A TRAILER-MOUNTED CRANE FOR INFIELD LOADING OF SUGARCANE

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Abstract

A small, truck-type slewing crane with a grab was centrally mounted at the front of an 8-ton box-type tipping trailer. The crane and grab were operated by the hydraulic system of the tractor. Attempts to modify the control valves of the crane were not successful and it was concluded that the standard controls supplied for truck-type cranes were not suitable for this purpose. A standard double-acting valve control bank was fitted and the results were satisfactory. Considerable modifications were made to the grab for it to operate efficiently. Various oil supplies to the crane hydraulics were evaluated to achieve a loading rate of 20 t h^{-1}.

Introduction

Analyses of costs of various loading and transport systems have indicated that it has not been economical to use a self-propelled loader for handling cane quotas of less than 50 t d^{-1}.

Using a small crane mounted on a box cane trailer was found to be a viable alternative if a loading and transport rate of 10 t h^{-1} could be achieved. This method provided two options; either cane could be loaded from small hand-made bundles and chained in the box-trailer for subsequent transloading with a conventional crane, or unchained cane could be tipped out at the loading zone to be loaded with a grab loader into Hilos.

Description

An 8-ton box tip trailer was built to carry a small truck-type crane (Figure 1) to which a grab with an hydraulic rotator had been fitted (Figure 2).

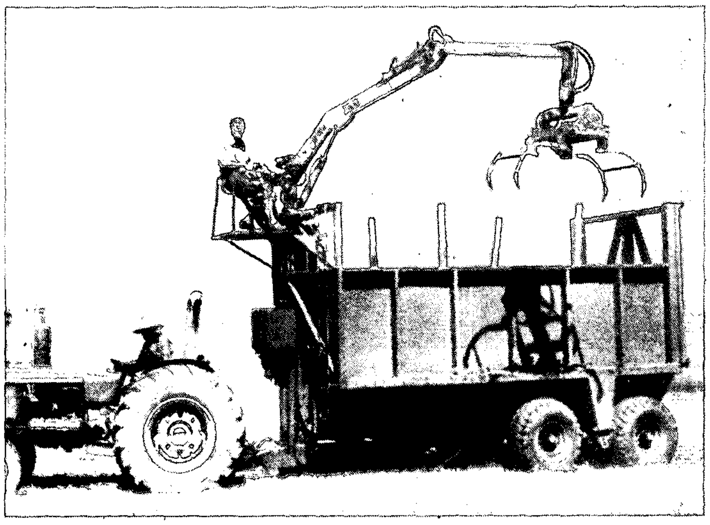

FIGURE 1 8-ton box tip trailer fitted with a grab.

A pair of hinged doors at the rear of the trailer folded back and were hooked firmly against the sides of the trailer to allow cane to be tipped out freely.

The wheels were attached to a double axle walking beam bogie and were equipped with safety air brakes.

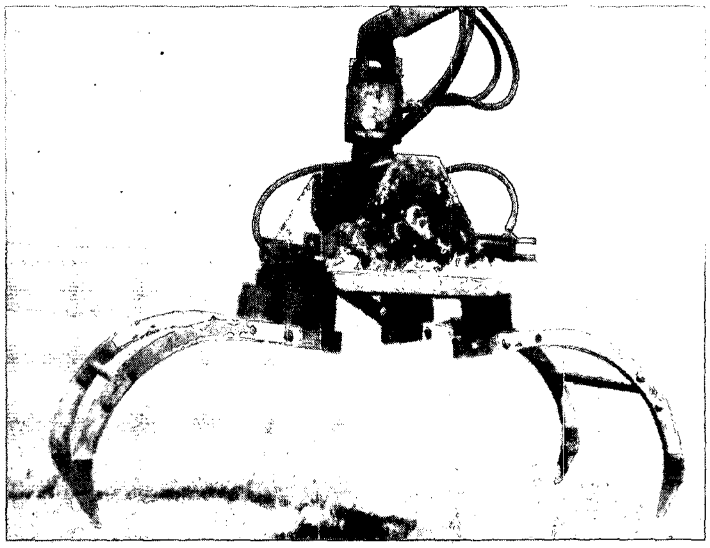

FIGURE 2 Grab with hydraulic rotator.

Operation

A tractor of about 50 kW was required to pull the trailer. The crane was powered by the tractor's internal hydraulic system and during loading, an operator on the trailer worked the crane controls.

Bundles weighing about 300 kg were needed to achieve an optimum loading rate.

For optimum output, there had to be complete understanding between tractor driver and crane operator; the tractor had to stop so that the trailer was positioned close to the cane bundle which had to be in line with the crane and at right angles to the centre line of the trailer. This obviated the need for small adjustments being made to the crane during loading. If a bundle was small, it was lifted approximately a metre off the ground while the tractor and trailer moved forward, so that it can be added to the next bundle so increasing the mass loaded.

The crane was not able to compact the cane in the trailer effectively, therefore the bundles had to be placed carefully for the best possible payload to be achieved.

The grab

The first grab used was capable of holding more than 300 kg of cane. This, together with the mass of the grab itself (200 kg), caused the relief pressure of the hydraulic system to be exceeded. This meant that the operator had to adjust the load each time the grab picked up too much cane. A smaller grab with a mass of 75 kg which could not hold more than 300 kg of cane was constructed and with this the specified load of 435 kg could not be exceeded (Figure 2).

The hydraulic system

A tractor with an oil supply of 20 ℓ min^{-1} was used to supply the crane which loaded hand-made bundles of 200 to 250 kg. The poor loading rate of only 10 t h^{-1} was achieved and this was ascribed to the low oil supply. A tractor with an oil supply of 50 ℓ min^{-1} was therefore used but there was no appreciable improvement in performance.

The control bank of the crane was then checked and reset to the highest available pressures. This also made no difference and even after fitting a set of controls from a much larger truck crane, there was no appreciable improvement in the loading rate. It became clear that the overload protection system of a truck-type crane not only prevents overloading in mass, but also prevents high speed operation by bypassing excess oil.

Because the smaller grab was not able to hold more than the maximum safe load, a relief pressure of 17 MPa (2 500 psi, the normal tractor relief pressure) could be allowed, with no bypass until this pressure was reached. A standard bank of, double-acting valves was fitted and an oil flow of 20 ℓ min⁻¹ was applied again, this time with better results.

To establish the effect of oil flow to the crane, a number of loads were evaluated at flows of 15, 20, 25 and 30 ℓ min^{-1}. It would have been desirable to increase the flow to 50 ℓ min^{-1}, but a tractor with this hydraulic capacity was not available. The results are given in Table 1. Initially, an increase of only 5 ℓ min^{-1} resulted in an improvement in the operating rate of the crane. The loading rate could be expected to improve continuously with increased oil flow to between 30 to 50ℓ min^{-1}, but at this point, the operator's ability would become the limiting factor.

TABLE 1

Loading rate as affected by hydraulic oil supply

Oil flow to crane (ℓ min^{-1})	Average loading rate (t h^{-1})
15	9,93
20	13,72
25	15,03
30	16,70

Trailer

The trailer chosen was not suitable for this operation. Its limited ground clearance caused it to foul on conservation structures in the field and on access roads. The design of the trailer was such that the unladen mass was 5 tons and this was considered to be too heavy.

Tipping bundles at the zone presented problems because the rear deck of the trailer dug into the ground when it was fully tilted, preventing the tractor from moving forward. The tractor could move forward if the deck was not fully tilted, but this resulted in an untidy, dispersed bundle.

Tipping out loose cane saved 1,3 minutes per cycle compared with removing chained bundles with a crane. This performance could be improved if a more suitable trailer were used.

Daily capacity

Based on a 30 ℓ min^{-1} oil flow to the crane and an average loading rate of 16,7 t h^{-1}, the total time per cycle, excluding travelling time, was calculated for loads of 5 and 7 tons (Table 2).

TABLE 2

Cycle time, excluding travelling time

Capacity of trailer (tons)	Loading trailer (@ 16,7 t h^{-1}) (min $cycle^{-1}$)	Average cycle time (mins)			
		Unloading	Handling chains	Downtime	Total time
5	18,0	1,7	2,4	3,1	25,2
7	25,2	1,7	2,4	3,1	32,4

The number of cycles and tons that could be expected per day from a rig travelling at an average speed of 15 km h^{-1} can be determined by adding downtime and the time spent unloading and handling chains to the travelling time over a range of distances. Results obtained for distances up to 2 km and working a six-hour day, are given in Table 3.

By working an eight-hour day, a 5-ton or a 7-ton rig would be able to handle 50 t d^{-1}.

TABLE 3

Daily capacity, related to distance travelled

Distance to zone (km)	Travel time @ 15 km h^{-1} (min)	Cycle time (no. of cycles)		No. of tons in a 6-hour day	
		5 ton	7 ton	5 ton	7 ton
0,50	4,0	29,2 (12)	36,4 (9)	60	63
0,75	6,0	31,2 (12)	38,4 (9)	60	63
1,00	8,0	33,2 (11)	40,4 (9)	55	63
1,50	12,0	37,2 (10)	44,4 (8)	50	56
1,75	14,0	39,2 (9)	46,4 (8)	45	56
2,00	16,0	41,2 (9)	48,4 (7)	45	49

Economics and feasibility

The cost of using a small, self-propelled grab loader with a tractor and standard box-trailer was compared with that of a trailer fitted with a slewing crane. It was assumed that the cane was transported from a field 1,5 km from the zone at an average speed of 15 km h^{-1} (Table 4).

TABLE 4

Comparison of loading and transport costs using a trailer-mounted crane and a self-propelled grab loader over a 1,5 km haul (costings based on SASA Experiment Station standards)

Quota (t a^{-1})	Cost (R t^{-1})		Difference (R t^{-1})
	7-ton trailer with self-propelled loader	7-ton trailer with mounted crane	
3 000	7,70	6,50	1,20
5 000	5,10	4,39	0,71
8 000	3,49	3,28	0,21
10 000	3,12	2,91	0,21
12 000	2,84	3,30*	−0,46
15 000	2,51	3,17*	−0,66

* 2 units

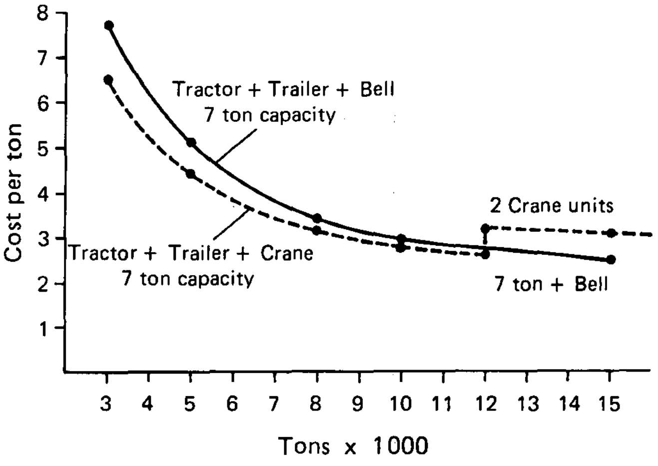

FIGURE 3 Comparison of costs of a trailer-mounted crane and a self-propelled grab loader over a 1,5 km haul.

The trailer-mounted crane would not be able to manage 12 000 tons, so two units would be required and costs per ton would be considerably increased. When handling between 8 000 and 12 000 tons a saving of R0,21 per ton using the trailer-mounted crane rather than the grab loader, is of little consequence and growers may prefer to use a small, self-propelled loader. Where less than 8 000 tons are handled, there is no doubt that the use of a crane is the most economical systen (Table 4). However, this presupposes that the tractor is used only for haulage. The data in Table 4 are illustrated in Figure 3.

The effect of using the tractor to its fullest extent for 1 000 h a^{-1}, ie not only for haulage but also for other farm work, is shown in Table 5. The result is that the costs of the 'grab loader' system are reduced and the 'crane' system would only be worth considering for crops less than 5 000 tons.

TABLE 5

Comparison of loading and transport costs over 1,5 km when annual use of tractor (including work other than haulage) = 1 000 h a^{-1}

Quota ($t\ a^{-1}$)	Cost ($R\ t^{-1}$)		Difference ($R\ t^{-1}$)
	7-ton trailer with self-propelled loader	7-ton trailer with mounted crane	
3 000	5,78	4,73	1,05
5 000	4,07	3,67	0,40
8 000	3,03	3,11	−0,08
10 000	2,85	2,91	−0,19
12 000	2,68	2,65	−0,25
15 000	2,48	2,91	−0,61

The cost saving by white growers if they used the trailer-mounted crane instead of the loader, is shown in Table 6. If every grower used the trailer-mounted crane instead of a self-propelled grab loader, the saving to the industry is estimated to be R2 813 635.

TABLE 6

Cost saving by using the 'trailer-mounted crane' system

Growers' cane deliveries by categories 1981/82 (tons)	* Cane (tons)	** Average savings ($R\ t^{-1}$)	Total savings (R)
3 000 - 4 000	592 824	1,05	622 468
4 000 - 5 000	805 373	0,85	684 567
5 000 - 6 000	945 437	0,61	576 716
6 000 - 7 000	884 084	0,43	380 156
7 000 - 8 000	834 501	0,28	233 660
8 000 - 9 000	830 988	0,21	174 507
9 000 - 10 000	674 101	0,21	141 561
			2 813 635

* Personal communication: M Murdoch, SASA Experiment Station
** Average cost savings from Figure 3

Conclusion

Using the trailer-mounted crane system instead of the self-propelled loader results in savings, but its full potential has not yet been realised. Indications are that when the crane's performance equals the loading rate of a small grab loader, with a lighter trailer, the tractor will be able to operate faster and costs will be reduced even further.

The present 'crane rig' system seems to be worthwhile only for growers producing less than 7 000 tons of cane annually, but with further developments, it may suit growers producing up to 12 000 tons of cane. Those growers who previously could not justify using a mechanical loader, may now find it feasible to do so.