IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 4 Ver. I (Jul. - Aug. 2015), PP 48-52
www.iosrjournals.org

Technical Study on the Design and Construction of a Pedal Powered Hacksaw Cutting Machine

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Abstract: *This project work deals with the design and fabrication of a pedal powered hacksaw cutting machine. The aim of this work is to develop a modernized and less stressful operation for cutting wood, metals and plastic materials. It is very useful for cutting PVC materials (pipes) and can be used widely in lather and in furniture making industries. This work can also serve as an exercising machine for fitness while cutting, it uses the principle of a slider crank mechanism which converts the rotary motion of the flywheel to the reciprocating motion of the hacksaw during pedaling. The machine was tested and continued to be very efficient with an ideal mechanical Advantage of 0.5 (less than 1), velocity ratio of 0.65 (less than 1), a power output of 5.72KW and an efficiency of 76.9%, which makes it very adequate and capable for cutting.*
Keywords: *pedal power, Hacksaw, reciprocating, motion.*

I. Introduction

Pedal powered Hacksaw cutting machine is a manually pedal operated system which is mainly used for cutting metals, wood and plastics.

The pedal powered hacksaw setup has a simple mechanism operated with chain and sprocket gear arrangement. During pedaling, the wheel rotary motion is converted into the “To and Fro” motion of the cutting tool (Hacksaw). That is the principle of slider crank mechanism. The size and shape is similar to a bicycle, it can be operated by very low power since it requires a very low pedaling power. The means of transmission is through a simplex chain mechanism and thus it transmits power without much loss.

The lubrication of the chain and crank arrangement is made by applying SAC 20 or SAE 30, a very high viscous lubricant. The system also uses the flywheel which reduces the fluctuations speed caused by the fluctuations of pedaling and also uniform cutting. The flywheel also serves as an energy reservoirs that stores energy when it is excess and release it when there is shortage of energy within the system.

1.2 Purpose Of The Study

The aim of this work is to design and construct a pedal driven hacksaw machine that will use a less effort pedaling power to produce uniform cutting of PVC pipes, metals, wood and as the same time serve as an exercising machine for fitness. it is also done to show the performance difference between hand driven and pedal driven hacksaw.

1.3 Benefit Of Study

This work is design to overcome the stress attached to hand cutting of engineering materials by turning it into an exercise for body fitness.

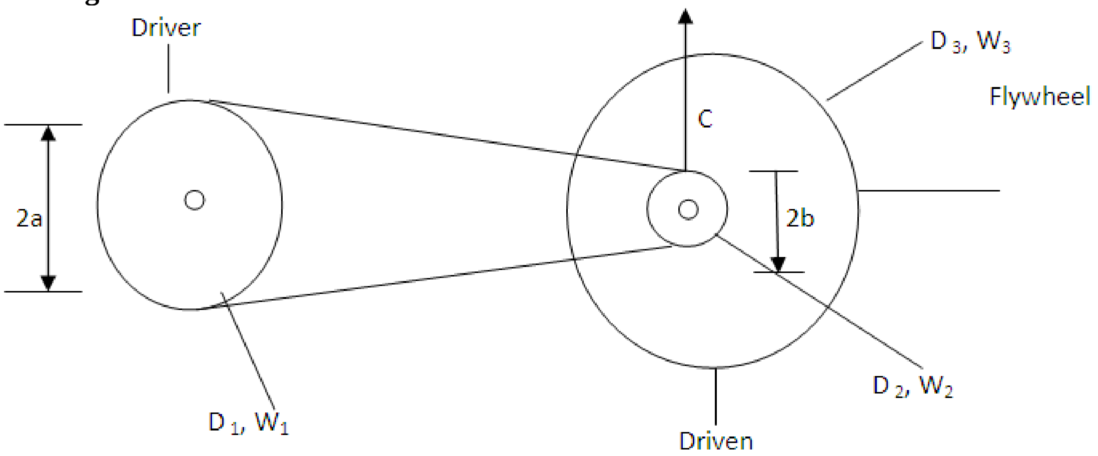
1.4 Limitation Of The Machine

- Not fit for heavy production
- It is totally manually operated
- Time consuming as compared to electrical powered hacksaw machines.
- Without human effort it cannot be operated.

II. Design Analysis

2.1 Design Data: Human energy expended say 70Kg (150 1b) person: for cycling @ 15Km/hr (16-24Km/h)=1.62KJ/Kg, the average cycling speed = 15.5km/h. (Stephen, Tambari; Ibor, Benjamin (2014) the cycling speed in r. p. m = 120 rpm (Faruk Yildiz, 2009)

2.2 Design Calculations



The block diagram representation of speed ratio of the system.

$W_2 = W_3$

The ideal Mechanical Advantage (IMA) = $\frac{D_{Driven}}{D_{Driver}}$

$\Rightarrow IMA = \frac{D_{Driven}}{D_{Driver}} = \frac{W_{IN}}{W_{OUT}}$

Where: D_{Driven} = Diameter of driven sprocket = D_2

D_{Driver} = Diameter of driver sprocket = D_1

W_{IN} = Input rotational velocity of wheel = W_1

W_{out} = Output rotational velocity of wheel = W_2

And, $IMA_{Total} = IMA_1$

Also $IMA_{Total} = \frac{W_{IN}}{W_{out}}$

So, using the datas below:

Sprocket 1, Driver(D1) = 210mm

Sprocket 2, Driven(D2) = 105mm

Flywheel Diameter (D3) = 310mm

No. of Teeth of D1 = TN1=35

No. of Teeth of D2 = TN2 = 28

$IMA_1 = \frac{D2}{DI} = \frac{105}{210} = 0.5$ = IMA TOAL

Which is less than 1.

So, using N_{IN} = 120 RPM (Faruk Yildiz, 2009)

$\Rightarrow W_{IN} = \frac{2\pi Nin}{60} = \frac{2x3.142x120}{60} = 12.568$ rad/s

$IMA_{Total} = \frac{W_{IN}}{W_{out}}$

$\Rightarrow W_{out} = \frac{Win}{IMA_{Total}} = \frac{12.568}{0.5} = 25.14$ rad/s

:. W_{out} = 25.14rad/s

:. The output rotational speed of the flywheel = 25.14 rad/s

$\Rightarrow$The power output, P =FC X V

Where F_C = centrifugal force on the flywheel.

and V = Linear Velocity

but V = W_{out} x where r = radius of flywheel.

So, using the weight of an average man say 60-75kg and 15kg mass of flywheel

But flywheel radius = $\left(\frac{D3}{2X100}\right)$ metres = $\left(\frac{310}{2X100}\right)$ m

= 0.155m

= 155m

⇒V = 25.14 X 0.15

= 3.89M/S

and

FC = mrw^2

=15x0.155 x 25.14^2

= 1469.45N

= I.469KN

:. The power, P = F_C x V = 1469.45x3.89

= 5716.14W

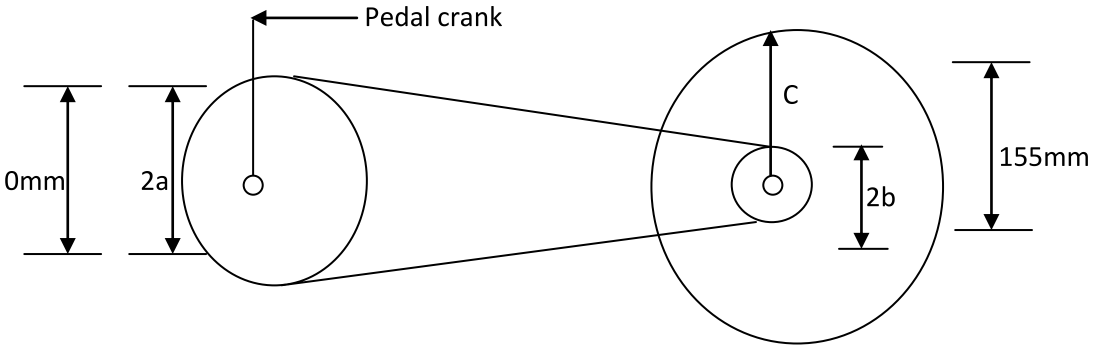
= 5.72KW

:. The Torque, T = F_C x V = 1469.45 x 0.155

= 227.76Nm

= 0.228KNm

Velocity Ratio



V.R = $\frac{\text{effort distance}}{\text{load distance}}$ = $\frac{\text{length of crank pedal}}{\text{hacksaw cutting stoke}}$

= $\frac{\text{100mm}}{\text{radius of flywheel}}$ = $\frac{100}{155}$ = 0.65

:. V.R = 0.65 which is less than 1.

Efficiency Of The Machine

Efficiency = $\frac{M.A}{V.R}$ = $\frac{IMA}{V.R}$ x 100%

Where I.M.A = Ideal Mechanical Advantage

= 0.5 (as calculate earlier)

:. Efficiency = $\frac{0.5}{0.65}$ x 100%

= 76.9%

III. Results And Discussion

The machine was tested for three different materials (mild steel pipes, wood and plastic pipes). The ideal mechanical advantage of 0.5, power output of 5.72KW and efficiency of 76.9% makes it very adequate and efficient as a useful machine for exercise and as a cutting machined compared to the existing ones.

IV. Recommendations

(1) Farm implements or small machines can be driven at speeds up to 800RPM using this pedal powered machine. High speeds (500 – 800RMP) can be achieved by using chain drive or V – belt that must be properly tensioned in order to deliver adequate torque without slipping.
(2) For speed less than 500RPM, and especially for very high torque applications such as grinding, roller - chain drivers are recommended. Speeds in excess of 800RPM can be achieved by using larger diameter pulleys.
(3) V – belts or roller chains must be adequately tensioned, otherwise chains will derail, and belts will slip.
(4) Flywheels are often helpful because they store energy. For metal cutting and grinding of grains, the use of flywheel is recommended.
(5) 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 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.

(6) The seat should be adjusted to permit full extension of the legs during pedaling.
(7) It is important to choose pulleys and sprockets that sized to create drive ratios which enable the operator to maintain the desired pedaling speed (usually about 50 – 60RPM).

V. Conclusion

At the end of the design, construction and testing, a satisfactory pedal powered hacksaw machine having Ideal Mechanical Advantage of 0.4 and a power output of 30KW was fabricated using available raw materials and techniques. Metals pipes, plastics and pieces of wood were cut successfully using this machine and the overall performance was confirmed to be efficient compared to already existing ones. The cost of production and maintenance is relatively cheap. Hence, the machine will be welcomed by industries given its performance, affordability and simplicity.

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