A REVIEW OF THE DEVELOPMENT AND PERFORMANCE OF ARTICULATED CANE HAULERS AT IYSIS

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Abstract

In 1986 IYSIS replaced a 186 000 ton transship chopped cane haulage system with a wholestick direct bin system. This system has worked well; by the end of the 1987/88 season a substantial saving of R1,02/t compared to the transship system was achieved. It was therefore decided to try to replace the remaining 270 000 ton transship bundle system with a direct system in order to cut costs and reduce infield damage. The considerations that led to the introduction of the articulated cane hauler are reported and it is shown that the first season's operations resulted in savings of R1,64/t.

Introduction

Inyoni Yami Swaziland Irrigation Scheme (IYSIS) in the north of Swaziland grows cane under irrigation on approximately 4 200 ha. From 1 800 ha, which is sprinkler irrigated, 186 000 tons are delivered direct to Mhlume mill in 10 ton bins on tandem trailers, hauled by Bell 1756 tractors, at a cost of R6,64/t.

The remaining 2 400 ha producing 270 000 tons are furrow irrigated, and until 1989 the crop was hand cut and loaded into bundle trailers by slew loaders, and then transshipped at loading zones into contractors' trucks, at a cost of R7,66/t.

After the direct bin system had been successfully operated for two years, the saving of R1,02/t and other advantages were such that it was decided to consider possible savings on the bundle-harvested cane from the furrow- irrigated fields. The obvious areas of attention were the transshipping operation, the possibility of increasing payload, improving field hygiene factors to decrease the deterioration of yields, and to improve the usage of existing staff and facilities.

Method

The first step was for the field staff to look at the existing system and to define the requirements of any new system, which were as follows :

- To minimise the in-field compaction by keeping tyre pressures as low as possible, preferably below 200 kPa. This is the tyre pressure below which, on a 30% clay soil at or below 50% Readily Available Moisture content (RAM), the effects of compaction can be ignored
- The wheels of the system selected must fit into the existing 1,5 m row spacing, i.e. a maximum width of 2,3 m. The cane is grown in 1,5 m centred rows, (700 mm ridge with cane, 800 mm furrow : 2 furrows plus 1 ridge 2,3 m)
- The system should be legal in terms of the road ordinance, i.e. maximum of 20 m long and 2,5 m wide
- The system had to fit in with the mill reception system as there were no plans to change cane reception.

These requirements immediately ruled out the further expansion of the bin system, for the following reasons :

- There is insufficient spare rota tippler capacity in the Mhlume mill to cope with much extra cane
- The bin trailer wheel spacings are wider than 2,3 m and too unstable to be reduced
- The bin units payload cannot be increased and still stay within 20 m legal length.

The above factors defined the unit required as being 20 m long, 2,3 m wide with approximately 45 ton gross mass. Walking beam trailer axles were required because of field conditions.

The problem was to define the type and number of tyres that at 200 kPa pressure could carry 45 tons, i.e. 25 tons of cane, 12 tons of trailer, and 8 tons of tractor unit. This problem was put to the tyre agents, and when a maximum speed of 50 km/h was agreed upon, they recommended either 23,5 × 25 or 20,5 × 25 XRB radial tyres.

From prices for these tyres, and manufacturers' quotes to give a fairly accurate trailer price, and from the list price of various tractors, the South African Sugar Association Experiment Station mechanisation costing technique (unpublished) was used to cost several options. This had been written up as a spread sheet programme on Lotus 123. The most favourable at this stage was a five bundle tractor trailer system.

Using the running cost projected by the Experiment Station technique and assuming reduced crane cost, a dummy operating budget was compiled. A comparison of this with the actual 1987/88 budget, showed enough of a saving to request board approval to purchase a trial set of bundle trailers to be pulled by one of the bin system 1756 tractors.

A professional design engineer was commissioned to design the trailers to ensure that stress and strains were calculated, and that the correct size and type of material was used, in order to minimise weight. The result was one three-bundle and one two-bundle trailer in tandem. In order to be within 20 m the bundle compartments were limited to 2,5 m.

This unit was built in Pietermaritzburg during April/May 1988 and trials commenced in June. By September 1988 sufficient data had been recorded and the trial rig results indicated that :

- It was impossible to get consistent loads of 25 tons into the 2,5 m bundle pockets
- There were problems in turning across the furrows next to the field canals.

The trial data also enabled the SASA Experiment Station costing to be run again with accurate cycle times, costs and projected tyre wear rates. Appendix 1 shows the final run of the costing programme from which the economics of an Articulated Cane Hauler (ACH) became evident. This provided the costs for operating estimates to be done.

The Articulated Cane Hauler appealed for a number of reasons :

- The positive steering. Articulated steering is such that once the steering is turned, the unit is already at an angle to the trailer and therefore has to turn
- The tight tracking. The articulation causes the rear axle to turn the opposite way to the front; hence on tight turns

the rear wheels almost follow in the front tracts and the pup trailer only cuts into a corner by 1 m

- The articulated power unit is 1 m shorter than the conventional tractor unit and the direct coupling saved another 500 mm, allowing the bundle pockets to be extended to 2,8 m
- The lack of a front steering axle, which had no king pins to break or small tyres to puncture
- The positive coupling between tractor and first trailer, eliminating bounce and snaking
- The ergonomic factors of air suspension ride and comfortable cab.

Disadvantages were also noted at this stage :

- The questionable stability under steep conditions
- The question of drive only to the front wheels
- The fact that is was an untried system in the southern Africa cane industry.

At this stage extensive discussions were held with various suppliers, that resulted in orders for seven 130 kW power units and six trailer units being placed in November 1988 for delivery by 1 April 1989. The 130 kW unit was chosen because the 1756 tractors that IYSIS operate had coped with 47 ton gross loads for three years without problems on similar haul conditions. The only special feature was the fitting of no-spin differentials.

Results

Table 1 shows the estimated cost for the existing transship system, an estimate for running the ACH bundle system, and the actual results at the end of the first year.

The projected benefit of the ACH bundle system of R400 682 was the basis of the profit analysis shown in Table 2, using a 12% discount factor.

Table 1

Operating estimates and actual cost comparison for 1989/90 season

Estimated cane yield 1989:252 000 t
Actual Cane yield 1989: 249 564 t

	1989/90 Transship estimate		1989/90 ACH estimate		1989/90 ACH actual	
	R total	R ton	R total	R ton	R total	R ton
Loader cost	202 393	0,80	211 283	0,84	236 336	0,95
Crane cost	248 554	0,99	104 981	0,42	126 854	0,51
Haulage cost	336 957	1,34	741 322	2,94	649 732	2,60
General cost	297 868	1,18	216 816	0,86	252 466	1,01
Contract cost	602 949	2,39	000 000	0,00	000 000	0,00
Depreciation	242 256	0,96	255 893	1,02	255 983	1,03
Totals	1 930 977	7,66	1 530 295	6,07	1 521 371	6,10
Benefit			400 682	1,59	409 606	1,64

There is a slight difference between the old and the new systems in that whenever possible the loaders should start so that a hauler is filled travelling towards the road side of the field. This involves the loaders in extra travel around the field; hence the difference of 4 c/t. For the ACH system the actual is above the estimated cost by 11 c/t due to grab and mast problems totally unrelated to the change of system.

A substantial drop in crane cost (57 c/t) was possible as the transship element of the operation was eliminated and cranes are only required to tension the bundle chains. The actual costs are above estimate due to a transmission failure on a 15 year old unit.

Haulage cost for the transship system is for the operation of 12 Ford 6610 tractors and triple bundle trailers. The difference of 34 c/t between estimated and actual for the ACH system is due to low tyre cost in year one, as the tyres will not require replacing until year two. The saving would have been greater, but several trailer hubs had to be replaced because they came from a faulty batch of castings.

General cost for all three columns is made up of the cost of in-field gleaners, chainmen, supervisors and labour transport. The reduced requirement of chainmen was worth a saving of 32 c/t. The actual saving was only 17 c/t because rain resulted in cane having to be carried out to the field edge.

The contract cost of R2,39/t appearing in the transship estimate only is the price quoted by the contractor to haul the cane from the zone to the mill for the 1989/90 season.

The depreciation cost of all three columns is the straight line depreciation of all the equipment. The difference of 1 c/t between ACH actual and estimate is due to the reduced crop.

The R/ton figure for the two estimate columns is the total divided by the estimated yield, and for the ACH actual is the total divided by the actual yield.

Table 2 shows a total estimated saving of R4 928 266 over the projected eight years, 20 000 hours of life of the system. These projected annual saving figures were then further analysed to confirm that the benefits were real and not imagined. This was so despite the current cost of money and the fact that, due to company policy, the equipment would have to be financed by an offshore sterling loan.

Table 2

Profit analysis per annum for expected life

	Total Cost Old system	Total Cost New system	Difference Profit
	R	R	R
Year 1	1 930 977	1 530 295	400 682
Year 2	2 162 694	1 713 930	448 764
Year 3	2 422 218	1 919 602	502 616
Year 4	2 712 884	2 149 954	562 930
Year 5	3 038 430	2 407 949	630 481
Year 6	3 403 041	2 696 903	706 138
Year 7	3 811 406	3 020 531	790 875
Year 8	4 268 775	3 382 995	885 780
Total benefit			4 928 266

Table 3 shows that the Net Present Value after eight years at 12% is a saving of R944 603. A saving of R4 928 266 less the cost of the equipment (R1 917 412) should have shown a saving of R3 010 854; but in eight years time that saving is worth R944 603 today, if inflation runs at 12%.

The Internal Rate of Return (IRR) shows that the project will be viable as long as inflation stays below 23% per annum.

Any interest payable on the offshore loan is not shown, as it is treated in the company books as an overhead cost. It is more than covered by the IRR of 23%.

Table 3
Financial Analysis

Net Present Value (NPV)		
NPV of new system (estimate compared with the price of money borrowed from CDC		
Estimated Discount Rate		12,00%
		R
Capital Out	Year 0	(1 917 412)
Savings	Year 1	400 682
	Year 2	448 764
	Year 3	502 616
	Year 4	562 930
	Year 5	630 481
	Year 6	706 138
	Year 7	790 875
	Year 8	885 780
Net Present Value (NPV)		944 603
Internal Rate of Return (IRR)		23,06%

Discussion and Conclusion

Estimates indicated that a cane haulage operation based on the Articulated Cane Hauler concept would work, and the results shown in Table 1 demonstrate that the system has worked for a year. While some of the figures vary from the estimate, the end result shows the move to have been successful. Reduced crop yields caused the cost per ton figure to be higher than budgeted.

Non financial benefits that have been observed are :

- The units perform very well in wet conditions and can be "walked out" of muddy field edge drains (scuppers)
- The more comfortable ride and ergonomic design of the ACH cab reduces driver fatigue and boosts morale, resulting in less down time
- At off crop service, after 2 600 hours work, all seven units required no repairs at all and only routine maintenance was done. The benefits of having a well designed trailer have also shown that only minor modification to the axle hangers have been required, and only one 100 mm crack in the body work of one trailer was found
- The challenge of introducing such a different system and having to justify every step and analyse its effect on the rest of the system has benefitted other sections. For example, shift start times have been changed to get the standing period of the day during workshop working hours, so that any repairs do not keep a machine out of the field
- By starting at 18h00 the cut to crush time has been reduced by 36 hours in that the cane cut on day one gets delivered the same night and on the morning of day two, whereas with the old transship system, day one's cut cane would be moved to the zone on day two for delivery during day three
- First results from compaction tests done by IYSIS agronomists indicate that damage to fields harvested by the ACH system is less than by the old transship system. Certainly after rain vehicles of the ACH system are able to enter the fields a lot sooner than they were with the bin system or the old transship system, with much less visible damage to the soil. It is hoped this can be quantified in some way so as to put a value to it.

Minor disadvantages found were :

- Steep turns out of scuppers had to be taken with care or the centre section could have fallen over
- Once the unit was stuck, it took a large tractor to pull it out
- The fact that five bundles are carried and not an even number, caused the mill a problem, in that chains had to be sorted especially, and three lifts of the gantry crane yielded only 25 tons as opposed to 27 tons with the old system

The change of haulage system at IYSIS has shown, and will continue to show cost savings and other benefits, making the change to an ACH based bundle haulage system a successful move.

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APPENDIX 1

SASA machinery costing estimate analysis for direct bundle harvesting options

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	1756 ACH	BELL B18	CAT D250	BELL 1756	BELL 1756	Description
1 Costing for machine	5 Bundle	5 Bundle	4 Bundle	5 Bundle	Bin Syste	
2 Life in hours	20 000	20 000	20 000	15 000	15 000	Manufacturers economic life in hrs.
3 Life in years	8	8	8	8	6	Life in hours/hours a year.
4 No of days in season	180	180	180	180	180	Milling days in Swaziland season.
5 Pay load (tonnes)	25	25	20	25	20	Tonnes cane in each load.
6 Av. speed (km/hr)	30	35	35	30	30	Average speed on full cycle.
7 One way trip (km)	12.00	12.00	12.00	12.00	12.00	Average one way haul distance.
8 Annual tonnage	270 000	270 000	270 000	270 000	270 000	Tonnes cane to be hauled annually.
9 Interest rate (0.XX)	0.12	0.12	0.12	0.12	0.12	12% interest rate used.
10. Fuel Price (R/l)	R0.86	R0.86	R0.86	R0.86	R0.86	IYSIS current fuel cost.
11 Fuel consumption (ℓ/hr)	11	13	18	11	11	Actual ℓ/hr from trials.
12 Number of tyres	10	10	10	10	10	Treated as having 10 tyres.
13 Cost per tyre	R4,500	R4,500	R4,500	R3,200	R2,300	Average price of tyres on machine.
14 Total tyre cost	R45,000	R45,000	R45,000	R32,000	R23,000	Tyre price * number of tyres.
15 Tyre life (hrs)	5 000	5 000	4 000	3 000	2 500	Actual from trial results.
16 Capital investment						
17 Price of basic unit	R273,916	R413,640	R242,864	R273,884	R280,664	Forecast price for 01/04/89 delivery.
18 Accessories added	R4,250	R4,250	R2,250	R4,250	R4,250	Tachos and EPUs added.
19 Total investment (I)	R278,166	R417,890	R245,114	R278,134	R284,914	Full purchase price of 1 unit
20 Deduct tyre value	R45,00	R45,000	R45,000	R32,000	R23,000	
21 Deduct resale value	R13,696	R20,682	R12,143	R13,694	R14,033	5% of I (I = price of 1 unit)
22 Total to be depreciate	R219,470	R352,208	R187,971	R232,440	R247,881	I - tyres and resale value
23 Fixed costs						
24 Interest.I/2 * x%	R16,690	R25,073	R14,707	R16,688	R17,095	(I/2) * Interest %.
25 Licence etc	R5,563	R8,358	R4,902	R5,563	R5,698	2% of I.
26 Depreciation	R27,434	R44,026	R23,496	R29,055	R41,313	(I-tyres and resale value)/Life (yrs).
27 Operator costs	R8,960	R8,960	R8,960	R8,960	R8,960	Cost of 2 operators at IYSIS.
28 Total fixed cost P.A.	R58,647	R86,417	R52,065	R60,266	R73,067	
29 Variable costs						
30 Fuel PA	R26,272	R29,077	R40,987	R26,272	R25,542	(ℓ/hr) * hrs * R/ℓ.
31 Tyres pro rata cost	R24,994	R23,407	R29,787	R29,623	R24,840	(Tyre costs/tyre life) * hrs.
32 Maintenance & repair	R38,035	R53,790	R32,152	R50,708	R50,520	1*((hrs/yr)/hrs life).
33 Contingency	R1,389	R1,300	R1,324	R1,389	R1,350	50 cts hr.
34 Total variable costs	R90,690	R107,575	R104,251	R107,991	R102,252	
35 Total costs, F & V	R149,337	R193,992	R156,317	R168,257	R175,318	
36 Cost per hour	R53.77	R74.59	R59.04	R60.59	64.93	
37 Cost per tonne	R3.87	R5.03	R4.36	R5.84		
38 Fuel cost/hr	R9.46	R11.18	R15.48	R9.46	R9.46	
39 Tyre cost/hor	R9.00	R9.00	R11.25	R10.67	R9.20	
40 Variable cst/hr	R32.66	R41.36	R39.37	R38.89	R37.87	
41 Cycle times						
42 Working days/week	6	6	6	6	6	
43 Hrs per day	20	20	20	20	20	Hrs worked in a day (2*10 hr shifts).
44 Travelling times (min)	48	41	41	48	48	(Distance/speed)*60
45 Unloading time (min)	20	20	18	k20	20	Mill average.
46 Loading time (min)	30	30	25	30	30	In field actual.
47 Down time (min)	10	10	10	10	10	10 mins per cycle.
48 Total cycle time (min)	108	101	94	108	108	
49 Tonnes per day	1 500	1 500	1 500	1 500	1 500	Theoretical daily rateable.
50 Available time min	960	960	960	960	960	Available time*80% availabiliyt.
51 Trips per day	60	60	75	60	75	Available time/cycle time.
52 Pay load	25	25	20	25	20	
53 Number of units reqd	6.75	6.32	7.35	6.75	8.44	((Trips/day)*cycle time)/available time
54 Actual no units reqd	7	7	8	7	9	Next whole number after ine 53.
55 Available hrs/unit/yr	3 600	3 600	3 600	3 600	3 600	Clock hrs
56 Tonnes/unit/yr	38 571	38 571	33 750	38 571	30 000	
57 Engine hrs/yr (total)	19 440	18 206	21 182	19 440	24 300	Clock hrs*0.8.
58 Engine hrs/unit/yr	2 777	2 601	2 648	2 777	2 700	
59 Total running cost PA	R634,829	R753,025	R834,009	R755,936	R920,264	Variable cost*Number of units.