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Performance Evaluation of Matching Gadgets for Camel Powered Rotary Transmission System

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Abstract: Camel is a major draught animal, which is widely used for agriculture and transportation purpose in arid and semi-arid regions of India. Still the major part of the animal power is unutilized. To enhance the utilization of draft animal power a rotary power transmission system is suitable method through which number of matching gadgets can easily be operated. A power transmission system was developed for the purpose. The system consisted of a set of crown, pinion and spur gears. The initial speed of rotation of animals was stepped up in the ratio of 1:125. A final drive shaft consisting of pulleys, fly wheel and a ratchet was provided to transmit power. The power was transmitted from gear box to this final drive shaft through an underground shaft encased in a pipe for operation of different matching gadgets. The system worked satisfactorily up to a draught of 125 kgf. Different matching machines namely maize dehusker sheller, groundnut decorticator and air compressor were operated by the power transmission system and their performance and animal's fatigue level was evaluated. The draught requirement of the selected machines was well within the draught capacity of the animals.

Key words: Draught animal power, rotary transmission system, load, matching gadgets, fatigue level, draught.

Throughout the developing countries of the world, draught animals are still vitally important part of highly appropriate and effective system of food production and transportation. Further, because of the high capital and operating cost of machines, draught animals are likely to remain essential power sources for the developing countries. Draught animal power is not only based on renewable energy sources, but is also economically and socially appropriate in the communities in which they are used.

Draught animals will continue to be used in Indian agriculture, which is a time tested renewable source of energy for sustained agriculture in the face of dwindling reserves of the non-renewable source of energy (Yadav, 2001). The draught animals supplied 14.5% of total farm power in India (Singh, 1999). Moreover draught animals being the holistic source of rural power need to be maintained, improved and used efficiently for local business developments through entrepreneurship for higher economic returns, besides cultivation operations and transport. It is estimated that liquid fuel and natural gas would exhaust by 2050 and coal by 2250 at the present rate of use. These predictions and their consequences are applicable to India as well (Sukhatme, 1997). The annual use of draught animals varies greatly. It ranges from about 300 to 1500 hours annually. The annual utilization of draught animal power could be increased by developing animal powered agro processing machines. This type of activity may increase the annual utilization of animals by 1000-1500 hours (Srivastava, 1989).

A large part of Rajasthan comes under the Thar Desert. Camel can adopt itself in the arid region and subsists on coarse kind of feed which is generally unsuitable for herbivorous animals. In India one hump camel, the Arabian form is found in Gujarat, Punjab, Western Uttar Pradesh, Haryana, but Rajasthan has maximum number of camels. Camel is the major source of power for transport in Rajasthan. Camels are used for very limited period for farm operations. During the idle period they are extensively used for transportation purpose.

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Table 1. Specification of rotary mode

Components	Specifications	Materials
Horizontal hitch beam	0.075x 0.075x 0.008 m square beam having the length of 5.4 m	MS
Vertical input shaft	Diameter 0.065 m	MS
Crown gear Pinion gear	Number of teeth are 38 and 6, respectively and having the face width of 0.060 m	Heat-treated alloy steel 300 BHN
Spur gear Spur pinion	Number of teeth are 58 and 12, respectively and having the face width of 0.040 m	Cast steel 240 BHN
Universal coupling	Diameter of pin - 0.038 m and diameter of shaft - 0.038 m	MS
Underground shaft	Diameter - 0.025 m	MS
Ratchet	Number of teeth - 18 and face width - 0.010 m	Cast steel
Fly wheel	Mass - 15 kg and Radius - 0.3 m	Cast iron

Use of camel power operating different matching machines is an appropriate approach to increase utilization and supplementing the rural energy needs. A number of power transmission units have been developed to harness animal power in rotary mode of operation. The efficiency of the developed systems was low and power losses were observed to be very high. However, a system acceptable to farmers is not yet available, which can be used for operations like chaff-cutting, flour grinding, threshing, etc. (Doshi and Tiwari, 2008). In order to mitigate the problem of power losses and improve the efficiency an attempt was made to develop a power transmission system for operating various gadgets according to the local needs.

Materials and Methods

The power transmission system was developed for 1.5 kW input power. Detailed technical specifications of the rotary transmission system are given in Table 1. The system consisted of a centrally mounted gear unit of crown, pinion and spur gears, which was driven by a camel (Fig. 1). The total step up in velocity was 147.9. The output was made available outside the circular track through underground shaft. This power can be utilized to run the machines requiring power up to 0.75 kW. The developed power transmission system consisted of a horizontal hitch beam, gear unit, universal couplings, shafts, ratchet, flywheel and pulleys. Different components of gear unit were mounted on a MS angle frame. A horizontal hitch beam made of hollow MS square section was used to transmit the animal power to the vertical input shaft of the power transmission unit. A seat was provided at the outer end of the beam for the operator and a pneumatic wheel was used to support the beam. The vertical input shaft was mounted at

Fig. 1. General view of animal powered rotary complex

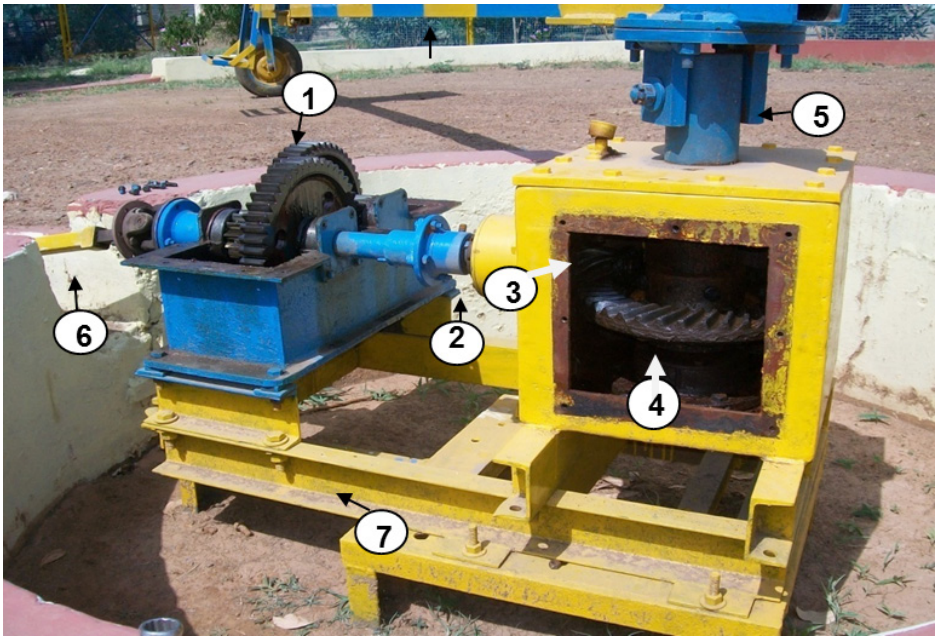

Fig. 2. Gear unit of power transmission system, 1. Spur gears, 2. Bearing housing, 3. Pinion gear, 4. Crown gear, 5. Vertical input shaft, 6. Universal coupling and telescopic shaft and 7. Frame.

the centre of the gear unit with the help of two thrust bearings encased in cast steel housings. Inner end of the hitch beam was clamped with the gear unit through a pin joint allowing the hitch beam to move vertically thus preventing the damage to the system due to vertical component of forces acting on the beam. The gear unit was installed inside a circular pit at the centre of the circular test track. The gear unit was designed to step up the RPM and change the direction of motion. It consists of a set of crown and pinion gear and two sets of spur and pinion gears (Fig. 2). A crown gear fixed with vertical input shaft meshed with pinion mounted on a shaft enclosed in housing with two ball bearings provided at both the ends. A spur gear was fixed at the other end of the pinion shaft meshing with a spur pinion mounted on a counter shaft supported by two pedestal bearings. At the other end of the counter shaft a similar spur gear was mounted, which in turn meshed with another spur pinion. This set of crown and pinion gear and two sets of the spur and pinion gears stepped up the average rotational speed of 2-3 rpm of draught animals in the range of 250 to 375 rpm at the power out put shaft.

The output shaft of the second stage spur pinion was connected with the help of two universal couplings, flanges and mild steel shaft to an underground shaft. The universal

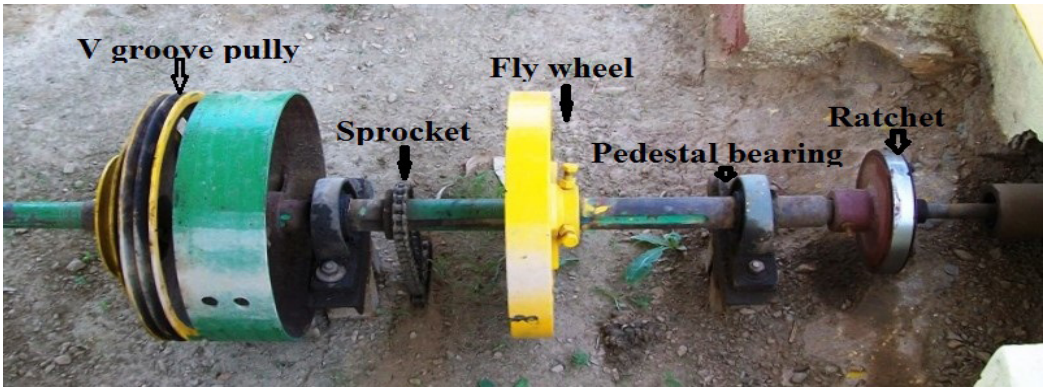

Fig. 3. Output end of the power transmission system.

Fig. 4. Hitching arrangement for camel.

couplings easily transmitted power at an angle between the output shaft and underground shaft. To avoid the hindrance in the path of animals an underground shaft encased in a hollow pipe was laid under the test track at depth of 300 mm. The extreme outer end of the underground shaft and final out put shaft were connected through a pawl and ratchet (Fig. 3). It allowed power to be transmitted in one direction only preventing the backward flow of power avoiding hammering on the legs of animals when they stop or slow down. A flywheel was mounted on final output shaft to maintain inertia and conserve energy. Different sizes of pulleys were mounted on the power output shaft to operate matching machines.

Two beams similar to the hitching arrangement of camel cart were used to hitch the camel with the horizontal hitch beam. Bushes made of hollow pipe were provided at the ends of the pull beams. A swingle tree made of hollow pipe was inserted in these bushes for providing movement in vertical plane. Further, this swingle tree was attached with horizontal hitch beam through a turntable arrangement to facilitate swinging movement of the pull beams in horizontal plane (Fig. 4). This beam was attached with turntable through a pin joint for allowing movement in vertical plane while movement in horizontal plane was maintained by turntable as in case of camels. The movement in both the planes was provided to avoid the effect of unwanted forces acting on the vertical input shaft.

Railings made of slotted channels were grouted for installation of different matching

Fig. 5. Testing of maize dehusker sheller in rotary transmission system.

Fig. 6. Testing of groundnut decorticator in rotary transmission system.

Fig. 7. Testing of air compressor in rotary transmission system.

Fig. 8. Loading car for imparting load.

gadgets with proper alignment. The railings were provided for the easy movement of agro processing machines in both parallel and perpendicular directions to power output shaft.

On the basis of local needs, three matching machines i.e. maize dehusker sheller, groundnut decorticator and air compressor were selected for exploring their suitability with the developed power transmission system.

Fig. 9. Measurement of operating and physiological parameters of camel; (a) Measurement of draught, (b) Measurement of respiration rate, (c) Measurement of pulse rate and (d) Measurement of body temperature.

These machines were modified according to the power produced by a camel and their performance was evaluated (Figs. 5, 6 and 7). A load cell was attached between horizontal pull beam and animal hitching system to measure the actual load on the power transmission system for operating each matching gadgets.

An animal loading car developed by Central Institute of Agricultural Engineering, Bhopal (India), was attached with the help of chain sprocket (Fig. 8) to the output shaft of the rotary transmission system. The load was fixed according to the draught requirement of the gadgets and camel was allowed to operate in the continuous working condition.

Camel's physical and physiological parameters were recorded for evaluating the fatigue level of the animal for operating these selected gadgets. A fatigue score card suggested by Bhatt *et al.* (2002) was used to indicate

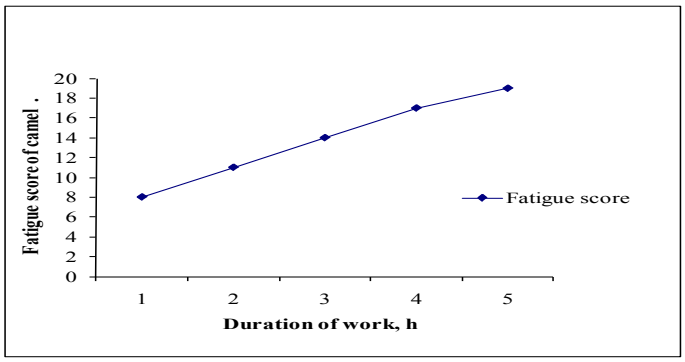

Fig. 10. Variation in fatigue score of camel at simulated load with duration of work.

Table 2. Performance of maize sheller dehusker in rotary mode of operation

Operating rpm	Dehusking efficiency %	Shelling efficiency %	Broken grain %	Cleaning efficiency	Output (kg h^{-1})	Draught (kgf)
400	94.7	95.5	5.12	96.1	165	55-60

comparative stage of fatigue of camel. The score card was based on total seven parameters on four point scale. The total fatigue score would be 28 from this score card. However, for deciding the fatigue score limit 21 point score had been considered as a safer limit for working of camels at different draught levels. Further this score card had been divided in four zones i.e. less tired, tired, more tired and excessive tired with their respective fatigue score of 0-7, 7-14, 14-21 and 21-28.

For all the experiments data from three replications were recorded and average value of different parameters are discussed.

minutes were required to compress air upto the compression limit of 8.45 kg cm^{-2} (Table 4).

When the air compressor was operated with the rotary mode the load was increased with the increasing air pressure, but within very short period of time the air pressure reached to the highest level. No fatigue symptoms were observed as only 12 minutes was required to compress the air upto its limit. CIAE loading car was used to apply load on the camel and the different physical and physiological parameters of camel for continuous working were observed at equivalent draught of maize dehusker sheller and groundnut decorticator

Table 3. Performance of groundnut decorticator in rotary mode of operation.

Operating rpm	Decortication efficiency %	Broken grain ratio	Output (kg h^{-1})	Draught (kgf)
300	97.72	0.038	204.73	55

Results and Discussion

A camel Bikaneri breed in the age group of 9-10 years was used for the experiments. The weight of camel was 550 kg. During the test, camel was hitched at a working radius of 3.5 m. The results of feasibility trials showed that selected matching gadgets requiring less than 0.75 kW could easily be operated by the power transmission unit.

The draught requirement to operate the maize dehusker sheller in the rotary mode of operation was in the range of 55 kgf to 60 kgf. Performance of the maize sheller dehusker in rotary transmission system was satisfactory (Table 2). For operating groundnut decorticator in the rotary transmission system 55 kgf of average draft was imposed on the camel. The performance of the groundnut decorticator was much higher than the manual operation (Table 3). Draft requirement to operate the air compressor increased with the operating time due to increase in air pressure in the air storage tank. In rotary transmission system only 12 (Fig. 9). Both the machines required same range of draught of 55 to 60 kgf, which is about 10 to 10.9% of draught with respect to camel's body weight. The loading car was set for the draught of 11% of camel's body weight for rotary mode of operation. Then the physical and physiological parameters were taken (Table 5). By using fatigue score card for camel the fatigue score was determined for different interval (Fig. 10). The physical behavior and the fatigue score indicate that for this load camel could be made to work continuously for 5 hours. Fatigue score was calculated by using the fatigue score card, developed by Bhatt *et al*. (2002). Physical parameters of camel were also observed at every hourly interval. After first hour of work the fatigue score of camel was 8 and it was increased to 19 after fifth hour of work in the rotary mode with simulation load of 11% of body weight. First three hours of working of camel in the rotary mode with simulating load came in the category of 'tired' and fourth and fifth hour of working of camel came in the category of 'more tired'.

Table 4. Performance of air compressor in rotary mode of operation.

Operating rpm	Average pressure rise (kg cm^{-2} per min)	Time required (s)	Highest draught (kgf)
300	0.6846	720	90

Table 5. Physiological behavior and fatigue score of camel at simulating load of 11% of body weight

Time (h)	Respiration rate, breaths min^{-1}	Pulse rate, beats min^{-1}	Body temperature ^oC	Speed km s^{-1}	Fatigue score
0	6	38	37.4	0	0
1	10	43	38	2.56	8
2	11	44	38.2	2.35	11
3	12	45	38.4	2.26	14
4	13	48	38.7	2.15	17
5	13	49	39	2.1	19

Conclusions

The developed power transmission system is suitable to operate at load of 125 kgf. The draught camel can work comfortably with the developed matching gadgets. Maize dehusker sheller and groundnut decorticator can be operated continuously for 5 hours in the rotary transmission system for sustained working of camel. The idle period of camel can be efficiently utilised and annual use can be increased by operating various matching gadgets using the developed power transmission system. Considerable amount of conventional energy can be saved with the use of developed system. It will also help in generating self-employment to rural people and improving their socio economic status.

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