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Research Article

Design and Fabrication of Pedal Powered Circular Saw for Wood Working Applications

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Abstract

In this paper, Pedal operated circular saw machine which can be used for industrial applications and household needs is fabricated. It does not requires any specific input energy or electric power. The objective of this model is using the conventional mechanical process which plays a vital role. This project consists of a larger sprocket which rotates with a help of human powered pedal. The smaller sprocket is connected to the plane which is mutually perpendicular to the axis of the larger sprocket is made rotated by using chain drive. The smaller sprocket is rigidly supported by means of shaft and bearing support. The circular saw is mounted on the same shaft where the smaller sprocket is mounted. When the pedal is operated, circular saw rotated which in turn cuts the wooden block material. The main aim is to reduce the human effort for machining various materials such as wooden blocks etc. The power circular saw machine, which runs on human power, works on the principle of the conversion of rotational motion in a mutually perpendicular axis. Importance of this paper lies in the very fact that it is green project and helps us to reduce our electricity need too. Secondly, this cutter can be used and transferred to our working place easily. Moreover, if needed we can generate electricity with our project by connecting it to dynamo, diode and battery.

Keywords: *Frame, Circular Saw, Pedal, Shaft, Chain Drive, Bearing, Power generation*

1. Introduction

Pedal power is the transfer of energy from a human source through the use of a foot pedal and crank system. This technology is most commonly used for transportation and has been used to propel bicycles for over a hundred years. Less commonly pedal power is used to power agricultural and hand tools and even to generate electricity. Some applications include pedal powered laptops, pedal powered grinders and pedal powered water wells. Some third world development projects currently transform used bicycles into pedal powered tools for sustainable development. This project concentrates on pedal powered hacksaw machining.

An individual can generate four times more power by pedaling than by hand-cranking. At the rate of ¼ HP, continuous pedaling can be served for only short periods, approximately 10 minutes. However, pedaling at half this power (1/8 HP) can be sustained for close to 60 minutes but power capability can depend upon age. 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.

A saw is a tool that uses a hard blade or wire with an abrasive edge to cut through softer materials. The cutting edge of a saw is either a serrated blade or an abrasive. A saw may be worked by hand, or powered by steam, water, electric or other power. An abrasive saw uses an abrasive disc or band for cutting, rather than a serrated blade.

2. Pedal power circular saw

The principle of pedal power Circular saw is to change circulatory motion or cycling motion into translatory motion with the help of metal cutting rod. This is mainly used for cutting metals and plastics. It is manually pedal operated system.

If we use dynamo then we can produce electricity which will be help to lighting the work piece area when electricity is not available in mechanical workshop.

A Circular saw is a fine-tooth saw with a blade under tension in a frame, used for cutting materials such as metal or plastics.

Hand-held Circular saws 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 Poly vinyl chloride pipes. It would be useful in many projects discussed on

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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.

There are three types of saw

- Simple Circular saw which can be used for hand cutting things.
- Small Electrically Hacksaw for personal uses.
- Large Cutter Machines used for Industrial Purposes.

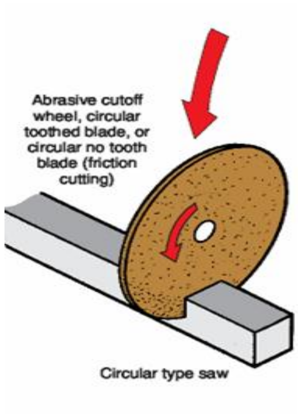


Figure 2 Pedal power circular saw cutting system

3. A reciprocating power circular saw

Definite pressure feed-yields a pressure on the blade that is uniform regardless of the number of teeth in contact with the work. The depth of the cut varies with the number of teeth contacting the work. This condition prevails with gravity feed

Feed can be adjusted to meet varying conditions. For best performance, the blade and feed must be selected to permit high-speed cutting and heavy feed pressure with minimum blade bending and breakage.

Standard circular metal cutting saws are available in sizes from diameter 150mm to 630mm or 5-1/2 to 7-1/4 inches. The saws can be fitted with many accessories, including quick-acting vises, power stock feed, power clamping of work, and automatic cycling of the cutting operation. In latter it moves and work out for the required distance, clamps it, and makes the cut automatically. The cycle is repeated upon completion of the cut.

High-speed cutting requires use of a coolant. Coolant reduces friction, increases blade life, and prevents chip-clogged teeth. Cast iron and some brass alloys, unlike most materials, do not require coolant.

4. Selecting a power circular saw blade

Proper blade selection is important. Use the three-tooth rule at least three teeth must be in con-tact with the work .Large sections and soft materials require a coarse-tooth blade. Small or thin work and hard materials require a fine-tooth blade.

For best cutting action, apply heavy feed pressure on hard materials and large work. Use light feed pressure on soft materials and work with small cross sections.

Blades are made in two principal types flexible-back and all-hard. The choice depends upon use.

- Flexible-back blades - should be used where safety requirements demand a shatter proof blade. These blades should also be used for cutting odd-shaped work if there is a possibility of the work coming loose in the vise.
- All-hard blade - For a majority of cutting jobs, the all-hard blade is best for straight, accurate cutting under a variety of conditions.
- Blades are also made from tungsten and molybdenum steels, and with tungsten carbide teeth on steel alloy backs.

The following rule-of-thumb can be followed for selecting the correct blade:

- Use 10- and 14-tooth blades primarily on light duty machines where work is limited to small sections requiring moderate or light feed pressure.
- Use a 4-tooth blade for cutting large sections or readily machined metals.
- Use 10- and 14-tooth blades primarily on light duty machines where work is limited to small sections requiring moderate or light feed pressure.

5. Mounting of power circular saw blade

The blade must be rigidly mounted on the shaft where the smaller sprocket is connected. The blade must also lie perfectly flat against the mounting shaft. If long life and accurate cuts are to be achieved, the blade must be properly tensioned.

Many techniques have been developed for properly mounting and tensioning blades. If the information (proper torque for a given blade on a given machine) is not available, the following methods can be used:

- Tighten the blade until a low musical ring is heard when the blade is tapped lightly. A high- pitched tone indicates that the blade is too tight. A dull thud means the blade is too loose.
- The shape of the blade pin hole can serve as an indicator of whether the blade is tensioned properly. When proper tension is achieved, the pin holes will become slightly elongated.
- Blade will become more firmly seated after the first few cuts and will stretch slightly. The blade will require re tensioning (retightening) before further cutting can be done.

6. 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 cyclists' foot or shoe and the crank allowing the leg to turn the bottom bracket spindle and propel the bicycle's wheels.

Figure 6 Pedal

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 bearings with respect to the spindle.

7. Stand setup parts

Stands are introduced to immobilize the apparatus. Various components used are fixed to this arrangement. The chassis of the bicycle is used as the stand setup parts.

The stand described below is designed to support most bicycles.

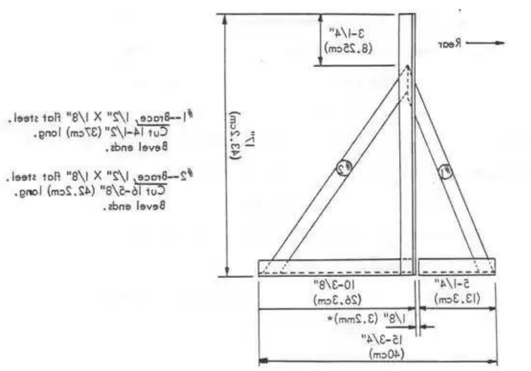


Figure 7 Stand Setup

8. Bicycle seat

Figure 8 Bicycle seat

A bicycle seat, unlike a bicycle saddle, is designed to support the rider's buttocks and back, usually in a semi-reclined position. Arthur Graford is credited with inventing the padded bicycle seat in 1892, and they are now usually found on recumbent bicycles.

Material	High carbon steel
Pitch	12.7mm
Width	30mm
Teeth	16
Balls	High carbon high chromium steel

Bicycle seats come in three main styles; mesh, hard shell and combination

9. Mesh

A typical mesh seat consists of a metal frame with mesh stretched over it and secured with adjustable straps, zip ties, string or shock cord.

10. Hardshell

Hard shell seats are normally made of a composite material such as GRP or carbon fiber although metal and wood versions do exist. A hard-shell seat is normally covered with some-form of padding, this is usually closed or open cell foam although some extreme racing machines do not have any padding on the seat to reduce weight and increase efficiency. Hard-shell seats are generally used at more reclined angles than mesh seats.

11. Combination

A combination seat has a padded hard seat base with a mesh back

12. Sprocket pinion

Sprocket is the major component of this system because it is power transmitting device. It gets power from the chain drive and make this system to work. It is the device which transmits the linear motion of meshing chain drive into rotary motion by means of the tooth found on it. The sprocket with ball bearing is said to be free wheel.

Figure 12 Sprocket Pinion

Since it is a free wheel it allows toothed part to rotate free from central position in a direction. Hence this type of sprocket is used as rear power transmission device in by cycle that makes the wheel to rotate and also allows toothed area to rotate in anticlockwise when pedaled anti clockwise directions. This actions of sprocket allows attached lifting lever to adjust freely automatically or manually when it does not engage with pushing lever properly.

Since the sprocket transmits the power from chain drive, it should have the capability to withstand the heavy loads of engine. So to withstand those impacts on toothed area, it's made of high carbon steel. The ball bearings are made up of high chromium steel. Hence all these material gives following properties for sprocket.

- Heavy duty
- Smooth running
- Tempered
- Long life

Hence the sprocket is considered as heart of this system

13. Circular saw

A circular saw is a power-saw using a toothed or abrasive disc or blade to cut different materials using a rotary motion spinning around an arbour. A whole saw and ring saw also use a rotary motion but are different from a circular saw. Circular saws may also be loosely used for the blade itself. Circular saws were invented in the late 18th century and were in common use in sawmills.

A circular saw is a tool for cutting many materials such as wood, masonry, plastic, or metal and may be hand-held or mounted to a machine. In woodworking the term circular saw refers specifically to the hand-held type and the table saw and chop saw are other common forms of circular saws. Skill saw has become a generic trademark for conventional hand-held circular saws. Circular saw blades are specially designed for each particular material they are intended to cut and in cutting wood are specifically designed for making rip-cuts, cross-cuts, or a combination of both. Circular saws are commonly powered by electricity, but may be powered by a gasoline engine or a hydraulic motor which allows it to be fastened to heavy equipment, eliminating the need for a separate energy source.

Typically, the material to be cut is securely clamped or held in a vise, and the saw is advanced slowly across it. In variants such as the table saw, the saw is fixed and the material to be cut is slowly moved into the saw blade. As each tooth in the blade strikes the material, it makes a small chip. The teeth guide the chip out of the work piece, preventing it from binding the blade.

- Cutting is by teeth on the edge of a metal blade or by an abrasive wheel
- The cut has narrow kerf and relatively smooth surface finish
- Cuts are straight and relatively accurate
- The saw usually leaves burrs on the cut edge of metal and plastic (which should then be addressed with sand paper)
- Saw setting should be done geometrically.

14. Hand held circular saw

In woodworking the term circular saw is most commonly used to refer to a hand-held, electric circular saw designed for cutting wood, but may be used for cutting other materials with different blades. Circular saws can be either left or right-handed, depending on the side of the blade where the motor sits. A left-handed saw is typically easier to use if held in the right hand, and contrariwise for the right-handed saw, because the user does not need to lean across the saw to see the cutting line.

Blades for cutting wood are almost universally tungsten carbide tipped (TCT), but high speed steel (HSS) blades are also available. The saw base can be adjusted for depth of cut and can tilt up to 45° and sometimes 50° in relation to the blade. Adjusting the depth of cut helps minimize kickback. Different diameter blades are matched to each saw and are available ranging from 14 centimeter's (5.5 in) to 61 centimeter's (24 in).

The saw can be designed for the blade to mount directly to the motor's driveshaft known colloquially as a sidewinder, or be driven indirectly by a perpendicularly mounted motor via worm gears, garnering considerably higher torque called a worm-drive saw.

The worm-drive portable circular saw was invented in 1923 by Edmond Michel. In 1924 Michel formed a partnership with Joseph Sullivan, and together they started the Michel Electric Handsaw Company, with the sole purpose of manufacturing and marketing the saw invented by Michel. The company later renamed itself Skilsaw Inc., which today is a subsidiary of Robert Bosch GmbH. Portable circular saws are often still called Skilsaws or Skil saws. Its successor is still sold by Skil as the model 77. To get around the Skil patents, Art Emmons of Porter-Cable invented the direct-drive sidewinder saw in 1928. Recently smaller cordless circular saws with rechargeable batteries have become popular.

15. Working principle

It consists of the pedal arrangement which rotates the larger sprocket in which the power is transmitted to the smaller sprocket. This mechanism is used to rotate the shaft connected to the smaller sprocket which is having an extended rod connected to the circular saw directly by means of a bearing support. The circular saw is mounted on the shaft by means of maintaining the cutting axis. As the user operated the pedal, the circular saw cuts the various materials automatically with less power.

This project consists of a larger sprocket which rotates with a help of human powered pedal. The smaller sprocket is connected to the plane which is mutually perpendicular to the axis of the larger sprocket is made rotated by using chain drive. The smaller sprocket is rigidly supported by means of shaft and bearing support. The circular saw is mounted on the same shaft where the smaller sprocket is mounted. When the pedal is operated, circular saw rotated which in turn cuts the wooden block and Poly Vinyl Chloride material. The main aim is to reduce the human effort for machining various materials such as wooden blocks and Poly Vinyl Chloride etc. The power circular saw machine which runs on human power, works on the principle of the conversion of rotational motion in a mutually perpendicular axis. Importance of this project lies in the very fact that it is green project and helps us to reduce our electricity need too. Secondly, this cutter can be used and transferred to our working place easily. Moreover, if needed we can generate electricity with our project by connecting it to dynamo, diode and battery.

16. Design consideration

When designing our attachment, the following considerations were taken into account

- The device should be suitable for local manufacturing capabilities.
- The attachment should employ low-cost materials and manufacturing methods.
- It should be accessible and affordable by low-income groups, and should fulfill their basic need for mechanical power.
- It should be simple to manufacture, operate, maintain and repair.
- It should be as multi-purpose as possible, providing power for various agricultural implements and for small machines used in rural industry.
- It should make use of standard bicycle parts wherever possible.
- Though the device should be easy to take off the bicycle, it is assumed that it would usually remain attached to facilitate readiness and ease of transport from site to site. The device, therefore, should not interfere with the bicycle's transportation mode.
- The broad stand, which provides stability during power production mode, can be flipped upward during the transport mode. This stand/carrier would be a permanent fixture of the dual- purpose bicycle.
- The power take-off mechanism should be as efficient as possible, and should develop relatively high r.p.m. (close to 200) for versatility of application. We had seen designs for devices that take power from the rear tire by means of a friction roller pressed against it, but we had doubts about the efficiency of this arrangement. In order to improve efficiency we used hard bearing surfaces such as roller chains, sprockets and ball bearings. We decided that the most appropriate location for this power take-off mechanism would be at the front of the bike near the fork tube.
- Care must be exercised to insure that the power take-off assembly is far enough forward so as not to interfere with pedaling. Most standard adult bicycle frames have plenty of room for the power take-off mechanism and pulley. Power is supplied to the shaft by means of a chain from the bike's chain wheel (crank) to a ratcheted sprocket on the shaft.
- The device should contain a ratcheting mechanism that would let the operator coast periodically to rest and conserve energy. A free wheel from any bicycle can be easily adapted for this purpose.
- Excessive weight should be avoided, as durability is a prime consideration.

17. Design calculation

Design of Chain Drive

Maximum Speed N_1=3000 rpm
Minimum Speed N_2=1500 rpm
Centre Distance a*=560 mm

Step1: Calculation of Speed ratio

Speed ratio i = Maximum Speed/Minimum Speed

$i = N_1/N_2$

$= 3000/1500$

$\mathbf{i = 2}$

Step2: Calculation of Number of Teeth

From PSG Data Book Page No: 7.74

$\mathbf{Z_1 = 25}$

$Z_2 = i*Z_1$

$= 2*25$

$\mathbf{Z_2 = 50}$

Step3: Calculation of Pitch Value P

From PSG Data Book Page No: 7.74

A = 30P

560 = 30P

Pitch P = 18.67 mm

A = 50P

560 = 50P

Pitch P = 11.2 mm

Ranges from 11.2 to 18.67

Step4: Selection of Chain

From PSG Data Book Page No: 7.72

Based on Pitch Value we selected **'R50'**

Step5: Calculation of Total Load

From PSG Data Book Page No: 7.78

Total Load $\Sigma_p = P_t+P_c+P_s$

Tangential Force P_t= 102*N/V

From PSG Data Book Page No: 7.77

Power N = $\sigma AV/10^2*K_S$

Stress = 1.85*9.81/10^-6

Stress = 18.15*10^6 N/mm²

From PSG Data Book Page No: 7.72

Bearing Area A = 0.7 cm^2

= 0.7*10^-4

A = 7*10^-5 m²

Chain Velocity V = $P*Z_1*N_1/60$

= 15.875*10^-3*25*3000/60

V = 19.84 m/s

From PSG Data Book Page No: 7.77

Service Factor K_s = $K_1*K_2*K_3*K_4*K_5*K_6$

Constant Load K_1 = 1.0

Fixed Centre Distance

K_2 = 1.25

a_p = 30to 50P

K_3 = 1

Position up to 60̊

K_4 = 1

Drop Lubrication

K_5 = 1.0

Single Shift K_6 = 1.0

K_s = 1.25

Power

N = (18.56*10^6)*(7*10^-5) *19.84/10^2*1.25

Power N = 988 kW

Tangential Force P_t= 10^2*988/19.84

= 5079.43 kgf

P_t = 49.82 kN

Tension due to Sagging of Chain

P_s = K*w*a

From PSG Data Book Page No: 7.78

Coefficient of Sag K= 6

From PSG Data Book Page No: 7.72

Weight per meter w = 1.01 kgf

W = 9.91 N

Tension due to Sagging

P_s = 6*9.91*0.56

= 33.29 kgf

P_s = 326.64 N

Centrifugal Tension

P_c = $w*v^2/g$

= $9.91*19.84^2/9.81$

= 397.63 kgf

P_c = 3.9 kN

Total Load Σ_p= $P_t+P_s+P_c$

= (49.82*10^3) +326.64+ (3.9*10^3)

Σ_p = 54.05 kN

Step6: Calculation of Design Load

Design Load = Σ_p*K_s

= (54.05*10^3)*1.25

Design load = 67.56 kN

Step7: Calculation of Factor of Safety FSw

FSw = Breaking Load/Design Load

From PSG Data Book Page No: 7.72

Breaking Load

Q = 2220 kgf

= 2220*9.81

= 21.77 kN

FSw = 21.77/67.56

FSw = 0.32

Step8: Calculation of σ_{roller}

σ_{roller} = Σ_p*K_S/A

= (54.05*10^3)*1.25/ (7*10^-5)

σ_{roller} = 965.17*10^6 N/m²

Step9: Calculation of Chain Length

From PSG Data Book Page No: 7.75

Length of Chain = l_p*P

Length of Continuous Chain in Multiple of Pitches

l_p = $2a_p+ (Z_1+Z_2/2) + ((Z_2-Z_1/2Л)^2/a_p)$

Approximate Centre Distance

a_p = a*/P

= 560/15.875

a_p = 35.27

l_p = $(2*35.27) + (25+50/2) + ((50-25/2Л)^2/35.27)$

l_p = 108.05 mm

Length of Chain L = 108.05*15.875

L = 1.72 m

Step10: Exact Centre Distance

Centre Distance a = $(e+\sqrt{(e^2-8m)})*P/4$

e = $l_p-(Z_1+Z_2/2)$

= 108.05-(25+50/2)

e = 70.55 mm

m = $(Z_2-Z_1/2Л)^2$

= $(50-25/2Л)^2$

m = 15.83

Centre Distance a =70.55+($\sqrt{}70.55^2$-(8*15.85))*15.875/4

a = 557.93 mm

Step11: Calculation of Sprocket Diameter

d_1 = $P/\sin(180/Z_1)$

= 15.875/sin (180/25)

d_1 = 126.66 mm

d_{01} = $d_1+0.8d_r$

= 126.66+ (0.8*10.16)

d_{01}= 134.78 mm

d_2 = $P/\sin(180/Z_2)$

= 15.875/sin (180/50)

d_2 = 252.82 mm

d_{02} = $d_2+0.8d_r$

= 252.82+ (0.8*10.16)

d_{02}=260.94 mm

Design of Ball Bearing

Axial Load F_a = 1000 N

Radial Load F_r = 1500 N

Speed N = 1500 rpm

Life in hours = 15000 hrs

Step1: Calculation of Radial and Axial Force

Axial Load F_a = 1000 N

Radial Load F_r = 1500 N

Step2: Calculation of F_a/F_r

Axial Load/Radial Load

= F_a/F_r

= 1000/1500

= **0.667**

Step3: Selection of Bearing

From PSG Data Book Page No: 4.13

Speed N = 1500 rpm

Bearing of Basic Dimension, **'SKF 6236'**

Step4: Calculation of Static and Dynamic Load Carrying Capacity

From PSG Data Book Page No: 4.13

For 'SKF 6236'

Static Load Rating C* = 204000 N

Dynamic Load Rating C= 76000 N

Step5: Calculation of F_a/C^* ratio

Axial Load /Static Load Rating

$= F_a/C^*$

$= 1000/204000$

$= \mathbf{0.0049}$

Step6: Selection of e Value

From PSG Data Book Page No: 4.4

e = 0.22

Step7: Selection of Radial Load Factor and Thrust Load Factor

From PSG Data Book Page No: 4.4

Radial Load Factor X = 0.56

Thrust Load Factor Y = 2

Step8: Selection of Service Factor

From PSG Data Book Page No: 4.2

Rotatory Machine with No Impact

Service Factor S = 1.5

Step9: Calculation of Equivalent Load P

From PSG Data Book Page No: 4.2

Load P = (X*F+Y*F) S

= (0.56*1500+2*1000)1.5

Load P = 4260 N

Step10: Selection of C/P ratio

From PSG Data Book Page No: 4.6

C/P = 11.5

C = 11.5*P

= 11.5*4260

C = 48990 N

Step11: Check for Selected Bearing

Calculated C Value= 48990N

Standard C Value = 176000N

Selected Bearing 'SKF 6236'

Design is Safe

Step12: Calculated of Expected Life in hours

Expected Life L = $60nL_n/10^6$

= 60*1500*15000/10^6

L = 1350 million revolution

Design of Shaft

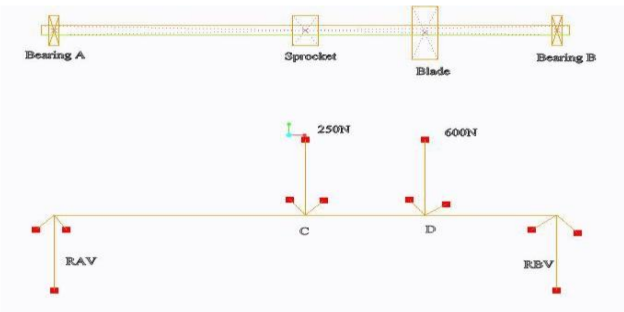
Load of Sprocket = 250 N

Load of Blade = 600 N

Length between Bearing = 1240 mm

Length between Sprocket and Bearing = 620 mm

Length from Blade to Sprocket = 310 mm



Step1: Vertical Bending Moment Diagram

R_{BV}*1240-(600*930)-(250*620) = 0

R_{BV} = 575 N

$R_{AV}+R_{BV}$ = 250+600

R_{AV}+575 = 850 N

R_{AV} = 275 N

Bending Moment at B

= 0 Nmm

Bending Moment at D

= 575*310

= 1.75*10^5 Nmm

Bending Moment at C

= (575*620)-(620*310)

= 1.70*10^5 Nmm

Bending Moment at A

= 0 Nmm

Maximum Bending Moment

= 1.78*10^5 Nmm

$m_e = (Л/32)*\sigma_b*d^3$

$1.78*10^5 = (Л/32)*2*40*d^3$

d = 28.22 mm

d = 30 mm (approximately)

Since bearing diameter 30mm is not available, next standard diameter 32mm is used in our project

18. Base frame

Plan view of frame in support position. All pieces 3/4 (19mm) steel angle.

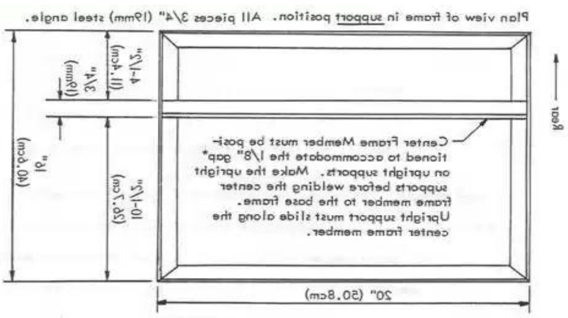


Figure 18 Base Assembly

19. Upright support assembly

Make two pieces of upright supports: one as shown and another one a reflection of the one shown below. All pieces are made of 3/4 (19mm) steel angle, unless specified otherwise. Weld all joints.

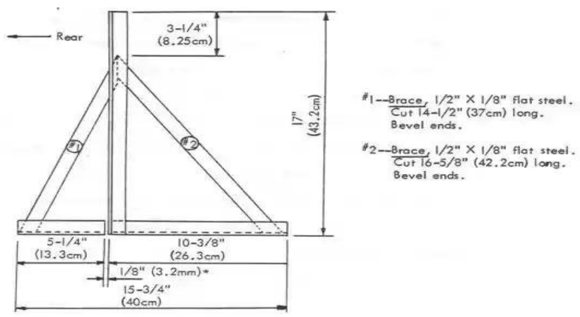


Figure 19 Upright Support Assembly

Advantages

- Time saving as compared to simple hacksaw
- Power saving as it is manually operated
- Easy machinery used
- As it is pedal operated so good for health
- Comfortable then ordinary hacksaw
- It is portable .It could be used wherever metal cutting is done in small scales, including at construction sites and furniture units, or to cut metal for windowpanes.

21. Fabricated model circular saw

Figure 21.1 Circular Saw

Chain Drive

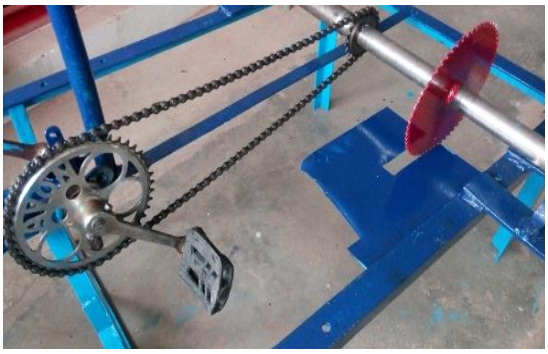


Figure 21.2 Chain Drive

Assembly Model

Figure 21.3 Assembly Model

Conclusion

Thus a low cost and simple design pedal operated circular saw machine is fabricated. This machine reduces the human effort and hence we need two persons to cut the wooden logs. This simple design of conventional design which can enhance day today 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.

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