Study and Analysis of Animal and Human Muscle Power for Electricity Generation

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***Abstract*— The main objective of this paper to utilize the muscle power of human and animal for powered battery charging system. It consists of a mechanical gear reduction device driving an alternator and operates at variable speed. The alternator is connected to a battery bank via rectifier. The characteristic of the system depends on the gear reduction system, the car alternator, and the system configuration. The electricity generation by animal and human power is a novel technology. The electricity generated is stored in the batteries of different capacity and used for lighting, cooking and minor irrigation. This equipment needs less maintenance. Also this equipment is emission free, low cost and has long life.**

Keywords- Animal power, human power, speed increaser, lead acid battery.

I. INTRODUCTION

The technologies of renewable energy are known to be less competitive than conventional electric energy conversion systems, mainly because of their intermittency and the relatively high maintenance cost. The several advantages renewable energy sources such as the reduction in dependence on fossil fuel resources and the reduction in carbon emissions to the atmosphere. Renewable energies avoid the safety problems derived from power of atomic. It has become more desirable to adopt renewable energy power plants.

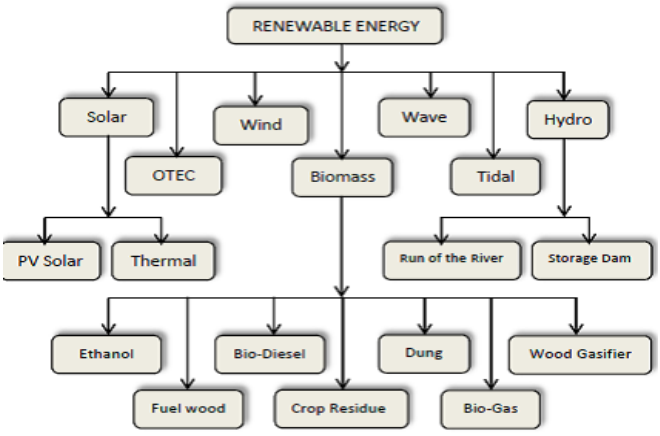

Figure 1: Renewable energy sources

The introducing of animal and human muscle power for the system as new power sources. We know the draught animal's power has been the main source of farm areas for farmers. It growth in power operated machinery and increased mechanization, there has been the population of draught animal decrease but still animal power plays an important role to perform various agricultural operations. Table 1 shows the sustainable power of individual animals in good condition [4].

Table 1: Sustainable power of individual animals in good condition

Animal	Typical weight kN (kgf)	Pull-weight ratio	Typical pull N (kgf)	Typical working speed m/s	Power output W	Working hours per day	Energy output/ day MJ
Ox (Bullock)	4.5 (450)	0.11	500 (50)	0.9	450	6	10
Buffalo	5.5(50)	0.12	650 (65)	0.8	520	5	9.5
Horse	4.0 (400)	0.13	500 (50)	1.0	500	10	18
Donkey	1.5 (150)	0.13	200 (20)	1.0	200	4	3
Mule	3.0 (300)	0.13	400 (40)	1.0	400	6	8.5
Camel	5.0 (500)	0.13	650 (65)	1.0	650	6	14

II. EXPERIMENTAL SETUP DETAILS

The experimental setup block diagram as shown in fig. 2.In this setup firstly the animal and human power connected to wooden belan to transmit the muscle power to gear reduction through mechanical link. The gear reduction drives by muscle power and its increases the speed of system and to produce mechanical energy. The production of mechanical energy converts into electrical energy with the help of alternator and its store in storage system.

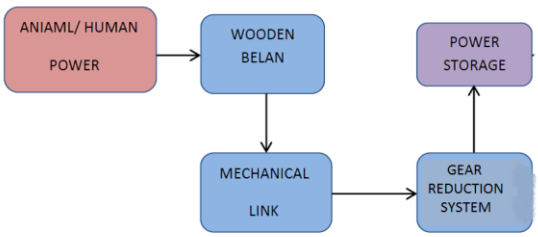

Figure 2: Block diagram of the battery charging system and produce electricity system

A. Human Muscle Power

The human power use to drive the mechanical device. In this device converts the human power into mechanical power. The two person of 65 kg and 70 kg of age 27 year were worked as a human energy source.

Figure 3: Human muscle power operating to gear reduction system

B. Animal Muscle Power

The main object is to use the animal power for generating electricity for agriculture and domestic use. In Indian agriculture the bullocks are mainly used for different purposes. The pair of bullocks used in this experimental study. The bullock's weight is 460-480 kg.

C. Stand of Gear Ssystem

The gear stand for holding the all gear system in proper way. The gear stand made of mild steel angles having 690 mm × 690 mm at the top and 780 mm × 780 mm at bottom. In this system having a four set of spur gears housed in a stand. It is having 4 numbers of stages with gear ratio of 1:4.5. Input shaft of the gear system having 50 mm diameter and 610 mm length of mild steel material is in vertical position whereas output shaft having 50 mm diameter and 460 mm length of mild steel material of the same is also in vertical position. The vertical shafts are supported with taper roller bearings at top and bottom of the stand.

D. Power transmission unit of Belt and Pulley and Mechanical link

The power transmission unit of belt, pulley and mechanical link is installed in gear system stand. Here the mechanical link is used as input side transmission and belt-pulley is used as output side of the system. Mechanical link of mild steel material having 52 mm diameter and 230 mm length with extended extra strong GI pipe of 3000 mm length and 4.5 mm wall thickness. The pulley of diameter is 228.6mm (9 inch) was mounted on the output shaft of the gear system and counter pulley is mounted on car alternator having diameter of pulley is 76.2mm (3 inch). There by 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.

E. Generator and Storage system

The car alternator selected as a generator 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.

In this experiment a typical 12V 40Ah, Lead-acid automotive battery is used. This automotive battery is used as power storage of electricity. It shows 12.6 volt at full charge and at fully discharged: 11.6V. Charging time depends on the capacity of that battery and the resting voltage of that battery when you begin to charge it.

Figure 4: Lead acid battery and voltage testing by Voltmeter

F. Gear setup and design

The gear setup and design is backbone part of the whole system. Four sets of spur gears transmit the power among parallel shafts to each other and perpendicular to stand. The spur gears are made of cast iron (S_{ut} = 320 N/mm^2) 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 85 mm respectively. The speed ratio of 1:4.5 is obtained in single stage. The spur gear addendum is 1 module and dedendum = 1.157.

Calculation of some parameter of spur gear:

Tooth thickness (t) =1.571 * module = 1.571*5 = 7.855mm

Face width (b) = 5.4 * module = b = 5.4*5 = 27mm

Whole depth = 2.25 * module

Fillet radius = 3.9 * module

Gear teeth denoted as 'z'

Pitch circle diameter = z*m = 68*5 = 340mm and 15*5 = 75mm

Outside diameter = (z+2)*m = 350mm and 85mm

Calculation of strength for spur gear:

Using Lewis equation-

Tangential load F = σb*y*Pc*b

Where, 'σ_b' is the allowable stress,

'y' is Lewis form factor = 0.1034

'Pc' (Circular pitch) = π* module

'b' is the face width of the gears,

'd' is the pitch circle diameter of the gear

The calculating force on gear, F = 2*500 = 1000N

The value of F putting in Lewis equation

1000 = σ_b*0.1034*(π*5)*27

σ_b= 22.81N/mm^2

σ_{all} of Cast iron (high grade) = σ_{ut}/3

= 320/3 = 106.67 N/mm^2 = 22.8 N/mm^2

III. METHODOLOGY OF THE SYSTEM

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 this electrical energy stored in storage system.

Figure 5: Gear system operating through the Bullock

The car alternator for generating electricity which has the ideal speed of 1800 rpm – 5000 rpm but effetely work at 3500 rpm. And animal and human have very low speed (v = 1.2 m/s). 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 m (2× π× 2.5). And the distance cover in one minute by bullock is 1.2×60=72 m. Hence the initial rpm is 4.58(72/15.7). Due to compatibility 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 that the rpm of output gear [6].

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

$(N_f)_g = 4.58*4.5*4.5*4.5*4.5 \approx 1878$ rpm.

Before staring 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 elbow and nut-bolt at one end and another end was coupled on belan with the help of GI wire such that the centre of belan coincide at 2500mm of mechanical link. The speed increaser was fixed in the pit of 780mm×780mm×300mm. 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. In this experiment seven automotive battery of 12V 150AH were charged with animal power system and seven automotive battery of 12V 180AH were charged with animal power system. Also two of 40AH, 100AH were charged by animal and human power. The batteries were charged from different states of charge i.e. 25%, 50%, 60%, 65%, 70%, 75% and 80%.

IV. RESULT AND DISCUSSION

In this experimental study the humans' and animals' effort and speed depend on the load subjected. Animal and human speed changes very quickly and abruptly. So it is very difficult to taking speed reading continuously. After experiment every four minutes within one hour the readings taken. The fig. 6 shows the graph of state of charge vs. time to fully Charge in hour. In this graph x co-ordinate denotes the hour and y co-ordinate charging percentages. In this graph clearly shown if battery discharges at 50% then time taken for charging is 3 hours. Similarly 70% discharges time taken for charging is 1.5 hours. In fig. 2 shows the graph between times (in minutes) vs. RPM of the car alternator. In this graph x co-ordinate denotes the speed of car alternator and y co-ordinate time of the car alternator speed varying. In this graph clearly shown the car alternator speed has small variation according to time increases; in here it's around 4500 rpm speed of alternator. After charging battery was used for home lighting, minor irrigation and cooking food through inverter.

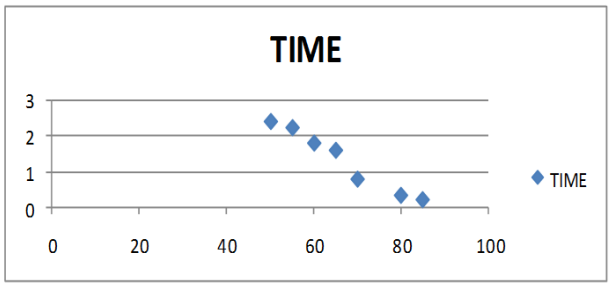

Figure 6: Battery charging % vs. Time(hour) to fully Charge in hour

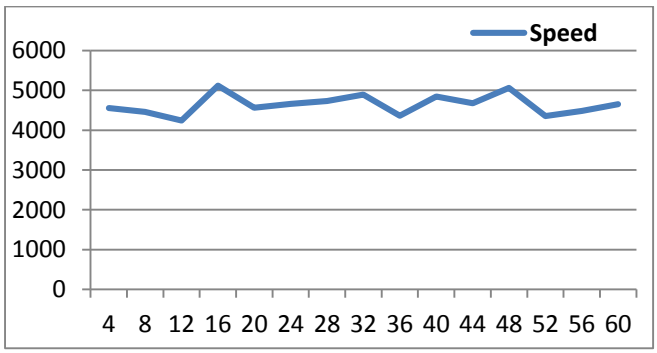

Figure 7: Time (in minutes) vs. RPM of alternator

V. CONCLUSION

In this experimental study utilize animal and human energy source for generating electricity with proper way. The project goal was to design, fabricate and cost estimation of

mechanical device to charge a battery array with a 12V DC output. The present work provides a mechanical device for micro industry for producing electricity for battery charging using the biological energy of the muscles of animal and human. This goal had to be met within the constraints of a low production cost and high safety. This is also concluded that fabricated mechanical device is itself a cottage industry for charging batteries at rural and isolated areas. This system is very effective for villager and rural areas there is absences of electricity.

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