PROGRESS REPORT ON THE SASABY WHOLE STALK CANE HARVESTER

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Abstract

The principle on which the first two prototype Sasaby green cane harvesters was operated, was used in the construction of a much smaller machine based on a Ford 6 600 tractor. The aim was to achieve a harvesting rate of 10 t h⁻¹ and an acceptable trash content in the harvested cane. The latest model of the Sasaby forms bundles of approximately 250 kg of cane and deposits them in neat rows ready for mechanical loading. The limitations of power requirements, cooling of the engine and hydraulic oil, conveying and dumping of cane, and general utilization of hydraulic power, are discussed.

Introduction

From January 1978 to December 1979, the Sasaby whole stalk green cane harvester was designed, built and tested (Pilcher and Boast[1]). A second Sasaby was subsequently built to correct the shortcomings of the first.

The Sasaby II cut a single row of cane and fed it into a bin. A crane with a grab mounted on the harvester loaded the cane directly from the bin into trailers travelling alongside the harvester (Figure 1) (Anon[2,3]).

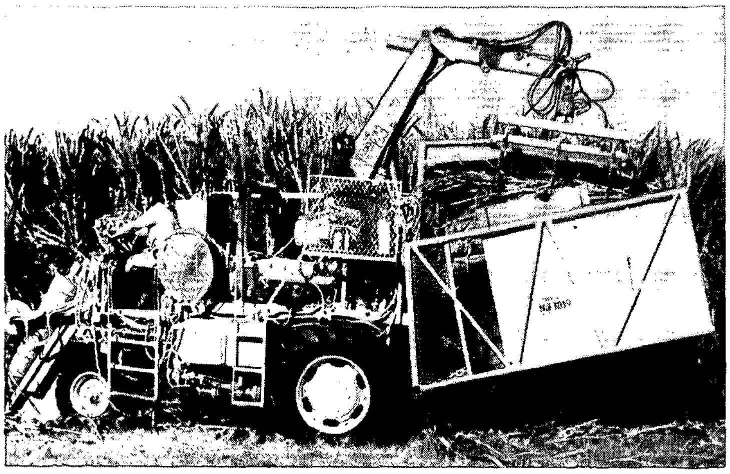

FIGURE 1 Sasaby II.

This machine was capable of harvesting 30 t h^{-1} at which rate the extraneous matter content was 8% and losses were less than 5%.

The experience gained from Sasaby I and II was used to build a third prototype which is a smaller machine built onto a Ford 6 600 tractor. It is a single row harvester which delivered cleaned cane into a bin at the rear. Up to 200 kg of cane is collected before it is dumped in bundles on the ground (Anon[4,5]).

Description

The tractor was fitted with a chassis-like frame in order to accommodate the base cutters and feed rollers, and to widen the wheel track of the tractor which improved its stability.

The standard front axles of the tractor are attached to pivoting arms and held in the vertical plane by hydraulic rams. This enabled the height of the front of the machine and the base cutters to be adjusted (Figure 2). In addition to the base cutters and rollers, crop dividers and an external topper are fitted. To fit components within the maximum machine width allowed by the South African Road Ordinances, i e 3 500 mm, all feed rollers are reduced to a length of 680 mm and a diameter of 400 mm. The diameter of the lower pick-up roller is 220 mm.

FIGURE 2 View of Sasaby showing the front suspension arm.

The radiator is removed from the front of the tractor and mounted above the draw rollers. An axial flow fan is used to draw air through the radiator and blow downwards to remove loose trash (Figure 3).

A bin with a cross-conveying chain and dumping section is fitted on the rear of the tractor.

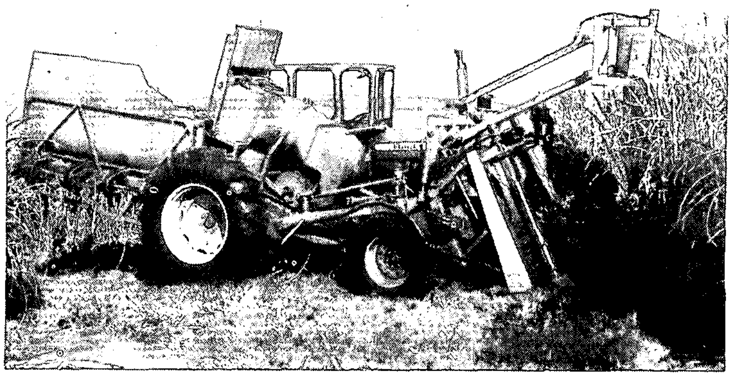

FIGURE 3 New position of radiator on Sasaby.

A 120 litre hydraulic oil tank is fitted in place of the radiator and below this, a gearbox driving a pair of double hydraulic pumps is fitted. This gearbox is driven from the front of the engine crankshaft. The hydraulic pumps feed oil into a bank of remote controlled valves situated on the side of the oil tank (see Figure 2).

Hydraulic oil flow is supplied to moving parts as follows:

- one pump (120 ℓ min⁻¹) directly to the cooling fan; a 6 mm (¼") line is taken off this pressure line to supply the control valve to engage the bank of remote controls
- one pump (100 ℓ min⁻¹) feeding two controls through a T-piece and flow is divided by feeding the oil from each control through separate motors driving each end of a common shaft, and then supplying the balance of the hydraulic motors equally
- one pump (70 ℓ min⁻¹) supplying a single control to the base cutters which are connected in series
- one pump (60 ℓ min⁻¹) supplying a single control to feed the crop dividers, topper and knockdown roller
- the hydraulic rams and bin conveyor chain are supplied from the tractor's internal hydraulic pump with a delivery of 40 ℓ min⁻¹.

Height control

The height control rams are coupled into one end of a 50 mm ram with a 300 mm stroke while the annular end is coupled onto the pressure line of the base cutters. It had been determined that more than 6 MPa would move the 50 mm ram. The oil on the other side of the piston is pressurized and so raised the machine. A drop in pressure to 6 MPa would lower the machine to its pre-set height. Although not totally automatic, this arrangement is very useful during harvesting.

Croplifters and topper

The croplifters are of a conventional spiral design on parallel shafts and rotate outwards. A single hydraulic motor is used in the topper which is built according to the standard Sasex design.

Knockdown roller

This roller bends the crop forward to an angle of 45° and consists of a 300 mm diameter tubular roller with four toothed slats 70 mm in depth and to which twelve 380 mm long curved tines are welded.

Base cutters and feed rollers

The base cutters are similar to those of most cane harvesters except for two small butt-lifting wings which are welded onto the base of each cutter disc. The shape of these wings eliminates the need for a bikini-plate between the base cutters (Figure 4). The upper feed rollers are mounted on pivoting arms linked by a torque tube and were spring-loaded to prevent bouncing. The design of the feed rollers is similar to that of the first two prototypes.

FIGURE 4 Base cutters showing wings to lift cane into the pick-up rollers.

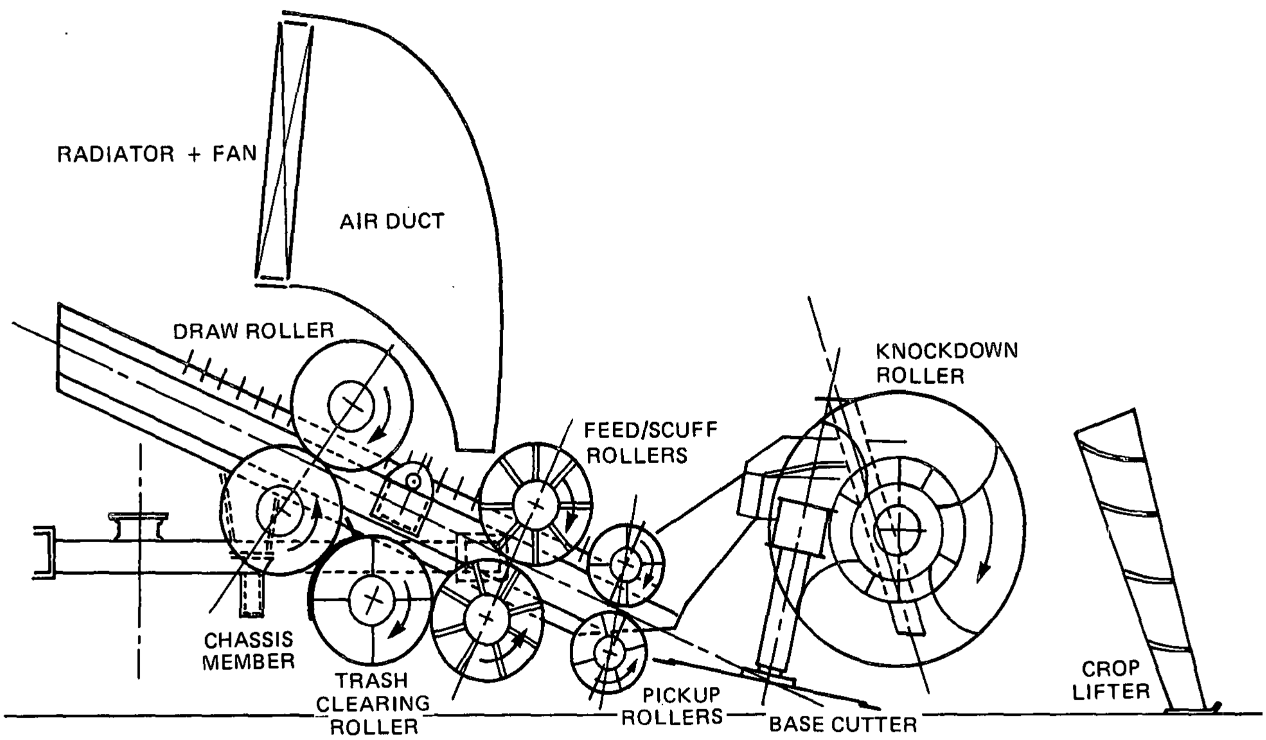

FIGURE 5 Optimum position of working components of Sasaby.

Draw rollers

The draw rollers consist of drums 500 mm in diameter and are coated with linatex rubber. The upper roller is hinged and spring-loaded.

Trash cleaning roller

The roller is slatted and consists of a centre tube 150 mm in diameter to which four sections of 125 mm flat bar are welded, giving an overall diameter of 400 mm. The roller is situated 100 mm below the line of travel of the cane and 50 mm away from the lower draw roller. This roller is partially cowled to prevent the trash, which had been removed, from being fed back onto the draw rollers (Figure 5).

Operational problems and modifications

- The uneven feed of cane was considerably improved by adding three large discs (800 mm diameter) to the knockdown roller. The discs are reinforced with 4 × 20 mm diameter tubing across the circumference between the discs.
- Loose trash collected in the outer croplifter caused it to jam frequently. This croplifter was found to be unnecessary and was replaced by a small 40 mm × 40 mm × 2 m long hollow section, pointing forward horizontally and 1 m above the ground to prevent the cane falling at right angles to the row and causing bridging across the base cutters.
- Curved tines 120 mm long and 16 mm in diameter were welded at 200 mm intervals onto the upper pick-up roller. These improved the feed of stalks as well as loosening trash from them.

  Pins made from 25 mm long and 16 mm diameter bar were welded at 70 mm intervals onto the feed rollers to improve the grip on the cane.
- A chassis member below the lower draw roller caused trash to accumulate between the draw rollers and the bin, blocking the flow of cane. This was improved by changing the shape of the member.
- Another chassis member which prevented material from falling freely was repositioned and a small four-tined spinner was fitted in front of the axle to clear away trash and any pieces of cane. However, persistent wrapping of trash around this spinner eventually led to it being discarded.
- The bin could hold cane stalks up to 2 m long only if the tops had been removed. The external topper removed only about half the tops and those on long stalks caused blockage. To overcome this problem, an internal topper, with a powered spinning disc 390 mm in diameter with eight blades protruding 45 mm, was fitted forward in the bin (Figure 6). As the cane was moved across to the dumping section with their butt-ends in line the internal topper cut the tops off.

The bin and conveyor system was a constant source of trouble. Because of their length, the dumping tines ploughed into the ground whenever the Sasaby traversed waterways and conservation structures and shortening the tines by 500 mm solved this problem. Another problem was stretching of the bin conveyor chains and subsequent jumping of sprockets. These were replaced by pulleys, new chains were fitted and the unsatisfactory uni-directional movement of the conveyor was altered to a backward and forward motion, thus transferring the cane into the dumping section of the bin. The change in motion was effected by fitting a small hydraulic valve into the system to alter the direction of the conveyor at the end of each stroke. This alteration enabled the machine to operate with the conveyor either up or down the slope. After the alterations the actual operation of the conveyor was satisfactory but its reliability was still poor. Numerous changes were made and although there was a considerable improvement, its performance was still not acceptable.

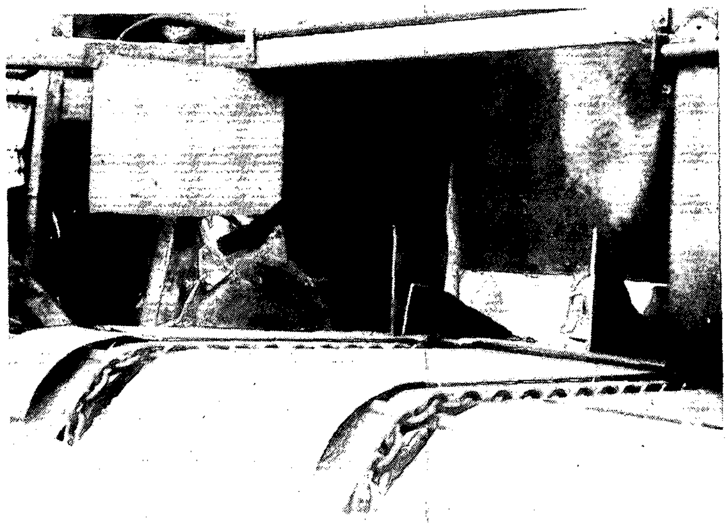

FIGURE 6 Inside of the bin showing internal topper and conveyor chains.

A simple, spring-loaded plate was attached to the outer door of the bin which prevented incoming cane from dropping into the dumping section while the bundle was being dumped.

- The extraneous matter content of samples taken from the bundle was between 8 to 10% and there was another 3 to 5% on the ground under the bundle. A large rake was fitted to clear an area next to a bundle while it was being dumped, thus preparing an area for the next bundle. This resulted in a maximum reduction of 1,5% in the extraneous matter content under the bundle. An average total extraneous matter content of 10% was achieved but at a maximum harvesting rate of 7,5 t h^{-1}.
- Because the engine overheated too frequently, the cooling system had to be improved and this was achieved by coupling two radiators in series and installing a larger fan to blow air through them.
- The design of the front stub axles and bearings was such that it did not allow them to bear the extreme stresses caused by traversing structures in the field. The problem was solved by replacing these with heavier components. The hinged member carrying the front axles also became twisted eventually and had to be reinforced.
- Trash wrap around the bearings carrying the rollers caused them to fail and also caused the demand on power to be excessive. Anti-trash wrapping devices were fitted and these proved to be very effective.
- Because the rubber on the draw rollers did not adhere to the metal drum, it was clamped onto the drums to form rubber slats.

Major faults

Chassis

An attempt to increase the low harvesting rate by increasing the harvester's forward speed resulted in severe jamming and an increase in the extraneous matter content of the cane. This was caused by the position of a chassis member under the lower draw roller which did not allow sufficient clearance for the trash, which had already been removed from the cane, to pass underneath the machine.

Trash removing roller

The trash removing roller was relocated to a point just above the rear axle between the draw rollers and the edge of the bin.

This alteration enabled the harvesting rate to be increased from 10 to 15 t h^{-1}, but the trash clearing roller became inefficient in its new position, and jamming occurred frequently. In another attempt to overcome this problem, an axial flow fan was placed above the trash roller but there was little improvement. To correct this it will be necessary to redesign and reconstruct the machine.

The numerous modifications made necessitated changing the hydraulic circuit, which was achieved by placing the knockdown roller in series with the base cutters. The draw rollers and internal topper were fed by the supply to the radiator fan through a separate control valve. The motor to the conveyor was replaced by a smaller motor and an oil flow control valve was fitted to the 'services' circuit in such a way that neither was interrupted by the operation of the other.

Tractor gearing

The tractor had a County crawler gearbox which allowed speeds as low as 0,63 km h^{-1} (at full throttle) to be reached. The large difference between second and third gear (Table 1) was partly responsible for a low harvesting rate. In many instances, a gear between second and third would have given the most suitable speed to achieve a better harvesting rate of 12 to 15 t h^{-1}.

TABLE 1

Forward speeds of tractor at 2 400 rpm (engine) in low ratio with crawler gearbox engaged

Gear selected	Speed km h^{-1}	Output t h^{-1}		
		in 100 t ha^{-1}	in 90 t ha^{-1}	in 80 t ha^{-1}
1st	0,631	9,5	8,5	7,5
2nd	0,789	11,8	10,6	9,5
3rd	1,363	20,4	18,4	16,0
4th	1,875	28,0	25,3	22,5

A harvesting rate of 20 t h^{-1} was achieved in burnt cane, but the unreliable conveyor caused frequent jamming and it was not possible to exceed this rate.

Conclusion

Although the output of the harvester was too low, the extraneous matter content was too high and the reliability of the bin and conveyor was poor, the machine was able to harvest cane yielding from 40 to 120 t ha^{-1} on slopes up to 26% with losses less than 5% (Table 2). An increase of 10 to 15% in engine power, together with an improved hydraulic circuit would be the first step in achieving satisfactory performance. The second step would be to redesign the layout of the chassis, to reconstruct the bin, and to provide a more satisfactory conveyor system.

TABLE 2

Results of 0,15 ha test plot: 12 rows harvested; average row length 81,3 m; rows at 1,5m spacing

Harvesting time (mins)	Turning time (mins)	Total time (mins)	Average speed (km h^{-1})	Cane harvested (metric t)	Crop yield (t ha^{-1})	Harvest rate t h^{-1}	
						Operating	Field
51	8,3	59,3	1,17	10,5	70	12,35	10,11

Average extraneous matter in bundles = 9,2%
Cane lost during harvesting before gleaning = 3,3%

It is disappointing that a commercially acceptable machine has not been produced, but the knowledge and experience gained from the problems which have been encountered, and the efforts to correct them, have yielded sufficient information for a fully commercial machine to be designed and constructed whenever the need arises. Such a machine, fitted with a 70 kW engine, should deliver 20 t h^{-1} with extraneous matter levels of about 10% and with losses less than 5%.

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