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Design and Fabrication of a Physiotherapy Manually Driven Washing Machine.

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Abstract

Cloth washing is one of the essential parts of the life but it is considered undesirable because of the involvement of efforts, time, energy and cost. Nowadays a wide variety of washing machines are available in the market and there is a tough competence among the manufacturers. Very costly washing machines are equipped with facility of dry cleaning too. All of the washing machines available in the market are electric power driven and basic principle of their operation depends upon creation of the turbulent flow of detergent around the dirty clothes. Drying of the clothes is based upon rotation of wet clothes at very high rpm so that water droplets can be separated out due to centrifugal action. In our country where approximately 70% population is living with very poor economic status, those people cannot have a washing machine because of cost constraints and unavailability of electricity due to any reason. The present work is an attempt to develop a concept to make a cloth washing mechanism which can meet out the requirements of above mentioned 70% population of the nation. Working principle of this concept is no more different from available similar type of machine with a difference driving mechanism of the machine. The objective of bringing down the initial cost and operating cost of washing machine is almost achieved in present work within the limitation of work as mentioned.

Keywords: *Effort, Energy, Time, Cost, Washing machine, Electric power motor.*

Introduction

Washing machine is a machine that washes dirty clothes. It contains a barrel into which the clothes are placed. This barrel is filled with water, and then rotated very quickly to make the water remove dirt from the clothes. Most washing machines are made so that detergent (liquids or powders) can be put into the machine which helps make the clothes cleaner. The term is mostly applied to machines that use water as opposed to drying cleaning machines (which use alternative fluids and is performed by specialist business).

Washing machine technology is developed as a way to reduce the manual labor spent, providing an open basin or sealed container with pedals to automatically agitate the clothing.

The earliest machines were hand operated and constructed from wood, while the later machines made of metal permitted a fire to burn below the washtub, keeping the water warm throughout the days washing (Wikipedia). Depending on the position of loading in clothes, electric washing machines are of 2 types: top loading and front loading machine. The typical electric washing machine on average will consume 500watts for 0.25hours of washing and as such, one must have access to a reliable electricity source if he is to use this machine. The national electrification rate in Nigeria is estimated at 14% with the rural population having even a lower rate of below 7%. Power shortage remains one of the greatest challenges in rural areas, regardless of the government's effort to electrify rural areas. (Web site: International Cooperation and Development visited on 10/09/2020). An electric washing machine will therefore be very expensive to operate and unreliable in most rural areas of Uganda.

Among those greatly affected by this condition are the Rural Health centers. These hospitals are not in position to safely wash contaminated laundry using the electric washing machines, which is the standard for performing such a task as to design and construct a manually operated washing machine that can function in two direction as to wash close and also physiotherapeutic treatment for the body. The pedal driven washing machine does not need

electricity to operate and as such, can be used in rural areas with no electricity supply. This machine generates power through human pedaling and with the drive mechanism, converts the pedaling motion into required rotary motion of the drum. With the help of compound gear system, the machine achieves the desired speed for different purposes like washing, rinsing and drying. Its innovation lies in its simple design and use of inexpensive parts

This project makes laundry washing safe by reducing workers' contact with the contaminated laundry which is apparently exposing them to a high risk of infection from the clothing, reduce human effort and save time.

DESIGN METHODOLOGY

Component of the machine

i. **SEAT**: A seat is place to sit, often referring to the area one sits upon as opposed to other elements like armrests. Seat is a arrangement in any bicycle on which a person can sit comfortably. In seating arrangement the design factor is always consider according to their use in any vehicle. Seat may be made of plastic, rubber, metal etc material. In some seating arrangement suspension is also consider.

ii. **PEDAL**: 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 or shoe and the crank allowing the leg to turn the bottom bracket spindle and propel the bicycle's wheels. Pedals 21 usually consist of a spindle that threads into the end of the crank and a body, on which the foot rests or is attached, that is free to rotate on bearings with respect to the spindle. Pedals were initially attached to cranks connecting directly to the driven (usually front) wheel. The safety bicycle, as it is known today, came into being when the pedals were attached to a crank driving a sprocket that transmitted power to the driven wheel by means of a roller chain.

iii. **GEAR**: Bicycle gearing is the aspect of bicycle drive train that determines the relation between the cadence, the rate at which the rider pedals, and the rate at which the drive wheel turns. On some bicycles, there is only one gear and the gear ratio is fixed. Many contemporary bicycles have multiple gears and thus multiple gear ratios. A shifting mechanism allows selection of the appropriate gear ratio for efficiency

or comfort under the prevailing circumstances: for example, it may be comfortable to use a high gear when cycling downhill, a medium gear when cycling on a flat road, and a low gear when cycling uphill. Different gear ratios and gear ranges are appropriate for different people and styles of cycling.

i. **BEARING:** A bearing is a machine element that constrains relative motion between moving parts to only the desired motion. The design of the bearing may, for example, provide for free linear movement of the moving part or for free rotation around a fixed axis; or, it may prevent a motion by controlling the vectors. Bearings are classified broadly according to the type of operation, the motions allowed, or to the directions of the loads (forces) applied to the parts.

ii. **CHAIN AND SPROCKET**: 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. Bicycle chains are fairly simple, requiring only one inexpensive tool to remove and attach links. Since a recumbent cycle will often require a chain that is one and a half to 3 times the length of a regular upright bicycle chain, some basics should be known, as you will probably need to create the chain for your vehicle.

iii. **CATCHER**: Catcher is a part of rickshaw on which sprocket could be mount. On it threaded design is made .by using it sprocket could be tighten.

iv. **SHAFT:** Shaft is a mechanical component for transmitting torque and rotation, usually used to connect other components of a drive train that cannot be connected directly because of distance or the need to allow for relative movement between them. Drive shafts are carriers of torque: they are subject to torsion and shear stress, equivalent to the difference between the input torque and the load. They must therefore be strong enough to bear the 29 stress, whilst avoiding too much additional weight as that would in turn increase their inertia. To allow for variations in the alignment and distance between the driving and driven components, drive shafts frequently incorporate one or more universal joints, jaw couplings, or rag joints, and sometimes a splined joint or prismatic joint.

v. **SHAFT COLLAR**: The shaft collar is a simple, yet important, machine component found in many power transmission applications, most notably motors and gearboxes. The collars are used as mechanical stops, locating components, and bearing faces. The simple design lends itself to easy installation. Many people will be familiar with shaft collars through using Meccano.

vi. **DRUM AS A WASHING CHAMBER**: It is just a 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.

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

   ii. Outer drum: Outer drum is used to store water used for washing the clothes.

vii. **CYCLE FRAME ARRANGEMENT:** A bicycle frame is the main component of a bicycle, on to which wheels and other components are fitted. The modern and most common frame design for an upright bicycle is based on the safety bicycle, and consists of two triangles, a main triangle and a paired rear triangle. This is known as the diamond frame. Frames are required to be strong, stiff and light, which they do by combining different materials and shapes.

Design specification

The Loading condition is as well necessary in designing a washing machine. There are two types of loading condition viz: Front loading, where the cloths are being loaded horizontally and the top loading, where the cloths are being loaded vertically. For the purpose of this research, the front loading mechanism was chosen because of its advantages over top loading. The washing machine is made up of the following components**:**

1. Inner tub
2. Outer tub
3. Shaft
4. Bearings
5. Pulley

6. Pedal
7. Chain

Design Consideration and Calculation

Certain calculations were made on certain parameters so as to make correct choices in selecting them. Design calculations were carried out on the following: Inner tub, Outer tub, Chain, Shaft, and Frame support.

***Inner tub*: The design An arbitrary size was chosen for the inner tub; the** readily available paint container was selected. Parameters: Circular Truncated Cone: Volume of the inner tub is as expressed in equation

$$V = \frac{1}{3}\pi(R_1^2 + R_1.R_2 + R_1^2).h$$

Where R_1 = lower radius = 0.1425m

R_2 = upper radius = 0.1325m

h = height = 0.345m

V = $\frac{1}{3}\pi$ {$(0.1425)^2$ + (0.1425 x 0.1.325) + (0.1325)2 } x 0.345

V = 0.02m^3 = 20 litres Therefore, Volume of the inner tub = 20 liters

The inner tub was drilled with numerous holes to allow for passage of water in and out of the tub. An arbitrary hole size of 10 mm was chosen in order to compensate for the strength of the tub.

Outer tub design Space and the materials/clothes to wash are determining factors in choosing the sizes of washing machine. However, a typical washing machine has the following dimensions:

• Top loader: 20 - 27 inches wide, 27 to 28 inches deep. And 34 to 43 inches high. • High capacity front loader: 24 to 29 inches wide, 30 to 34 inches deep, and 35 to 42 inches high.

The outer tub dimension was determined about the inner tub. Taking an assumption that when the inner tub is spinning for drying of the nylon, the pressure at which the water hits the wall of the outer tub should be 4kpa. Also, assuming the outer tub to complete two revolutions in one second, then a number of revolutions of the inner tub is 120 rpm

Recall

Angular acceleration, ω =$\frac{d^2\theta}{dt^2}$

Converting angular acceleration to linear acceleration

$a = \omega^2 r$ r = radius of inner tub

a =a =

Therefore, the angular acceleration, a = 42.6477 m/s^2

Torque = moment of inertia x angular acceleration.

Where, I = moment of inertia,

a = angular acceleration

I = ½ mr2

Where

Mass of the bucket (m) = 0.75 kg

Radius of the bucket (r) = 0.095m

I =x 0.75 x 0.095

I = 0.035625 kg.m2

Recall that from calculation, angular acceleration is

42.6477m/s^2

Torque = 0.035625 x 42.6477

Torque = 1.52Nm

Hence, parameter for outer tub

Diameter = 470 mm

Length/height = 470 mm

Volume = 0.0358848m3

Therefore, V = 35.88 litres.

Shaft design

The shaft was subjected to both torsional and bending stresses. It was also assumed that the shaft undergoes fluctuating load during working condition simply because the amount of water is not the same for practical operations. According to the AMSE code for Shaft, the maximum permissible working stress in tension and compression for a shaft without allowance for keyway is 112Mpa.

Assuming a factor of safety of 2 (i.e. the shaft can bear a load double the original load it is subjected to)

$\delta = \frac{112}{\delta}$ = 56Mpa

Using the relation in equation (5)

$$d^3 = \frac{16}{\pi\delta} = \sqrt{(Kt\,Mt) + (Kb\,Mb)}2 \qquad (5)$$

Recommended Values for Kb and Kt (according to Khurmi and Gupta).
Where:

Kt = shock and fatigue factor for torsion = 1

Kb = shock and fatigue factor for bending = 1.5

For a shaft driven by pulley, the torsional moment of the shaft is given as:

$Mt = (T_1 – T_2) R$

Mt = (199.706 – 101.525) x 0.141

Mt = 13.8435Nm

Hence the torsional moment is 13.8435 Nm.

From bending moment calculations, maximum bending moment was found to be:

Mb = 15.06158Nm.

Recall Mt = 13.8435Nm

Mb = 15.06158

d = 13.4067 mm

Using size of tandard shafts:

d = 20 mm

N.B: $\delta = 56Mpa = 56 \times 10^6\ N/m^2$

Frame support

The frame support is the structural member carrying the entire structure. The loads being carried are analyzed as shown below:

Assuming the outer tub is filled with water:

Density of water $= \frac{mass\ of\ water}{volume\ of\ the\ tub}$

1000 kg /m = $\frac{m_w}{v}$

Different parameters of model

S. No.	Parameter	Dimension
1	Inner drum diameter	36cm
2	Outer drum diameter	52cm
3	Length of inner drum	37cm
4	Length of outer drum	50cm

5	Height of shaft	39cm
6	Distance between shaft and cycle	50 cm
7	Height of base above ground	6 cm
8	Length of base	93 cm
9	Width of base	67 cm
10	Height of seat	80 cm
11	Height of handle	76cm
12	Total volume of outer drum	106L
13	Total volume of inner drum	37.6L

Working Principle

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. With the help of compound gear system, the machine achieves the desire speed for different purposes like rinsing, drying etc.. Washing entails immersing, dipping, rubbing, or scrubbing in water usually accompanied by detergent, or bleach. The simplest machines may simply agitate clothes in water while switched on; automatic machines may fill, empty, wash, spin, and heat in a cycle. Most washing machines remove substantial amounts of water from the laundry at the end of a wash cycle, but do not completely dry it. In our project the rotation of drum is possible through wheel rotation .Wheel is rotated by chain drive. When a person start peddling, the gear connected through sprocket by chain start to transmit power, the rotation of drum is dependent on man power. In our project the complete process is depend on compound gear system. Gear drive is a way of transmitting mechanical power from one place to another. It is often used to convey power to the wheels of a vehicle, particularly bicycles and motorcycles. It is also used in a wide variety of machines besides vehicles. Most often, the power is conveyed by a roller chain, known as the drive chain or transmission chain, passing over a sprocket gear, with the teeth of the gear meshing with the holes in the links of the chain. The gear is turned, and this pulls the chain putting mechanical force into the system. Another type of drive chain is the Morse chain. Sometimes the power is output by simply rotating the chain, which is used as input for the washing drum. In other situations, a second gear is placed and the power is recovered by attaching shafts or hubs to this gear. Though drive

chains are often simple oval loops, they can also go around corners by placing more than two gears along the chain; gears that put power into the system or transmit. By varying the diameter of the input and 40 output gears with respect to each other, the gear ratio can be altered, so that, for example, the pedals of a bicycle can spin all the way around more than once for every rotation of the gear that drives the wheels

Wash Cycles

A stand-alone spin dryer used for extracting water from laundry The earliest washing machines simply carried out a washing action when loaded with clothes and soap, filled with hot water, and started. Over time machines became more and more automated, first with very complex electromechanical controllers, then fully electronic controllers; users put clothes into the machine, select a suitable program via a switch, start the machine, and come back to remove clean and slightly damp clothes at the end of the cycle. The controller starts and stops many different processes including pumps and valves to fill and empty the drum with water and rotating at different speeds, with different combinations of settings for different fabrics.

Fabrication Process Used in the Project

Welding

Cast iron can be welded perfectly well using a stick welder and nickel rods, or with preheating by a gas welder using cast iron rod. Welding cast iron is a precision task that requires high heat, and often expensive equipment. You should not attempt it on the strength of reading a brief Internet article, no matter how informative. However, understanding the basics can help you prepare for a qualification course, or to make better decisions for welding projects run by qualified personnel under your supervision. Always preheat or precool cast iron using the same method throughout. Changing methods can cause stress and fractures in the cast iron. These may ruin your project, or be small enough to go unnoticed until the iron fails catastrophically during normal operation. Cast iron is typically higher in carbon than steel. This makes the iron brittle, and more difficult to weld than other industrial metals.

Dimension Of The Base Frame

- Length:- 600 mm

- Width:- 500 mm
- Thickness:- 18mm
- Material used: squared metal pipe.

Assembly Procedure

The assembly of manually power washing machine involves number of steps, these are started from the frame of cycle which is the initial part of the structure:

STEP 1: The cycle frame consist of sprocket, chain, catcher, pedal, etc. With the help of Gas welding, the stand & seat is welded to the frame of cycle. The seat & stand are made of mild steel. The pedaling gear is connected to the sprocket with the help of chain.

STEP 2: The catcher contains one more gear (i.e. freewheel) of bigger diameter. The sprocket & freewheel are mounted on the same shaft, So the speed of sprocket & freewheel are same. This big gear transfer this rotary motion to the another gear which is much smaller than this gear.

STEP 3: This assembly of 4 gear with chain is known as COMPOUND GEAR SYSTEM. This small gear is coupled with washing chamber (i.e. drum) by using fasteners. In this type of arrangement, the output is much larger than the input given in the form of pedaling motion. For this there is the ratio of I/p & O/p is 1:9.

STEP 4: There are two drums are mounted on that output shaft; outer & inner drum. The inner drum contains clothes and water & it rotates in the same speed that of gear. The outer drum consists of water only & it is stationary. The inner drum rotates freely without any obstacle.

STEP 5: The metal base frame comprises of this whole arrangement. The nuts & bolts are used to fix this assembly and it gives the rigidity to the whole structure.

STEP 6: To give the aesthetic appearance to the machine, the wooden ply board is used to make the housing. This housing protects the outer drum perils of outsiders. For washing, the speed is quite low i.e. 30-40rpm & for drying, the higher speed i.e.800-900 rpm is required. This speed can be attaining by a normal woman & men.

Fig 2.1: Diagram Of Assembled Manual Washing Machine

Fig 2.2: Design Diagram Of Assembled Manual Washing Machine

2.8 Equipment Used

S/N	EQUIPMENT NAME	USES
1	Drilling Machine	It was used to drill the hole in the inner drum
2	Filling machine	It was used in filing and smoothening the body of the work
3	Grinding machine	It is used in cutting certain metals
4	Hammer	It was used in hitting metal into different shapes
5	Lathe machine	It was used to design the sprocket holder for the construction
6	Welding Machine	It is the most important machine used in the construction because it was used welding and joining metal parts
7	Spanners	It was used in tying bolt and nut of the machine

Test and results

Testing:

This machine Work tested the concept by washing 4 T-Shirts and 2 Capris constituting the weight of dry cloth approximately 2Kg. The detergent used was one of the commonly recommended detergents for washing machine. We use the water approximately 30L. The washing time was 15 min after that the detergent was drained out through valve and fresh water used to rinsed the cloth. Then clothes are dried by draining out the absorbed water for this purpose there is a need to pedal the machine at higher rpm. The capability of machine to dry out the clothes depends upon rpm. So the extent of dryness is not better than the manual squeezing of the clothes. The total washing time observed approximately 30mins. After completion of the washing cycle clothes were observed satisfactory clean. The whole exercise is equivalent to doing cycling for a period of 30min at speed of 20km/hr.

Result and Discussion

Most of the components being proposed for physical demonstration of the concepts are taken from different parts of different similar types of articles like washing machine, bicycle, stainless steel drum .So no load related calculation ate shown for their design. It is assumed that all of these components will work satisfactorily in the physical demonstration of this concept**.**

Safety Precaution during Testing

During testing the course of testing the machine the following safety precaution were noted;

1. Protective hand glove was worm before operating the machine
2. It was ensured that the machine was not load beyond the maximum allowable load it can process
3. Personal proactive equipment such as cover all and safety boot was worm before testing the machine
4. The clearance between the screw shaft and the cage was reduced in order to achieved a compressive effect

Maintenance

The frame of the machine is painted with red oxide before applying the main parts, this is to beautify the machine and also prevent corrosion of the metal of the machine always check the mounting bolt to see if there is a loosen or bolt failure to be replace worm out bolt and nuts. The different activities required to carry out to achieve an optimal performance of the design within its life spam include:

i. There should be daily inspection before production operation
ii. There should be periodic test regularly
iii. Proper monitoring of the system should not be neglected
iv. There should also be lubrication on the rotating parts of the machine
v. Production record should be kept to determine the life span and for future reference

CONCLUSION

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. This eliminates the need to order or import components just for the washing machine. The machine also uses bicycle parts for all the precision parts. These parts are very inexpensive because rural areas have a

surplus of unused bicycle parts. 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 help 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. If women in the cooperative accept and use the machines, then they will serve as spokes-people for the new machine in their local community. Their support will greatly increase the credibility of the machine so that local people will be willing to try it.

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