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Mechanical 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. We all wash our clothes either by hands or by machine. Paddling washing machine can clean these cloths more efficiently and faster without using electricity and not polluting the environment. It can physical exercise when implemented in urban areas. It also consumes less water and protects skin from harmful chemical of detergent. Almost 60 percent of our population lives in rural areas where it is impossible to use electric powered washing machines. Paddling washing machine needs low initial cost of manufacturing and low maintenance cost. So we use pedal operated washing.**

***Keywords*: Bicycle chain, Pedal power, Shaft, Freewheel, Sprocket, Washing machine, Pedal Power.**

1. Introduction

Washing machines are one of the most useful devices in households today. A washing machine is basically a machine designed to wash or clean laundry such as socks, clothing and hanky etc. Generally, we use electrical washing machine which consume more electrical power. By reducing this power loss we use pedal operated washing machine. Pedal power is the transfer of energy from a human source through the use of a foot pedal and Gear system. It is a machine which generates force initial cost of manufacturing and low maintenance cost.
Adarsh Ranjan, Kushagra Sharan, Sudeep Mazumdar [3]. It is a machine which generates power through human pedaling and with the drive mechanism, converts the pedaling motion into required rotary motion of the drum. Its innovation lies in its simple design, use of inexpensive parts, very low repairing and maintenance cost, affordability to each member of the society and it does not affect the environment. Our team intends to directly address the problems faced in washing clothes, and thus have developed a new design for easy effort in washing, rinsing and drying clothes. PPWM is a completely new concept, which in its one laundry cycle does washing, rinsing and drying of clothes similar to that of an automatic washing machine available in the market.

Tawanda Mushiri, Tererai J. Mugova,Charles Mbohwa [4], We all wash our clothes either by hands or by machine. A washing machine is a device designed to wash laundry such as clothes and sheets. These washing machines cost between $350 to $750 depending upon functions and features. All of these washing machines are powered by electricity and the basic principle of operation is by creating a turbulent flow of the detergent around the dirty clothes. Almost 60 percent of our population lives in rural areas where it is impossible to use electric powered washing machines, mainly due to the unavailability of electricity or the absence of the machine itself due to high costs of purchasing a new washing machine. The machine can also be used in urban areas to save electricity and also to exercise. The machine does not require electricity or an engine but uses human power. The transfer of human energy through the use of a foot pedal and crank mechanism is what is known as Pedal power. This is the mechanism that has been used to propel bicycles.

A. Design specifications

The most important aspect in the design of the washing machine is its ability to make the washing of clothes easier and faster. 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.). In order to make the machine successful and more useful, a number of goals with varying degrees of importance were identified. Since chain drives have certain safety risks, a number of safety features should be included in order to extenuate the inherent safety issues. The size and weight of the machine should be such that it is portable so that it is possible to share among families and also so that it can be transported close to a nearby water source for operation, or so that it fits in households where space is limited. Load sizing, pricing and water usage depend on the targeted community. Since the quantity of laundry varies between families, an initial size was selected based on existing washing machines, and designs allowing for easy re-sizing were preferred.
The specifications are summarized below:

- *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.

2. Components

The components used for POWM are

A. 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 A chair can be used instead of a bicycle seat for sitting and pedaling for making of clothes more comfortable. The seat we used in our machine is as shown in Fig. 1.

Fig. 1. Seat

B. Pedal arrangement

Fig. 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. 2, shows the pedal arrangement in our washing machine which used to transmit pedaling motion to the intermediate shaft.

C. 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 drum is connected to this intermediate shaft through two different mechanisms, one being a regular sprocket and chain 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.

D. Bearing

In POWM we used two bearings on the drum shaft to support the drum. These bearings are placed on either side of the drum shaft resting on a support on the frame of the machine. And we use two other bearing to support freewheel to handle the other shaft. Bearings help in smooth rotation of the shafts thereby reducing the pedaling effort. Fig. 3, shows bearing component.

Fig. 3. Bearing

E. 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. 4.

Fig. 4. Chain

F. 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. 5. 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. 5. Hub

G. 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.

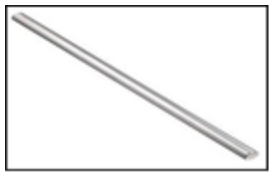

Fig. 6. Shaft

H. 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. 7.

Fig. 7. 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.

I. 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. 8 shows the frame of our washing machine.

Fig. 8. Frame

3. 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.

Table 1
System parameters

S. No.	Speed (rpm)	Load (kg)	Time (min)
1	45	1	23
2	45	1.5	29
3	45	2	36

Washing the clothes are washed due to tumbling action of the drum by the chain and sprocket mechanism as shown in Fig. 9. After the cycle used water can be let out through the outlet and clothes are ready for the spinning cycle.

Fig. 9. Chain and sprocket

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 high speed mode consists 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.

4. 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.10.

Table 2
Tabulation shown for Spinning Cycle

S. No.	Speed (rpm)	Load (kg)	Time (min)
1	75	1	9
2	75	1.5	12
3	75	2	15

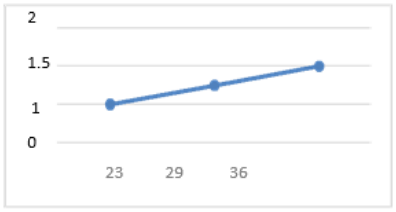

Fig. 10. Weight on X-axis and time on Y-Axis

For spinning cycle the results are tabulated and plotted as in Table 2 and Fig. 11.

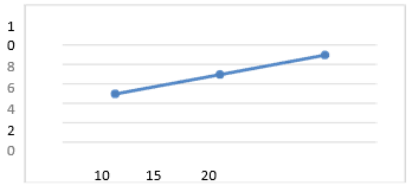

Fig. 11. Weight on X-axis and time on Y-Axis

$$\text{and intermediate sprocket} = \frac{\text{Pedal Sprocket Diameter}}{\text{Intermediate Sprocket Diameter}} = \frac{17}{} = 1.888 \quad (1)$$

5. Calculations

A. Drum speed during washing cycle from [4] Gear ratio between pedal sprocket

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

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.

$$\text{Using arc length formula, } L = \frac{L}{} = \frac{9}{}$$

B. Advantages

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

- Affordable
- Easy to build and affordable
- Eco-friendly
- Efficient
- Reliable
- Chip
- Low maintenance

6. Conclusions

In order for the machine to be accepted in the community, it must be inexpensive and easy to build. 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. Therefore there is no need to import components

should they wear out. The machine 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. The product designed has zero operating cost, cost-effective, and it can be used with minimal effort. 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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