

Inflation Pressure Effect on Coefficient of Rolling Resistance of Two Wheel Camel Cart

Ajay Kumar Verma and Pratap Singh

Department of Farm Machinery & Power Engg., College of Technology and Agricultural Engineering, Rajasthan Agricultural University, Udaipur - 313 001 India

Abstract Tyres of ten different sizes commonly used in two wheel camel carts in western Rajasthan were tested at different inflation pressures and payloads to find out the optimum values of inflation pressures. It was found that coefficient of rolling resistance (CRR), decreased by about 8 to 19% on sandy terrain and increased by about 7 to 12% on tarmac road, by reducing the normal tested range of inflation pressure.

Key words Inflation pressure, Coefficient of rolling resistance, Pneumatic wheels

Sandy soils cover a large part of Rajasthan and are not suitable for transportation because of their low strength. In rural areas most people live at considerable distance from a conventional road and are not adequately served by the transportation system. Camel carts having cut and worn out tread

discarded automobile tyres are the cheapest means of transportation for short haul freight between villages and market. It is generally observed that the camel cart owners operate their carts on high inflation pressure, both on tarmac road as well as on sandy terrain. Considerable amount of energy

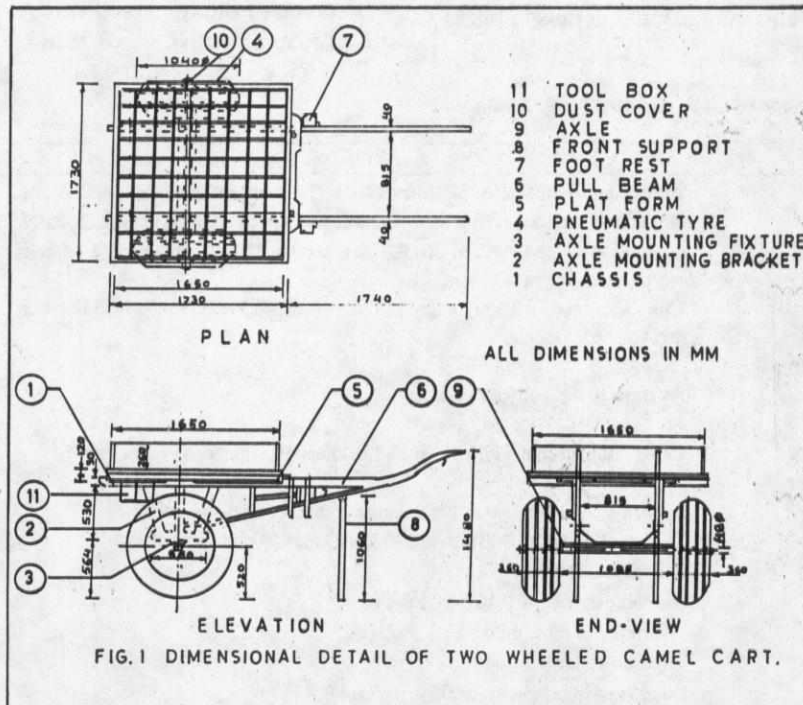


Fig 1 Dimensional details of two wheeled camel cart

losses occur because these tyres are not studied for the matchable inflation pressure with respect to the payload. Inflation pressure is one of the dominant factors affecting the rolling resistance of pneumatic wheels, because this pressure controls the extent to which the tyre is flexed and the degree to which the soil is compacted. For the same tyre loading the reduction in inflation pressure in the wide base tyres was suggested by D' Avello (1964). By using low pressure tyres, Perdok (1978) had achieved an improved efficiency of transport on the soft loose soil. On undeformable surface Taylor (1967) and Perdok (1978) found that at normal load for the same tyre, increase in inflation pressure, CRR decreases.

The paper presents the results of a study carried out at Agricultural Research Station, Bikaner to achieve this objective.

Materials and Methods

Investigation was carried out with ten different tyres (Table 2) and camel cart was used as a loading device. The major specifications of the cart are given in table 1 and dimensional details in fig. 1.

Experimental parameters : All the tyres were tested for two operating conditions, namely compact loose sand and tarmacadam road at several payloads. The range of payload and inflation pressure were 446.35 to 2015.95 daN and 34.47 to 344.75 kPa, respectively, based on load carrying capacity of cart and safe range of inflation pressure for discarded automobile tyres. The tyres were tested by step by increasing payload and inflation pressure by 392.4 daN and 34.47 kPa, respectively.

Determination of draught requirement : The draught was measured with the help of load cell and indicator. A Special coupling was fabricated and mounted on the pull beams to hold a load cell. The draught requirement was measured between the tested range of payloads by the step of increase in payload 392.4 daN (400 kg) for all the tyres at each inflation pressure.

Physical properties of sandy terrain : All the pneumatic wheels were tested on the test track made of soil having, compacted medium grained sands, 2.48% moisture, 1.43 g cm⁻³ bulk density and 30.3% porosity. It was noticed that penetration resistance of the track soil was very low at the top i.e. at 50 mm depth it was 0.2818 kgf cm⁻² at 115 and 140 mm it was 5.482 and 9.642 kgf cm⁻², respective-

Table 1 Specification of camel cart used for the investigation

Parts	Specifications
Body frame	According to the size of platform 1730 x 1730 mm, cross section 30 x 35 mm. Angle iron on body frame at both lower and upper size 30x30 mm. (Sisso Wooden)
Beams	Cross wise to the length of cart 6, Cross section 40 x 40mm, length 1730 mm Length-wise to the platform-2 spacing-815 mm, Cross section 40 x 9 mm, length of mainbeam 3525 mm, Angle iron fixed on pull beams 40x40 mm (Sisso Wooden)
Axle mounting bracket	As show in fig. 1 (Sisso wooden)
Beam on axle	Length 1050 mm width 300 mm, thickness 50 mm (Sisso Wooden)
Platform	Length 1730 width 300 mm, thickness 25 mm (Acacia wooden)
Side Panel	Length 1770, width 300 mm, thickness 25 mm (Acacia wooden)
Tyre	See table-2 (Nylon)
Rim	See table-2, length 1810 mm (mild steel)
Bush	Diameter 40 mm (mild steel)
Bearings	Tapered roller bearing Load carrying capacity 2000 kg, useful life 15 years

Table 2 Tyre, rim size and range of inflation pressure used for the investigation

	Type of tyre	Tyre width (mm)	Wheel radius (mm)	Rim diameter (mm)	Rim width in (mm)	Range of inflation pressure in kPa	
						Sandy terrain	Tarmacadam road
T ₁	Aeroplane	440	550	406	318	34.47–137.95	68.95–241.32
T ₂	Trade tyre	305	520	508	252	68.95–241.32	68.95–241.32
T ₃	Balloon tyre	360	515	508	252	68.95–241.32	68.95–241.32
T ₄	Tread tyre	296	520	508	252	68.95–241.32	68.95–241.32
T ₅	Balloon tyre	340	506	508	252	68.95–241.32	68.95–241.32
T ₆	Tread tyre	288	520	508	252	68.95–241.32	68.95–241.32
T ₇	Balloon tyre	320	500	508	252	68.95–241.32	68.95–241.32
T ₈	Animal drawn vehicle ADV	204	490	483	168	68.95–241.32	68.95–344.75
T ₉	Tread tyre	192	400	407	238	68.95–241.32	68.95–344.75
T ₁₀	Tread tyre	154	392	407	238	68.95–241.32	68.95–344.75

Balloon Tyre ** :

Scrapped out tread tyres and toroidal in shape commonly and locally called as "Balloon Tyre". Procedure involved to convert tread type of tyres into the Balloon tyre is as follows :

- (i) If there are cuts on the tyre, they are repaired,
- (ii) treads of the tyres are completely chiselled off
- (iii) finally a thin layer 5-10 mm of rubber is glued around the periphery of the tyres

ly. This type of soil condition provides a higher wheel sinkage.

Method of computing coefficient of rolling resistance

: These coefficients were obtained by dividing the rolling resistance (draught) by load on the wheels i.e. the tare weight of the cart and payload.

Results and Discussion

Inflation pressure effect on CRR: The observed/computed values of CRR for different tyres, payloads and inflation pressure on sandy terrain and tarmacadam road have been given in Fig. 2 A and 2 B.

It was found that as the inflation pressure decreased, CRR on sandy terrain decreased but after optimum value of inflation pressure (where CRR was minimum) the rate of reduction in CRR became either very slow or it became constant. In few tyres (T₈, T₉, T₁₀) CRR increased with further reduction of inflation pressure (Fig. 2 A). This may be explained by the fact that at particular payload, higher inflation pressure results in an increased ground penetration work, therefore high CRR value, conversely, lower inflation pressure, while

decreasing ground penetration, increased the deflection of tyre and hence hysteresis losses. Therefore an optimum value of inflation pressure existed. At particular payload by decreasing the inflation pressure from highest tested inflation pressure to the optimum inflation pressure it was found that percentage reduction in CRR varied from 7 to 12 % for aeroplane tyre (T₁), from 7 to 15 % for balloon tyres and 8 to 20 % for the tread tyres.

CRR varied from 0.06 to 0.12 for different tyres at tested range of payloads depending upon the tyre size, the lowest value of CRR was for (T₁) and maximum for smaller tyres (T₉) and (T₁₀). Comparatively less wheel sinkage was observed for (T₁) and (T₃) due to the large structural air vessels as it results less wheel sinkage and more flexibility.

Percentage reduction in CRR on Tarmacadam road by the use of lower values (68.95 to 172.37 kPa) in place of upper values of inflation pressure (172.37 to 344.75 kPa), for the particular payload varied from 7 to 12% for all the tyres. It was noticed that with the increase in inflation pressure CRR decreased, after reaching an optimum values

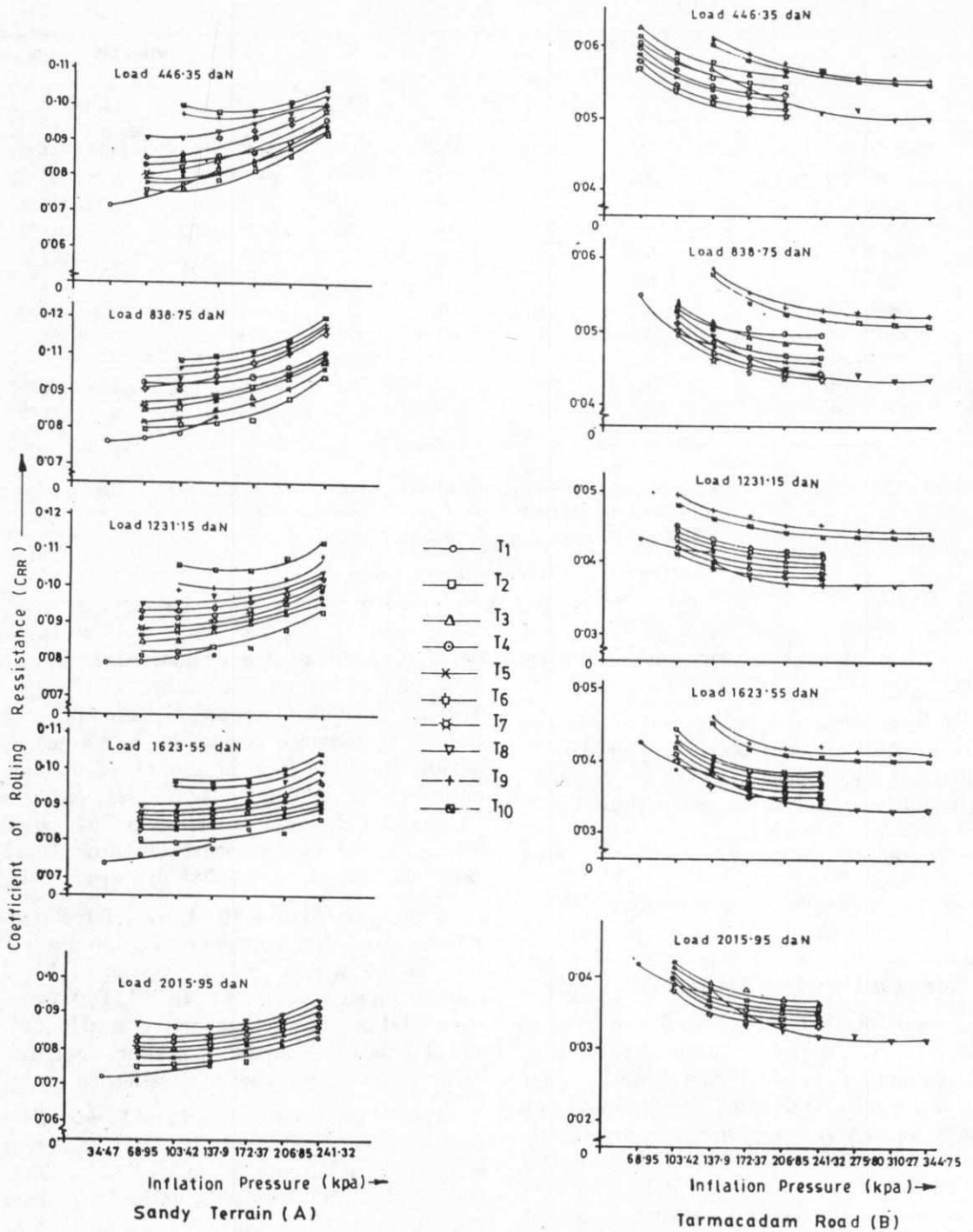


Fig 2 Relationship between inflation pressure and coefficient of rolling resistance on sandy terrain (A) and tarmac road (B)

(where CRR was minimum), CRR became either constant or decreased with very slow rate with further increase in inflation pressure i.e. for tyre (T₁), (T₂, T₃, T₄, T₅, T₆, T₇), (T₈) and (T₉, T₁₀) CRR values were 137.80, 241.32, 310.27 and 344.75 kPa, respectively.

At the tested range of inflation pressure (344.75 to 103.42 kPa) and payload the CRR for the smaller size tyre varied from 0.03998 to 0.05719. For the aeroplane tyre, tread tyres and balloon tyres the CRR value varied from 0.03531 to 0.05608, from 0.03706 to 0.05600 and from 0.03934 to 0.05090 kPa, respectively.

Tread and balloon tyres performed almost similar on the undeformable tarmacadam road. It was observed that the tyre diameter was more effective parameter as compared to tyre width, because smaller diameter tyre had about 50 to 70% more CRR compared to all other tyres tested for the investigation.

Comparison of performance of various tyres on sandy and tarmacadam road: It was observed from the study that CRR at full load (2015.75 daN) for tyre (T₁), (T₃, T₅, T₇) and (T₂, T₄, T₆, T₈) were 0.043, 0.045 to 0.0565 and 0.049 to 0.057 respectively, whereas for tarmacadam road it were 0.0379, 0.036 to 0.0348 and 0.0370 to 0.033, respectively.

On sandy terrain, CRR were more compared to tarmacadam road, by about 16 %, (25 to 47%) and (35 to 72%) for tyre (T₁), (T₃, T₅, T₇) and (T₂, T₄, T₆, T₈), respectively.

From the results it is recommended that aeroplane tyres (T₁) requires least energy, both on sandy and tarmacadam road among the tyres tested but its cost and limited availability restrict its use (Table 4). Balloon tyre of size (360 -508 mm) can be used for sandy and tarmacadam road as it performs as good as the aeroplane tyre and are easily available.

Table 3 Recommended inflation pressure on sandy terrain and tarmacadam road for different types of pneumatic wheels

Tyre Size (mm)	Load on the wheels (daN)	Lowest value of CRR Obtained at inflation pressure (kPa)	
		Sandy terrain	Tarmacadam road
Aeroplane tyre	446.35 – 2015.95	34.47	137.90
T ₁ (440mm – 406mm)			
Tread tyre			
T ₂ (305mm – 508mm)			
T ₄ (296mm – 508mm)	446.35 – 2015 – 95	103.42	241.32
T ₆ 288mm – 508mm)			
Balloon Tyre			
T ₃ (360mm – 508mm)	446.35 – 2015.95	68.95	241.32
T ₅ (340mm – 508mm)	446.35 – 1632.55	68.95	241.32
T ₇ (320mm – 508mm)	1623.5 – 2015.95	103.42	241.31
ADV Tread tyre			
T ₈ (204mm – 483mm)	446.35 – 2131.15 1231.1 – 2015.75	103.42 137.90	310.27 310.27
Small tyre			
Tread tyre			
T ₉ (192mm – 407mm)	446.35 – 1231 – 15	103.42	310.27
T ₁₀ (154mm – 407mm)	1231.15 – 1623.55	137.90	344.75

Table 4 Rolling resistance of various tyres

Type of tyre	Rolling resistance per 90.1 daN in N	
	Sandy terrain	Tarmacadam road
Aeroplane tyre	33.3	30.1
Tread tyre	40.4 to 43.5	27 to 31.5
Balloon tyre	36.8 to 41.4	28.0 to 30.0
ADV tyre	46.8	25.5
Small tread tyre	51.7 and 62.8	33.3 to 35.4

Conclusions

1. Inflation pressure is one of the most important factor affecting coefficient of rolling resistance of pneumatic wheels of two wheel camel cart. For particular payload, decrease in inflation pressure from highest tested value to the optimum value resulted a decrease in C_{RR} by about 15 to 19% on sandy terrain and an increases by about 7 to 12% on Tarmacadam road.
2. On sandy terrain the value of coefficient of rolling resistance varies from 0.07 to 0.12 and from 0.03 to 0.059 on tarmacadam road.
3. Minimum value of C_{RR} were found for the wider width of aeroplane tyre (T_1) on

sandy terrain and Animal Drawn Vehicle tyre (T_8) on tarmacadam road.

4. Ballooning of the tyres decreases C_{RR} by about 12 to 16% on sandy terrain, whereas there is an increase of about 5 to 7% in case of tarmacadam road.

References

- D'Avello 1964 Deflection of a moving tyres on firm to soft Surface. Research Bulletin 1028 AMES IOWA 15-22
- Perdok VD 1978 A Prediction Model for the Selection of Tyres for Towed Vehicles on Tilled Soil. *Journal of Agricultural Engineering Research* 23 369-383
- Taylor J H, Vanden Berg & Reed I F 1967 Effect of diameter on the performance of powered tractor wheels. *Transaction the ASAE* 19 1062-1064

(Received August 1992

Accepted October 1992)