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Studies on draftability and enhanced utilization of small size bullocks of Odisha for pulling improved steel cart on tar road

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ABSTRACT

An improved steel bullock cart (2.0 tones capacity) of INSDAG (Institute of Steel Development and Growth, Kolkata) design has been evaluated after putting rubber liner on its wheels as a modification, with a view to study its suitability in preventing the surface of rural roads. The cart with and without rubber liner was tested in the tar road of animal test track existed in the premises of OUAT, Bhubaneswar, Odisha during the year 2012 with a pair of non-descript small size bullocks having a pair body weight of 420 kg. The results indicated that the small size bullocks could sustain pulling a pay load of 1200 kg continuously for three hours with rubber liner with the work rest cycle of 1 hour work + 15 min rest + 1 hour work + 20 min rest + 1 hour work as against 900 kg without rubber liner in tar road.

Key words: Bullock power, Rural transport, Steel bullock cart, Tar road.

INTRODUCTION

Bullock cart is still in existence in rural areas of India, mostly in the regions dominated by tribal people where it is used as a mode of transport for small and even medium distance for carrying the agricultural inputs and produce to the nearby markets (Anonymous, 2012). Use of bullock cart will also remain in existence in tribal populated areas for long future due to the predominance of bullock farming system and poor socio-economic condition of the people (Srivastava, 2000). It has been estimated that there are at present 15 million bullock carts in India, out of which 80 % are of conventional type (Ghosal *et al*. 2012). The prime limitations of the traditional carts are their low pay load capacity, lack of standard design, poor stability and lack of proper alignment between the yoke and the platform (Ramanujam, 1993). An improvement of the traditional bullock cart with steel frame and pneumatic tyre has proved better with respect to draft and power requirements (Deshpande and Ojha, 1985). Keeping in view of the importance and need of cart mechanization in near future particularly for tribal dominated areas and in rural sectors, one organization namely, Institute of Steel Development and Growth (INSDAG), Kolkata has designed and developed an improved steel bullock cart for higher pay load, stability and more comfort to the bullocks compared to conventional bullock cart (Anonymous, 2005). The cart of INSDAG make has been designed to carry higher pay load, provision of lubrication system with bearing in the wheel, braking system, increased durability and lighter weight compared to traditional wooden cart. The information on the suitability of steel cart of 2.0 tonnes capacity for small size bullocks of Odisha is not available. Out of three local non-descript breeds of bullocks namely Ghumsari, Binjharpuri and Mottu existing in Odisha, Mottu breed is the smallest size of bullocks and found in the tribal districts of the state (Behera *et al*., 2006). The pair weight of Mottu breed of bullock varies from 350-500 kg (Anonymous, 2010). Studies (Ghosal *et al*. 2011) on the performance of steel cart (2.0 tonnes capacity) of INSDAG design revealed that the existing rural road conditions (earthen and tar road) were found unsuitable for long hours of use due to high friction between the metallic rim and the road surface causing partial damage to the track as well as wheel. Hence it was felt necessary to put a rubber liner on the iron wheels of the cart, as a modification, in order to prevent the damage of the rural road. The present study was therefore taken up to evaluate the suitability of steel cart of 2.0 tonnes capacity for small size bullocks of Odisha and to assess the feasibility of using rubber liner from wearing point of view.

MATERIALS AND METHODS

The two-wheeled steel cart (2.0 tonnes capacity) developed by the Institute of Steel Development and Growth (INSDAG) and fabricated by M/S Viswakarma Fabricators, Aska, Ganjam, Odisha has been procured for the study. The iron wheels of the steel cart have been modified by putting rubber liner around their periphery to protect the road from damage by iron wheels alone. The rubber material was collected from the middle portion of an old and rejected tyre of the truck and its thickness was 1 inch. The cost of rubber liner for both the wheels was Rs. 1000/- (@ Rs. 25/- per feet for 40 feet long liner). The study was conducted in the test track available in the premises of College of

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Table 1: Specifications of two wheeled steel cart (2.0 tonnes capacity) pulled by a pair of bullocks

Components	Dimension
Wheel diameter (mm)	1500
No. of spokes in wheel	18
Axle diameter (mm)	40
Axle length (mm)	1750
Platform size (mm x mm)	3100 x 1000
Yoke length (mm)	1700
Height of platform from ground (mm)	1000
Length of cart (from rear to yoke) (mm)	5200
Ground clearance (mm)	80
Distance between wheels (mm)	1480
Pay load carrying capacity, tonne	2.0
Weight (kg)	280
Wheel bearing	Roller type
Brake	Shoe type
Cost (Rs.)	17,000

Agricultural Engineering and Technology, OUAT, Bhubaneswar, Odisha, India during the year 2013. The specifications of steel cart have been mentioned in Table 1. The photographs of steel cart without and with rubber liner are shown in Figures 1 and 2 respectively.

Standard techniques were used for measurement of the different parameters to study the performance of the cart. The experiment was conducted at three hours for each payload and the observations were taken in one hour interval. Ten points were marked on each wheel of the cart in order to measure the wear during the experiment. The wear of the rubber liner was measured with the help of vernier calipers at each pay load after three hours of running the cart. Mean values of percentage of wear were finally calculated by taking the data of ten points in each wheel in each experiment. The modified cart has been evaluated with the help of two non-descript small size bullocks (pair weight 420 kg) commonly available in the tribal districts of Odisha.

i) Observations

ii) Pay load, kg

iii) Draft, N

iv) Forward speed (m/s)

v) Wheel slippage (%)

vi) Physiological responses of bullock (pulse rate, respiration rate, body temperature)

vii) Fatigue score

viii) Wear pattern (decrease in thickness) of rubber liner used in both the wheels

RESULTS AND DISCUSSION

Evaluation of steel cart without and with rubber liner on the wheels for tar road

The cart was evaluated without and with rubber liner on the wheels by the small size bullocks of Odisha under tar road condition. In the first phase, the performance of the cart without rubber liner was studied for seven days with the change of pay loads ranging from tare weight to 1000 kg. The work rest cycle of 1 hour work + 15 min rest + 1 hour work + 20 min rest + 1 hour work was followed during the test period. The total hours of operation were 21 in first phase for 3 hours of use in a day. In the second phase, the performance of steel cart with rubber liner was studied for the same work rest cycle with the change of pay loads ranging from tare weight to 1300 kg. The total hours of operation were 22 in the second phase. The fatigue score, corresponding to different pay loads during the test period indicated to limit the test up to pay loads of 1000 kg and 1300 kg with the wheels without and with rubber liner respectively. Therefore the duration of test was restricted accordingly. The results of the experiment conducted for the various pay loads in case of without and with rubber liner on tar road are presented in Tables 2 and 3 respectively and in figure 3.

The results indicated that the average draft increased from 137.34 to 421.83 N when pay loads increased

Fig 1: Photograph of two wheel steel cart (2.0 tones capacity) without rubber liner on its wheel

Fig 2: Photograph of two wheel steel cart (2.0 tones capacity) with rubber liner on its wheel

Table 2: Performance of steel bullock cart (2.0 tones capacity) with iron wheel without rubber liner pulled by a pair of small size bullocks on tar road

Pay load (kg)	Av. Draft (kg)	Av. Draft (N)	Draft, (%) ofbody weight	Av. Speed (m/s)	Av. Speed (km/h)	Av. Power, requirement (kW)	Av. wheel slippage (%)	Fatigue score
Tare(280+50)	14	137.34	4.04	0.91	3.27	0.15	0.56	8
400	22	215.82	5.23	0.89	3.20	0.19	0.54	10
600	26	255.06	6.19	0.84	3.02	0.21	0.51	13
700	30	294.3	7.14	0.81	2.91	0.23	0.47	15
800	35	343.35	8.33	0.76	2.73	0.26	0.40	18
900	39	382.59	9.28	0.73	2.62	0.27	0.35	19
1000	43	421.83	10.23	0.71	2.55	0.29	0.31	22

Table 3: Performance of steel bullock cart (2.0 tones capacity) with iron wheel with rubber liner pulled by a pair of small size bullocks on tar road

Pay load (kg)	Av. Draft (kg)	Av. Draft (N)	Draft, (%) ofbody weight	Av. Speed (m/s)	Av. Speed (km/h)	Av. Power, requirement (kW)	Av. wheel slippage (%)	Fatigue score
Tare(280+50)	11	107.91	2.61	1.1	3.96	0.11	0.40	6
400	19	186.39	4.52	1.0	3.6	0.18	0.36	8
600	23	225.63	5.47	0.87	3.13	0.19	0.32	10
800	32	313.92	7.61	0.80	2.88	0.25	0.30	12
900	37	362.97	8.80	0.77	2.77	0.27	0.26	15
1000	39	382.59	9.28	0.75	2.7	0.28	0.23	16
1200	42	412.02	10	0.71	2.55	0.29	0.22	19
1300	45	441.45	10.71	0.67	2.41	0.29	0.21	23

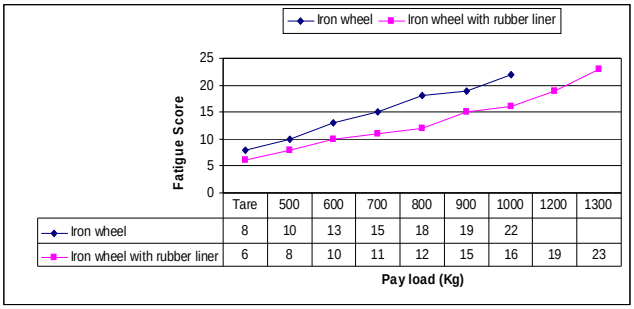

Fig 3: Comparative fatigue scores of bullocks for steel cart of iron wheels with and without rubber liner on tar road

from tare weight to 1000 kg in case of iron wheel without rubber liner as against average drafts from 107.91 to 441.45 N with increase of pay loads from tare weight to 1300 kg for iron wheel with rubber liner on the tar road. The average speeds were found to decrease from 3.27 to 2.55 kmph from tare weight to 1000 kg in case of iron wheel of cart without rubber liner as against average speeds from 3.96 to 2.41 kmph with increase of pay loads from tare weight to 1300 kg for iron wheel with rubber liner. Similarly, the power requirements increased from 0.15 to 0.29 kW when pay loads increased from tare weight to 1000 kg in case of iron wheel of cart without rubber liner as against the same from 0.11 to 0.29 kW with increase of pay loads from tare weight to 1300 kg for iron wheel with rubber liner. The average wheel slippage percentage decreased from 0.56 to 0.31 when pay loads increased from tare weight to 1000 kg in case of iron wheel of steel cart without rubber liner as against the same from 0.4 to 0.21 with increase of pay loads from tare weight to 1300 kg for iron wheel with rubber liner. It was found that non-descript small size bullocks could sustain pulling only 900 kg pay loads for three hours of use of the above cart on the tar road in case of wheels without rubber liner as fatigue score was calculated to be 19. Similarly, the sustainable pay load for the same small size bullocks in case of wheels with rubber liner was observed to be 1200 kg on the tar road with the fatigue score of 19, just below the threshold fatigue level of 20 (Upadhay and Madan, 1985). With further increase of pay load to 1300 kg, the fatigue score reached to 23.

Wear pattern study of rubber liner for both the wheels of steel cart on tar road

While studying the performance of cart with the wheels having rubber liner, the wears (decrease in thickness of rubber liner) of both the wheels were measured on hourly basis with respect to increased pay loads and time. But mean percentage wears of rubber liner on each wheel at each pay load after 3 hours of use have been mentioned in Table 4. The total hours of operation were 22. On the tar road, the small size bullocks were found to pull a sustainable load of 1200 kg continuously for three hours after following a work rest cycle of 1 hour work + 15 min rest + 1 hour work + 20

Table 4: Wear pattern (decrease in thickness) of rubber liner on iron wheels of 2.0 tonnes capacity steel bullock cart on tar road

Payload(kg)	Mean percentage wear of rubber liner on right wheel after 3 hours of use	Mean percentage wear of rubber liner on left wheel after 3 hours of use	Mean percentage wear of rubber liner for both wheels after 3 hours of use
Tare (280 + 50)	0.155	0.341	0.248
400	0.260	0.434	0.347
600	0.354	0.489	0.421
800	0.420	0.552	0.486
900	0.443	0.613	0.528
1000	0.468	0.664	0.566
1200	0.533	0.670	0.601
1300	0.185	0.225	0.605

min rest + 1 hour work. Thereafter, the wear pattern was studied for a sustainable load of 1200 kg for seven days with 3 hours of use in each day and the data were placed in Table 5. In the first phase, the pay loads were increased from the tare weight to 1300 kg. It was observed that for all pay loads, the wears at the ten different points in the left wheel were more than those of right wheel. This may be attributed to the existence of slope in the test track and also due to the difference in the height of neck of both the bullocks used for the study. The mean percent of wears were observed to be from 0.155 to 0.533 for right wheel with pay loads ranging from tare to 1200 kg on tar road. Similarly, the mean percent of wears were from 0.341 to 0.670 for left wheel with pay loads ranging from the same tare to 1200 kg on the tar road. Also the mean percentage decrease in thickness of rubber liner for both the wheels from initial to 3rd hour of each pay load was calculated and found to be varied from 0.248 to 0.601 for the pay loads ranging from tare to 1200 kg. The small size bullocks of Odisha were found pulling a sustainable load of 1200 kg for three hours with the above work rest cycle on the tar road with a fatigue score of 19. The experiment was also continued to the next day with a further pay load of 1300 kg. After 1st hour of operation, the distress symptoms of both the bullocks were observed to be so prominent that the experiment was stopped on that day as fatigue score reached to 23. The experiment was started in the same manner in the next day directly with the sustainable load of 1200 kg and continued for seven days. The total hours of operation at sustainable load were 21. The wear patterns for both the wheels have been shown in figure 4.

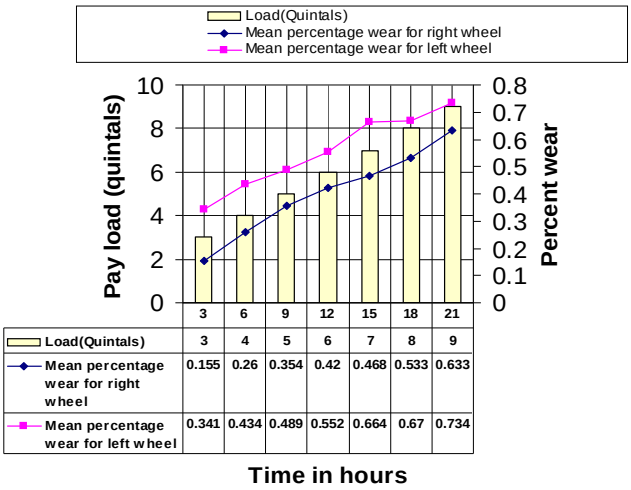

Fig 4: Mean percent wear of rubber liner for both the wheels of steel bullock cart with respect to time and payloads on tar road

The predicted equation for the variation of mean percent of wear with the time of operation for both the wheels at the sustainable load has been derived to calculate the percent of wear with the use of the rubber liner for their replacement. Allowing about 10 percent wear of rubber liner

Table 5: Wear pattern (decrease in thickness) of rubber liner on iron wheels of 2.0 tonnes capacity steel bullock cart at a sustainable load of 1200 kg on tar road

Day of Experiment (3 hours use in each day)	Total Hours of use (hr)	Mean percentage wear of rubber liner on right wheel after 3 hours of use in each day	Mean percentage wear of rubber liner on left wheel after 3 hours of use in each day	Mean percentage wear of rubber liner for both wheels after 3 hours of use in each day
1st	3	0.583	0.685	0.634
2nd	6	0.586	0.690	0.638
3rd	9	0.605	0.718	0.661
4th	12	0.611	0.723	0.667
5th	15	0.634	0.743	0.688
6th	18	0.649	0.755	0.702
7th	21	0.659	0.788	0.723

(Kravckenko et al. 2012) for safe use before replacement, it can be used for about 550 hours with the steel cart on tar road without affecting the surface of the track.

CONCLUSION

The steel bullock cart (2.0 tonne capacity) has been tested with and without the use of rubber liner in tar road after modifying the periphery of its wheels with rubber lining. The steel cart was operated with a pair of non-descript small size bullocks of Odisha having pair body weight of 420 kg. The work rest cycle followed was 1hr work + 15 minutes rest + 1 hr work + 20 minutes rest + 1 hr work. The cart was found to be working nicely without damaging the road. The small size bullocks were found to be sustainable within the threshold fatigue level for pulling 1200 kg pay load for 3 hours with the above work rest cycle after modifying the wheels with rubber lining as compared to 900 kg without rubber lining on tar road condition. The rubber liner can be used safely in the steel cart for about 550 hours without damaging the surface of tar road before its replacement.

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