DEVELOPMENT OF A PEDAL POWERED HACKSAW

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ABSTRACT—*Pedal Powered Hacksaw can be used for light duty cutting operations of plywood, soft-bamboo, and iron rod. This paper consists of a crank and slider mechanism. In the mechanism, pedal is directly connected to the hacksaw through crank and slider mechanism for the processing of cutting the plywood, bamboo, and iron rod. The aim is to develop a Pedal Powered hacksaw for the cutting of engineering materials for rural and urban areas when there is inadequate power supply. In order to ascertain the effectiveness of the machine, performance evaluation was carried out. The machine was tested for two different materials, which are soft bamboo and iron rod of 20mm diameter. The experimental result shows that cutting depth of about 10 mm can be obtained in 60 cutting strokes for around 60rpm; also a cutting depth of 31mm for bamboo is obtained with the same number of strokes. The results indicated that the Pedal Powered Hacksaw had given better, accurate and faster cuts when compared with hand hacksaw at different rpm. Pedal Powered Hacksaw helps to obtain less effort uniform cutting.*

Keywords- *crank, development, hacksaw, mechanism, pedal, powered, slider*

1 INTRODUCTION

Pedal powered hacksaw is a machine is used for cutting engineering materials in which there is a transfer of energy from a human source through the use of a foot pedal and crank system. Pedal powered technology (PPT) is most commonly used for transportation, and has been used to propel bicycles for over a hundred years. Pedal powered technology (PPT) can also be used to power agricultural and hand tool and even for generation of electricity. Pedal powered laptops, pedal powered grinders and pedal powered water wells are some applications. For sustainable development, "used" bicycles is converted into pedal powered tools in some third world development works. This work concentrates on pedal powered hacksaw for cutting operation. A tool that uses a hard blade or wire with an abrasive edge to cut through softer materials is known as a saw tool. The cutting edge of a saw is either a serrated blade or an abrasive one. A saw may be worked by hand, or powered by steam, water, electric or other power source. Rather than serrated blades, an abrasive saw uses an abrasive disc or band for cutting. I made use of the serrated blade. A serrated blade is a type of blade used on saw, it is also known as a dentate, saw tooth, or toothed blade.

A blade which is serrated has a cutting edge that has many small points of contact with the material being cut. Due to the fact that it has less contact area than a smooth blade, the applied pressure at each point of contact is relatively greater and the points of contact are at a sharper angle to the material being cut. This causes a cutting action that involves many small splits in the surface of the material being cut, which cumulatively serve to cut the material along the line of the blade [1]. Cuts made with a smooth blade are smoother and more precise than cuts made with serrated blade. Serrated blades can be more difficult to sharpen using a whetstone or rotary sharpener than a non-serrated; however, they can be easily sharpened with a diamond. These blades stay sharper longer than a similar straight edged blade. They also have a faster cut but a plain edge has a cleaner cut. [2].

The Pedal Powered Hacksaw is working on Slider Crank Mechanism. It is used to cut material in

small scales. Pedal powered hacksaw helps to obtain a less effort, uniform cutting. Pedal Powered Hacksaw can be used in places where electricity is not available. It is designed as portable as possible for cutting engineering materials in various Places. The main parts are hack saw, reciprocating rod welded to the pedal of a bicycle, flywheel, sprocket and chain drive, wheel and multi-utility drum. As a consequence of the brainstorming exercise, it was apparent that the primary function of pedal power one specific product was particularly useful: the bicycle. Many devices can be run right away with mechanical energy [3].

Dharwa [4], designed and developed a machine for cutting, grinding, etc which do not require electricity supply. Due to the fact that electricity is not needed, the design is ideal for use in the developing world and can be built using metal base, chain, pulley, rubber belt, grinding wheel, saw, bearing, foot pedal (operated by human), electric motor, chain socket. Linxu *et al* [5], according to a research, the testing of the generator carried out on an automatically reciprocating pedal powered electricity generator (ARPPEG) in conjunction with the management and control over harvesting the kinetic energy, electricity generation, electric storage and the output of electricity.

Subash, and Jayakaran [6], designed a Pedal operated hacksaw machine which can be used in industries and domestic areas, in where constant electricity supply is not needed. The main aim is to reduce the human effort for machining various materials such as wooden blocks, steel, PVC, etc. Girish and Parameswaramurthy [7], developed a prototype of water pumping and battery charging cross trainer which is user friendly, easy to do exercise, save and stores the energy of the users muscle efforts.

This paper is aimed at developing a pedal powered hacksaw for the cutting of engineering materials for rural and urban areas where there is lack of constant power supply.

2 MATERIALS AND METHODOLOGY

2.1 Material selection

The materials chosen for the design of the various parts of the machine such as the vice-clamp, frame body and saw blade were all well considered so as to ensure the maximum efficiency and durability of the machine. Factors such as ease of fabrication, availability and hardness of the engineering material were all considered while selecting the materials used in the fabrication of each part of the design. Steel pipe was selected for the design of the frame body of the machine, because it is readily available, and also cheap to purchase. A high speed steel (HSS) saw blade which is relatively hard was selected instead of a high carbon steel saw blade because of the thickness of the materials which the pedal powered hacksaw is meant to be cut with.

2.2 Pedal Powered Hacksaw Frame

In the fabrication of the frame, a 50mm x 25mm thick square steel pipe was used to form the frame of the pedal powered hacksaw. The steel pipes were cut and arranged by placing the handle frame stand and the seat stand 0.65m away from each other. The pipes being cut were then assembled together through electric arc welding process. The frame work was then erected on a steel pipe of 0.1m in height, which is situated at the four end corners of the frame. This serves as the main base that carries the load of the design. The length of the PDH frame is 1.23m, and width 0.35m. After achieving all these, the pedals, carrying the pedal sprocket, was then fixed in between the seat and the frame handle at a height of 0.45m from the base of the frame to determine the alignment of the transmission system.

2.3 The Transmission System

There are two intermediary shafts, the smaller shaft of length 0.1m with thickness of 10mm, and the big shaft of length 0.35m and thickness 25mm. In assembling the transmission system, the pedal sprocket of diameter 0.16m has forty teeth (40T). Two sprockets of diameter 0.08m with 18 teeth and 20 teeth respectively was coupled at both end of the smaller shaft, which is 0.4m away from the pedal sprocket. The big shaft carries a single sprocket of diameter 0.17m and forty-four teeth (44T), held on both side to the frame by a two

pillow bearing. Connected to the big shaft is a Crank (rotating disc) of diameter 0.2m and 5mm thick.

2.5 The Crank and Slider Mechanism

A connecting rod of 0.25m length which is 8mm thick connected to the rotating disc at one end, and to the saw blade frame at the other end. The hacksaw movement is guided by two flat bar of height 0.46m and thickness of 10mm.

2.6 The Hacksaw

The saw blade which we used is 0.4m in length is coupled to the hacksaw frame. A flat bar of thickness 8mm was cut and welded together to form the saw blade frame. The length of the saw-blade frame is 0.48m and height 0.19m.

2.4 Mechanical vice Clamp

A U-channel of 0.05m by 0.038m (Inner U-channel) was fitted into a 0.07m by 0.038m U-channel. A plate of 8mm thick was welded to both U-channels to form the clamp. A hole of diameter 0.015m was drilled on the plate of the inner U-channel, in which a shaft of 0.2m and 15mm thick is inserted to form the handle of the vice. The U-channel used is 0.17m long.

The pedal powered hacksaw machine is able to cut soft bamboo and iron rod of 12mm-50mm thickness. In that regard a 16" high speed steel (HSS) saw blade was used. The vice used to hold the materials being cut was strong enough to withstand the force and heat involved during the cutting process. In that regard a u-channel of 3"by1" was used as the external frame of the vice and a 2.5"by1" was used as the internal frame of the vice. The pedal powered hacksaw machine is comfortable for a man or woman of average height, (5ft -6ft) to pedal. I designed a seat of height 28" from the base frame of the machine for the comfort ability of the operator.

Theoretical Analysis of the Transmission System

(i) Pitch Circle Diameter of the Sprocket.

Let d = pitch circle diameter of the sprocket

T = number of teeth on sprocket

P = pitch of the chain

Therefore,

$P = AB = 2AO \sin(\frac{\theta}{2})$ ……..... (2.1)

$P = 2.\frac{d}{2}\sin(\frac{\theta}{2})$

$P = d.\sin(\frac{\theta}{2})$ ……..... (2.2)

Thus, the diameter, d can be evaluated from equation (2.2)

$d = P \operatorname{cosec}(\frac{\theta}{2})$

Also, $\theta = \frac{360}{T}$ … …….... (2.3)

Substituting the value of θ from equation (2.3), we get;

$d = P \operatorname{cosec}(\frac{180}{T})$ … … …….. (2.4)

$R = \frac{P}{2}\operatorname{cosec}(\frac{180}{T})$

Where R = radius of the sprocket

(ii) The Length of the Transmission Chain

From belt drive equation below, length of belt (L) is given as:

$L = \pi(R_1 + R_2) + 2x + \frac{(R_1 - R_2)^2}{x}$ ……..... (2.5)

Comparing the parameters of the pulley of a belt drive with the sprocket of chain drive,

$R_1 = \frac{P}{2}\operatorname{cosec}(\frac{180}{T_1})$ ……..…..... (2.6)

$R_2 = \frac{P}{2}\operatorname{cosec}(\frac{180}{T_2})$……..... (2.7)

$\pi(R_1 + R_2) = \frac{P}{2}(T_1 + T_2)$. [8]……. (2.8)

From equation (2.8), R_1 and R_2 can be evaluated as;

$R_1 = \frac{P(T_1 + T_2)}{2\pi} - R_2$…… (2.9)

$R_2 = \frac{P(T_1 + T_2)}{2\pi} - R_1$ …… (2.10)

$m = \frac{centre\ distance}{pitch} = \frac{x}{P}$……..... (2.11)

Where, m = the number link on the chain,

Replacing these parameters, gives;

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

[8]..... (2.12)

To Determine the Speed

Using the gear system of the sprocket,

$N_1T_1 = T_2N_2$.[8]……. (2.13)

Where N = Numbers of revolution made per minute by sprocket.

For a compound chain drive where d_1, d_2, d_3, d_4 are the pitch circle diameter of the sprockets, N_1, N_2, N_3, N_4 are the speed measured in revolution per minute and T_1, T_2, T_3, T_4, are the numbers of teeth on the sprockets. The relationship between

the input and the output speed (N_1 and N_4) is given as;

$$\frac{\text{speed of last driven}}{\text{speed of first driver}} = \frac{\text{product of diameter of drivers}}{\text{product of diameter of drivens}}$$

$$\frac{N_4}{N_1} = \frac{d_1 d_3}{d_2 d_4} \quad \text{..... (2.14)}$$

Therefore,

$$\frac{\text{speed of last driven}}{\text{speed of first driver}} = \frac{\text{product of numbers of teeth of drivers}}{\text{product of numbers of teeth of drivens}}$$

$$\frac{N_4}{N_1} = \frac{T_1 T_3}{T_2 T_4} \quad \text{..... (2.15)}$$

(iii) To Determine the Velocity of the sprocket, V

$V = w \times r$ ..... (2.16)

Where;

w = angular velocity

r = radius of pitch circle diameter of sprocket;

$$r = \frac{d}{2}$$

d = pitch circle diameter of sprocket

$$w = \frac{2\Pi N}{60} \quad \text{..... (2.17)}$$

(i) Calculating the Pitch circle diameter of sprocket using equation (2.1)

Having a standard chain of 12.7mm, the sprocket diameters are; Sprocket 1 has 40 teeth (40T)

Therefore the pitch circle diameter "d" of sprocket 1 is;

From equation (2.4),

$d = P \text{ cosec } (\frac{180}{T})$

d= 161.87mm

Also, sprocket 2 has 18 teeth (18T)

Therefore the pitch center diameter "d" of sprocket 2 is;

From equation (2.4),

$d = P \text{ cosec } (\frac{180}{T})$

d = 73.14mm

Also, sprocket 3 has 20 teeth (20T)

Therefore the pitch center diameter "d" of sprocket 3 is;

From equation (2.4),

$d = P \text{ cosec } (\frac{180}{T})$

d = 81.18mm

Also, sprocket 4 has 44 teeth (44T)

Therefore the pitch center diameter "d" of sprocket 4 is;

From equation (3.4),

$d = P \text{ cosec } (\frac{180}{T})$

d = 178.02mm

To determine the length of chain needed for each link

Using equation (2.12)

From equation (2.4),

$m = \frac{\text{center diameter}}{\text{pitch}} = \frac{x}{p}$

Approximate center distance (x) = 300mm

m =23.62

Then, using equation (2.12);

L = 974.81mm

Link B

Using equation (2.12)

From equation (2.11),

$m = \frac{\text{center diameter}}{\text{pitch}} = \frac{x}{p}$

Approximate center distance x = 180mm

L = 779.32mm.

Speed transmitted to the hacksaw

Since multiple chain drive system is being employed, then using equation 2.15

$$\frac{\text{speed of last driven}}{\text{speed of first driver}} = \frac{\text{product of numbers of teeth of drivers}}{\text{product of numbers of teeth of drivens}}$$

From equation (2.15)

$\frac{N_4}{N_1} = \frac{T_1 T_3}{T_2 T_4}$

N_4 = 30.30 rpm

To calculate the angular velocity of the driver, □□□

Using equation (2.17)

$w_{in} = \frac{2\pi N_1}{60}$

w_{in}= angular velocity of the first sprocket, (driver).$w_{in} = \frac{2 \times \pi \times 30}{60}$

w_{in}= 3.142 rad/sec

The velocity (v) of the driver,

$V = w_{in}\, r$

V = 254.30 mm/s

To calculate the angular velocity of the driven,w_{out}

$w_{out} = \frac{2\pi N_4}{60}$

w_{out}= angular velocity of the last sprocket, (driven).

$w_{out} = \frac{2 \times \pi \times 30.30}{60}$

w_{out}= 3.173 rad/sec

To get the velocity, V of the driven,

From equation (3.16)

$V = w_{out}\, r$

V = 279.66 mm/s

Fig.1 CAD aided design of Pedal Powered Hacksaw

Fig.2 Pedal Powered Hacksaw

TABLE 1
Frame parts and Sizes

Parts	Size(m)
Handle height	0.91
Seat (or saddle) height	0.71
Length of frame	1.24
Width of frame	0.36
Height of frame stand	0.1

3 RESULTS and DISCUSSION

Having completed the fabrication of the machine, the hacksaw was attached to the crank or rotating disc through the connecting rod. Several types of engineering materials were then held with the mechanical vice in turns. The machine was tested for two different materials (mild steel pipes, wood). The operator mounted on the bicycle and paddled the pedal. Consequently the following results were obtained:

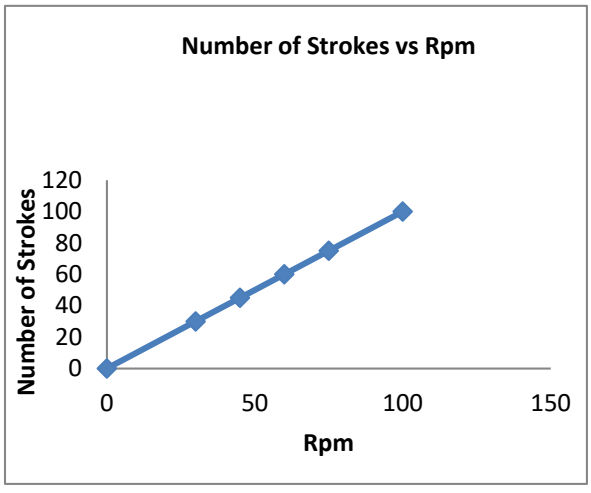

Fig.3 Variation of number of strokes with RPM

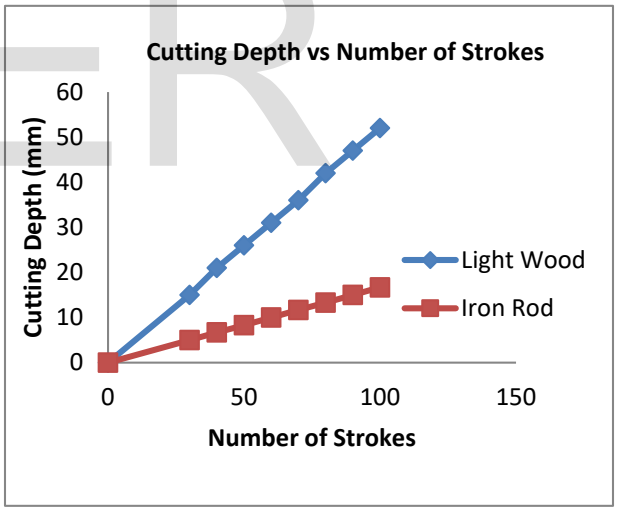

Fig.4 Variation of cutting depth with number of strokes

Since there is the problem of erratic power supply in the country, this pedal driven hacksaw is a reliable alternative to the conventional electric hacksaw. It has to be understood that in rural areas where there is problem of electricity shortage or no electricity, it is a very stressful and laborious task to perform machining operations. So the pedal driven machine, satisfies the need of rural people

by giving them an alternative way of performing machining operations such as cutting, which cost-effective and eco-friendly. The machine designed has zeroed operating Cost.

4 CONCLUSION

Thus a low cost and simple design pedal powered hacksaw machine is fabricated. This machine reduces the human effort and hence we don't need two persons to cut the wooden logs. This simple design can enhance day to day household needs and daily day to day purposes and it can be also used in for industrial applications during power shut down scenarios. By using this method we can do any operation as per our requirement without the use of electricity, so we can save the electrical power.

The ply wood can be cut without any external energy like fuel or current, therefore making it very cheap. Experimental result shows cutting depth of about 16.7 mm can be obtained in 100 cutting strokes around 100rpm. Pedal driven hack saw helps to obtain less effort uniform cutting.

4.1 Recommendations

Chain drive must be properly tensioned in order to deliver adequate torque without slipping. For speed less than 500RPM, Speeds in excess can be achieved by using larger diameter sprockets. Roller chains must be adequately tensioned otherwise chains will derail, or slip.

During testing, it was shown that, maintaining a constant pedaling speed of between 30 and 40rpm is very important for efficient use of human muscle power. Consequently, it is important on load or the feed rate to be sympathetic to the speed of the person pedaling. Overload should be avoided, as it breaks the pedaling rhythm, and usually realms in an interior and less uniform job.

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