FIELD TO TRANSLOADING ZONE TRACTOR HAULAGE TESTS

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Abstract

A large proportion of sugarcane harvested in the South African sugar industry is hauled by tractor/trailer units on gravel hardened roads. Queries from sugarcane growers prompted an investigation to determine whether the performance of a haulage unit would be affected if different tractor rear wheel tyres were used. Radial-ply tyres of 34 inches rim diameter, and cross-ply types of 30 inches and 34 inches rim diameter were tested on the same tractor. Road speed, loads, fuel consumption and wheelslip were measured over a 4,3 km route divided into a series of gradients where the distances for each gradient were known. With the smaller diameter tyres the tractor rear wheels tended to slip more on the steeper gradients. The tests showed that when the three different tyres were used there were no significant differences in the performance of the haulage unit.

Introduction

Excessive wheelslip and loss of traction sometimes occur when sugarcane is hauled on gravel hardened roads. The relative performances of different types of tyres have been tested on tilled soils, the bulk densities of which ranged from 0,91 to 1,64 g/cm^3. Radial-ply tyres marginally out-performed the other tyres tested (Taylor *et al*, 1976, and Lyne *et al*, 1981). However, different results may be obtained when the tyres are used on sugarcane haulage units on hard surfaces which have high bulk densities. This led to an investigation to the effects of different tyres in overcoming this traction problem.

When fitted with various rear tyres on gravel hardened farm roads, a Ford 5610 two-wheel drive tractor coupled to a walking beam axle cane trailer was used to evaluate haulage performance. To determine its performance two types of tests were performed on the haulage unit. These were a static pto dynamometer test and a road haulage test. The power (kW), torque (Nm) and specific fuel consumption (l/kWh) were determined using a M & W P2000 pto dynamometer and Micro Oval II fuel flow meter. Road speed (km/h), haulage capacity (t/h), specific fuel consumption (l/tkm), and percent wheelslip were calculated from data acquired from the road haulage test.

Materials and Methods

The road haulage tests were conducted on gravel hardened boundary and access roads on the SASA La Mercy Farm. The circular route is 4,3 km long and was divided into 12 sections according to the different gradients, that range from 0% to 10%. Three tests were performed for each set of tyres and the circuit was travelled in opposite directions alternately for each load. Seven different loads were imposed on the tractor for each set of tyres. The three types of tyres tested were:

(i) 18.4/15-30 R1 6 ply rating (Dunlop)
(ii) 18.4/15-34 R1 8 ply rating (Goodyear)
(iii) 18.4/15-34 BIB XM18 3ST (Michelin)

To determine whether any change in haulage performance was induced by different tyres, the gross imposed load, fuel consumption, ground speed, productivity and wheelslip were measured on each section. The tyre pressures used were those specified by the manufacturers or from the TREDCO handbook.

To evaluate the performance of the haulage unit, the following criteria were used:

Power determination

The actual power output of the tractor engine was measured at the pto with a M & W P2000 pto dynamometer. This power was compared with the manufacturer's specifications to determine whether the performance of the tractor engine was acceptable for road haulage testing. The fuel consumption in l/h was recorded with a Micro Oval II fuel flow meter, which opened and closed a magnetic reed switch for every millilitre of fuel flowing through it (Boevey and Meyer, 1984), and the specific fuel consumption (l/kWh) was calculated.

Gross imposed load

The gross imposed load is the mass of the trailer plus payload. Steel blocks were used as ballast and individual axle loads were weighed on the weighbridge at the Mount Edgecombe mill. For all the tests, the same blocks were placed in the same positions on the trailer, thereby eliminating the effects of variations in weight transfer.

Fuel consumption

The fuel required to travel each section was recorded with a Micro Oval II fuel flow meter. This information was recorded on an electronic data logger mounted on the tractor.

Speed

The speeds were determined by the times taken to travel each section, of which the distances were known. The data logger had a built-in clock which was activated at the start of each section, and the times to travel each section were recorded in the data logger memory facility.

Wheelslip

Revolutions of the rear wheels over each section were measured by means of a magnetically activated switch, and these data were also recorded. The theoretical and actual revolutions of the rear tyre for each road section were then known and the wheelslip could be calculated.

Results

The manufacturer's specifications for the Ford 5610 tractor engine are as follows:

Engine	: ADE 236 normally aspirated
Rated engine power at 2 300 erpm	: 52 kW
Maximum flywheel torque at 1 400 erpm	: 269 Nm
High idle	: 2 530 rpm

The results of the pto dynamometer test, which was performed on the pto at full throttle setting, are presented in Table 1. The tested pto power, torque and the specific fuel consumption are presented.

Table 1
Results of pto dynamometer test

Engine speed (erpm)	Pto speed (rpm)	Pto power (kW)	Pto torque (Nm)	SFC (1/kWh)
2 179	619	-	-	-
2 112	600	31,8	507	0,36
2 101	597	36,1	578	0,34
2 006	570	38,7	649	0,33
1 760	500	37,7	720	0,34

The results of the road haulage tests were averaged over the haulage route and are presented in Table 2. Three tests were done with each type of tyre to determine their performance with loads ranging from an empty trailer (3,90 tons gross imposed load) to a loaded trailer of 11,30 tons gross imposed load. The speed, productivity and specific fuel consumption for the various loads are listed in Table 2. The tractor rear tyre pressures used and the tractor rear axle weights measured on the weighbridge are also given. The results of speed and specific fuel consumption are represented graphically in Figures 1 and 2 respectively.

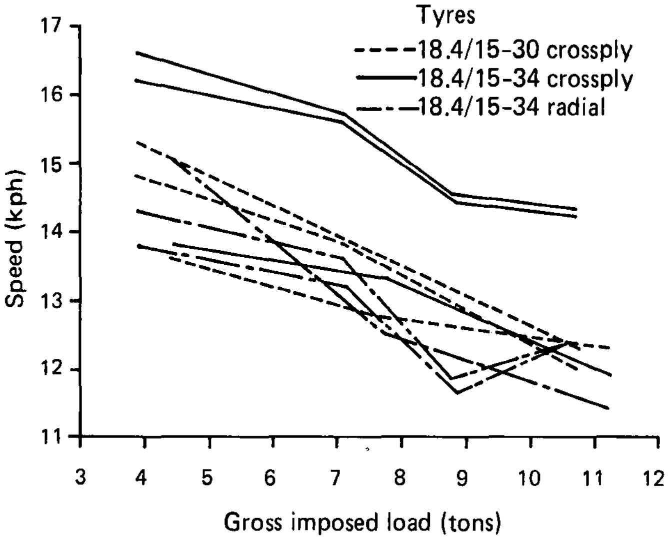

Figure 1 Ground speed (kph) versus gross imposed load (t).

Table 2
Results of road haulage tests

Tyre	Test number	Rear tyre pressure (kPa)	Gross imposed load (tons	Tractor rear axle wt (tons)	Speed (km/h)	Haulage capacity (t/h)	Specific fuel consumption (l/t km)
18.4/15-30 (Cross-ply)	1	110	4,44	4,14	13,6	8,8	0,096
		140	7,68	4,42	12,8	14,5	0,080
		160	11,30	5,48	12,3	19,6	0,080
	2	110	3,90	4,04	15,3	8,7	0,101
		120	7,14	4,32	13,9	14,6	0,069
		140	8,84	5,28	13,1	16,9	0,065
		160	10,76	5,44	12,3	19,1	0,063
	3	110	3,90	4,04	14,8	8,6	0,094
		120	7,14	4,32	13,8	14,6	0,072
		140	8,84	5,28	13,0	16,5	0,066
		160	10,76	5,44	12,0	18,7	0,060
18.4/15-34 (Cross-ply)	1	140	4,44	4,14	13,8	8,93	0,093
		160	7,68	4,42	13,3	15,0	0,070
		170	11,30	5,48	11,9	18,9	0,065
	2	110	3,90	4,04	16,2	9,4	0,096
		160	7,14	4,32	15,6	16,3	0,070
		160	8,84	5,28	14,4	18,4	0,065
		160	10,76	5,44	14,2	21,9	0,061
	3	110	3,90	4,04	16,6	9,6	0,099
		160	7,14	4,32	15,7	16,2	0,072
		160	8,84	5,28	14,5	19,3	0,065
		160	10,76	5,44	14,3	22,0	0,063
18.4/15-34 (Radial)	1	160	4,44	4,14	15,1	9,8	0,099
		160	7,68	4,42	12,7	14,0	0,077
		160	11,30	5,48	11,4	17,2	0,069
	2	160	3,90	4,04	14,3	8,2	0,105
		160	7,14	4,32	13,6	14,4	0,073
		160	8,84	5,28	11,8	15,2	0,071
		160	10,76	5,44	12,4	19,0	0,062
	3	160	3,90	4,04	13,8	7,9	0,098
		160	7,14	4,32	13,2	13,8	0,071
		160	8,84	5,28	11,7	15,1	0,070
		160	10,76	5,44	12,4	19,2	0,060

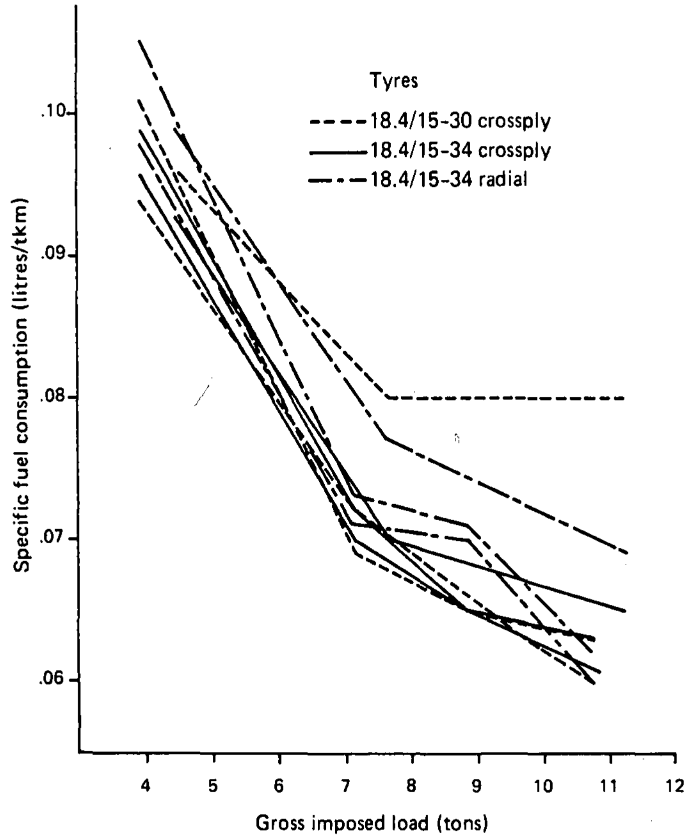

Figure 2 Specific fuel consumption (litres/tkm) versus gross imposed load (t).

As has been show before (Boevey and Meyer, 1984), the speed decreased with increasing load, while the haulage capacity which is the product of speed and load and measure of productivity increased. The specific fuel consumption, measured in litres per ton-kilometre (l/tkm), initially decreased at a rapid rate and then levelled out, indicating that fuel consumption is more efficient for heavier loads. When Figures 1 and 2 were examined, no conclusive trends could be observed to determine whether the different tyres tested had any influence on the performance of the haulage unit.

The number of revolutions of the rear wheel were measured over the various sections. From these measurements the wheelslip that occurred while travelling over each section was calculated. The average wheelslip on tests 2 and 3 was used to compare the performance of the different tyres. The results from test 1 were not included, as the gross imposed loads of test 1 were different to those of tests 2 and 3.

Comparisons of wheelslip were made between the 18.4/15-34 cross-ply and the 18.4/15-34 radial-ply tyres (Figure 3) and between the 18.4/15-30 cross-ply and the 18.4/15-34 cross-ply tyres (Figure 4). In these graphs, positive values represent greater wheelslip for the cross-ply tyres and the smaller diameter tyres respectively.

From Figure 3 it can be seen that there was generally about a 3% difference in measured wheelslip between the cross-ply and radial-ply tyres which, for practical purposes, is not significant. When different diameters of tyres were compared, (Figure 4), there was also about a 3% difference in measured wheelslip between the 18.4/15-30 cross-ply and the 18.4/15-34 cross-ply tyres. The smaller diameter tyres tended to slip more than the larger diameter tyres on the steeper gradients. An increase in gross imposed load did not appear to cause an increase in wheelslip. This was probably due to increased weight transfer from the tractor front axle and the trailer onto the tractor rear axle.

Discussion

In testing a tractor/trailer haulage unit, there are factors other than tyres that have a greater effect on the performance of the haulage unit. These factors include the condition of the road surface, engine performance, gear ratios, climatic factors, topography, and operator technique.

The haulage unit was found to be more comfortable to operate when the tractor had larger diameter tyres. The Ford 5610 has 8 forward speed gears with constant mesh gearbox. Thus, this tractor is not the most suitable haulage unit when compared with other tractors, which have been designed for cane haulage, that have more gears and synchromesh gearboxes.

The differences in performance due to the different tyres were too small to be measured with the available equipment. Also, no conclusive trends could be identified when the specific fuel consumption versus gross imposed load and ground speed versus gross imposed load curves were examined. The differences that were measured were due to a combination of individual factors that could not be separated by the test apparatus and test procedure.

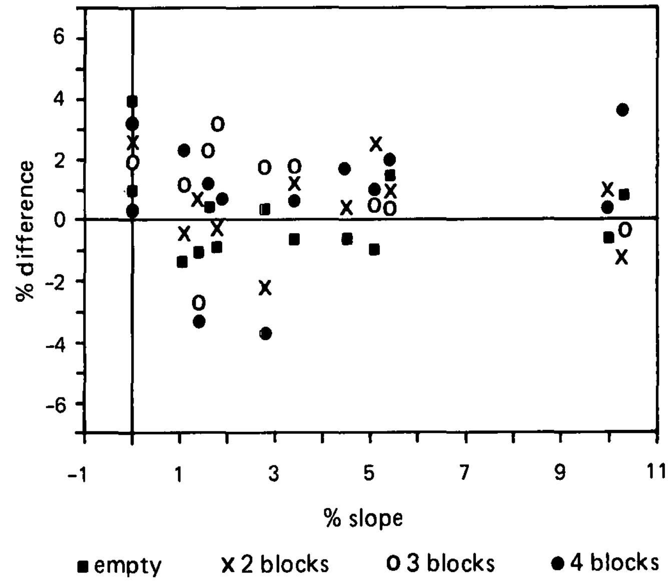

Figure 3 Comparison of wheelslip for various gross imposed loads and slopes; crossply vs radial tyres.

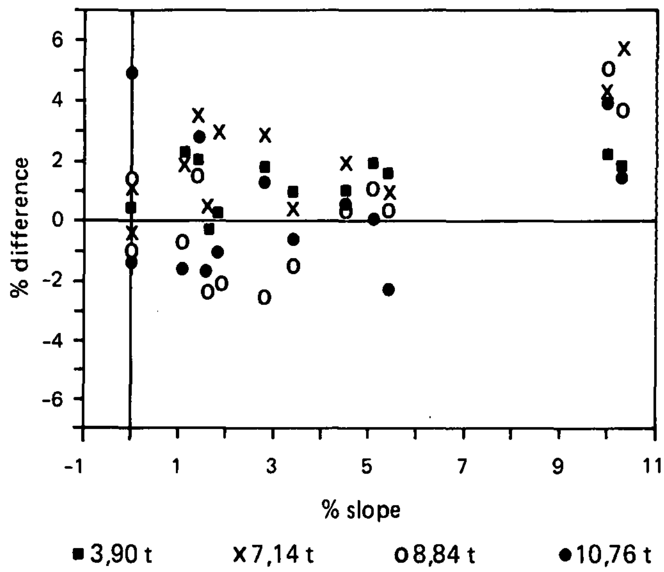

Figure 4 Comparison of wheelslip for various gross imposed loads and slopes; 18.4/15-30 vs 18.4/15-34 tyres.

Conclusion

Only three types of tyre of the many available to the sugarcane grower were tested on a haulage unit. From the tests performed with these tyres it has been shown that, under certain conditions, larger diameter wheels tend to slip less than smaller diameter wheels. But, the average performance of the haulage unit over the test route did not change significantly when different tractor rear wheel tyres were used. Other types and combinations of tyres need to be tested. For example, dual tyres and industrial haulage tyres should be used before conclusions can be drawn regarding the performance of a haulage unit on a hardened gravel road, and whether there would be any advantage if the type of tyre on the driving wheels were to be changed.

Acknowledgements

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