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"Fabrication and Experimental Study of an Animal Powered Mechanical Device with Horizontal Output for Electricity Generation"

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Abstract—*In this paper authors fabricate and experimentally studied a mechanical device with horizontal output which convert high-torque low speed into low-torque high speed to covert muscle energy into electrical energy. That device named as speed increaser. It has unique features of using animal power as prime mover for electric generator. Muscle 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 electricity generated is stored in the batteries of different capacity and used when required. This equipment is emission free, low cost and has long life. Also this equipment needs less maintenance and any person can run either skilled or unskilled.*

Keywords*: Muscle energy, speed increaser, electric generation, dc battery.*

1. INTRODUCTION

Over 1.5 billion people rely on kerosene for light. Lack of suitable home lighting is directly linked to illiteracy, poverty and health problems. The current widespread burning of kerosene also results in environmental pollution. It is very difficult and very costly to available grid power everywhere specially at remote isolated communities in developing countries. Although from beginning of mankind animals have been using for domestic works at rural and remote areas, but the electricity generation by muscle power is a novel technology [1-9].

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 [1-9].

The device called speed increaser comprises of a mechanical link means provided with an extended pipe to transmit muscle 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 18 teeth gear for converting muscle power received from a mechanical link in the form of a high-torque low-speed to low-torque high-speed in three stages; in fourth stage there is bevel gear set which convert vertical motion into horizontal motion; 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. The prime mover is preferably at least one draught animal.

2. FABFRICATION DETAILS

(I) Muscle Power: The authors' main object is to use the muscle power for generating electricity for domestic and agriculture use. The weights of bullocks are 466 kg and 488 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.

(II) Gears: Speed increaser is a three set of spur gears housed in a frame of mild steel angles having 690 mm × 690 mm at the top and 780 mm × 780 mm at bottom. It is having 3 numbers of stages with gear ratio of 1:3.78. 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 in fourth stage there is one set of bevel gears having teeth 64 and 8. The shafts are supported with taper roller bearings at top and bottom. Bearings are fastened on tie-bars which are welded on frame.

(III) Belt and Pulley transmission unit: The final speed increasing is done by using belt and pulley system. One pulley of 9 inch was mounted on the output shaft of the speed riser and counter pulley was mounted on car alternator having 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.

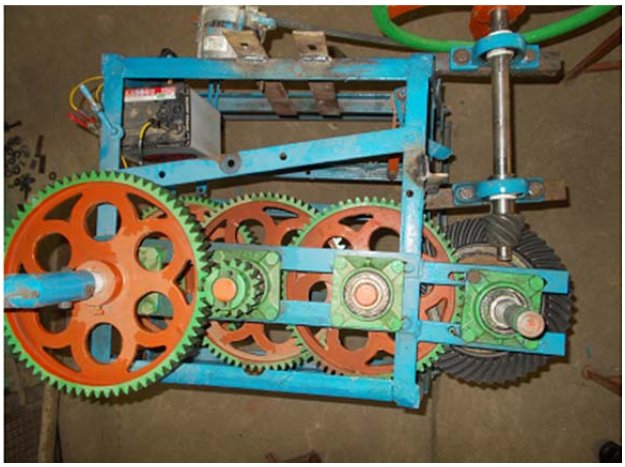

Fig. 1: Complete system of Speed Increaser.

(IV) Generator: In this experimental study authors select the car alternator to generate electricity. Lucas-TVS car alternator of 12V and 40 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.

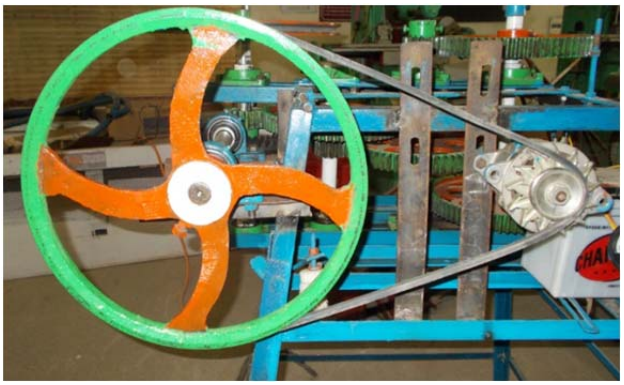

Fig. 2: Belt and pulley unit of speed increaser.

(V) Storage system: In this experiment a typical 12V, 40AH 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.

3. FABRICATION AND PROCEDURE

In The fabrication of speed increaser was done very carefully because there are four 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 20 mm from the color which meshes with the second gear having 18 teeth mounted on second shaft at 20 mm above from the collar. The third having 68 teeth was mounted on second shaft 50 mm above the second gear and meshes with the fourth gear having 18 teeth which was mounted on third shaft at the same height. The fifth gear having 68 teeth was mouthed on third shaft 50 mm above the fourth gear and meshes with the sixth gear having 18 teeth which was mounted on the fourth shaft at the same height. The seventh gear is a bevel gear having 64 teeth was mounted on fourth shaft 50 mm above the sixth gear and meshes with the eighth gear having 8 teeth which was mounted on fifth shaft horizontally. The pulley of 18 inch was mounted on fifth which drive the pulley of 3 inch mounted on alternator and alternator was fabricated on the frame with the help of nut and b**olt**.

Authors select the car alternator for generating electricity which works on speed of 1000 rpm. And animal have very low speed (v = 1m/s) [1-9]. 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 1×60=60 m. Hence the initial rpm is 3.82(60/15.7). 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 according to S S Ratan [11].

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

$(N_f)_g = 3.82*3.78*3.78*3.78*8 \approx 1771$ 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 center of belan coincide at 2500 mm of mechanical link. The speed increaser was fixed into the pit of 780mm×780mm×300mm. The bullock pair was harnessed with traditional means. When shephered applied 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. First time the battery was 50% discharge i.e. 12V 40AH. The experiment had done 9 times using same bullocks and animal had taken care regularly.

Fig. 3: Mechanical device for generating electric power using animal power.

4. RESULTS AND DISCUSSION

The animals' effort and speed depend on the load subjected and force applied by shepherd. Animal speed is change very quickly and abruptly. It is very difficult to taking speed reading continuously because animals got puzzled. The readings are taken after every four minutes within one hour and results are shown in graphs. Speed vs. Time graph shows that average speed of alternator is mostly changes, but it is within the ideal working range of alternator. Speed vs. Current shows that at low rpm at starting of animal motion it is not generating current, but as well as rpm is increasing and reaches to ideal working rang alternator producing high value of current. Experimental result shows that animals take very little time to get their average speed of 0.8 m/s to 1 m/s. But still alternator is not generating current as expected and specified by company due to very quick and abrupt changes in animal speed. Voltage vs. RPM proves to be completely unchanging as expected and alternator generates constant voltage of 12V as specified after reaching ideal speed. Finally result was found that at least 4 hrs (6pm – 10pm) the home will be lighted using that system.

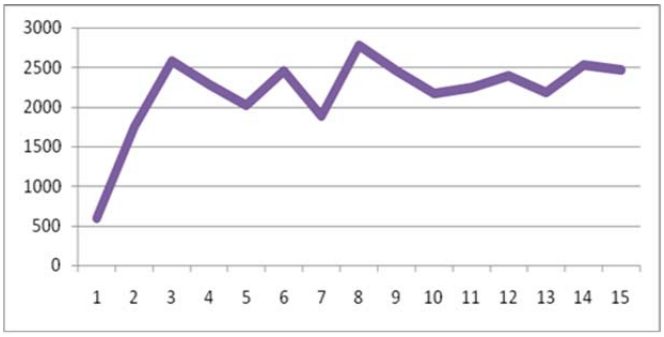

Fig. 4: Time (in minutes) vs. RPM of alternator.

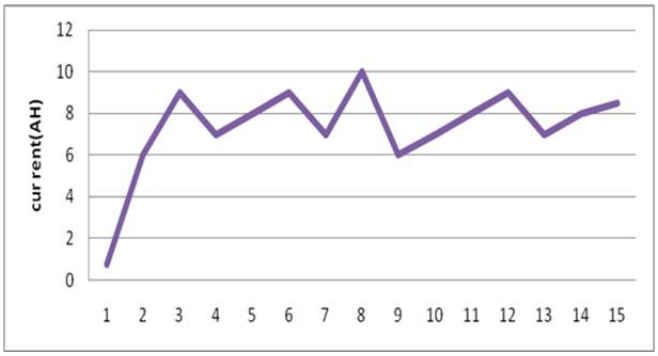

Fig. 5: Alternator RPM vs. Current in Amp.(DC)

5. CONCLUSIONS

The present work provides a mechanical device for producing electricity for home lighting using the biological energy of the muscles of animals. The project goal was to fabricate and experimentally studied of mechanical device to charge a battery array with a 12 volt DC output for 1.5 billion people who rely on kerosene for light. 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.

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