PRIME MOVER FOR SOFT GROUND AREAS

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In 2010, the oil palm planted area in Malaysia was 5.0 million hectares. The oil palm industry is labour-intensive, requiring many workers for the various plantation operations. The current system of infield collection of oil palm fresh fruit bunches (FFB) using trailer-type vehicles; in particular the mini-tractor-trailer system, is well-received by estate management. However, their usage is confined to firm ground on flat and slightly undulating areas. On soft-textured soils, such as flood-prone coastal areas, the use of the mini-tractor is limited due to poor traction. Apart from the mini-tractor, other prime movers have also been investigated and evaluated on soft soils. To improve traction, these prime movers have been fitted with low ground pressure (LGP) tyres and seem to work under certain conditions. The concept of full-track machines has been investigated, but their high maintenance cost is not attractive to the industry. A new prime mover and track system is now offered to the industry.

THE PRODUCT

A four-wheel transporter having a single chassis configuration resting on two axles, and equipped with four equal-sized tyres, was designed, developed and tested in the workshop and in the field. A 35.3-hp YANMAR 4-cylinder diesel engine, coupled to a 5-speed gearbox was selected based on total engine power requirement. The overall dimensions of the transporter are 3420 mm length, 2200 mm width and 1760 mm height. The estimated cost of production of the transporter is RM 85 500.00. Detailed technical specifications of the transporter are given in *Table 1*.

Vehicle Development

The design of the 4-wheel drive transporter with a moderate weight of up to 1250 kg, including a 500-kg payload and a high ground contact area, provides the transporter with a lower normal ground pressure of 1.15 kg cm^{-2}. This results in the transporter having lower sinkage and rolling resistance, thus providing high tractive effort and yielding higher travel speeds. The computer-aided design Auto CAD software package was used to develop the three-dimensional design of the 4-wheel drive

TABLE 1. TECHNICAL SPECIFICATIONS OF THE 4-WHEEL DRIVE TRANSPORTER

Item	Specification	
Engine	YANMAR diesel V2203-E, 4-cylinder, naturally aspirated, water-cooled	
	Bore x stroke (mm), 87 x 92.4, with displacement of 2197 cc	
	Rated power (Pr), 35.3 hp @ 3000 rpm	
Transmission	5-speed gearbox	
Steering system	Fully hydrostatic steering	
Wheel	Permanently engaged 4-wheel drive	
Tyres	Four equal-sized tyres 12.4-16-6 ply (traction lugged)	
Fuel tank	35 l	
Oil tank	20 l	
Fruit bin	Length	1465 mm
	Width	1200 mm
	Height	975 mm
Overall dimensions	Length	3420 mm
	Width	2200 mm
	Height	1760 mm
	Maximum dumping height	750 mm
	Payload	500 kg
Weight	1250 kg	

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transporter components. All of the components of the 4-wheel drive transporter, such as the vehicle main chassis, undercarriage (including front and rear axles) and fuel tank, have been designed based on identified optimised design parameters. Furthermore, the operator cab has been designed and strategically located based on field requirements and transporter stability during turning. *Figure 1* shows the 3D-CAD drawing and geometrical dimensions of the 4-wheel drive transporter.

two axles. The distance between these two axles is 1750 mm, which helps to prevent chassis deflection under any working condition. With this axle arrangement, a better load distribution can be achieved hence improving the traction of the transporter under demanding conditions. The transporter has been designed so that low ground pressure tyres and tracks can be fitted in place of conventional tyres, and these will enable the transporter to traverse on soft ground areas.

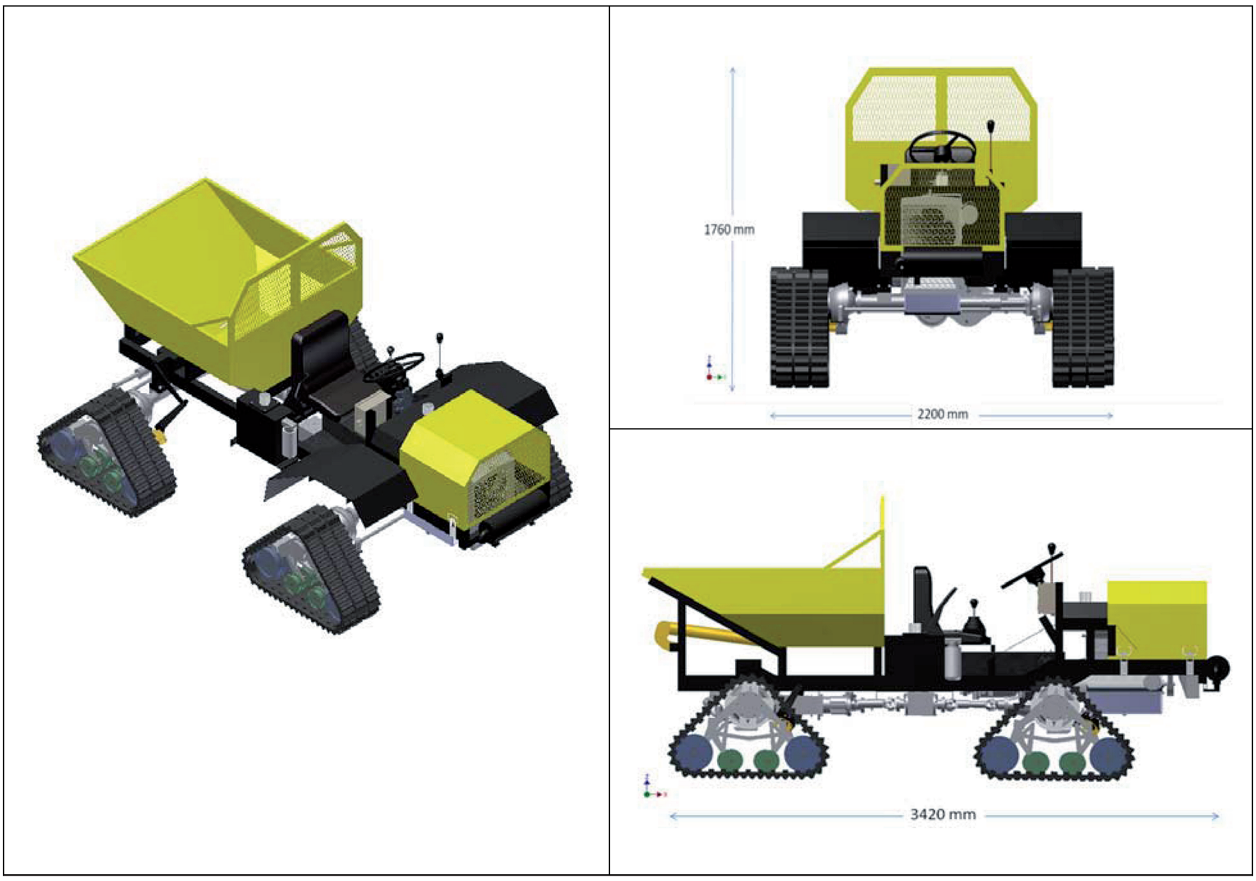

Figure 1. CAD drawing and geometrical dimensions of the transporter.

Chassis

The transporter chassis was designed in an innovative way that enables the mounting of all the components, such as axle, engine and hydraulic pump, to encounter minimum vibration even when the hydraulics reach the maximum torque of 1000 Nm. Mild steel C-channel of 4 mm thickness was considered for building each component of the transporter chassis to avoid deflection of the vehicle frame even when the load was double the total vehicle weight. Two frames are connected by two 1137-mm long hollow rectangular bars with cross-sections to the C-channel of dimensions of 75 mm x 100 mm, and with a thickness of 4 mm. Furthermore, the chassis frame is supported by

FIELD PERFORMANCE TEST

The 4-wheel drive transporter has been tested for field performance. The selected plot was almost flat with 14 rows of planted palms. There were on average 24 palms in a row, and the palms were 14 years old. The soil conditions on the day of the field test were soft and soggy. A total of nine collection trips were made during the field test. The transporter had to cover two harvesting paths or four palm rows to complete one collection trip. *Figure 2* shows the transporter during the field test. The test parameters were recorded as soon as the 4-wheel drive transporter entered the field and started to collect the FFB. The machine operator directly unloaded the contents of the collection at the collection point on the roadside or into a bin.

Figure 2. The 4-wheel drive transporter during field testing.

Operation of the 4-wheel drive transporter was limited to the machine path, headlands and the roadside. Each FFB had an average weight of 18 kg, and was left at the palm base after harvesting on the test days. At the start of the test, the operator of the 4-wheel drive transporter switched on the engine and drove the machine towards the first FFB in the first harvesting path. The operator steered the machine to the nearest available FFB along the harvesting path where the bunches had been lined up by the harvester. Upon reaching each FFB, the loader spiked it and loaded it into the bin. After collection, the operator drove the transporter with its load to the collection point to dump the harvest.

COST ANALYSIS

Cost analysis was carried out to estimate the operational cost of the 4-wheel drive transporter. Machine cost is very crucial in the management of farm machinery with the aim of maximising profit. The total cost of using the 4-wheel drive transporter comprises fixed costs and operational costs. The fixed costs include depreciation, interest on investment, taxes, and housing and insurance, whereas operational costs include repair and maintenance, fuel consumption and labour. The estimated fabrication cost for the 4-wheel drive transporter with the track system is RM 85 500.00, of which the cost for the prime mover amounts to RM 45 500.00 while the four tracks cost RM 40 000.00. The estimated total accumulated operating hours per year is 2496 hr, based on field operation over eight working hr day^{-1} and 26 working days $month^{-1}$. The mean field collection time per trip by the 4-wheel drive transporter is 13.7 min with a loading capacity of 1.8 to 2.2 t hr^{-1}. Assuming the FFB loading capacity to be 2.2 t hr^{-1} and the cost of the prototype to be RM 85 500.00, the estimated collection-transportation operation cost would be RM 8.83 t^{-1} FFB.

CONCLUSION

The achievable output of the 4-wheel drive transporter is in the range of 12 and 16 t day^{-1} under the described conditions. The output of the 4-wheel drive transporter is very much dependent on the fruit density (available ripe bunches) and topography of the plots.

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