

Experimental Study on Hybrid Power Combining Animal Energy and Human Energy for Minor Irrigation System

Sharad Kumar Chandrakar¹, Manish Kumar Dudey^{2,3}, Amit Kmar Soni³,
Gaurav Kumar Pal⁴, 5Hari Ram Chandrakar⁵ and Pukhraj Kumar Sahu⁶

^{1,2,3,4,5,6}SSGI Bhilail

E-mail: ¹shrd15@gmail.com, ²mdubey@gmail.com, ³amit135@gmail.com,
⁴gkpal145@gmail.com, ⁵786hr@gmail.com, ⁶pksahu@gmail.com

Abstract: In this paper a hybrid power system combining animal power and human power is experimentally studied to supply continuous power for minor irrigation. The animal power is used as main energy source while the human power system is used as secondary or back-up energy source. This invention provides animal powered and human powered mechanical device for prime mover to electric generator. Human and animal energy in form of high-torque low-speed can be converted into low-torque high-speed through speed increaser to energize the electric generator. The results show that even when the animal power is not available; the system is reliable and available and it can supply high-quality power to the water pump by the human power system.

Keywords: Hybrid system, animal power, human power, speed increaser, minor irrigation.

1. INTRODUCTION

In developing countries like India who depend on agriculture need continuing power supply for different processes like crop dryer, harvesting, paddy dryer, food storage, hot water for germination, suction of wet air, irrigation etc. For irrigation farmers use natural sources such as pond water and dam water through canal but from the well water is used either means of diesel-pump set or means of electric pump set. At the remote areas availability of grid power is very costly and very difficult, but it is necessary of power supply. To achieve this goal consists of using renewable energy sources, not only for large-scale energy production, but also for stand-alone systems. Renewable energy technologies are known to be less competitive than traditional electric energy conversion systems, mainly because of their intermittency and the relatively high maintenance cost. However, renewable energy sources have several advantages, such as the reduction in dependence on fossil fuel resources and the reduction in carbon emissions to the atmosphere. There are many renewable power sources like solar power, wind power,

hydropower, bio-energy, geo-thermal power, tidal energy etc, but all have their limitations.[1- 3].

In this paper authors introducing the animal power and human power as hybrid energy system. The force exerted by a working animal is approximately equal to 10-12% of its live weight, and this means for example, that a buffalo has a power output of about 300 W, or 5.4 MJ/d, if it is assumed that the animal works for 5 h per day. And Peak power output for a fit and healthy adult is about 900W but this can only be sustained for a few seconds. Putting this power output in some context, activities such as hoeing and tree felling require 300-500 W and 600W of gross power respectively [4-6].

The methodology of human power system and animal power system is very simple. The device called belan pulled by human or animal comprises of a mechanical link means provided with an extended pipe to transmit animal power in form of high-torque low-speed to a speed increaser; a speed increaser provided with an input shaft mounted with 68 teeth gear and an output shaft mounted with 15 teeth gear for converting human power received from a mechanical link in the form of a high-torque low-speed to low-torque high-speed in four stages; a belt and pulley system which is connected to the output shaft of the speed increaser for transmitting mechanical energy in form of low -torque high- speed received from the speed increaser to generator; generator to convert mechanical energy into electrical energy; and a storage system

2. EXPERIMENTAL DETAILS OF HYBRID POWER SYSTEM

(i) **Minor irrigation system:** The 0.5 hp/0.37 kwatt centrifugal water pump of RC Energy metering (P) Ltd is used for experiment. The specification of water pump is shown in table.

Drive	0.5HP/0.37KWatt
Voltage (V)	220 \pm 5%
Frequency (Hz)	50
Suction head (meter)	8 MTRS
Discharge head (meter)	27 MTRS
Discharge (L/min)	33 LPM

(ii) **Animal power:** The authors' main object is to use the animal power for generating electricity for domestic and agriculture use. And bullocks are mainly used in Indian agriculture for different purposes. For this experimental study authors use the pair of bullocks. The weights of bullocks are 456 kg and 478 kg. The mechanical link is fitted with a device pulled by pair of bullocks called bellan which is made of wood and has the weight of 105 kg.

(iii) **Human power:** The group of two person of 56 kg and 61 kg of age 22 year were worked as a energy source. The human pulled the wooden device called belan (dhouri) of 105 kg

(II) **Speed Increaser:** Speed increaser is a four set of spur gears housed in a frame of mild steel angles having 690 mm \times 690 mm at the top and 780 mm \times 780 mm at bottom. It is having 4 numbers of stages with gear ratio of 1:4.5. Input shaft of the speed increaser having 50 mm diameter and 600 mm length of mild steel material is in vertical position whereas output shaft having 50 mm diameter and 450 mm length of mild steel material of the same is also in vertical position. The shafts are supported with taper roller bearings at top and bottom.

(ix) **Gears:** Four sets of spur gears transmits the power among parallel shafts. The spur gears are made of cast iron having module 5 mm. the spur gears has 68 teeth while the spur pinions has 15 teeth. The pressure angle is 20 degree and outside diameters are 350mm and 85mm respectively. The speed ratio of 1:4.5 is obtained in single stage.

(III) **Belt and Pulley transmission unit:** The final speed increasing is done by using belt and pulley system. One pulley of 228.6mm (9 inch) was mounted on the output shaft of the speed riser and counter pulley was mounted on car alternator having 76.2mm(3 inch) thereby stepping up the speed in the ratio 1:3 when connected with belt. According to Indian Standard Code (IS: 2494-1974), the A type of belt is selected which has power ranges 0.7kW – 3.5 KW.

(IV) **Generator:** In this experimental study authors select the car alternator to generate electricity. Lucas-TVS car alternator of 12V and 95 AH is used. Car alternator needs high rpm to work efficiently. It produces constant voltage but current depends on rpm and produce high as rpm is high. The direction in which the alternator is oriented to spin does not affect its output power. The alternators rotor can be rotated either clockwise or counter clockwise and achieve the same output values. Once the pulley belt is connected between the

output gear shaft and alternator head the alternator must be wired to output DC power.

(V) **Storage system:** In this experiment a typical 12V, 150AH Lead-acid automotive battery is used. An automotive battery is a type of rechargeable battery that supplies electric energy to an automobile. Charging time depends on the capacity of that battery and the resting voltage of that battery when you begin to charge it.



Fig. 1: Integrated Belan, Speed Increaser, belt&pulley, alternator and battery.

3. FABRICATION AND PROCEDURE

The fabrication of speed increaser was done very carefully because there are five vertical shafts which are supported by taper roller bearing. The bearing covers were fitted with the help of nut and bolt on the mild steel ties, which are welded on the frame at top and bottom. Collars are provided at bottoms of shaft to support the load on bearings. Gears are fitted by means of nuts by drilling two holes on the shafts and on gear houses. There are four step gear transmission system. The first gear of 68 teeth was mounted on first shaft at 20mm from the color which meshes with the second gear having 15 teeth mounted on second shaft at 20mm above from the collar. The third having 68 teeth was mounted on second shaft 50mm above the second gear and meshes with the fourth gear having 15 teeth which was mounted on third shaft at the same height. The fifth gear having 68 teeth was monthed on third shaft 50mm above the fourth gear and meshes with the sixth gear having 15 teeth which was mounted on the fourth shaft at the same height. The seventh gear having 68 teeth was mounted on fourth shaft 50mm above the sixth gear and meshes with the eighth gear having 15 teeth which was mounted on fifth shaft at same height. The pulley of 228.6mm was mounted on fifth shaft at 200mm from the bottom which drive the another pulley of 76.2mm mounted on alternator and alternator was fabricated on the frame with the help of mechanical linkage.

Authors select the car alternator for generating electricity which has the ideal speed of 2000rpm – 6000rpm but effetely work at 3500 rpm. And animal and human have very low speed ($v = 1\text{m/s}$) [4]. If bullock rotates at radial distance (r) of

2.5 m from the main shaft (first gear) then the distance at one revolution is $15.7 \text{ m } (2\pi \times 2.5)$. And the distance cover in one minute by bullock is $1 \times 60 = 60 \text{ m}$. Hence the initial rpm is $3.82(60/15.7)$. Due to compactibility and resources available author select the gears used in sugarcane juice machine of speed ratio 4.5. Four stage gear system is used. Output rpm is increased by using pulley and belt which has speed ratio 3. So the speed of output gear according to S S Ratan[8].

$$\frac{N_8}{N_1} = \frac{Z_1}{Z_2} \times \frac{Z_3}{Z_4} \times \frac{Z_5}{Z_6} \times \frac{Z_7}{Z_8} \quad (1).$$

$$(N_f)_g = 3.82 \times 4.5 \times 4.5 \times 4.5 \times 4.5 \times 4.5 \approx 1567 \text{ rpm.}$$

Before starting the experiment the alternator was connected with battery and ampere meter was jointed in series. The mechanical link GI pipe was fitted with the first shaft of speed increaser by means of elbo and nut-bolt at one end and another end was coupled on belan with the help of GI wire such that the center of belan coincide at 2500mm of mechanical link. The speed increaser was fixed in the pit of $780\text{mm} \times 780\text{mm} \times 300\text{mm}$. The bullock pair was harnessed with traditional means. The shepherded applied the force the bullocks started moving into the circular path and also the belan along with mechanical link rotate the first shaft of the speed increaser. At the starting the rpm was very low hence the alternator was not responding but as well as speed was increasing the alternator start to generating power. Bullocks were need to applied force time to time to maintain average speed. The rpm and generated volt & current were taken after every four minutes. The batteries were 50% charged and it took approximate 2 hours to charge fully (multimeter indicate 12.6V). In first two experiments the automotive battery of 12V 150AH was charged with animal power system and the 0.5 hp water pump run using inverter of 1000VA. The suction head was 4.7 meter and it took 28 second to deliver 15 litter water. Next two experiment the battery was charged with human power system and water pump run using same inverter.



Fig. 2: Mechanical device for generating power using animal power.

This time it took 26 second to deliver 15 litter water. Finally charged batteries by human power and animal power were connected to inverter in parallely and 0.5 hp water pump run very efficiently and deliver water continuously for long time and up to 75% discharge.



Fig. 3: Human powered mechanical device for generating power.

4. RESULTS AND DISCUSSION

The humans' and animals' effort and speed depend on the load subjected. Animal and human speed are change very quickly and abruptly. It is very difficult to taking speed reading continuously because animals get puzzled. The readings are taken after every four minutes within one hour. Speed vs. Current shows that at low rpm at starting of animal motion it is not generating current by both alternator, but as well as rpm is increasing and reaches to ideal working rang alternators producing high value of currents. Experimental result shows that animals take very little time to get their average speed of 1 m/s. Alternator generates constant voltage of 12V as specified after reaching ideal speed. Fully charged battery shows 12.6V.

When 0.5 hp water pump run with automotive battery through inverter it delivers 15 litters in 28 second and worked for 4 hours and 15 minute. So that it delivered 4000 litter of water upto 75% discharge. Finally charged batteries (two with human power and two with animal power) were connected to the inverter two batteries are connected in series after than connected in parallel] and 0.5 hp water pump run very efficiently and delivered water continuously for long time up to 75% discharge. Combine system takes 26 second (average) to deliver 15 litter and worked for 9 hours and 06 minute and delivered 19000 litters of water. Hence human power and animal power are good combination for minor irrigation system.



Fig. 4: The water pump powered by hybrid system to deliver water from the shallow well.

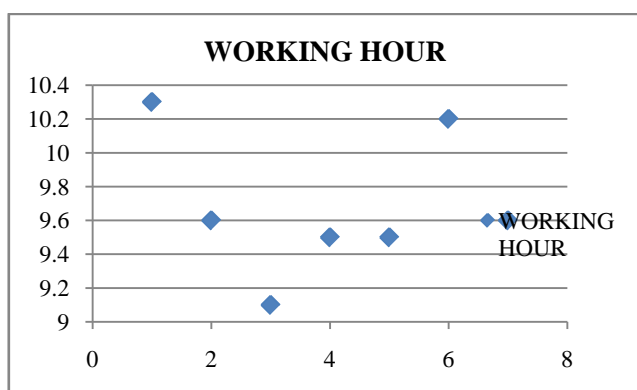


Fig. 5: Water deliver time of the 0.5 hp water pump from shallow well.

5. CONCLUSIONS

The present work provides a system and method for producing electricity for minor irrigation system using the muscles power of animal and human by means of a mechanical device. The project goal was to combining the solar power, human power and animal power for minor irrigation which can also work when even sun is not available. This goal had to be met within the constraints of a low production cost and high safety. The project has to offer a durable product with relatively good

efficiency and emission free system at low cost. This is also concluded that animals and humans are the great energy source for generating power for farmers for minor irrigation even having low speed.

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REFERENCES

- [1] Fuller R. J., Aye LU, 2012, "Human and animal power – The forgotten renewables" *Renewable Energy* 48 (2012) 326-332.
- [2] Draught animals. From (<http://www2.sjsu.edu/faculty/watkins/animalpower.htm>) Metric conversion by Tim Lovett.
- [3] Nagendra Pathak, Pushpito Kumar Ghosh, Sohan Lal Daga, Virendra J ayantilal Shah, Sanat Natubhai Patel "Animal powered mechanical device for water destination" US 7,387,728 B2. July 17, 2008.
- [4] Maximo Gomez-Nacer, "Animal powered electricity generator" Patent no-US 2005/0161289 A1, July 28, 2005.
- [5] Udayasankar Devanaboyina, "System for driving an animal powered vehicle" Pub. No: US 2011/0308868 A1, Des 22, 2011.
- [6] FAO. Draught animal power – an overview. UN Food and Agriculture Organisation; 2010.
- [7] Wilson RT. The environmental ecology of oxen used for draught ower. *Agriculture, ecosystems and environment* 2003;97:211-37.
- [8] FAOSTAT. Production; live animals. Available from <http://faostat.fao.org/>;2011 [accessed 13.12.11].
- [9] Pearson A. Animal power: matching beast and burden. *Appropriate Technology* 1991 ; 18 (3): 11-4.
- [10] Bhandari, V. B., 1994, "Design of Machine Elements," Tata McGraw-Hill.
- [11] Ratan S S., "Theory of Machines," Tata McGraw-Hill.