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"Design, Fabrication and Experimental Study of Human Muscle Powered Mechanical Device for Electricity Generation, Irrigation and Winnowing"

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Abstract—*In this research work authors, design, fabricate and experimentally studied a human muscle powered mechanical device for electricity generation for battery charging, to run centrifugal pump for irrigation and winnowing system for cleaning seed. It has unique features of using human power as prime mover for electric generator. Muscle energy in the form of high-torque low-speed can be converted into low-torque high-speed through speed increaser to energize the electric generator. The car alternator of 12V and 40 AH is used for electricity generation. The electricity generated is stored in the batteries of different capacity and used when required. The centrifugal pump of 0.5 hp is used for irrigation which discharged 15 liters of water when suction head is 4 meters. Also the winnowing system work very efficiently. 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*: Human muscle energy, speed increaser, electric generation, irrigation, winnowing fan.*

1. INTRODUCTION

Over 1.5 billion people rely on kerosene for light and fossil fuel for irrigation and winnowing. 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 human have been doing for domestic works, but the electricity generation by muscle power is a novel technology.

Human power is a work or energy that is produced from the human body. It can also refer to the power (rate of work per time) of a human. Power comes primarily from muscles, but body heat is also used to do work like warming shelters, food, or other humans. A trained cyclist can produce about 400 watts of mechanical power for an hour or more, but adults of good average fitness average between 50 and 150 watts for an hour of vigorous exercise. A healthy well-fed laborer over the course of an 8-hour work shift can sustain an average output of about 75 watts. The yield of electric power is decreased by the efficiency of the human-powered generator [1-9]

2. FABFRICATION DETAILS

(i) Human Power: The authors' main object is to use the human power for domestic and agriculture use. The group of two people of 64 kg, 57kg of age 21 years are worked as an energy source. The human applied force on the mechanical link (handle) of the speed increaser.

(ii) Mechanical link: Two identical Mechanical link of mild steel plate having 25 mm wide, 5 mm thick and 400 mm length, capable of transmitting power in form of high torque low speed are attached to speed increaser first shaft at the both ends. Mechanical link starts moving when human applied force from both the ends.

(iii) Gears: Spur Gears are very useful in numerous applications. Not only can they transfer velocity and torque from one shaft to another, but, by using different size gears, they can alter the ratio between velocity and torque as they transfer them; a gear with many teeth driving a gear with fewer teeth will have less torque, but greater velocity and vice versa. Four sets of spur gears transmit the power among parallel shafts. The spur gears are made of mild steel. The spur gears have 68 teeth while the spur pinions has 18 teeth. The pressure angle is 20^{O}.

(iv) Speed increaser Speed increaser is a two set of spur gears housed in a frame of mild steel angles. It is having 2 numbers of stages with gear ratio of 1: 3.8. Input shaft of the speed increaser having 50 mm diameter and 800 mm length of mild steel material is in horizontal position whereas output shaft having 50 mm diameter and 600 mm length of mild steel material of the same is also in horizontal position. One pulley of 18 inch is mounted on the side of the out-put shaft of gear

system. The horizontal shafts are supported with roller bearings at the both ends.

Fig. 2.1: Human muscle powered Speed increaser.

(v) Belt and Pulley transmission unit: According to Indian Standard Code (IS: 2494-1974), the A type of belts are selected which has power ranges 0.7kW – 3.5 KW. There is one set of pulley (Ring) and belt system. One pulley of 18 inch is mounted on the output shaft of the gear system and counter pulley of 3 inch is mounted on alternator thereby stepping up the speed in the ratio 1: 6 when connected with belt.

(vi) 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.

(vii) Storage system: A typical 12 V, 40AH Lead-acid automotive batteries is selected. 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. If battery is 50% or more full, it takes less time to charge.

(viii) Hand Winnowing Fan: Hand Winnowing Fan is a set of spur gears housed in a frame of mild steel angles. It is having two stage speed increasing system with gear ratio of 1: 3.8 and one set gear with gear ratio 1:1 to increase height of winnowing fan. Input shaft having the gear with 68 teeth and meshing gear having the 18 teeth and made of ductile cast iron material. The shafts are supported with the roller bearings.

Fig. 2.2: Hand Winnowing Fan.

(ix) Water Pump 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 ±5%
Frequency (Hz)	50
Suction head (meter)	8 MTRS
Discharge head (meter)	27 MTRS
Discharge (L/min)	33 LPM

3. FABRICATION AND PROCEDURE

The fabrication of human handle powered mechanical device called speed increaser is done on the upper frame of paddle powered mechanical system. There are two step gear transmission system and one step pulley and belt transmission system. The bearing covers are fitted with the help of nut and bolt on the mild steel frame. Gears are fitted by means of nuts by drilling two holes on the shafts and on gear hubs. The first two identical gears of 68 teeth are mounted on first shaft which mesh with the second two identical gears having 18 teeth mounted on second shaft. The third gear having 68 teeth is mounted on mid of the second shaft and meshes with the fourth gear having 18 teeth which is mounted on mid of third. The first pulley of 18 inch is mounted on end of third shaft which drives another pulley of 3 inch mounted on alternator/ pump and alternator/ pump is fabricated on the frame.

If human rotates the starting gear having 68 teeth with average 30 rpm then the meshing gear having 18 teeth rotates with 30*3.78 rpm. Since gear of 68 teeth is fabricated in same shaft hence it also rotates at 30*3.78 rpm which rotates the fourth gear having 18 teeth with rpm of 30*3.78*3.78. The first pulley of 18 inch is mounted on same shaft; it has the same speed of 30*3.78*3.78 rpm. The counter pulley of 3 inch mounted on car alternator thereby stepping up the speed in the ratio 1:6; hence the car alternator/ pump rotate at 30*3.78*3.78*6 rpm.

30*3.78*3.78*6 = 2571 rpm

[A] ELECTRIC GENERATOR

The system is tested by means of human handle power for many times. Before staring the experiment the alternator is connected with battery and ampere meter is jointed in series. Two mechanical links called handle are fitted with the first gear of first shaft by means of nut-bolt at one end and another end is free to applied force. When human applied force through arm at handle the first gear start rotate and drive the meshing gear as well as pulley one. The pulley one transmits power to counter pulley. At the starting the rpm is very low hence the alternator was not responding but as well as speed is increasing the alternator start to generating power. Human are need to applied force to maintain average speed. The rpm and generated volt & current were taken after every minute.

Figure 3.1 Complete system of electricity generation.

Fig. 3.2 Human handle powered mechanical system for electricity generation.

[B] CENTRIFUGAL PUMP

Before staring the experiment the centrifugal pump is connected with the pipe of 30 mm diameter having football at the end. Two mechanical link handles is fitted with the first shaft by means of nut-bolt at one end and another end is free to applied force. When human applied forces through handle the first gear starts rotate and drive the meshing gear as well as pulley one. The pulley one transmits power to counter pulley.

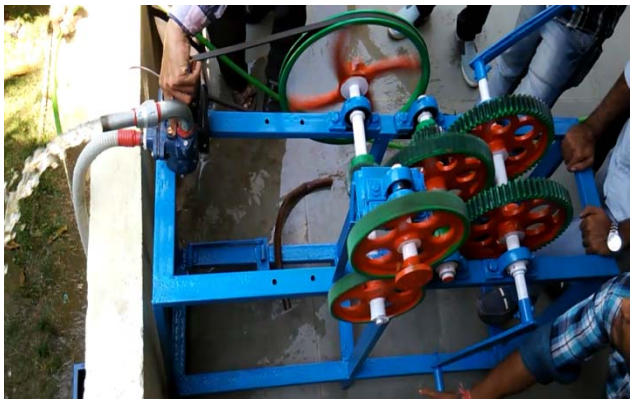

Fig. 3.3 Human handle powered irrigation system.

[C] WINNOWING FAN

For human rotates the starting gear having 68 teeth with average 60 rpm then the meshing gear having 18 teeth rotates with 60*3.78 rpm. Since gear of 68 teeth is fabricated in same shaft hence it also rotates at 60*3.78 rpm which rotates the fourth gear having 18 teeth with rpm of 60*3.78*3.78. The first idle gear is mounted on same shaft; it has the same speed of 60*3.78*3.78 rpm. The counter gear mounted with a plastic fan thereby stepping up the speed in the ratio 1:1; hence the fan rotates at 60*3.78*3.78*1 rpm.

60*3.78*3.78*1= 856 rpm.

Fig. 3.4: Human muscle powered winnowing fan

4. RESULT AND DISCUSSION

(A) Electricity generation

The humans' effort and speed depend on the load subjected. Experimental result shows that human take very little time to get working speed of 1000 rpm. Alternator generates constant voltage of 12V as specified after reaching ideal speed. The readings are taken after every minute. Speed vs. Current shows that at low rpm at starting motion it is not generating current by alternator, but as well as rpm is increasing and reaches to ideal working rang alternators producing high value of currents. The force applied by human muscle is varying so that the alternator rpm is also changing time to time and generated current also changing time to time. The average rpm of human muscle power system is 2200 rpm and average generated current is 12AH. The experiment had done 9 times.

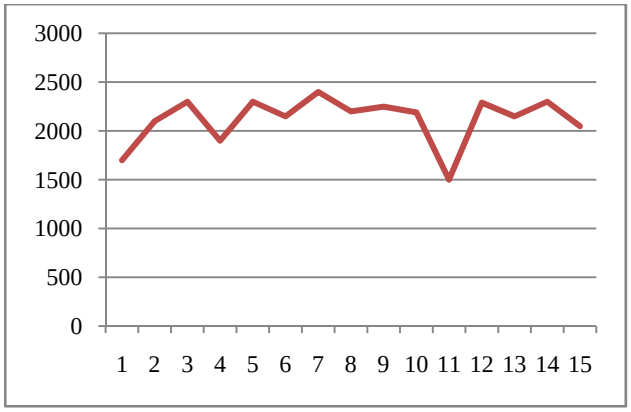

Fig. 4.1: Time (in minutes) vs. RPM of alternator.

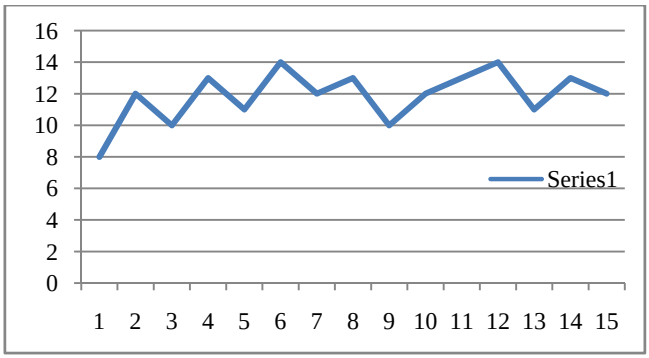

Fig. 4.2: Time (in minutes) vs. Current in AH.

(B) IRRIGATION SYSTEM

The humans' effort and speed depend on the load subjected. The suction head is 4 meter. The experiment had done 15 times. Experimental result shows that human take very little time to get working speed. The readings are taken after discharging 15 litters. Figure No of Experiments Vs. RPM of Centrifugal Pump shows that rpm is almost constant in every experiments. The force applied by human paddle power is varying so that the discharge from centrifugal pump is varying during experiment. The average rpm of human muscle powered water system is 2700 rpm. Figure between No of Experiments Vs Time for 15 LTR (in seconds) shows that the time taken to discharge 15 liter water is almost constant and the average time to discharge 15 liters is 39 seconds for 4 meter suction head of 0.5 hp centrifugal water pump.

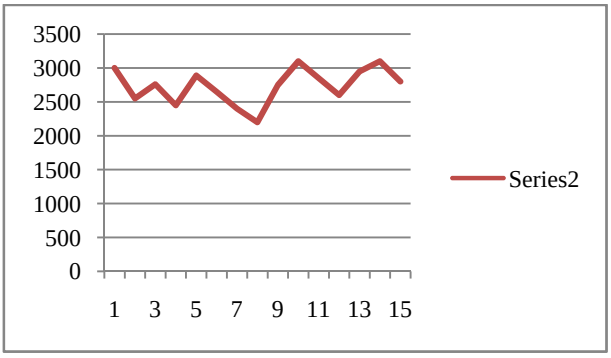

Fig. 4.3: No of Experiments Vs. RPM of Pump.

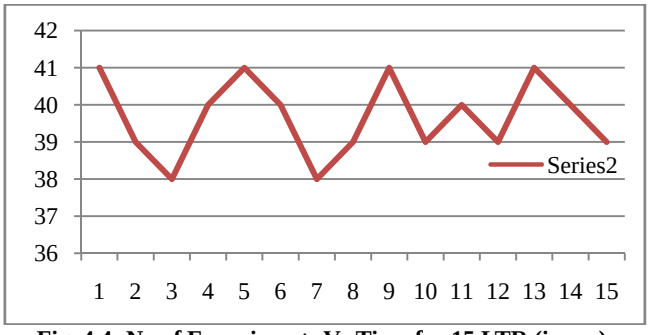

Fig. 4.4: No of Experiments Vs Time for 15 LTR (in sec).

(C) WINNOWING SYSTEM

The humans' effort and speed depend on the load subjected. The power required to drive the winnowing fan is very low. The experiment had done many times. Experimental results show that human take very little time to get working speed. The readings are taken time to time. Figure No of Experiments Vs. RPM of winnowing fan shows that rpm is almost constant in every experiments. The average rpm of human handle powered water system is 900 - 1000 rpm. Experiment also shows that light dust particle can easily remove but heavy particle need high speed of wind.

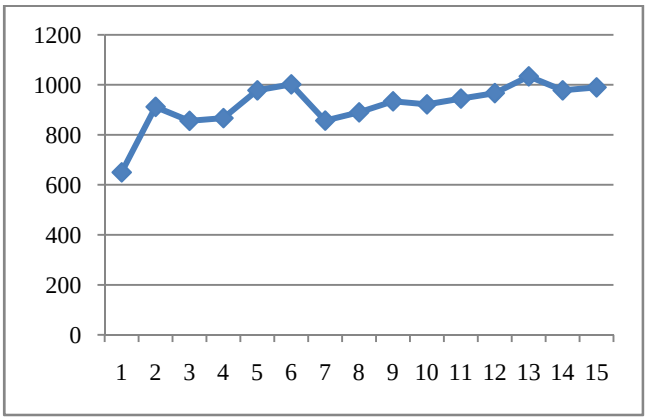

Fig. 4.5: No of Experiments Vs. RPM of winnowing fan.

5. CONCLUSIONS

The present work provides a mechanical device for producing electricity for home lighting, water pumping system for irrigation and winnowing system using the biological energy of the muscles of human. The project goal was to design, fabricate and experimentally studied of mechanical device to charge a battery 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. This is also concluded that fabricated mechanical device is itself a very small scale industry for charging batteries at rural and isolated areas. The present work also provides a hand winnowing fan for producing wind for cleaning the seed and a mechanical device for to run centrifugal water pump for irrigation using power of the muscles of human.

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