

To Overcome the Problem of Air during the Electricity Cut in summer by Foot Operating Paddle Fan

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Abstract – In the modern era the technology is higher, seeks into more facts of daily uses the old fashioned singer’s foot powered mechanism of sewing machine has not quiet gone out of style. Paddle fan is being designed to problem of power cut off during summer season. As it uses very less human power with higher power output makes it the best for commercial as well as domestic uses rather than hand fan. Further it will also be an exercise machine but no expensive to pay and helpful mainly for arthritis disease. This mechanism, utilizes the mechanical power to generate the electricity and it also works as a grinding machine, if grinding wheel is attached on the output shaft.

Key Words: Paddle fan, Flywheel, Pulley, Gear, Frame, Shaft, Treadle.

1. INTRODUCTION

The paddle fan is a mechanical device which runs on the basis of foot pressed treadle mechanism used in sewing treadle machine. It can run from 600 to 800 rpm. It uses very less human power and gives smooth operation. It has been designed to overcome the problem of power cut during summer seasons as new batteries per year are not affordable to all together with electricity expense. Further, it is much better than hand fan namely (pankha).

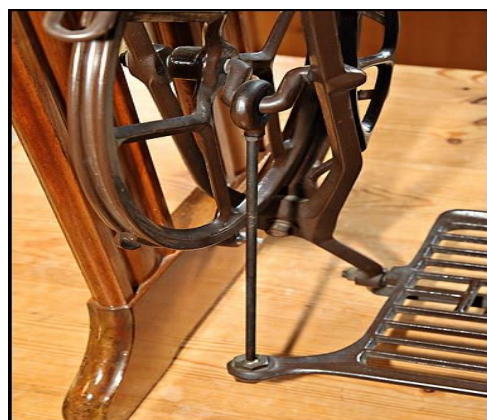


Fig. 1 Treadle mechanism of Singer’s sewing machine

2. THEORY

Paddle is operated by human feet requires maximum effort once and runs continuously for certain period due to inertia effect of paddle as well as flywheel next requires much less effort for continuous motion. Paddle is like a lever whose mechanical advantage is kept greater than one ($M.A. > 1$, & $L_1 > L_2$) with specific dimension, requires less effort and obtains much greater effective force for driving flywheel. The line of action of force is kept along the central axis of pitmen whose one end is connected to the crank and one end is connected to paddle aligned in a plane for full effort transmission.

Further fan is being designed for running up to 800 rpm, therefore a small diameter pulley will be mounted to the output shaft to achieve those rpm and driven by the rope drive through large sheave, thus motion transforms. Rotor of fan may be designed later for better CFM (discharge at cubic foot per minute). As India is a developing country, poverty is the greatest problem. The paddle fan is low cost equipment provides sufficient discharge rate with easy operation.

3. METHODOLOGY

Oscillatory motion of treadle is converted into rotational motion of flywheel (large diameter sheave) through a link (pitmen). It is similar to the power transmission from the piston to the crankshaft via connecting rod.

3.1 Components of Paddle Fan

TREADLE

A Treadle is a big paddle like a lever that tips back & forth by applying effort through human feet during sitting on chair shown in figure. This action moves a push rod (connecting rod or pitmen) up and down, which cranks a flywheel results power at main shaft.

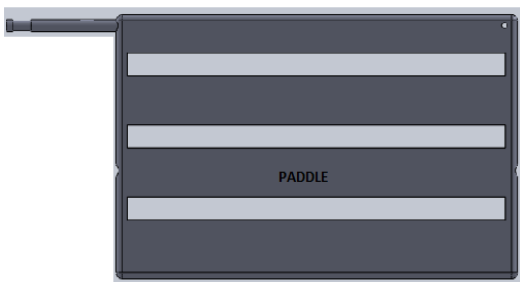


Fig 3.1 Paddle

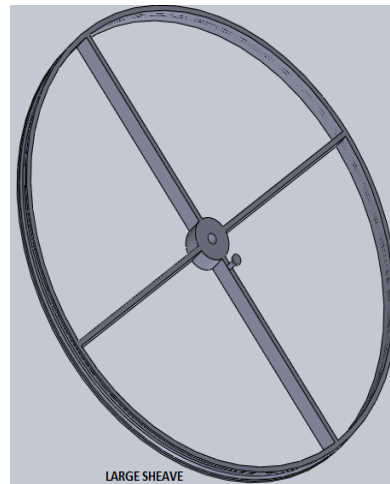


Fig. 3.3 Flywheel

FRAME

A structural component known as frame consist of some rigid cylindrical and rectangular bars well shaped and joined together through welding in accordance with design structure shown in figure.

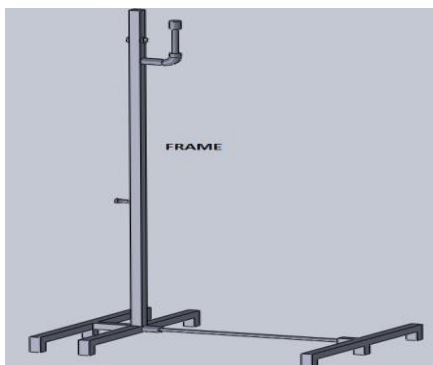


Fig. 3.2 Frame

CONNECTING ROD (PITMEN)

As in I.C. engines the reciprocating motion of piston is transmitted to crankshaft through a connecting rod, here also similar.

Power from treadle will be transferred to the flywheel by connecting a link between treadle and the flywheel known as PITMEN.



Fig. 3.4 Pitmen

FLYWHEEL

A flywheel is used to provide inertia effect. Actually it supplies uniform torque at the destination during power variations. It stores energy of excess and supplies it in recession. It is designed like a circular disc or ring.

Here, large sheave is used as a flywheel to transmit power at output shaft by a secondary small sheave.

PULLEY OR SHEAVE

This component is used to transmit power form one shaft to another shaft placed at long distances to each other. For moderate power with flat belt drive, maximum distance between two pulleys is 10metres. It is designed like a circular disc. Here it is a grooved sheave for cotton fiber rope drive. The groove for the sheave is of proper dimension.

BELT & ROPE

Belt or rope is mounted on the peripheral groove of both pulleys and their ends are cemented or laced together. It transmits power from one pulley to another pulley. Tension in the lower side (tight side) belt will be more than that in the upper side (slack side) belt.

For maximum power transmission arc of contact should be maximum between the smaller pulleys and the rope.

GEAR

A gear is a positive drive used where distance between the driver and the driven shaft is very small. A number of projections (teeth) are made on the periphery of wheel for engagement with another corresponding wheel in their recesses. It transmits power highly with exact velocity ratio. Here bevel gears may be used for multi direction flow of air.

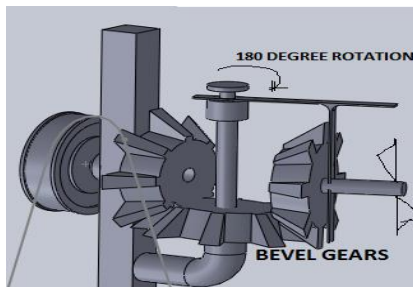


Fig. 3.5

ROTOR

A rotor consists of two components namely blades and hub. Flow ceases with approaching towards the centre of rotor, the large reduction in the speed of the blade section reduces the potential work and increases the mean blade angle. The hub allows termination of the blades at a point where they would cease to function efficiently and it prevents back flow of air at centre. The fan hub also serves a structural function in connecting the blades and imparting rotation to them.



Fig. 3.6

The angle of the blade to the plane of rotation will be small at the tip and increases as the hub approaches. The blades are joined to the hub for fluid motion is known as impeller or rotor. Lower RPM requires large number of blades and large hub's diameter & vice versa.

4. DESIGN STRUCTURE

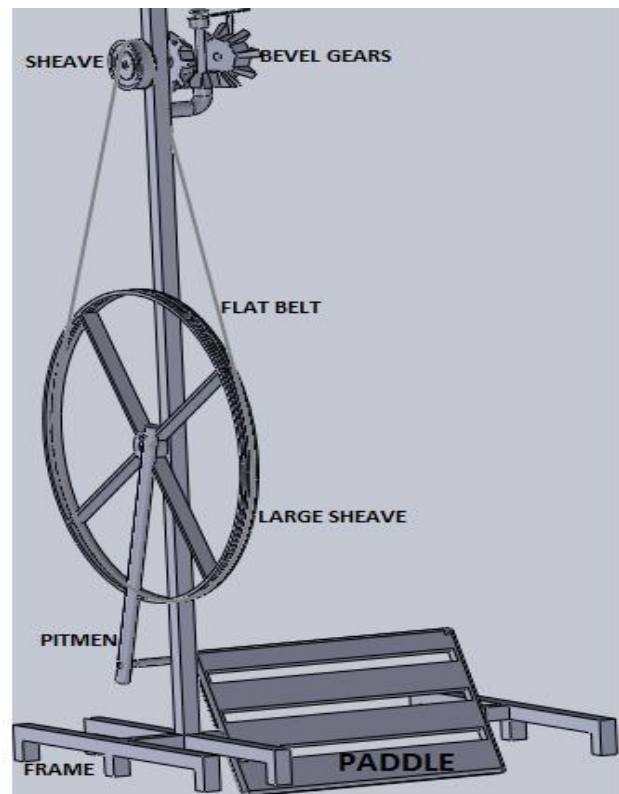


Fig. 4.1 Design Assembly

5. PERFORMANCE PARAMETERS

5.1 Paddle Effort

As earlier discussed, its operation requires less effort and mechanism optimizes the output power. So the challenge was to find out the maximum pushing effort a man can apply while sitting on a platform of average height up to .45 meters from the floor.

Maximum effort that a man can apply for pushing the treadle has taken by the use of weighing scale. As a weighing machine measures weight (mass) of the body by exerting the equal amount of resisting force by the spring of some known spring constant equalizes the weight of the body and the scale shows the corresponding measurement in kilograms.

Here the maximum effort has calculated by stretching the spring of weighing scale while sitting on the platform (chair, stool etc. with elevation up to .45 meter). Variation in load measurement was about 5 to 6 kg when pressure was exerted hardly.

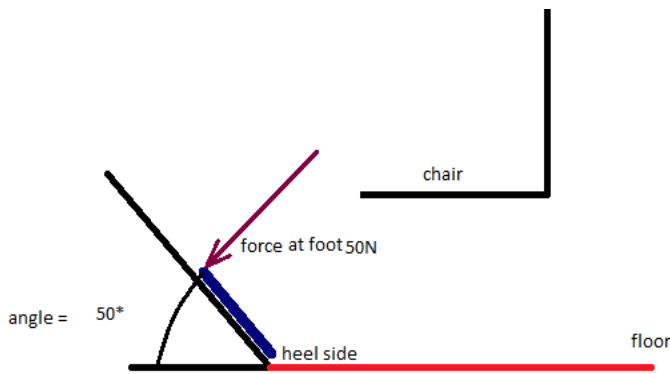


Fig. 5.1 Line diagram of foot effort

Let F be the force produced from lever then

$$F = P (L1/L2)$$

Where, P is the applied paddle effort through feet on lever arm $L1$

$$P = 5 \times 10 \text{m/s}^2 = 50\text{N}$$

$L1$ is the length of greater arm = .13 meters

$L2$ is the length of smaller arm = .09 meters

F is the produced force

Here $L1$ & $L2$ has taken by measuring the paddle of SINGER treadle mechanism which is currently used for stitching garments.

Hence, force produced $F = 50(.13/.09) = 72\text{N}$

5.2 Mechanical Advantage

Mechanical advantage is the ratio of load F to effort P .

$$\text{M.A.} = F/P = L1/L2 = 1.4$$

5.3 Leverage (L1/L2)

The ratio of arm on which, effort is applied to the arm on which effective force exerts. Here calculated leverage is 1.4.

A large force F can be exerted by a small effort P with increasing the leverage i.e., increasing $L1$ and reducing $L2$.

Accordingly, the mechanical advantage will vary in the following way:

When $L1 < L2$, mechanical advantage will be less than 1

When $L1 = L2$, mechanical advantage will be equal to 1

When $L1 > L2$, mechanical advantage will be greater than 1

5.4 Torque

During rotation, point of contact between pitman end and crank, follows a circular path whose centre will be concentric with the flywheel's centre. Radius of that circle is taken from the treadle mechanism to calculate the required torque & is 0.035m.

Torque produced $T = F \times R = 72 \times 0.035 = 2.52\text{N-m}$

Where, R is the radius of crank circle.

5.5 Velocity Ratio

Measured parameters

Diameter of large sheave $D1 = .44\text{m}$

Diameter of small sheave $D2 = .055\text{m}$

RPM at driven shaft $N2 = 700$

Then from relation $D1/D2 = N2/N1$

$N1$ becomes 88 rpm

5.6 Peripheral Velocity

V (Belt or rope)

$$V1 = V2 = \pi \times D2 \times \frac{N2}{60} = 2.01\text{m/s}$$

5.7 Centre Distance

For velocity ratio $< 3\text{m/s}$

$$C = D1 + 1.5D2 = .52\text{m}$$

5.8 Power

Power at driving shaft $P' = T \times \omega$

$$= T \times \frac{2\pi N}{60}$$

$$= 2.52 \times 2\pi \times 88 / 60 = 23.22\text{watt}$$

Where $N = 88$ rpm at flywheel, & ω is angular velocity

5.9 Fiber Rope And Sheave

Material of rope = cotton fiber

Material of pulley = cast iron

Note: design for fiber rope and sheave is done in similar way as V-belt design theorem.

5.10 Length Of Belt

Considering open V-belt drive,

$$\text{length of belt} = \frac{\pi}{2} (D1 + D2) + 2x + \frac{(D1-D2)^2}{4x} = 1.90m$$

5.11 Angle Of Contact

$$\theta = 2.38 \text{ radian}$$

5.12 Ratio Of Driving Tension For V-Belt Drive

$$T1/T2 = e^{\mu\theta \csc\beta} = 3.92$$

Where μ = coefficient of friction between cotton fiber rope and cast iron pulley = .22

θ = angle of contact between smaller pulley and rope = 2.38

β = angle of groove = 45°

$$T1 = 15.37N \text{ \& } T2 = 3.92N$$

5.13 Power Transmitted By Rope

$$P = (T1-T2) v = (15.6-3.92)2.01 = 23.01\text{watt}$$

5.14 Shaft Design

According to twisting moment

From design data book $\sigma_s = 43.2 \text{ MN}/m^2$

Shear stress $\tau = .3 \times \sigma_s = 12.96 \text{ N}/mm^2$

Twisting moment $T = \frac{\pi}{16} \tau d^3$

Diameter of shaft = 10mm

5.15 Sheave Design

$$a = 18\text{mm (measured)}$$

Diameter of rope = 7mm

$$l = 6\text{mm}$$

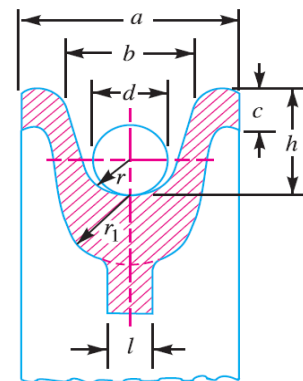
$$r = 3.71\text{mm}$$

$$r_1 = 7.7\text{mm}$$

$$b = 14.7\text{mm}$$

$$c = 2.8\text{mm}$$

$$h = 11.2\text{mm}$$



$r = 0.53 d$; $r_1 = 1.1 d$; $a = 2.7 d$; $b = 2.1 d$;
 $c = 0.4 d$; $h = 1.6 d$; $l = 0.75 d$
 (a) Wire rope sheave rim.

Fig. 5.2

6. FEATURES

- Simplest mechanism.
- Anyone can operate it (an old person, a boy, or a young guy etc.).
- It can be placed anywhere because of light weight.
- It is free from electric shocks.
- It requires very less paddle effort.
- It is capable to blow air up to 180 degrees in horizontal plane.
- It makes hand free operation.
- It can run up to 800 rpm i.e. comparable to an electric drive.

7. APPLICATIONS

- It can be used at shops, homes in ruler areas mostly.
- It can be used as an exercise machine mainly for arthritis.
- It can be used in area where electricity is not available till now.

8. FUTURE ASPECTS:

- It can be converted into cooler by making cool pad with sidewise water flow arrangement beside the rotor.
- Shaft can be coupled with dynamo to charge the battery for other uses.
- Two or three sheave may be coupled with driven sheave.
- Analysis over discharge rate.

9. CONCLUSION

- So from the above analysis of maximum paddle effort, it can be concluded that for the optimum design criterion.
- Mechanical advantage is greater than 1, & hence is also under optimum design criterion.
- Force produced is much greater than effort applied.
- Singer's concept is fully used.
- Optimal design structure.
- Required rpm achieved at driven shaft

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