© AUG 2019 | IRE Journals | Volume 3 Issue 2 | ISSN: 2456-8880

Performance Testing of Hacksaw (Pedal Power)

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Abstract - The pedal powered hacksaw machine which means operated by human effort which means by pedaling which can be used for industrial applications and household needs in which no specific input energy or power is needed. The pedaling plays a key role in creating energy which can be further transferred; this machine consists of a simple mechanism operated with chain and sprocket gear arrangement. In the mechanism, pedal is connected with the connecting rod for the process of cutting wooden blocks and polyvinylchloride (PVC) materials. Performance testing was carried out on the machine by cutting PVC pipes with different diameters. The time taken in cutting PVC pipe with three different diameters was recorded. Another performance testing was carried out on the machine by cutting wood. The time taken in cutting of wood was recorded.
Indexed Terms- pedal, powered, performance, time taken, simple mechanism

I. INTRODUCTION

With the invention of the bicycle came a veritable avalanche of pedal and machines. The bicycle influenced all aspects life: work, sports, leisure, and transportation. Errand boys, policemen, and post office workers discovered that the bicycle made them mobile or more efficient. And the sports world, which worshipped the speed of the trotter and race horse, turned to the bicycle racer, who promised undreamed-of speeds.

In energy terms the reason the bicycle is so efficient is that it uses the most powerful muscles in the body in the right motion, a circular pedaling motion, at the right speed, 60-80 revolutions per minute, and then transmits the power efficiently by means of a sprocket-and- chain mechanism and ball bearings.

II. PRINCIPLE OF PEDAL POWER HACKSAW

The principle of pedal power hacksaw is to change circulatory motion or cycling motion into translator motion with the help of metal cutting rod. This is mainly used for cutting metals and plastics. It is manually pedal powered system. If the dynamo has used it produce electricity which will be help to lighting the wok piece area when electricity is not available in mechanical workshop. A hacksaw is a fine-tooth saw with a blade under tension in a frame, used for cutting materials such as metal or plastics.

Hand-held hacksaw consist of a metal arch with a handle, usually a pistol grip, with pins for attaching a narrow disposable blade. A screw or other mechanism is used to put the thin blade under tension. It is a fine tooth hand saw with a blade under tension. It is used to cut metals and PVC pipes. It would be useful in may projects discussed on this site which used plastic pipes as materials. Blades of hacksaw are measured in TPI (Tooth Per Inch). Different TPI is needed for different jobs of cutting.

III. COMPONENTS REQUIRED FOR PEDAL POWER HACKSAW

The required components for construction of pedal power hacksaw are seat, pedal, crank, ball bearing, sprockets and chains, catcher, flywheel, shaft, hacksaw and hacksaw blades, bench vice. This model is constructed at technological university (Mawlamyine) for student mini project.

Fig 1. Constructed Model of Pedal Power Hack Saw

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

Figure 2. Seat

(b) Pedal
A bicycle pedal is the part of a bicycle that the rider pushes with their foot to propel the bicycle. Pedals are usually made of hard plastics mainly used to propel cycle or anything with the use of feet of humans. 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. Pedals 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 bearing with respect to the spindle.

Fig 3. Pedal

(c) Crank
The crank is the component of a bicycle drive train that converts the reciprocating motion of the rider's legs into rotational motion used to drive the chain or belt, which in turn drives the rear wheel. It has chain rings or chain wheels attached to the cranks, arms, or crank arms to which the pedals attach. It is connected to the rider by the pedals, to the bicycle frame by the bottom bracket, and to the rear sprocket, and freewheel is the chain.

Figure 4. Crank

(d) Bearings
A bearing is a machine element that constrains relative motion between moving parts to only the desired motion. The design of the bearing may 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 of normal forces that bear on the moving parts. Many bearings also facilitate the desired motion as much as possible, such as by minimizing friction.

(e) Types of Bearings
Bearings can be split into two groups: rolling bearings and sliding bearings.

i. Ball Bearing and Roller Bearing
A ball bearing is a type of rolling-element bearing that uses balls made up of steels or alloys to maintain the separation between the bearing races. The purpose of a ball bearing is to reduce rotational friction and support radial and axial loads of the rotating shafts. This is done by using at least two races to contain the balls and transmit the loads through the balls.

Roller bearings are a type of rolling element bearing that uses cylinders (rollers) to maintain the separation between the moving parts of the bearing. The purpose of a roller bearing is to reduce rotational friction and support radial and axial loads.

ii. Sliding Bearing
In sliding bearings, the sliding takes place along the surfaces of contact between the moving element and the fixed element. The sliding bearings in which the sliding action is guided in a straight line and carrying radial loads. It may be called slipper or guide

bearings. Such types of bearings are usually found in cross-head of steam engines.

(f) Sprockets and Chains

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

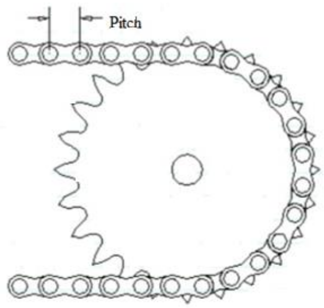

Figure 5. Sprockets and Chains

Chains have a surprising number of parts. The roller runs freely on the bushing, which is attached on each end to the inner plate. A pin passes through the bushing, and is attached at each end to the outer plate. Bicycle chains omit the bushing instead using the circular ridge formed around the pin hole of the inner plate.

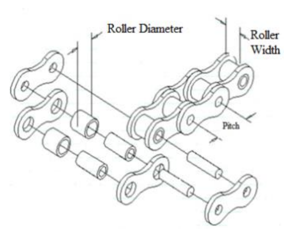

Figure 6. Chains

Sprockets should be as large as possible given the application. The larger a sprocket is, the less the working load for a given amount of transmitted power, allowing the use of smaller-pitch chain.

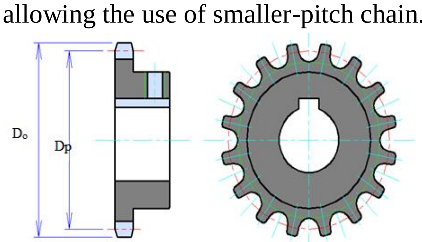

Figure 7. Sprocket

(g) Catcher

A 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.

Figure 8. Catcher

(h) Shaft

A 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. Drive shafts are carriers of torque to torsion and shear stress, equivalent to the difference between the input torque and the load.

(i) Hacksaw

A hacksaw is a fine-toothed saw, mainly used in purpose of cutting metal. Hacksaw can also be used to cut various other materials for example, plastic materials (PVC pipes and pipe fixtures) and wooden materials with them.

Hacksaw blades are metal strips having some teeth like cutting edges on one or both side of the metal strip. Such a blade is attached to the hacksaw frame to enable the cutting action.

Figure 9. Hacksaw

(i) Bench Vice

A vice is a job or work piece holding device. It is a mechanical apparatus used to secure an object to allow work to be performed on it. Vices consists two parallel jaws, one fixed and the other movable, threaded in and out by a screw and lever. Vice are generally fixed to the table or bench so as to provide necessary force for holding work piece during machining and also for reducing the vibrations generated due to machining.

Figure 10. Bench Vice

IV. DESIGN CALCULATION FOR PEDAL POWER HACKSAW

Diameter of pedal crank = 330.2 mm = 0.332 m
Cycling speed with experiment in rpm, N = 75 rpm
Weight of person, m = 50 kg
The number of teeth on larger sprocket and smaller sprocket are 48 and 16.The velocity ratio of chain drive is calculated by the following equation.

$$VR = \frac{N_1}{N_2} = \frac{T_2}{T_1}$$

(1)

where N_1 = speed of rotation of larger sprocket, rpm, N_2 = speed of rotation of smaller sprocket, rpm, T_1 = number of teeth on the larger sprocket, T_2 = number of teeth on the smaller sprocket, VR = velocity ratio
By using the datas below:
number of teeth on the larger sprocket, T_1 = 48
number of teeth on the smaller sprocket, T_2 = 16

$$VR = \frac{16}{48} = 0.33$$

(i) The Velocity of Pedal Crank
The velocity of pedal crank, V, is calculated by the following equation.

$$V = \frac{\pi D N}{60} \quad (2)$$

where D = diameter of pedal crank , m, N = speed of rotation, rpm
By using the datas below:
diameter of pedal crank, D = 0.3302 m
speed of rotation, N = 75 rpm

$$V = \frac{\pi D N}{60} = \frac{\pi \times 0.3302 \times 75}{60} = 1.29 \text{ m/s}$$

(ii) Power Rating of Simple Roller Chain
The power ranting is calculated by the following equation.

$$P_1 = F V$$

(3)

$$F = m g \quad (4)$$

P_1 = rating power, Watts, F = force by humman, N, g = acceleration due to gravity, m/s^2
By using the datas below:
weight of person, $m = 50$ kg
acceleration due to gravity, $g = 9.81 \text{m/s}^2$
velocity of rotation, $V = 1.29$m/s

$$F = m g = 50 \times 9.81 = 490.5 \text{ N}$$

$$P_1 = F V = 490.5 \times 1.29 = 0.633 \text{ kW}$$

From power rating value, chain number and speed of smaller sprocket,N_2, can be chosen. So chain number 08 B and 100 rpm for smaller sprocket are chosen.
According to Indian standard (IS: 2403 – 1991), selected values are as follow:
Pitch, $p = 12.7$ mm
Maximum roller diameter, $d_1 = 8.51$ mm
Minimum width between inner plates, $b_1 = 7.75$ mm
Breaking load, $W_b = 17.8$ kN

(iii) Calculation for Speed of Larger Sprocket
The speed of larger sprocket, N_1, is calculated from velocity ratio, VR.

$$N_1 = VR \times N_2 \quad (5)$$

where N_1 = speed of rotation of larger sprocket, rpm, N_2 = speed on the smaller sprocket, rpm
By using the following datas:
speed on the smaller sprocket,N_2 = 100 rpm, VR = 0.33

$$N_1 = VR \times N_2 = 0.33 \times 100 = 33 \text{ rpm}$$

(iv) Diameter of Sprockets
The diameter of the larger sprocket, D_1, is obtained by

$$D_1 = \frac{p}{\sin\left(\frac{180}{T_1}\right)} \quad (6)$$

where D_1 = diameter of the larger sprocket, mm, p = pitch of chain, mm,T_1 = number of teeth on larger sprocket
By using the following datas:
pitch of chain, p = 12.7 mm
number of teeth on larger sprocket, T_1 = 48

$$D_1 = \frac{p}{\sin\left(\frac{180}{T_1}\right)} = \frac{12.7}{\sin\left(\frac{180}{48}\right)} = 194.18 \text{mm}$$

Use D_1 = 196 mm.
The diameter of the smaller sprocket, D_2, is obtained by

$$D_2 = \frac{p}{\sin\left(\frac{180}{T_2}\right)} \quad (7)$$

where D_2 = Diameter of the smaller sprocket, mm, p = Pitch of chain, mm,T_2 = Number of teeth on smaller sprocket By using the following datas:
pitch of chain, p = 12.7 mm
number of teeth on smaller sprocket, T_2 = 16

$$D_2 = \frac{p}{\sin\left(\frac{180}{T_2}\right)} = \frac{12.7}{\sin\left(\frac{180}{16}\right)} = 65.09\,mm, \text{ Use } D_2 = 68\,mm$$

(v) Power Transmitted By Chain

Power transmission by chain on the basis of breaking load is given by the following equation.

$$P = \frac{W_b \times V}{n \times K_s} \quad (8)$$

where W_b = Breaking load, N , V = Velocity of chain, m/s, n = Factor of safety, K_s = Service factor

(vi) Factor of Safety for Chain Drives

Factor of safety for chain drives is defined as the ratio of breaking strength (W_b) of the chain to the load on the driving side of the chain (W). Mathematically,

$$\text{Factor of safety}, n = \frac{W_b}{W} \quad (9)$$

where n = Factory of safety, W_b = Breaking load, N ,W = Load on the chain, N

(vii) Load on the Chain

The load on chain, W, is calculated by using the following equation.

$$W = \frac{\text{Rated power}}{\text{Pitch line velocity}} = \frac{P_1}{V_2} \quad (10)$$

where, W = Load on the chain, N, P_1 = Power rating , W, V_2 = pitch line velocity or velocity of smaller sprocket, m/s

Velocity of smaller sprocket, V_2

$$V_2 = \frac{\pi \times D_2 \times N_2}{60} \quad (11)$$

By using the following datas:
Diameter of smaller sprocket, D_2 = 68 mm
speed on the smaller sprocket, N_2 = 100 rpm

$$V_2 = \frac{\pi \times D_2 \times N_2}{60}$$

$$V_2 = \frac{\pi \times 68 \times 100}{60} = 356.05 \text{ mm/s} = 0.356 \text{ m/s}$$

By using equation (10),

$$W = \frac{P_1}{V_2} = \frac{0.633}{0.356} = 1.78\,kN$$

By using equation (9),

$$\text{Factor of safety, } n = \frac{W_b}{W} = \frac{17.8}{1.78} = 10$$

(viii) Service Factor

The service factor, K_s, is the product of various factors, such as load factor, lubrication factor and rating factor. The values of these factors are taken as follows:

Load Factor, K_1= 1, for constant load
=1.25, for variable load with mild shock
= 1.5, for heavy shock loads

Lubrication factor, K_2 = 0.8, for continuous lubrication
= 1, for drop lubrication
= 1.5, for periodic lubrication

Rating factor, K_3 = 1, for 8 hours per day
= 1.25, for 16 hours per day
= 1.5, for continuous service

$$K_s = K_1 \times K_2 \times K_3 \quad (12)$$

$$K_s = 1.25 \times 1 \times 1.5 = 1.875$$

By using equation (8),

$$P = \frac{W_b \times V}{n \times K_s} = \frac{17.8 \times 0.356}{10 \times 1.875} = 0.338\,kW$$

(xi) Calculation for Length of the Chain

The length of the chain is determined by the following equation.

$$L = K \times p \quad (13)$$

where L = length of chain, mm, K = number of chain links, p = pitch of chain, mm

$$K = \frac{T_1 + T_2}{2} + 2m + \frac{\left[\operatorname{cosec}\left(\frac{180}{T_1}\right) - \operatorname{cosec}\left(\frac{180}{T_2}\right)\right]^2}{4m} \quad (14)$$

where T_1 = number of teeth on the larger sprocket, T_2 = number of teeth on the smaller sprocket

If x= m p, $m = \frac{x}{p}$

where x = center distance, mm, p = pitch of chain, mm

$$x = 30 \times p \text{ to } 50 \times p$$

Take $x = 30 \times p = 30 \times 12.7 = 381 \text{ mm}$

In order to accomodate initial sag in the chain, the value of center distance is reduced by 2 to 5 mm.

Correct center distance, $x = (30 \times p) - 4$ (15)

So, $x = (30 \times 12.7) - 4 = 377 \text{ mm}$

So $m = \frac{x}{p} = \frac{377}{12.7} = 29.69$

By using equation (14),

$$K = \frac{T_1 + T_2}{2} + 2m + \frac{\left[\operatorname{cosec}\left(\frac{180^\circ}{T_1}\right) - \operatorname{cosec}\left(\frac{180^\circ}{T_2}\right)\right]^2}{4m}$$

$$K = \frac{48+16}{2} + (2 \times 29.69) + \frac{\left[\operatorname{cosec}\left(\frac{180^\circ}{48}\right) - \operatorname{cosec}\left(\frac{180^\circ}{16}\right)\right]^2}{4 \times 29.69}$$

$$K = 92.4$$

Say K = 93

By using equation (13),

$$L = K \times p = 93 \times 12.7 = 1181.1 \text{ mm}$$

V. RESULTS AND TESTING

A. Performance Testing for PVC pipes

Table 1. Cutting depth and time taken on PVC pipes

Cutting Depth (inches)	Time (sec)
0.5 in	14
1 in	29
1.5 in	34

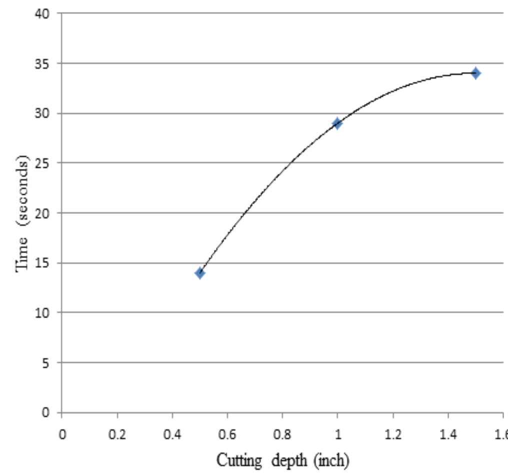

Figure 11. Graph of cutting speed against time for PVC pipes

B. Performance Testing for on Wood

Table 2. Cutting depth and time taken on wood

Cutting depth (inch)	Time (seconds)
0.8 in	26 s
1.2 in	39 s
1.5 in	60 s

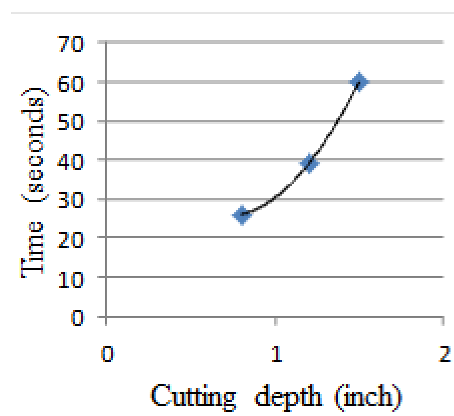

Figure 12. Graph of cutting speed against time for wood

VI. CONCLUSION

The hacksaw (pedal power) machine is tested successfully. The constructed design is a transportable one which can be used for cutting in various places. The output is verified by cutting pipes and wood with pedaling action. Since pedal driven hacksaw (PDH) uses no electric power and fuel, this is very economical and the best for small industrial applications.

VII. ACKNOWLEDGMENTS

The authors would like to thank all people who give their tremendous moral supports during our study.

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