DEVELOPMENT OF A SWEEP SAMPLING DEVICE FOR THE DIRECT SAMPLING OF KNIFED CANE FROM A BELT CONVEYOR

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Abstract

The sampling of knifed cane from a continuous belt conveyer poses many problems if representative samples are to be taken. These problems together with the design and development of a device for removing knifed cane from a belt conveyer are discussed.

Introduction

The cane preparation project that was conducted at Amatikulu during the 1976-77 cane season had the following objectives.

(a) To identify the most important parameters in a cane preparation station.
(b) To choose the values of the most significant variable parameters to optimise the design of cane preparation equipment.
(c) To determine what influence preparation equipment has on the permeability of a prepared cane bed.

To achieve these objectives it required, among other things, the direct sampling of knifed cane from a moving rubber belt conveyer of 2 m width for the determination of PI of the knifed cane. This paper deals with the design and development of such a device.

Design Requirements

T. Allen[1] states that as a general rule in all sampling, the sample should be taken when the material to be sampled is in motion. When a sample is to be collected from a conveyor belt, the best position for collecting the increments is where the material falls in a stream from the end of the belt. There are numerous devices available in the sugar industry for such sampling, some of which are discussed by Buchanan[2].

If we now consider the geographical layout of the cane preparation equipment at Amatikulu and refer to Figure 1 we see that there is no space available for such methods, as the knifed cane is conveyed from the knife house to the top of the shredder stand by means of a rubber belt and the shredder stand at A-belt head shaft is only a few centimetres below the overhead crane. Directly below the head shaft the knifed cane passes through a distributor before entering the two shredder chutes (during this season only one chute was in use). The short chutes take the knifed cane to feeders which feed the cane to kicker knives which send the cane into the shredder at high velocity. As access to the end of the belt is not possible, the sample had to be taken from the belt.

The belt could not be stopped for sampling, as this would have affected the power recording of the shredder. This meant that the knifed cane sample would have to be swept off the belt by some mechanical means, which would meet the following requirements.

1. The sample must be taken from the full width of the 2 m belt, as particles at the edge may not be the same size as those at the centre.
2. The sample must be taken to the full depth of cane, leaving a clean belt behind as particles on top of the cane are not the same as those at the bottom.
3. The sample must be of sufficient width to include any whole stick or semi-cut cane.
4. A sample should be taken from each bundle of cane in the test consignment (compounding of sample).
5. The operation of the belt must not be interfered with in any way.

Referring to Figure 1 and 2 it is seen that the whole length of A-belt from the knife house to the head shaft is fitted with side

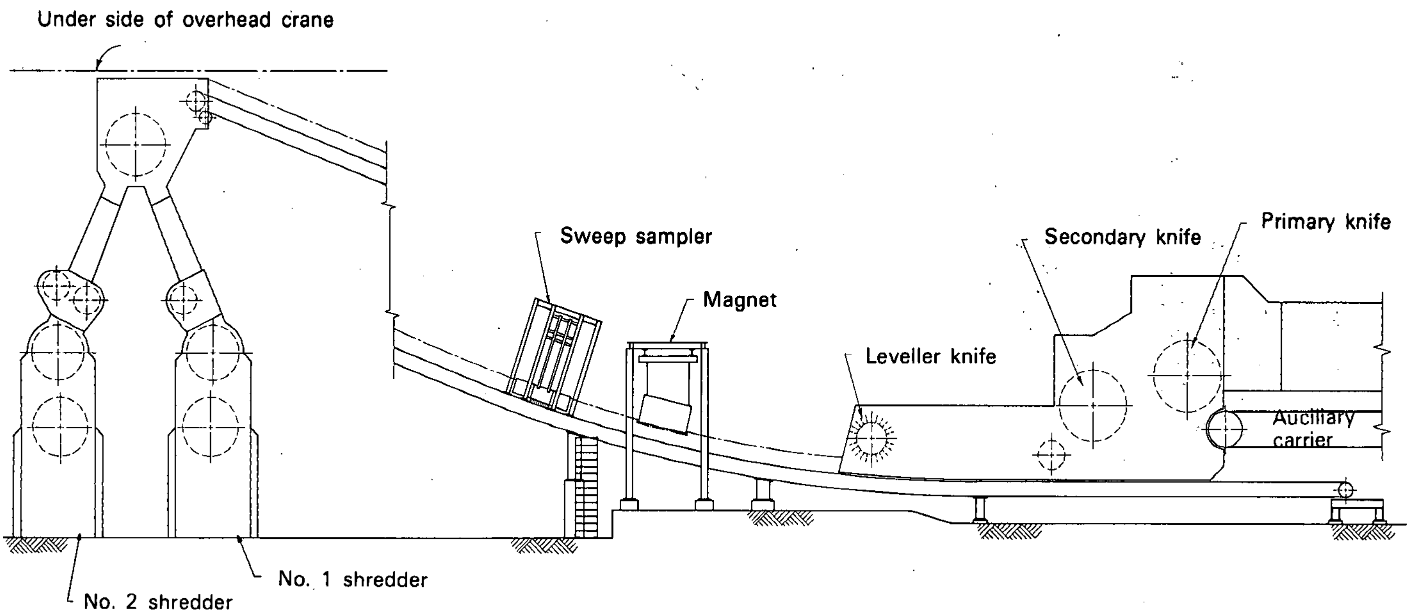

Figure 1: Geographical layout of cane preparation equipment, Amatikulu

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plates, to prevent knifed cane falling off the belt. Any device, therefore, for removing cane from the belt, would have to operate with these side plates in position to satisfy requirement 5. The side plates could however, be removed for short periods, while the knife cane sample was being taken.

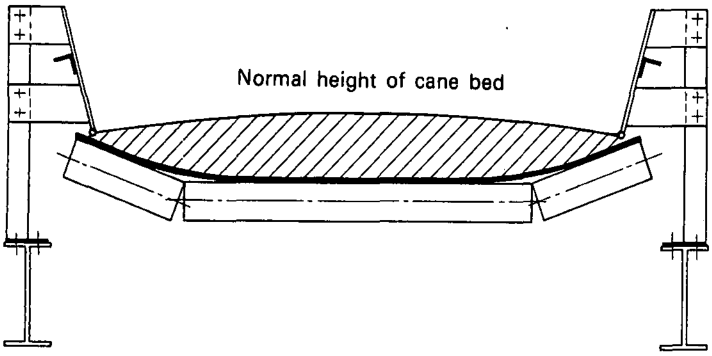


Figure 2: Typical section through A-belt showing position of side plates

First consideration

The first method we considered for removing the knifed cane from the belt was to plough it off by means of a plough operated from overhead, a system found in some bagasse stores. This method, although simple, did not meet with requirement 2, as the up and down movement of the plough into the cane on the belt would remove more cane from the top of the consignment than the bottom, thus biasing the sample.

Second consideration

The next method to be considered was that of a hydraulically operated blade to push the sample off the belt. To do this, the belt profile would have to be flattened to allow for a clean sweep of the belt by the blade. The disadvantages of this method was that on the return stroke the blade would have removed the same volume of cane as on the forward stroke. The blade could also not be left on the far side ready for the next sweep as the ram rod would foul the cane on the belt. Continuing along these lines, various devices were considered which would achieve the same ends.

Figure 3 shows the final design of a self driven trolley arrangement which would traverse the flattened belt and push a sample of knifed cane off the belt through opening side plates on the forward stroke and lift out of the way on the return stroke.

The average velocity at which the blade had to traverse the belt was calculated to be 8 m/sec [as the blade had to travel 2 m across a belt moving at ± 2 m/sec] in about 15 seconds. This would prevent the build up of cane on the edge of the blade, as the belt would only move half a metre while the blade swept off the sample. When the mass of the supporting structure required to support the blade and its operating mechanism, as well as the traverse motor, was considered, the power required to accelerate this mass from rest to 8 m/sec in ± 2 m, and the problem of bringing it to rest again in ± 1 m before returning the blade to the starting position, was unreasonable. The structure to support the blade on the included belt would also have been very cumbersome with a length of ± 5 m.

It was obvious that something more practical would have to be considered.

Third consideration

By arranging the idlers to give the belt a curved cross-section, the blade could now be hinged from a central pivot point above the belt, eliminating the tracks necessary with the other systems.

After preliminary sketches had been made, it was found that a radius of 2,6 meant that the edges of the belt were only raised by 100 mm above the existing belt height; this was considered reasonable.

The final design for the sweep sampler, shown in Figure 4, consisted of a space frame, straddling A-belt, from which the sweep arm was pivoted in the centre and was able to swing back and forth across the belt. The blade or sweep plate was hinged at the end of the sweep arm, which enabled it to be retracted for the return stroke. The side plates were also incorporated in the design. On the one side, the sweep plate was held in position parallel to the side plate by means of a locking arm. The other side plate was held by two arms which were hinged, so as to allow the side plate to lift out of the way as the sweep arm moved across the belt, allowing the cane sample to be swept off the belt into a catch. On the return stroke, this side plate was

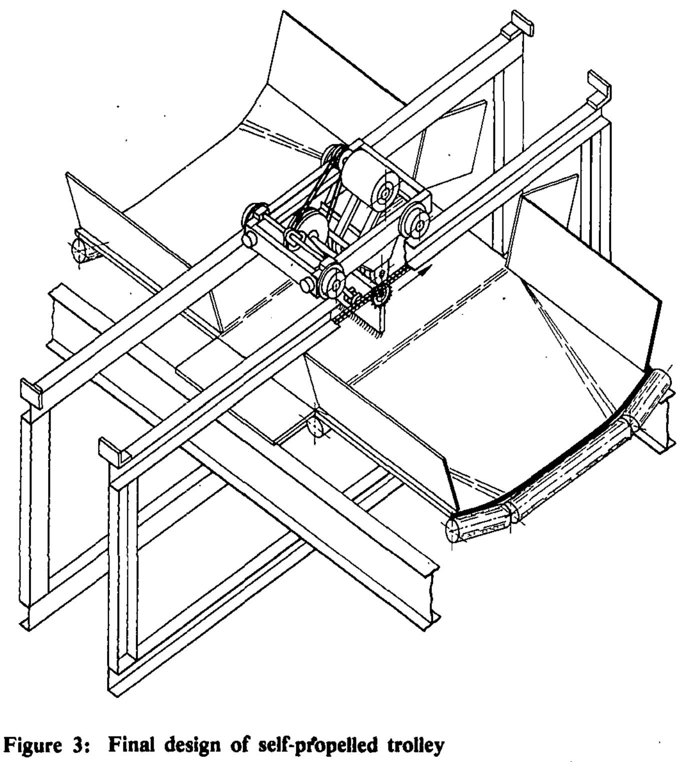


Figure 3: Final design of self-propelled trolley

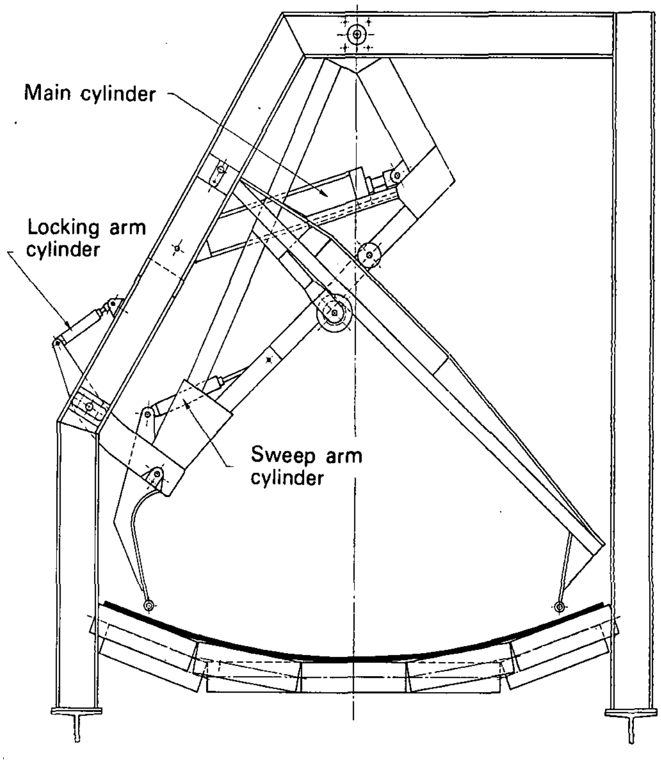


Figure 4: Sweep sampling device

again lowered into position, while the sweep plate was lowered and allowed to fall back and locked in position after completing the cycle.

Method of operation

The sampling device was operated pneumatically by means of a cascade system.

The sequence of operation was started by means of an electric solenoid valve; once energized, the sequence was automatic, returning the sweep arm to the start position ready to take the next sample.

Air was fed from an air receiver at 700 kPa to the locking arm cylinder which released the sweep arm. The main cylinder then pushed the sweep arm across the belt taking the sample. At the end of the stroke the sweep arm cylinder retracted the sweep plate allowing the sweep arm to be returned above the knifed cane on A-belt. At the end of the return stroke the sweep arm cylinder again lowered the sweep plate. Both cylinders were then exhausted and allowed to fall back onto the locking arm catch, which repositioned the sweep plate by means of a cam to align it with the side plates.

The pneumatic circuit for this sequence is shown in Figure 5, and built into the system was a reversing switch which allowed the operator to return the system to the start position at any point during the sequence. Another safety feature was the air receiver which held enough air to operate the sweep for two complete cycles, should the mill air pressure fail for any reason. The air receiver was also fitted with a pressure switch which did not allow the sweep to be operated if the air pressure was below 550 kPa.

Installation of sampler on A-belt

The sweep sampler was originally designed to operate on the horizontal section of A-belt, between the knife house and the magnet, but due to the numerous chokes that occurred in this area it was decided that the device would certainly inconvenience the operations side of the mill by hindering the cleaning of the chokes. The next best place was just after the magnet but as this was on the curved section of the belt the sweep sampler had to be installed higher up the belt. Some doubt was expressed as to the reliability of the sweep sampler having to operate at an angle of 21°. Although the sampler looked very awkward in this position, no mechanical difficulty was experienced with the operation during the test programme.

Operation of sweep sampler

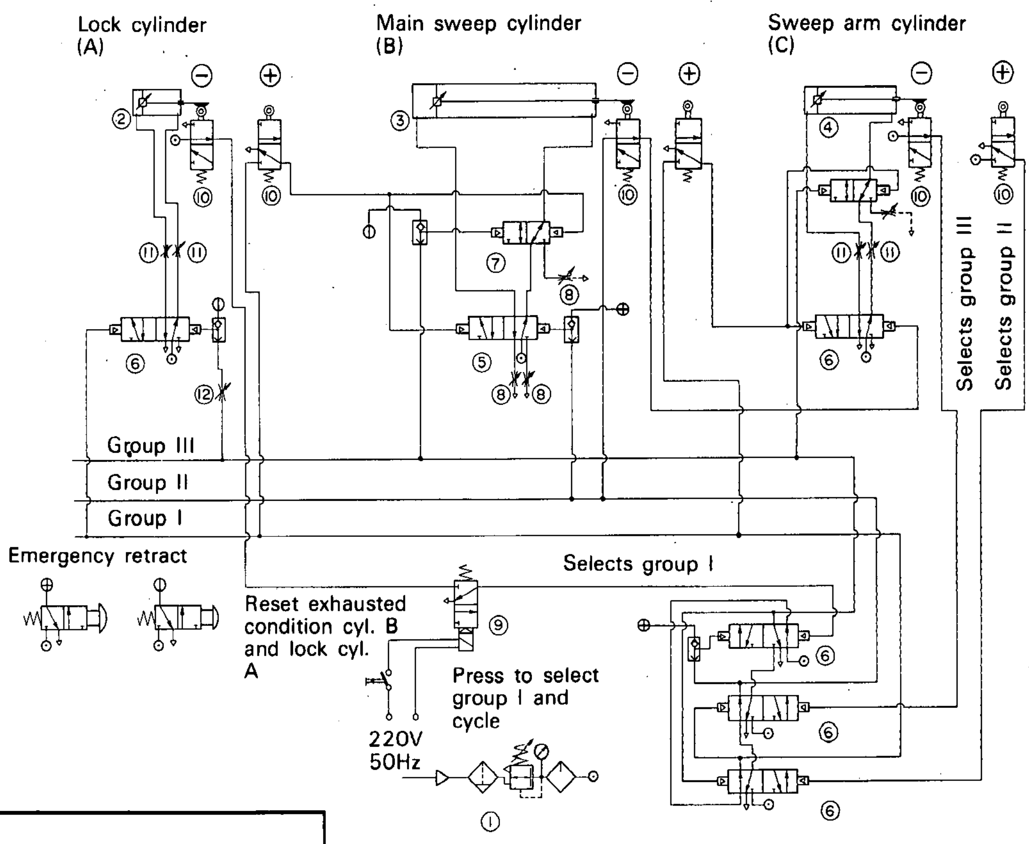
The sweep sampler was originally designed to work remotely but after installation and the removal of the second knife set, the uneven belt loading, shown in Figure 6, forced the operation to be visually controlled as it was felt that the sweep sampler would not be capable of removing a full belt load of knifed cane which represented about ± 1400 tch for a short duration of ± 2 m.

The high cost involved in the devlopment of the sweep sampler meant that the chute, designed to catch the cane samples, was not constructed.

The cane samples were simply collected by means of a plastic bag placed on the walkway alongside the belt and hung from the hand rail. This method of collecting the sample was very effective, and little or no cane was lost. It also provided an easy means of transporting the cane to the Y blender for subsampling.

The mass of cane removed with each sweep of the sampler depended upon the height of cane on the belt, but as this operation was visually controlled every effort was made to take samples where fairly stable conditions reigned. The mass of each sweep was approximately 30 kg, which meant that a maximum of three sweeps during one test consignment was all that could be handled. This did not lead to good compounding of the sam-

Ref.	Description
1	Air service Unit
2	Air cylinder
3	Air cylinder
4	Air cylinder
5	Pilot op'td valve
6	Pilot op'td valve
7	Pilot op'td valve
8	Flow regulators
9	Sol. valve 24v
10	Roller op'td valves
11	Flow regulators
12	Flow regulators



Operating sequence
1st A+ 2nd B+ group 1 3rd C+
4th B- 5th C- group II
6th B+ 7th A- group III Partial exhaust no pressure build up on other side of piston.
8th Stop Now awaits further signal from solenoid valve to repeat above sequence.

Figure 5: Pneumatic control circuit for sweep sampling device

ples as eight to twelve bundles of cane usually made up one test consignment.

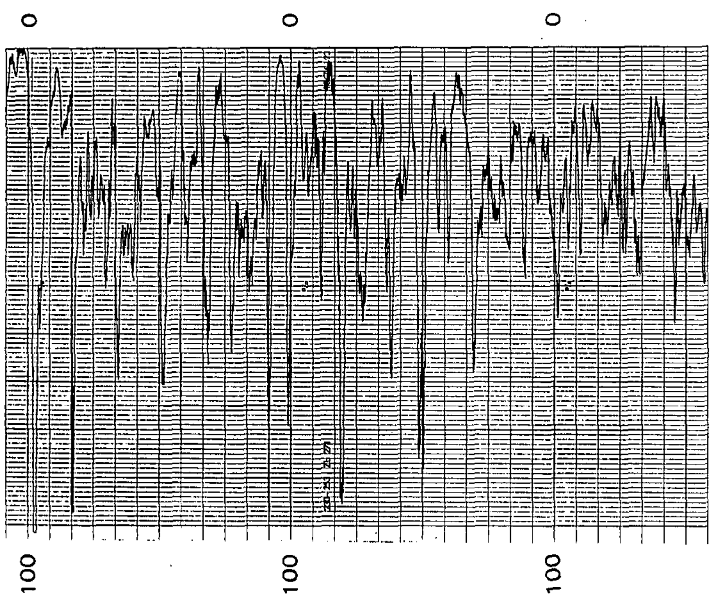


Figure 6: A-belt loading

Belt loading

The uneven loading of A-belt during the tests was a problem as the preparation of the knifed cane was not uniform. The uneven loading was due to the mill yard layout which is shown in Figure 7. The cane consignment that was to be sampled was always loaded onto B cross carrier as this carrier could be held for some time, being only loaded from the yard floor. The bundles were always chain lashed and loaded onto B cross carrier parallel with the auxiliary carrier. These bundles always entered the knife house tightly packed and end on to the knives. The auxiliary carriers fed the bundles into the knives at a fairly constant speed even though the carrier was on automatic control.

At the start of the bundle, when the knives were running at more speed ± 5 800 rpm on the turbine, the preparation was good, about 80 PI, but as the bundle was fed into them, the knives slowed down, and the preparation deteriorated to ± 65 PI, by which time the turbine speed would have dropped to ± 4 500 rpm. The last quarter of the bundle was usually pulled through intact by the slowed knives, momentarily loading the belt to a maximum. This process usually left a gap of no cane on the belt as the next bundle on the auxiliary carrier had not yet reached the knives. This type of loading is quite easily seen on the recorded graph of mass flow of cane on the belt (Figure 6). The automatic control of the belt was by means of the cane

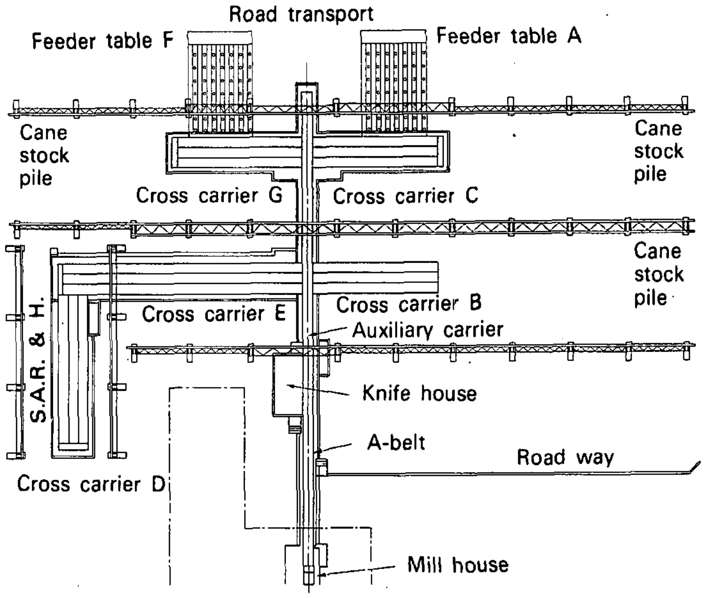


Figure 7: Mill yard layout

height in the shredder chute, but as it was some distance away from the knives, it was unable to cope with the situation, as the control was normally out of phase with the feed of the auxiliary carrier and some hunting always followed until a more even load of cane on the auxiliary carrier, from one of the other cross carriers, smoothed out the uneven loading again.

Conclusion

The sampler was used continuously for three months at the end of the season, operating approximately nine times a day. During this time no problems were experienced with its operation.

Acknowledgement

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