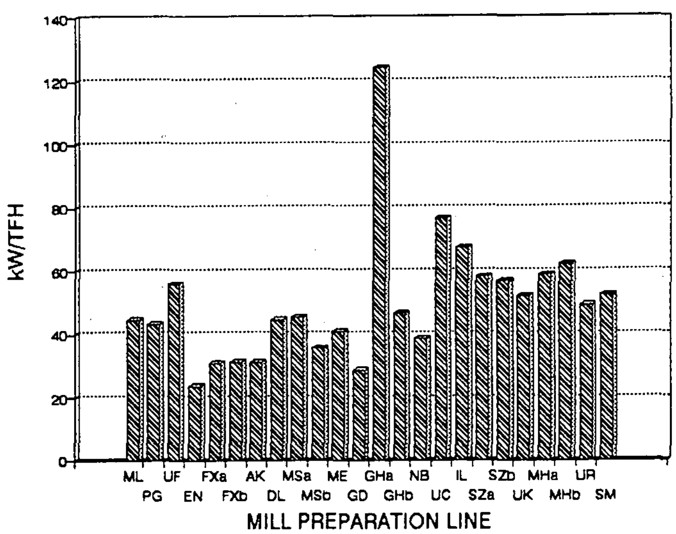

FIGURE 1 Distribution of specific power consumption of knives

but it is easily conveyed on the rubber belt. The preparation is very good when the knives have been freshly sharpened, and particularly when handling burnt cane.

The smooth, controlled feed into the shredder through hydraulically-driven feeder rolls was not very successful from the start and the operation of this part of the mill has been altered.

The total installed power of each of the preparation lines ranges from 242 kW at EN to 2235 kW at ML. These totals have been divided by the fibre throughput for the 1991/92 season, which season was selected because it was before the start of the drought. These specific installed power figures vary from 28 at GD to 126 at GH-A with the average being 50 kW per ton fibre per hour (See Figure 1). The high value for GH-A, which is the diffuser line, results from the fact that the main knife turbine is oversized, and its power is seldom used to the full.

The speed of rotation of cane knives varies from 250 to 960, with most being in the region of 600 rpm. The effectiveness depends to a large extent on the tip velocity of the knives which for the lines in the survey ranges from 22 (FX billeter) to 80 ms-1 (PG, NB) (see Figure 2).

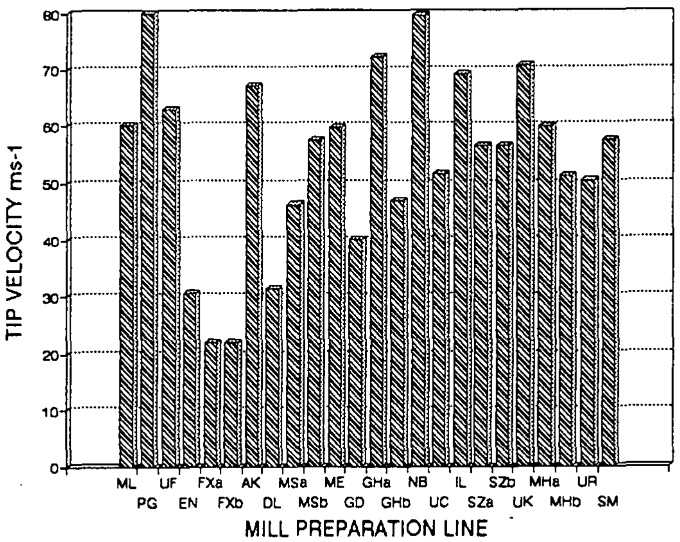

FIGURE 2 Distribution of the tip velocity of knives

Ten of the preparation lines have turbine drives for one or more of the knives. In these cases the power of each is higher than their electrically-driven counterparts.

Design and operational features

The typical knife rotor consists of a shaft to which twenty or more palms are keyed. Two knives are attached to each palm, and the palms are staggered in angular position along the length of the shaft.

The attachment of the knives varies in design, most using some kind of quick release arrangement in which centrifugal force tends to secure the knife. Some palms are pivoted to bosses on the shaft so that the knives can swing radially to avoid damage by rocks and tramp iron.

Most mills use the same design of knife consisting of a plate about 20 mm thick with a mass of between 12 and 20 kg. The cutting edge is provided by forging or gas cutting a chamfer on the leading edge and the end. The flat face of the knife is covered with a layer of hard facing which reinforces the cutting edge against wear. As the steel backing wears away, the layer of hard facing remains to provide a fairly sharp edge.

Maintenance

The major maintenance expenditure on knives is in refurbishing the cutting surfaces because of wear. This is caused by the relatively large amount of sand which is brought in with the cane, especially during rainy weather. Every knife must be built up and hard faced by arc welding on a weekly or fortnightly schedule, and the palms are usually built up and hard faced in the same way once or twice during the season.

Very little has changed in cane knife technology since the mid-seventies. Nurick (1975) completed a study of knifing and of the power absorbed by knives at FX (old mill), GH and SZ for his MSc, in which one of the main conclusions was that the power absorbed by knives had not changed for many years.

There have been some investigations by the SMRI and also by many mills into the materials and techniques used in hard facing. The SMRI conducted an extended research programme spanning four years from 1980 to 1983 into the wear on shredder hammers and knives. The specific work on knives took place during the last two years and was reported by Schlaudraff (1982, 1983). The most promising development from this work was in the use of high chrome cast alloy steel inserts such as "Apex 26" which could be either bolted or, preferably, welded to the knives and replaced as they wear.

It is expected that there will be a revival in the testing of wear resisting materials for hammers and knives in the near future, because there is no doubt that refurbishment of these remains one of the most expensive maintenance expenditures in the sugar mill.

Preparation achieved by knives

The preparation index (PI) of the knives is not measured regularly at any mills. Historical figures from those mills which did not have shredders, for example Empangeni, indicate that knives alone were able to give PI figures as high as 90 and in this instance in 1981 the EM diffuser was able to achieve an extraction of 97,76% with a bagasse diffuser. The range in PI was from about 75 up to 85 for those knives where PI was measured in 1974.

Moor (1974) reported that the knives at MS (then Tongaat) mill were providing a PI of between 65 and 70. Nurick (1975) reported PI figures from the final knives at the old FX mill, GH and SZ ranging from 46 to 79. The higher figure was achieved at GH where the knife was enhanced by welding a block of steel to the cutting edge, hence providing a certain amount of shredding action.It should be noted that it is not easy to measure PI of knifed cane because of the difficulty of ensuring a valid sample. The analyst may be tempted to remove any large pieces of whole-stick cane, thus inflating the PI measurement.

Hybrid types

Some hybrid type knives/shredders have appeared on the market and have achieved success in many parts of the world, but not yet in South Africa. The most popular example is the "Unigrator" of the Unice Machine Company, of the USA.

This machine combines the knifing and shredding operation in one unit. The rotor cuts upwards into the cane and then pulls it over onto a washboard where shredding takes place. The hammers are shaped in such a way that they can perform both functions (Ducasse, 1974).

Conclusions

It would appear that there are conditions in which the traditional cane knife in a sugar mill can be dispensed with altogether. This would be a very interesting development if it were to be tried in South Africa, where the opinion exists that the cane is much more difficult to prepare and process than in most countries.

There is still a large area of uncertainty surrounding the method of refurbishment of cane knives and hammers. This remains one of the most expensive maintenance functions and more research work is warranted to try to reduce these expenses.

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