# Design-Modification & Fabrication of Base Frame used in Four Way Hacksaw Machine

**Jeeoot Singh[1] Harshita Tewari[2] Anil Kumar Bharati[3] Deepak Babu[4] Sandeep Kumar[5]**
[1,2,3,4,5]Department of Mechanical Engineering
[1,2,3,4,5]Madan Mohan Malaviya University of Technology, Gorakhpur, India

***Abstract***—*Increasing productivity is the main requirements of production engineering these days. This is possible by either reducing the operation time or by improving the efficiency of the machine This project uses the Scotch yoke mechanism in four way hacksaw machine. This enables it to cut four components at a time thereby improving the productivity and reducing time consumption. The Scotch Yoke Mechanism is used to convert the rotary motion of crank into reciprocating motion of the hacksaw. Present machine is designed for improved force.*

**Keywords—**Hacksaw, Scotch Yoke, Experimental, Base Frame, Cutting

## I. Introduction

The four way hacksaw is a cutting machine designed to cut multiple wooden blocks simultaneously by applying Scotch Yoke mechanism. We are interested to increase the cutting force of Four Way Hacksaw machine. The main function of this hacksaw machine is to cut wood by motor power. The hacksaw is placed on opposite sides and as the crank moves, cutting operation is performed. The Scotch Yoke mechanism is used to convert the rotary motion into the reciprocating motion. Hence when the motor is switched on, the power from the motor is delivered to the crank wheel. The crank wheel rotates such that the hack saw blades reciprocate. The work pieces are mounted on the machine vice firmly and the entire system is switched on. Thus the four work pieces are cut simultaneously using the motor and the Scotch Yoke mechanism. Further, in order to increase the cutting force, the frame sides and the slider are connected using a hinge joint and the symmetric weight of the slider is increased.

## II. Literature review

N. R. Patel, et.al. , (June, 2013) has performed tests for different types of blades. He performed wear test, hardness test, tensile test, checked for performance under buckling and cutting performance. The most suitable blade material for different types of materials was then concluded. K. Prashant, et.al. ,(July 2004), developed a model of hacksaw machine which could cut many pieces simultaneously. This machine was able to cut four pieces simultaneously without any jerk and minimum vibrations. O. Cakir, et.al., (December, 2007), found out the cutting fluids which can be used in order to reduce the friction and for easy movement of parts. D. V. Sabarinanda, et.al. , (April 2014), gave an idea about the various components that will be required for the fabrication of the model of four way hacksaw machine. These components will help to get smooth working condition and future automation of different mechanical actions as well as linkages. R. Subhash, et.al. (2014), designed a Pedal operated hacksaw machine in which no specific input energy or power is needed. This project consists of a sprocket arrangement, the crank and slider mechanism, the chain drive. In this, the chain drive is directly connected to the hacksaw for cutting the wooden blocks. The objective is to use the conventional mechanical process. The main aim is reducing the human effort for machining various materials such as wooden blocks, steel, PVC etc. S. Verma and P. Raza in their project work made an effort to develop a modernized four way hacksaw machine. The aim was to develop a hacksaw machine that will use a less effort to produce uniform cutting of PVC pipes, metals, wood. The difference in performance between hand driven, pedal drive and four way hacksaw machine has also been shown in this. Their model converts rotary motion of crank to reciprocating motion of hacksaw blades, by using Scotch Yoke Mechanism. This motion is used for hacksaw machine. Hence, four hacksaws can be operated at a time. R. Ambade, et.al, (April 2015), developed a conceptual model of a machine which is both capable of performing different operation simultaneously and it is economically efficient .This machine was designed to be used in remote places where electricity is irregular or insufficient. It is designed as a portable machine. It can be used for operating on materials like thin metals, wood and p.v.c .The material can be cut without any external energy like fuel or current. Since, the machine does not use electric power and fuel, hence, it is very cheap.

## III. Mathematical calculations

### A. Equations Used

1) $F = \tau_{shear} \times area$

Where,
F= Required Force
$\tau_{shear}$= Shear Stress
Area = Area on which force is acting

2) $\omega = 2\pi N/60$

where,
$\omega$ = Angular Velocity
N= Rotations Per Minute

3) $V_{crank} = r \times \omega$

Where,
$V_{crank}$= Velocity of crank
r= radius
$\omega$ = Angular Velocity

4) $P = F \times V_{slider}$

Where,
P = Power Required for one hacksaw blade
$V_{slider}$= Velocity of slider

5) $\sigma_b = (M \times Y)/Ixx$

where,
$\sigma_b$ = Stress
M= Moment
Y= Perpendicular Distance
Ixx = moment of inertia about the X axis of square bar
Iyy = moment of inertia about the Y axis of square bar

6) $(\sigma_b)_{net} = \pm \frac{MY}{I} \pm \frac{P}{A}$

Where,
$(\sigma_b)_{net}$ = Net bending stress
P= Acting Force
A = Area on which force is acting

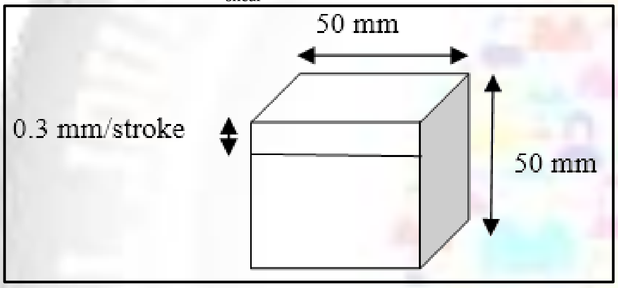
*B. Calculation for Requirement of Motor*

A block of dimensions 50×50 mm has been taken and the stroke length is 0.3 mm/stroke. After this from the table given below we have considered the value of maximum shear stress and assumed that our machine can cut any wood specie. This is done in order to calculate power requirement of motor.

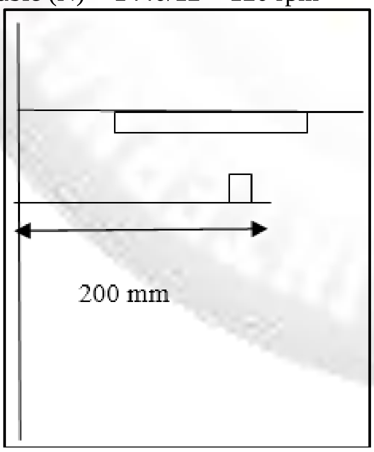
| Species (Types of Wood) | Shear stress (MPa) |
|---|---|
| Loblolly pine | 9.6 |
| Sitka pine | 7.9 |
| Red oak | 12.3 |
| Yellow poplar | 8.2 |
| Balsa | 2.1 |

Table 1: Mechanical Properties for Five Wood Species Properties of wood (Encyclopedia of Materials: Science and Technology,ISBN:0-08-0431526,pp. 9732-9736)

For all wood we take $\tau_{shear}$= 20 MPa




Depth of Cut (d) = 0.3 mm/ stroke
Force Required (F) = $\tau_{shear}$ x area
= 20 x 0.3 x 50
= 300 N
We take rpm of motor = 1440 rpm
Reduction Gear arrangement = 1:12
So rpm available (N) = 1440/12 = 120 rpm




We take stroke length = 100 mm
So, crank radius (r) = 100/2 = 50mm
Angular Velocity ω= 2πN/60
= (2π×120)/60
= 12.566 rad/sec

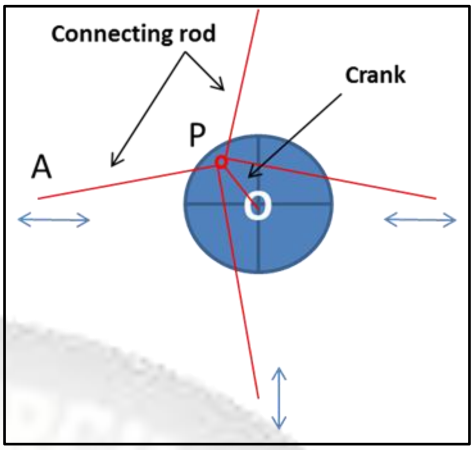


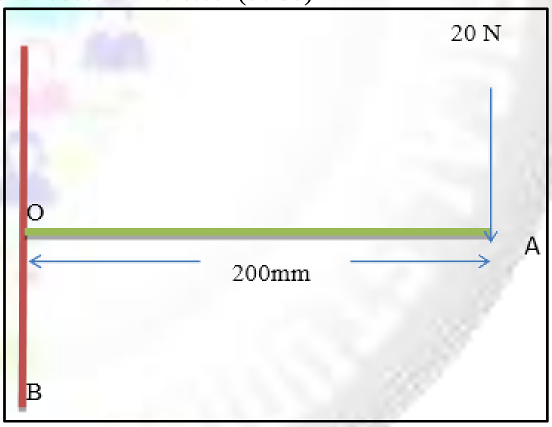

Fig.1Position Diagram of Hacksaw

Length of connecting rod = 450 mm
Velocity of Crank = r×ω
= 0.05×12.566 = 0.628 m/sec
Velocity of slider = $V_{crank}\times \cos 6.34^{\circ}$
= 0.628 × 0.9938
= 0.624 m/sec
Power Required for one hacksaw blade
= F ×$V_{slider}$
= 300×0.624 = 187.2 W
Total Power Required = 4 × F ×$V_{slider}$
= 4 × 187.2
= 748.8 W
= 1.0037 hp

Conclusion: Hence by calculation it is seen that we require 1 hp motor.

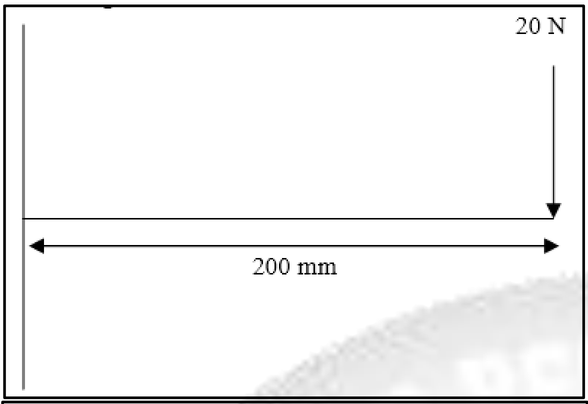
*C. Design Calculation*

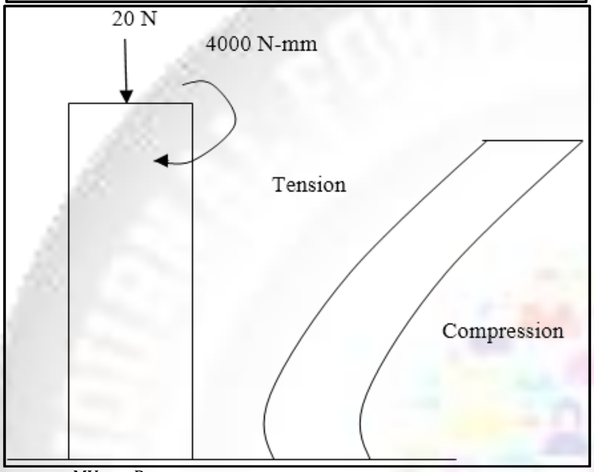
Material used – Mild steel (30C8)




Moment at point O =
$M_O$ = 2×10×200=4000 N-mm
$\sigma_b$=( M×Y)/Ixx
Ixx=Iyy= [( $25.4^4$)/12] –[($23.4^4$)/12] =9700.78 N/mm
Y=25.4/2=12.7mm
$\sigma_b$= (4000×12.7)/(9700.78)=5.2366 N/mm$^2$=5.2366MPa
Strength of Mild Steel =250 MPa
For Safe Design-
$\sigma_b$ × factor of safety≤ Strength of mild steel
5.2366×5=26.18≤250
Therefore, design is safe.

### *D. Buckling Consideration*




$(\sigma_b)_{net} = \pm \frac{MY}{I} \pm \frac{P}{A}$

At the left fibre (compression)

$\sigma_b = -\frac{MY}{I} - \frac{P}{A}$

$= -5.237 - (20/\ (25.4^2 - 23.4^2\ ))$

$= -\ 5.4419\ N/mm^2$

At the right fibre (Tension)

$\sigma_b = \frac{MY}{I} - \frac{P}{A}$

$= 5.237 - (20/\ (25.4^{\ 2} - 23.4^2\ ))$

$= 5.032\ N/mm^2$

## IV. Solution Methodology

Here analysis of the base frame has been done on Ansys. By using that the stress developed at different points and the deformation at different points has been shown. This has been done in order to ensure the safety of the base frame. Since the frame has to bear the stresses generated due to different conditions, the design must be safe.

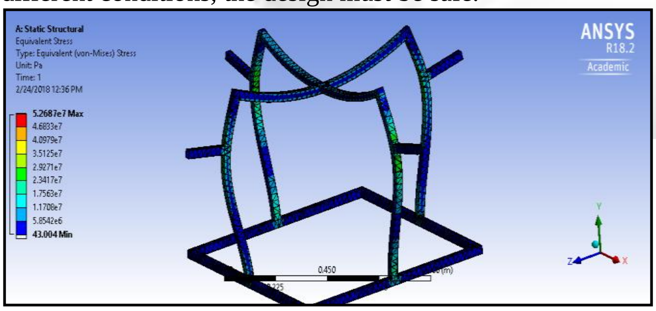



Fig. 2: Stress Diagram

Here we have done analysis for the stress acting on the frame. The stress acting at different points is indicated in the bar at te side of the figure.

Since, the values are in permissible range, hence, the design is safe. Factor of safety is 5.

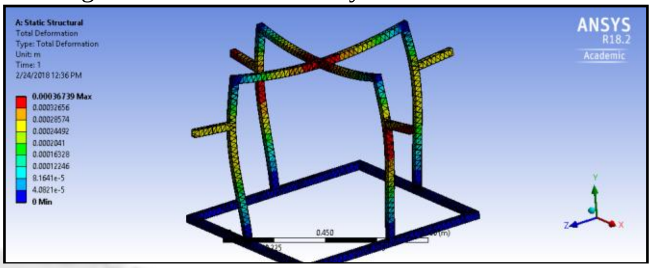



Fig.3: Total Deformation

Here the deformation produced in the frame due to different forces is shown. Since the deformation is in safe range hence the design is safe.

## V. Conclusion

Since all the values are in the permissible range the design is safe.

## VI. Working

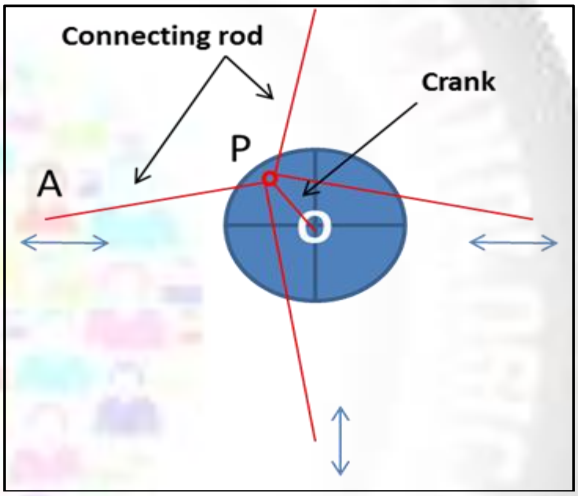



Fig. 4: Position Diagram of Hacksaw

The experimental setup of our project consists of a frame on which the hacksaw blades are mounted. The hacksaw blades are mounted on the four sides of the frame. The circular crank plate is mounted in the centre of the frame which is operated by a motor. Connecting rods are used to connect the crank wheel and the hacksaw blades. The Scotch Yoke mechanism is used to convert the rotary motion into the reciprocating motion. Hence when the motor is switched on, the power from the motor is delivered to the crank wheel. The crank wheel rotates such that the hack saw blades reciprocate. The work pieces are mounted on the machine vice firmly and the entire system is switched on. Thus the four workpieces are cut simultaneously using the motor and the Scotch Yoke mechanism.

The components were divided into two categories:

1) Components to be directly purchased from market.
2) Components that have to be modified.

For the modified components, material was purchased from the market and then the required modifications were made in it. The constrains are the dimensions of different parts that are taken while fabricating the model. These dimensions have been verified using the analysis for safety of the model. For the components that have to be directly purchased from the market, no modifications were required in it. The requirement for the parts like motor and reducing gear arrangement has been calculated in the mathematical calculations. They are purchased accordingly depending upon their specifications previously calculated.

| To be directly purchased from market | To be purchased and modified |
|---|---|
| Single phase electric motor | Disc |
| Hacksaw Blade | Connecting rods |
| Hacksaw Frame | Base |
| Material holding vice | Frame |

Table 4: List of Components

Parts are then fabricated according to the dimensions proposed safe by calculations and design analysis.

1) Firstly the base frame is constructed.
2) Then the slider and hacksaw arrangement is mounted on the frame.
3) After that vice is attached to end supports according to the height of hacksaw.
4) Then motor is mounted in the middle.
5) Then the reducing gear arrangement is fixed to the motor.
6) Crank disk is mounted on the reducing gear.
7) Then the connecting rods are attached to the camp on the hacksaw.
8) When electricity is provided, the set up becomes operational.

## VII. FABRICATED PARTS (WITH MODIFICATIONS)

Material for different parts has been purchased and the according to the requirement, the material has been used to make different components. The dimension of different components has been listed below. The dimensions are taken according to the analysis and calculations shown previously.

### A. *Frame*

Dimensions: 900×900×750 mm
Material: Mild Steel

Fig.3: Frame

### B. *Crank*

Material : Mild Steel
Dimensions: 100 mm diameter

Fig.4: Crank

### C. *Modified Hacksaw Frame*

Use: Guide Ways are provided to direct the cutting motion of hacksaw.

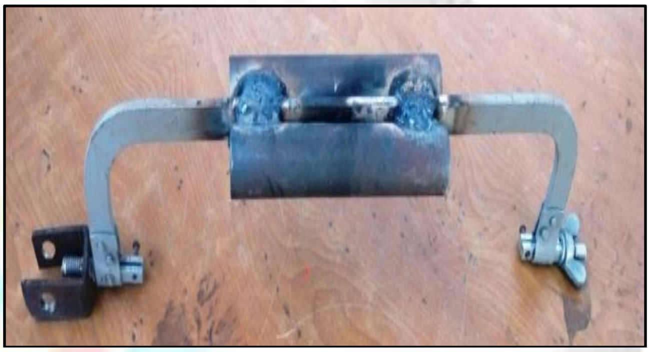


Fig.5: Modified Hacksaw Frame

### D. *Slider*

Material: Mild Steel
Use: For providing directed motion to hacksaw

Fig.6:Slider

### E. *Connecting Rod*

Material: Mild Steel
Use: For converting rotary motion of crank to reciprocating motion of hacksaw

Fig.7: Connecting Rod

### *F. Final Machine after Modification*

Fig.8: Final Model after Modifications

## VIII. RESULTS AND DISCUSSIONS

Hence, we can conclude that inspite of all the difficulties of vibrations and more number of moving parts, four way hacksaw machine proves to be useful. We were required to increase the cutting force. For this we connected the frame side rods and slider using hinge joint. Further, by increasing the overall weight of slider, pressure is generated which gives the cutting force. Since, the fabricated machine is capable of cutting wooden blocks with accuracy, so, the modification is appropriate. Since, we have considered the maximum values of shear stresses for calculating the power requirement, this machine is capable of cutting almost all types of woods taken according to the assumed dimensions. This machine proves to be useful as it is motor operated, so, human effort is reduced. The required speed can be easily modulated by changing the reducing gear arrangement. Instead of motor, pulley arrangement can also be used.

## IX. CONCLUSION

In present design and fabrication, design is modified to increase the cutting force with flexibility of requirements. Hence, this machine is overall economical to use. Further it has scope of being automated and micro controlled, hence, this machine has a long way ahead in field of development and research.

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