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Physiological Responses of Bullocks in Rotary Transmission System for Briquette Production

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ABSTRACT

Draught animals such as bullocks and he buffaloes are the important source of energy for agricultural operations on small and marginal farms of Chhattisgarh, which constitute three fourth (75.77 %) portion of total land holding. Draught animals used in this region are small sized. In this paper physiological response of non-descriptive breed of bullocks of Chhattisgarh region in rotary power transmission system for briquette production are described. The physiological responses of Bullock in terms of pulse rate, respiration rate and body temperature were recorded during the briquette production after every one hour workout. The average speed of bullock during briquette production and power output was recorded 0.84 m/s and 0.43 kW respectively. The power output reduced with passage of time. The operating speed of bullock varied with the working hour and the bullocks were not fatigue after 6 hours of work as they scored 16 points against the fatigue level score of 20 points.

Keywords: Rotary Transmission System, Biomass, Proximate Analysis, Briquettes, Physiological Response

Draught animals have been a major power source in Indian agriculture since centuries. Recent advances in mechanization and fuel run machines have reduced the area under draught animal cultivation system. Still a large number of marginal and small holdings are cultivated using draught animals. With the modernization of agriculture, the use of mechanical power in agriculture has increased but draught animal power (DAP) continues to be used on Indian farms due to small holdings and hill agriculture. More than 55% of the total cultivated area is still being managed by using draught animals as against about 20% by tractors (Phaniraja and Panchasarl, 2009).

In Chhattisgarh, bullocks and he buffaloes are among the prominent draught animals used for agricultural operations, which constitute 64.53 % and 14.32 % of total draught animal population respectively (Jogdand *et al.,* 2008). Use of bullocks for agricultural operations is limited to tillage, thrashing, and transportation in India. At present the utilization varies from 300-1500 hours, against ideal and economical utilization of 2500 hours per year. This is possible through employing animal in the rotary mode of power to operate different agro processing machines (Srivastava, 2000). In this view the draught animal power could be used to operate low hp post harvest machines. The machines are chaff cutter, grain grinder, grain cleaner-cum-grader, briquetting machine water lifting and generation of electrical power for lightening and domestic use. An animal drawn reciprocating pump was developed that used two units of hand pumps and reported that the pump was capable of delivering water at rate of 7 liter per second at a head of 6 meter (Khepar, 1975). The average speed draught animal on a circular track is 0.6 m/s for oxen and 0.7 m/s a donkey. The power output by a single animal is about 0.16 hp for donkey, 0.25 hp for horse or light ox and 0.32 for a bullock of 400 kg body weight. In practice one may expect with a pair of animals an output of 0.3 and 0.6 hp while utilizing buffalo in rotary mode of operation for the operation of paddy thresher and other stationary work (Singh and Singh, 2013). One of the ways of utilizing the bullock's power could be for briquette production in remote villages in hills or plain areas by using agricultural waste. In this paper effective

use of Non descript breeds of bullocks of Chhattisgarh region for low density briquette production using rotary transmission system has been described. The briquette can be used as fuel for cooking and other domestic purpose. The agricultural wastes which are unnecessary burnt may be utilized to fulfill the demand of fuels in rural areas.

MATERIALS AND METHODS

An animal driven briquetting machine was developed and operated by an existing setup of rotary transmission system installed by the AICRP on Utilization of Animal Energy at department of Farm Machinery and Power Engineering, Swami Vivekananda College of Agricultural Engineering and Technology, Faculty of Agricultural Engineering, IGKV Raipur. The detail of complete unit is given below.

Animal Driven Rotary Transmission Unit

The rotary unit, in fact is a power transmission system which convert the animal power into mechanical power for operating the different agricultural processing machines. To make the complete unit economically viable, one pair of bullocks was used to generate power. For safer design of animal powered rotary unit, the ultimate power developed by a pair of bullocks can be assumed as 0.75 kW. This power was used for operating briquetting machine. The rotary transmission system consists of a rectangular gearbox, beam, shafts and pulleys etc. The gear box consists of four shafts of which 3 are vertical and one horizontal namely input shaft, 2 intermediate shafts and final drive shaft. In gearbox; 4 spur gears, one bevel gear and one pinion were used to transmit power from input shaft to final drive shaft. Various gears were arranged in such a way that they raised rotational speed of bull gear to approx 34 times (speed ratio 33.78: 1). The pitch of gear was 6 mm. At the end of output shaft of gearbox V-groove pulley of 600 mm diameter was provided and connected with the V-groove pulley of 180 mm diameter mounted on the briquetting machine. This gave the speed ratio of 3.33:1 between pulley of briquetting machine and output shaft of gearbox. System resulted about 225 rpm of briquetting machine, when animals made two revolutions around the rotary track. A wooden beam of length 4 m was used at the input shaft of the power transmission system to give drive to gearbox through animal power.

A screw press extruder type briquetting machine was used to produce low density briquettes. It consists of screw, die, hopper and power transmission system. The raw material was fed to the hoppers, which convey it to screw by gravity. The material was pushed forward due to geometry of screw. As the material was pushed, it get compressed inside of the die and bonded material comes out from die in the form of briquettes or pellets. The briquetting machine was driven by 180 mm diameter pulley fitted on the input shaft and the driver pulley of 600 mm mounted at the output shaft of gearbox.

Installation

The gear reduction unit was installed underground on a cement concrete foundation. The main driving shaft of the gear system was attached to a wooden beam. The bullocks were hitched to this beam at the time of operation. The briquetting machine was placed near the output shaft of the gear reduction unit. It was fixed on a solid foundation on the ground by using nuts and bolts to secure it firmly. A pair of non-descriptive breed of bullocks was used for this study. The body weights of animals used to operate the rotary power transmission system was measured using an electronic weighing machine (capacity 0-1000 kg). The average heart girth, average body length, average height and body weight of the experimental bullocks was 2250 mm, 850 mm, 1440 mm and 470 kg respectively. Load cell (0-1000N) was used to measure the pull force of the bullocks to operate the rotary power transmission unit. The load cell was mounted between the beam and yoke through the rope. The values of pull were recorded after every 5 min. The angle of line of pull (6^0) and angle of inclination of rope (22^0) with the line of travel were determined by use of abney level. The speeds of operation, bull gear rev/min were recorded at the start and after every hour of work. The horizontal component of pull resulted draught force value. Speed of bullocks was determined by recording the time to travel one circle in rotary test track. The power requirement was calculated by using the equation,

$$P = \frac{D \times S}{1000}$$

Where, P = Power developed by bullocks in kW; D = Draft force in Newton and S = Speed in m/s.

For rotary power transmission drive it is important to

Fig. 1: Setup of rotary transmission system for measurement of draft, speed and power output during briquette production

determine torque as well as the number of revolutions (rpm). During the test, values of torque, speed and power output at the output shaft of box, rpm of bull gear and pulley mounted at briquetting machine were recorded.

Physiological Parameters

The physiological parameters of working bullocks such as heart rate, respiration rate, rectal temperature and fatigue symptoms were recorded at the start of work and after every hour of work. Observations on physiological parameters were taken by following standard methods i.e. a) **Heart rate (beats/min):** By sensing palpitation/min of the animal at coaxial artery at the rear of tail. b) **Breathing rate (breaths/min):** By counting nos. of air exhaled/min by the animal. c) **Rectal temperature (°C):** By inserting a clinical thermometer in the anus 50 mm inside. The sequence of observations on visual fatigue symptoms were recorded as per the fatigue score card (Upadhyay, 1987).

RESULTS AND DISCUSSION

At starting hour the speed of bullock as well as rotation of output shaft was higher i.e. 0.89 m/s and 318 rev./min respectively. As the work progressed the speed of bullock decreases which results reduction in rotation of output shaft. At the 6th hour of work the speed of bullock and rotation of output shaft was 0.80 m/s and 286 rev./min. Power output was maximum 0.53 kW at 297 rev./min of output shaft of gear box. Draft force and speed of bullock were 640 N and 0.83 m/s at 297 rev./min of output shaft of gear box (Table 1).

Table 1: Variation in rotational speed of output shaft and power output with the draft force and speed of bullock

Duration of work (h)	Speed of bullock (m/s)	Draft (N)	Rotational speed of output shaft (rpm)	Power output (kW)
1	0.89	325	318	0.29
2	0.83	635	297	0.52
		1 hour rest		
3	0.86	470	308	0.40
4	0.83	545	297	0.45
		1 hour rest		
5	0.83	640	297	0.53
6	0.80	530	286	0.42
Average	0.84	524	300	0.43

Physiological Response of Bullocks during Briquette Production

Physiological parameters and fatigue score of Non-descript breed of bullocks of Chhattisgarh region for 2 h work - 1 h rest – 2 h work – 1 h rest – 2 h work are given in Table 2. In general, the pulse rate, respiration rate and body temperature of bullocks increased with duration of operation. In the initial session of work, these parameters increased at higher rate in stating hours. In the last session of work after rest, the increase in pulse rate, respiration rate and body temperature was lower than that of first session. During the rest, the pulse rate, respiration rate and body temperature were observed to decrease gradually.

Variation in pulse rate

The pulse rate before start of work was 42 beats/min which increases to 59 and 68 beats/min during first two hour of work. During first one hour rest the pulse rate decrease from 68 to 48 beats/min. Similarly during second and third two hour work the pulse rate get increased and gradually decreases during rest. The maximum pulse rate observed was 82 beats/min at the end of 6th hour of work.

Variation in respiration rate

The respiration rate was observed at end of each hour of work as well as end of rest and the reading was recorded. Maximum respiration rate was of 48 breath/min was observed at the end of 6th hour of work. The maximum variation of 90% from the initial value of respiration rate was observed at the end of first two hour of work.

Variation in body temperature

The body temperature of bullock lies between 37.82 and 38.78 °C during the entire work. Maximum 1.34% of variation was observed at the end of second two hour of work and temperature at start of second two hour of work.

Variation in fatigue

Maximum fatigue score was 16 points at the end of 6th hour of work which is 4 point below the fatigue limit i.e. 20 point. Fatigue score of 16 point indicate that the bullocks were not get fatigued during the entire work.

Table 2: Increase in physiological parameters of bullocks during briquette production

Duration of work (h)	Pulse rate (beats/min)		Respiration rate (breaths/min)		Rectal temp. (°C)		Fatigue score
	Observed	% increasing from initial	Observed	% increasing from initial	Observed	% increasing from initial	
Initial	42	—	20	—	37.82	—	—
1	59	40	33	65	38.09	0.70	05
2	68	62	38	90	38.20	1.00	10
1 hour rest							
Initial	48	—	24	—	38.04	—	—
3	65	35	41	71	38.41	0.97	07
4	74	54	45	88	38.55	1.34	12
1 hour rest							
Initial	55	—	27	—	38.38	—	—
5	77	40	39	44	38.63	0.65	10
6	82	49	48	78	38.78	1.04	16

Table 3: The effect of speed and duration on production Paddy husk briquette

Duration of work (h)	Speed of bullock (m/s)	Feeding rate (kg/h)	Machine output (dry wt. kg/h)	Machine efficiency (%)
1	0.89	31.00	25.50	82.26
2	0.83	29.50	26.00	88.13
		1 hour rest		
3	0.86	30.00	25.00	83.33
4	0.83	29.00	25.50	87.93
		1 hour rest		
5	0.83	29.50	24.30	82.37
6	0.80	28.00	25.50	91.07
Average	0.84	29.50	25.30	85.85

The effect of speed and duration on briquette production

The briquetting machine was powered at different speed to study its effect on production (Table 3). It is clear from the table that operating speed of bullocks and power generated from the rotary unite varies with the working hour, it effect the speed of briquetting machine. The average operating speed of the bullocks 0.84 m/s, power output 0.43 kW and speed of machine as 300 rpm were recorded during the operation. The speed of machine was affected from the speed of bullock resultant the production of briquettes also affected.

CONCLUSION

The average speed, draft force and power output of Non-descript breed of bullock of Chhattisgarh region were 0.84 m/s, 524 N and 0.43 kW respectively, to operate the animal operated low density briquette production machine. The physiological parameter of bullock during briquetting gradually increases with operating time and decreases during rest. Maximum fatigue score observed was 16 points, which was 4 point below the fatigue limit of 20 point i.e. it indicate that the bullocks were not get fatigued during the entire work.

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