Performance Evaluation of pedal powered borehole hand pump.

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Abstract: **Drought produces a complex web of impacts that spans many sectors of the economy & reaches well beyond the area experiencing physical drought. This complexity exists because water is integral to society's ability to produce goods & provide service. During draught peoples have to travel across a large distance in search of water. Travelling a certain distance and then operating the hand pump and again returning back becomes quite tedious and physically demanding and leads to a fatigue. As legs can produce more power than hand cranking and bicycle is a common & cheapest mode of transportation, hence a mechanism to operate the hand pump with pedals is developed. Trials were taken and energy expenditure in both case i.e. hand operation and pedal powered is compared.**

Index terms: **Hand pump, pedal power, draught.**

I. Introduction:

There are many things happening around us which results in Drought, one of the reason is not receiving rain over a period of time. If you live in a place where most of the water you use comes from the river, a drought in your area can be caused by places upstream from you not receiving enough moisture.

Major part of our country come under the rural area, where there are not enough sources of water, electricity & many more. And when they get hit by drought then the thing is they've to walk miles to collect just bit of water on a hand pump generally or any other resource.

During Drought, the people have to walk miles in search of water & then have to work for collecting it. If the source of water is conventional bore well hand pump, then the exertion of walking followed by hand pump operation of bore well pump becomes quiet tedious job & results in fatigue.

II. Need of Pedal Power

The main objective is to design & develop a machine which uses human power as source of energy to drive the machine. It basically consists of a simple bicycle mechanism.

Pedal power is the transfer of energy from a human source through the use of a foot pedal and crank system [6] Since the thigh or quadriceps is largest and most powerful muscles in the human body it make sense to utilize it for generating as much as energy from human body. With the body in seat, the legs can provide a pedal work [7]. The person can generate four times more power(1/4 horsepower (hp)) by pedaling than by hand cranking. At the rate of 1/4 hp, continuous pedaling can be done for only short time ,about 10 minutes . However pedaling at half of this power (1/8 hp)can be sustained for around 60 minutes Maximum power produced with legs is generally limited by adoptions within the oxygen transportation system. On the other hand the capacity for arm exercise is dependent upon the amounts of muscle mass engaged and that is why a person can generate more power by pedaling than hand cranking [2]Pedal power enables a person to drive device at same rate as achieved by hand cranking but with less efforts and fatigue.

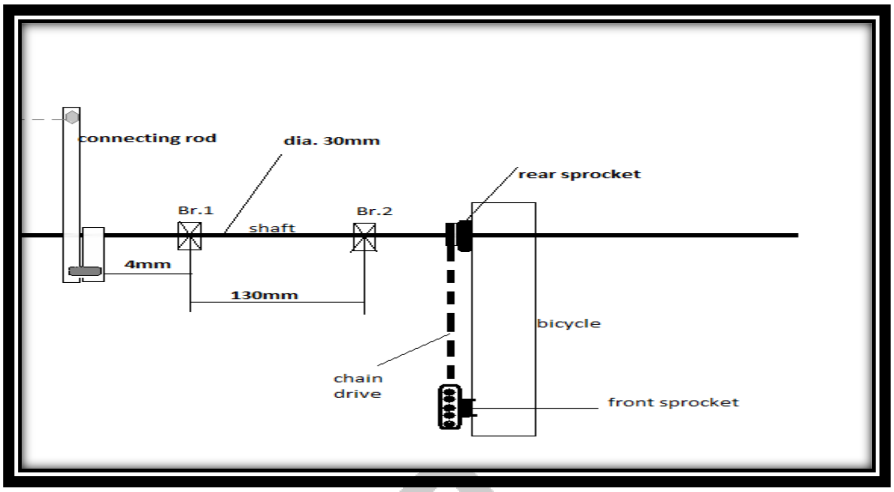
Keeping these thing in mind it was felt to develop a system to take dual advantage of pedal power hand pump operation and transportation and solution is bicycle mounted pedal powered hand pump operating mechanism.

III. Concept development:

The power levels that can be produced by an average healthy athlete is 75 W maximum[1]. A person can generate more or same amount of power for longer time if they pedal at certain rate. A simple rule is that most people engaged in delivering power continuously for an hour or will be more efficient when pedaling rate is in the range of 50-70rpm.[7]

Keeping these limitations of human capabilities in mind the proposed machine consists of simple bicycle system. In stationary position the rotational movement of rear wheel is extended through shaft. A crank is attached at other end of shaft and connecting rod attached to the end of crank. The schematic arrangement is as shown in figure no 1.

Figure 1:Schematics of proposed mechanism.



IV. Working Principle:

While pedaling the muscular energy of leg is applied on the pedal which converts into mechanical rotational energy of front sprocket of bicycle. Then the energy supply from front sprocket to rear sprocket through chain drive of bicycle. Now as in the construction there is a shaft fitted in hub attach to rear gear of the chain drive which also rotates with rear sprocket. After that energy is transmit from shaft to crank, and crank to connecting rod. Crank is constructed such as we can vary the crank length as per require stroke length of hand pump i.e. for the greater stroke we require greater crank length and vice-versa, mean's here crank length is directly proportional to stroke length of hand pump. Now here rotational energy of crank is converts into reciprocating energy of connecting rod. And this reciprocating energy is help to operate the hand pump as the conventional hand pump work.

V. OBSERVATION AND TRIALS

The readings were taken on hand pump.The temperature was observed to be 35℃ and 37˚C respectively.

When the person was in idle state pulse rate and oxygen rate of every individual was noted. To increase the accuracy of pulse oxy meter it was attached to finger head for about 10 seconds.

The individual was allowed to draw the water from hand pump by the traditional method i.e; by reciprocating the lever of hand pump for a fixed discharge of 15 Liters of water. After drawing water of 15 Liter, the pulse oxy meter was again attached for about 10 seconds for obtaining new pulse rate and oxygen rate . Also the time required for the discharge was observed.

The limits were applied to the lever of hand pump for reciprocation and thus the stroke while hand pumping as well as for pedaling was maintained constant .

Without disturbing the sequence on the next day on same time the individual was allowed to sit on the modified bicycle and again for obtaining the discharge of 15 liter they were asked to pedal. After drawing water suddenly the pulse oxy meter was attached to finger head for about 10 seconds and the pulse rate and oxygen rate along with time was observed.

VI. Results and Discussion:

The calculations for the energy expenditure were done for both hand pumping as well as pedaling the bicycle.

hand pumping

Estimate of VO2 max for humans, based on maximum and resting heart rates, was created by a group of researchers from Denmark. It is given by:

$$\mathrm{VO_2\ max} = 15\frac{\mathrm{HR}_{max}}{\mathrm{HR}_{rest}}$$

VO2 max = 15 (124/72)=25.83 mL/(kg/min)

This equation uses maximum heart rate (HRmax) and resting heart rate (HRrest) to estimate VO2 max in mL/(kg·min).

Oxygen consumption (VO2) in ml.kg-1.min-1:

The amount of oxygen consumed by the body each minute.

(Ml.kg-1.min-1 × body mass)/1000 = L.min-1

$$\frac{25.83 \times 5.10}{1000} = 0.13 \text{ ml.kg-1min-1}$$

Energy expenditure (EE):

VO_2 (L.min-1) × 20.1 = EE (kJ/min)

0.13X20.1=2.61 (KJ/min)

KJ.min-1 ÷ 4.186 = EE (kcal/min)

$2.61 \div 4.186 = 0.62(\mathrm{kcal/min})$

Kcal.min-1 ÷ 0.01433 = power output (W)

$0.62 \div 0.01433 = 43.56\mathrm{W}$

by bicycle pedaling

$$\mathrm{VO_2\ max} = 15\frac{\mathrm{HR}_{max}}{\mathrm{HR}_{rest}}$$

VO_2 max = 15(90/70)=18.75 mL/(Kg/min)

Oxygen consumption (VO_2) in ml.kg-1.min-1:

The amount of oxygen consumed by the body each minute.

(Ml.kg-1.min-1 × body mass)/1000 = L.min-1

(18.75x5.10)/1000 =0.10

Energy expenditure (EE):

VO_2 (L.min-1) × 20.1 = EE (kJ/min)

0.10×20.1=2.01 (KJ/min)

KJ.min-1 ÷ 4.186 = EE (kcal/min)

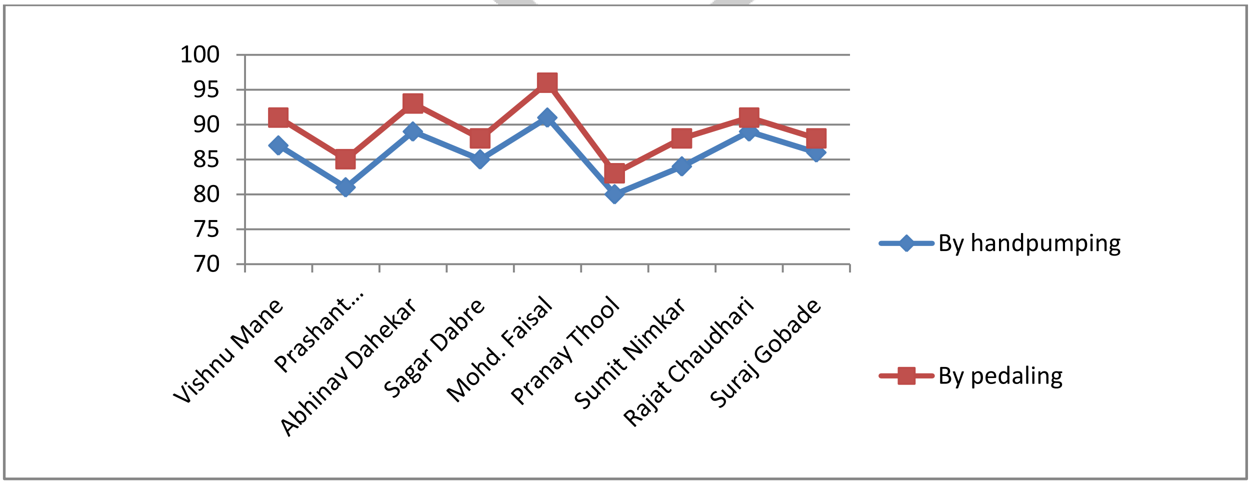
$2.01 \div 4.186 = 0.48\ (\mathrm{kcal/min})$

Kcal.min-1 ÷ 0.01433 = power output (W)

$0.48 \div 0.01433 = 33.51\ \mathrm{W}$

Similar calculations were done for all the trials and corresponding energy expenditure were calculated. from the calculations made it was observed that the time taken for hand pumping is less as compared to drawing water by bicycle. Although bicycle pedaling takes quite more seconds for same discharge but still it consumes less human energy compared to hand pumping. The variation energy expenditure is as in figure no2.

Fig 2: Comparison of energy expenditure for hand operation and pedal operation.



VII. CONCLUSION:

Thus a pedal powered hand pump mechanism is developed and trials were taken. Calculation for energy expenditure for both cases were done and it was observed that The average energy expenditure for hand pumping is observed to be 49.26 W and for pedaling is 38.70 W. Thus average 21.43% of saving of energy was observed which proves the effectiveness of the proposed work.

REFERENCES:

[1] Modak J, Bapat A. Design of experimentation for establishing generalized experimental model for a manually driven flywheel motor.Proc. International Conference on Modeling and Simulation. New Delhi, India. 1987 8(2): 127-140.

[2] .P.S.Tiwari,L.P.Gite,M.M.Pandey,A.K.Shrivastav a.Pedal power for occupational activities :Effect of power output & Pedalling rate on physiological responses. Internationl journal of Industrial Ergonomics 41 (2011);pp261-267.

[3] Modak J, Bapat A. Formulation of Generalised Experimental Model for a Manually Driven Flywheel Motor and its Optimization. Applied Ergonomics. 1994 25 (2):119-122.

[4] 4. Modak J, Moghe S. Comparison of some bicycle drive mechanisms designed in the light of transmission angle optimization and J. Papadopoulos Hypothesis, Part II. International Symposium on Machines and Mechanisms (ISMM '97), September 2-5, 1997.

[5] 5.Zakiuddin sayed kazi and J P Modak. Design and Development of human energized chaff cutter.New York science journal 2010.

[6] 6. Kajogbola R. Ajao, Kadiri Mustapha, Modupe R. Mahamood and Muritala O. Iyanda.Design & development of pedal powered soap mixer.New Yorkscience journal.2010;3(1)

[7] 7.David Gordon Wilson VITA volunteer. Undestanding the pedal power. ISBN: 0-86619-268-9