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Feasibility study of operating dhal mill by using bullock power through rotary mode

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ABSTRACT : Use of bullocks for agricultural work is limited to tillage, sowing and transportation. The total annual use of bullocks in the state of Odisha is less than 300 hours. But the potential use of bullocks in a year is nearly 800 hours. To enhance the utilization of bullock in the state, there is the need of using bullock power operated stationary machines requiring around 1 hp (0.8 kW) power for doing various post harvest operations like paddy threshing, paddy winnowing, chaff cutting, sugarcane crushing, groundnut decortications, oil expelling, pulse milling and dehusking etc. This would ultimately reduce the economic burden of owning a pair of bullocks. With this aim, a study was conducted for operating a mini dhal mill with the help of a rotary gear complex, installed in the premises of College of Agricultural Engineering and Technology (CAET), Orissa University of Agriculture and Technology, Bhubaneswar, Odisha. The experiment was conducted continuously for 3 hours with the measurement of physiological responses like respiration rate, heart rate, body temperature etc. of the medium sized non-descript breed of bullocks (pair weight of bullocks 620 kg) of Odisha at half an hour interval and calculation of fatigue score to know their comfortable working without inflicting any health hazards. The bullocks were observed to be loaded with 10.77 per cent of their body weight in operating the dhal mill and their speed was also measured. The draft and power delivered by the pair of bullocks were as well calculated. The dhal mill was run with a pair of bullocks in rotary mode of operation and two persons were employed for the purpose. The output capacity of dhal mill in rotary mode was observed to be 62 kg per hour as against 80 kg/h in electrically operated motor. The costs of operation in rotary mode and in electrically operated motor were calculated to be Rs. 82.35/q and Rs. 51.47/q, respectively.

KEY WORDS : Bullock power, Dhal mill, Physiological responses of bullock, Fatigue score

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Odisha is situated in the east cost of India extending over a geographical area of 15.17 mha (million hectares) with 6.55 mha under cultivation. In Odisha, around 77 per cent of the farmers are under small and marginal categories and they possess about 43 per cent of the total cultivable land. The numbers of operational holdings are about 40.30 lakhs with a cropping intensity of 160 per cent. The average size of holding is 1.5 ha. Due to small and scattered holdings and low input capacity, the farmers mainly depend on bullock power for performing different agricultural operations. About 82 per cent of the total cultivable land is still under the command of the draught animal power and the rest is under tractors and power tillers. Use of bullocks for agricultural work is limited to tillage, threshing and transportation in the state of Odisha (Kurup, 2003). The total annual use of bullock amounts to less than 300 hours. Cost of utilization is, therefore, very high as the bullocks are to be fed throughout the year whether they are in use or not (Anonymous, 2001). One way to reduce the economic burden of owning a pair of bullocks is to increase the utilization of bullocks which can be possible if the bullocks will be used to carry out operations like running a thresher, winnower, chaff cutter and other agro processing machinery with rotary gear system (Kurchania and Mishra, 2003). This study aims at use of bullock energy particularly during idle period so that their annual use will be increased and ultimately the cost benefit ratio will be improved besides providing useful information on the suitability of bullock power for use of stationary machinery in rotary mode of operations.

METHODOLOGY

The rotary gear unit has been installed in the premises of College of Agricultural Engineering and Technology, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha as shown in Fig. A.

Fig. A : Photograph of rotary gear complex

Rotary gear unit:

Gear box:

In the box different parts are assembled, it is made of 6 mm thick pressed mild steel plate. Shape of the box is rectangular having dimensions of 660 x 579 x 274 mm.

Spur gears:

Set of spur gears transmits the power between two parallel shafts. The spur gears are made of heat treated alloy steel having module 4.0 mm. The spur gear has 77 teeth while the spur pinion has 16 teeth. The speed ratio of 1: 4.8 is obtained.

Bevel gears:

Set of bevel gears transmits the power at 90^0, they are spiral tooth bevel gear having module 6.5 mm. The bevel gear has 43 teeth and bevel pinion has 7 teeth. The material of the bevel gear is heat treated alloy steel. The speed ratio is 1: 6.14. Combination of bevel and spur gear can produce the speed ratio of 1:29.56.

Shafts:

The first shaft of bevel gear is held in vertical position having diameter 50 mm and 63 mm at bottom side and top side, respectively. The second shaft for bevel pinion and spur gear has diameter of 50 mm. The third shaft used for bevel pinion has diameter of 30 mm.

Bearing:

One ball bearing 90x50x24 size is fitted on the 50 mm shaft and another ball bearing of 72x30x20 mm size is fitted on top of the same. One thrust bearing 60x38x20 mm size is fitted at the outer end of the pinion shaft with two ball bearings of 72x30x20 mm and 88x45x22 mm size.

Bearing cover:

One bearing cover n is used for thrust bearing 60x38x20 mm size. The cover is made of 45C8 steel.

Bushes:

Two bushes are used for the input shaft. One is fixed at the bottom plate of the box and the other is fixed at the cover plate. Necessary lubrication arrangement has been provided.

Belt pulley transmission unit:

The two transmission shafts are mounted on two pillars each. The diameter of the shaft is 50 mm. The first drive shaft was connected to the output shaft of the gear box through universal joint coupling. One pulley of 60 cm was mounted on the first drive shaft and the counter shaft is having a pulley of 35 cm thereby stepping up the speed in the ratio 1: 1.71 when connected with flat belt. For dhal milling operation, a 40 cm V-pulley is also mounted on the counter shaft which is connected through V-belt with the shaft of dhal mill having a 10 cm pulley, stepping up the speed in the ratio 1: 4. So for dhal milling, the final speed ratio is 1:202. The photograph of dhal mill is shown in Fig. B.

Fig. B : Photograph of operation of dhal mill through rotary mode by using bullock power

Evaluation of Dhal mill:

A dhal mill was used for milling of pulses along with cleaning of milled pulses. The dhal mill was tested continuously for 3 hours. The dhal mill can otherwise be operated with a one hp motor. The dhal mill was run with the bullocks in rotary mode of operation and two persons were

employed for the purpose. Standard techniques were used for measurement of the different parameters. The experiment was conducted for three hours and the observations were taken at half an hour interval. The cost of operation was calculated for milling in rotary mode of operation through bullocks and compared with electrically operated motor. The following assumptions were taken for calculating the cost (Table A).

Table A : Assumptions for computing cost of operation

Units	Cost (Rs.)	Life span	Repair and maintenance	Annual use (h)
Rotary unit	30,000	10	5 % of the cost	960
Dhal mill	11,460	10	-do-	240
Dhal mill with motor	25,000	10	-do-	240
Bullock pair	20,000	5	Rs5/h	1200

Variable cost for winnowing: Two persons and one bullock operator and labor charge Rs. 100/ day

■ RESULTS AND DISCUSSION

The data on performance evaluation of the dhal mill in rotary mode have been presented in Table 1. The draft requirement varied 686 N in the beginning to 637 N at the end. The mean draft was 655.63 N which was 10.77 % of the bodyweight of the bullocks. The increase in pulse rate and respiration rate as usual decreased with duration and varied between 50 to 77 and 14 to 38 within three hours, respectively. The corresponding mean values were 64 and 27. There was not much variation in the body temperature. Half hourly RPM of the bullocks were from 60 to 56 and gradually deceased with duration.

The mean linear speed of the bullocks was 2.72 km/h. The mean RPM of the dhal mill shaft was observed to be 305. The output of the machine gradually decreased with duration; may be due to decrease in the speed of the shaft of the dhal mill. The mean output was found to be 62 kg/h where as the output of milling in electric motor operated dhal mill was 80 kg/h. The power output was found to be 0.49 kW which indicated that the bullocks could easily do the milling operation and their utilization could be enhanced. The bullocks could sustain three hours of milling continuously without getting fatigue as the average fatigue score was calculated to

Table 1 : Physiological responses of bullocks and performance of dhal mill in rotary mode of operation

Parameters	Duration, h							Mean
	In	0.5	1.0	1.5	2	2.5	3.0	
Pulse rate, bpm	50	56	60	63	67	74	77	64
Respiration rate, bpm	14	20	24	27	30	33	38	27
Body temp, ^{0}C	37.9	38.1	38.2	38.4	38.5	38.7	38.8	38.37
Amb Temp., ^{0}C	25.1	25.5	26.3	27.6	28.8	29.3	29.5	27.44
Rh, %	38	35	35	34	34	33	33	34.57
Draft, N	-	686.7	667.08	667.08	637.65	637.65	637.65	655.63
RPM of bullocks/0.5h	-	60	60	58	58	56	56	58
Speed, km/h	-	2.82	2.82	2.72	2.72	2.63	2.63	2.72
RPM at dal mill shaft	-	320	310	310	300	300	290	305
Shelling efficiency (%)	-	68	65	65	64	60	60	63.66
Breakage (%)	-	7.2	7.0	7.0	6.6	6.6	6.4	6.8
Output, kg/h	-	64	64	62	62	60	60	62
Power output, kW	-	0.53	0.52	0.50	0.48	0.46	0.46	0.49
Fatigue score	-	12	14	14	16	17	18	15.16

Table 2 : Cost economics of rotary mode of operation for dhal milling

Machine	Fixed cost (Rs./h)	Variable cost (Rs./h)	Total cost (Rs./h)	Total cost (Rs/q)
Rotary unit	7.0	-	7.00	-
Bullock pair	3.91	5.00	8.91	
Man-hr	-	12.50	12.50	
One pair Bullock + one labourer	3.91	17.50	21.41	
Mini dhal mill	10.15	-	10.15	
Dhal milling in rotary mode	21.06	30.00	51.06	82.35
Mini dhal mill with 1 hp motor	12.18	4.00 (electric cost)	16.18	
Dhal milling in 1 hp motor	12.18	29.00	41.18	51.47

be only 18 which was less than the threshold fatigue score of 20.

Cost economics:

The cost economics of rotary mode of operation in decortications is presented in Table 3. The pulses milling in rotary mode (Rs. 82.35/q) were not economical compared to the same machine operated by electric motor (Rs. 51.47/q). The above economics suggests that rotary unit is not economical compared to milling by electric power but surely it will increase the utilization of bullock which otherwise would have been sitting idle and can save time in the above operations compared to traditional practices. The above operations through rotary mode were found to be within the draftability of the bullocks.

Conclusion:

The operations like dhal milling can be performed effectively by using dhal mill in rotary mode by using bullock power to enhance the annual utilization of bullocks.

The draft requirements of the mini dhal mill were found to be 10.77 %, respectively in terms of percentage of body weight of the medium size bullock. The bullocks could sustain the draft of dhal mill for 3.0 hours of continuous work.

The operation of mini dhal mill through rotary mode was not economical compared to be operated with electric motor. The costs of operation in rotary mode and in electrically operated motor for mini dhal mill were Rs. 82.35/quintal and Rs. 51.47/quintal, respectively.

The performance of mini dhal mill in rotary mode was observed to be, respectively 62 kg/h as against 80 kg/h in electrically operated motor.

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