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Pedal Operated Washing Machine

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Abstract: *In many developing countries it is not possible to machine wash clothes due to the lack of electric power or the absence of machine itself. Washing clothes by hand leaves one breathless and takes an awful amount of time. A washing machine is a machine designed to wash laundry. Generally, these machines are operated by electricity but pedal operated machine is human operated and totally eco-friendly. It can be used to save electricity and also get physical exercise when implemented in urban areas. In this project, we fabricated such a washing machine with both washing and rinsing mechanism.*

Keywords: *Bicycle chain, Pedal power, Rack and pinion, Sprocket, Washing machine.*

1. Introduction

Pedal power is the transfer of energy from a human source through the use of a foot pedal and Gear system. This technology is most commonly used for transportation and has been used to propel bicycles for over a hundred years [1]. An individual can generate four times more power (1/4 HP) by pedaling than by hand-cranking. At the rate of 1/4 HP, continuous pedaling can be served for only short periods, approximately 10 to 20 minutes. However, pedaling at half this power (1/8HP) can be sustained for close to 60 minutes but power capability can depend upon age.

Conditions vary in developing countries, but women in many regions are washing clothes manually while they could be doing more profitable or rewarding work elsewhere. Women wash clothes by hand, using cold or lukewarm water that they carry from a river or pull up from a well which is a very difficult task. Existing technologies for washing clothes do not work well in underdeveloped rural areas. In developing countries, rural women are among the least privileged.

Several local organizations have already expressed an interest in pedal-operated technology. It is an affordable, environmental-friendly alternative to devices operated by electricity or fossil fuels. Since it is based on bicycle components, the machines can be manufactured locally and repair parts are affordable and readily available.

Pedal operated washing is a machine, which does not require electricity for several operations like washing, drying, rinsing etc.The design is ideal for use in the developing countries because it doesn't require electricity and can be built using metal bars for frame, chain, sprocket, bearing, foot pedal and a drum. The main advantage of a pedal operated powering system would be its ease of use by any person who is young or old. After loading the machine, the washing machine is designed to run in two cycles, each with its separate driving mechanism. The first is a rack and pinion mechanism that allows the drum to rotate back and forth alternatively to emulate a washing cycle. The operator applies relatively less power and the drum operates a slower rate. This action is carried out for an extended period of time as required, till the clothes are desirably clean enough. Once the clothes have been washed, the second mechanism, which is a chain sprocket arrangement to multiply speed of rotation, is engaged that rotates the drum at a higher speed for a brief duration and the centrifugal force thus generated squeezes the water out from the clothes and it is drained out through the outlet valve.

Fig. 1 pedal operated washing machine

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2. Literature survey

The Pedal Operated washing machine is working on simple gear system. The PPWM is used to washing, drying, rinsing. POWM helps to obtain a less effort uniform spinning and washing. By pedaling the bicycle, the pedaling motion rotates the drum, the washing machine will be moving with the crank & rotate the multi utility drum for the washing. Thus the light material can be also washing the clothes without any external energy like fuel or current. Since this uses no electric power and fuel, this is very cheap and best.

The surveys of the literature regarding the POWM are listed below

Dharwachaitanyakirtikumar [1] designed and developed a multipurpose machine which does not require electricity for several operations like washing. This is a human powered machine runs on gear drives mainly with human efforts. It has special attachments to use both human power as well as electric power. The design is ideal for use in the developing world because it doesn't require electricity and can be built using metal base, chain, pulley, rubber belt, bearing, foot pedal (for operated by human), chain sprocket.

S.G.bahaley et al. [2] designed and fabricated a pedal powered multipurpose machine. It is a human powered machine which is developed for lifting the water to a height 10 meter and generates 14 Vol., 4 ampere of electricity in most effective way. Power required for pedaling is well below the capacity of an average healthy human being. The system is also useful for the work out purpose because pedaling will act as a health exercise and also doing a useful work.

Linxu, Weinanbai et al. [3] designed and developed a pedal driven washing machine, the main objective is to provide a product with an alternative way to wash clothes when there is no electricity. So the machine which is a pedal driven machine, it satisfies the need of rural people by giving them an alternative way of washing clothes which is quick, cost-effective and eco-friendly. This study aims to design and fabricate a pedal driven washing machine to obtain a less effort uniform washing and sinning and to have a comparison between hand driven and pedal driven washing machine.

3. Design specifications

The most important aspect in the design of the machine is its ability to perform as a device that eases the task of washing clothes. In order to be a viable solution in rural areas, the machine should be able to deliver the same quality of washing without adding excessive overheads (in terms of water use, clothing wear, effort required to operate, etc.). Thus the design and operation of the machine should be firmly grounded in the physics of clothes washing, with a special emphasis on the mechanical aspects (since water temperature and detergent composition are likely to vary).

A number of safety features should also to be included in order to mitigate the inherent safety issues involved in a chain-driven machine. If the machine was to be used in a home, insuring its portability of would allow it to be shared among families, transported close to a water source for operation or used in households where space is limited. Another set of specifications for load sizing, water usage and pricing, depend on the targeted community. Designs allowing for easy re-sizing were preferred [3].

- Cleaning: Machine-washed clothes must be as clean as those hand-washed for 5 minutes
- Gentleness: Must wear clothes at slower rate than hand-washing [hole/tear growth]
- Capacity: Minimum 2KG of clothes/load – should be easy to re-size.
- Water: Effective washing must occur in soft and hard water at temperatures from 20°C to 50°C
- Water usage: Maximum 10L water / 1kg clothes
- Active pedaling time for effective washing: Maximum 30 minutes for wash and 5 minutes for rinse cycles
- Total operation time: Maximum 1 hours, including fetching water, filling, washing, draining, and cleaning
- Power: Maximum 75W (comfortable level of human-power output)
- Cost: Maximum Rs.8000 (comparable to cost of other MP machine)
- Lifetime of structure: 5 years, assuming daily use
- Manufacturing location: local market
- Materials: local (wood, weldable metals, oil drum, bicycle parts, etc.)
- Dimensions: less than combined size of a bicycle and commercial washing machine
- Weight: Maximum 30kg, or 45kg if it has wheels (1 woman can move it indoors so it can't be stolen or damaged).
- Culturally acceptable: Suitable appearance, user position and motion such that most women are willing to use the machine.

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4. Components

The components used for POWM are

4.1 Seat

Seat is an arrangement in any bicycle on which a person can sit comfortably. Seat may be made of plastic, rubber, metal etc.The seat used here is of satisfactory softness and big enough for most users to use the machine without much fatigue. It has been borrowed from a regular bicycle that was designed for adults. A chair can be used instead of a bicycle seat for sitting and pedaling for making of clothes more comfortable [6].The seat we used in our machine is as shown in Fig.2.

Fig. 2 seat

4.2 Pedal arrangement

A bicycle pedal is the part of a bicycle that the rider pushes with their foot to propel the bicycle. It provides the connection between the cyclist's foot and the crank allowing the leg to turn the bottom bracket spindle and propel the bicycle's wheels. Fig.3 shows the pedal arrangement in our washing machine which used to transmit pedaling motion to the intermediate shaft.

Fig. 3 pedal arrangement

4.3 Gear

In POWM we are using two sprocket systems or circuits as shown in Fig.4 and Fig.5. The first circuit consists of the sprocket coupled to the pedal and another sprocket that is coupled to the intermediate shaft, where these sprockets are linked to each other with a chain. This circuit is used to provide continuous rotation in a single direction to the intermediate shaft. The second circuit consists of the intermediate shaft and the driving shaft that is coupled to the rotating drum. The drum is connected to this intermediate shaft through two different mechanisms, one being a regular sprocket and chain arrangement and the other being a rack and pinion arrangement. The first mechanism consists of 2 sprockets, one coupled to the intermediate shaft and the other coupled to the rotating drum. These sprockets are in turn, connected by a chain.

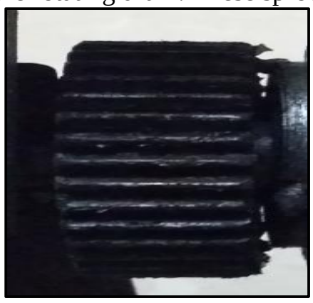

Fig. 4 pinion

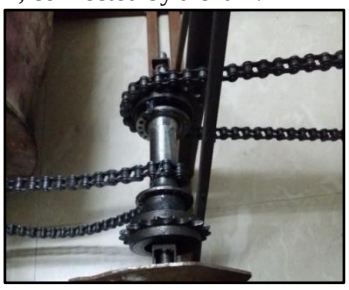

Fig. 5 sprocket

4.4 Bearing

A bearing is a machine element that constrains relative motion between moving parts to only the desired motion. In POWM we used two bearings on the drum shaft to support the drum. These bearings are

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placed on either side of the drum shaft resting on a support on the frame of the machine. Bearings help in smooth rotation of the shafts thereby reducing the pedaling effort. Fig.6 shows bearing component.

Fig. 6 bearing

4.5 Chain

When creating your own human powered vehicles, a chain drive will likely be your chosen power transfer system, as it is an inexpensive, easy-to-install and highly efficient drive mechanism.

Here in POWM we used a regular bicycle chain as shown in Fig.7. As mentioned above this system consists of two circuits, both of which need chain.

Fig. 7 chain

4.6 Hub

Hub is a part of cycle on which sprocket could be mounted on. In POWM we are using a Hub on to which the intermediate sprockets are mounted as shown in Fig.8. This helps in transferring pedaling motion of front sprocket to the drum shaft. The Hub used here is placed on the intermediate shaft. It carries 2 sprockets, one of which drives the drum and another which is connected to the pedal. It is also coupled to the cam plate which drives the rack and pinion.

Fig. 8 hub

4.7 Shaft

In the POWM, we used 3 shafts. The first shaft is coupled to the pedal and acts as a driving shaft. It also carries the pedal sprocket. The second shaft is the intermediate shaft that carries 2 sprockets and the cam plate: It has been designed so that only one mechanism is engaged at a time, thus allowing us to either pedal the machine in washing cycle or rinsing cycle. The third shaft carries the rotating drum and also the pinion and final sprocket.

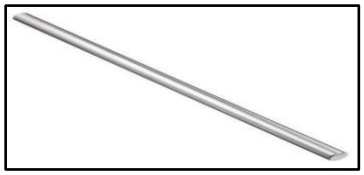

Fig. 9 shaft

4.8 Drum

It is the chamber in which water is filled with detergent further cloth is put inside it for rinse. In this type of machine, there are two drum are used, inner &outer as shown in Fig.10.

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Fig. 10 inner and outer drum

Inner drum: This drum consists of clothes & it is less in diameter as compared to outer drum. Inner drum is punched with holes throughout its body. It rotates with the help of sprocket & chain arrangement in the desired speed with respect to the purpose.

Outer drum: Outer drum is used to store water used for washing the clothes. Both the drums are provided with doors for filling water and loading clothes into them.

4.9 POWM frame

The frame is one of the main components of the POWM on to which all the other components like drums, seat, handle bar, sprocket and chain, rack and pinion etc. are mounted. Fig.11 shows the frame of our washing machine.

Fig. 11 frame

5. Working principle

The clothes to be washed are fed into the drum through the front door and water is allowed through the inlet. Detergent is added and then the machine door is closed. The cleaning of clothes happens in two cycles namely washing cycle and spinning cycle.

In washing cycle the clothes are washed due to tumbling action of the drum by the rack and pinion mechanism as shown in Fig.12. After the cycle used water can be let out through the outlet and clothes are ready for the spinning cycle.

Fig. 12 rack and pinion mechanism

While in spinning cycle the water from the clothes are removed due to centrifugal force of high speed rotating drum obtained by the chain and sprocket mechanism and thus the clothes are dried out.

The pedal is directly connected to a chain sprocket mechanism that transmits the power to the intermediate shaft. The intermediate shaft can be switched between two modes namely a low speed to and fro mechanism for the washing cycle and a high speed rotation mode for rinsing cycle. The low speed mode consists of a simple rack and pinion mechanism that consists of a rack coupled to the pedal, and the pinion is the follower which is coupled to the rotating drum. The high speed mode consist of a direct coupling to a sprocket of smaller diameter than the pedal which would act as a speed multiplier and effectively allows the user to rotate the drum at high speed thus draining the water out of the clothes due to high centrifugal force, which simulates the rinsing cycle. The soiled clothes are placed inside a rotating inner perforated drum which in turn is placed inside an outer stationary drum. The stationary drum acts as a reservoir thus containing the water within it.

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6. Conduction of experiment and tabulation of results

Following steps were done to conduct the experiment and the results were observed, tabulated and plotted [2].

1. Fill the drum with water with enough amount of detergent powder.
2. Add the clothes in the inner drum and close the cover.
3. Start pedaling and observe the performance of the machine.
4. Measure time using stopwatch at different speeds and loads at different operating weights.

For washing cycle the results are tabulated and plotted as in TABLE.1 and Fig.13

Table. 1 tabulation shown for washing cycle

Sl. No.	Speed(rpm)	Load(kg)	Time(min)
1	60	1	20
2	60	1.5	30
3	60	2	40

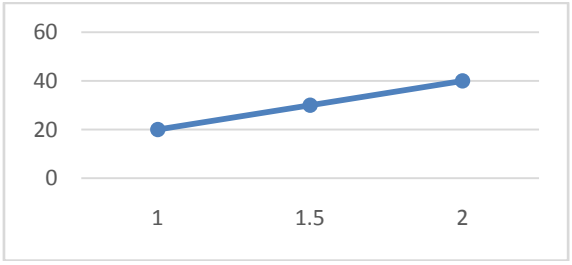

Fig. 13 weight on X-axis and time on Y-Axis

For spinning cycle the results are tabulated and plotted as in TABLE.2 and Fig.14

Table. 2 tabulation shown for Spinning Cycle

Sl. No.	Speed(rpm)	Load(kg)	Time(min)
1	90	1	5
2	90	1.5	7
3	90	2	9

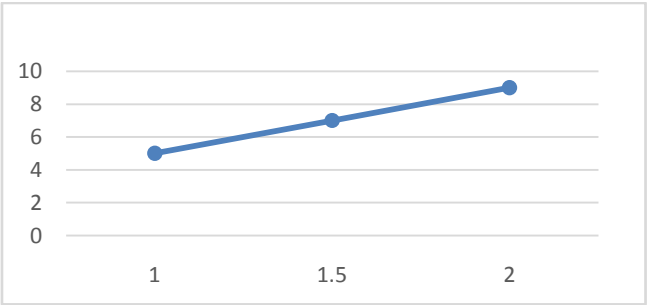

Fig. 14 weight on X-axis and time on Y-Axis

7. Calculations

7.1 Drum speed during washing cycle

From [4] Gear ratio between pedal sprocket and intermediate sprocket

$$= \frac{\text{Pedal Sprocket Diameter}}{\text{Intermediate Sprocket Diameter}} \quad (1)$$

$$= \frac{17}{9} = 1.888$$

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Also, it is equal to = $\frac{\text{Intermediate Sprocket Speed}}{\text{Pedal Sprocket Speed}}$ (2)

Assuming pedal speed to be 40-80 rpm

Intermediate sprocket speed=1.888×Pedal sprocket speed

Therefore; Drum Speed = 1.888×40=75rpm

And, 1.888×80=150rpm

7.2 Angle rotated by pinion

Distance travelled by rack=eccentricity of cam rod(e) ×2 (3)

where e =4.5cm

Distance travelled by rack=2×4.5=9 cm

Therefore, even pinion will rotate through 9 cm, since both are meshed together.

Using arc length formula, L= r×□, □ = $\frac{L}{r} = \frac{9}{4.5} = 2$ (4)

Converting into degree, □× $\frac{180}{\pi}$= 2× $\frac{180}{\pi}$ = 114.5°= Angle rotated by pinion

Since drum is coupled to pinion, Angle rotated by drum = 114.5°

8. Advantages

Following are the advantages of POWM, which were referred from [5]

- Affordable
- Easy to build and affordable
- Eco-friendly
- Efficient
- Reliable

9. Conclusions

The machine must be inexpensive and easy to build if it will be adopted into the community. We recognized this need and designed the machine from the start with low cost in mind. The machine will only contain parts that are readily available in rural areas. The machine also uses bicycle parts for all components. The pedal-powered washing machine is quite different from the community's current method of washing clothes; the community may be reluctant to try the new machine. To encourage the adoption of the washing machine, we will run multiple trials with local women so we can adjust the design to meet their needs. We will run the trial periods with groups like the women's cooperative who are already familiar with pedal powered machines; they have already proved they are willing to try new technologies. We achieved what we desired i.e. to build a manually driven pedal powered low cost washing machine using locally available materials and performing necessary function of washing and rinsing with ease. The washing machine can be used by the urban people also while workout and exercises. If the production of this washing machine is done at commercial scale then the total production cost of the machine can be reduced to 40% of estimated cost.

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