

Design and analysis of Power hack Saw attachment to a Center Lathe

Parvataneni Chaitanya

Vasavi College of Engineering, Email: pchaitanya9@outlook.com and Ph. No: 8019760145.

Abstract— This work provides a simple and economical Hacksaw attachment on a Centre Lathe. The conventional hacksaw machines which are available in the market cost around 30,000 to 40,000 Indian Rupees where as our hacksaw attachment on Lathe costs around 10,000 to 15,000 Indian Rupees only. In this attachment we can obtain various cutting speeds from the Lathe and also variable cutting forces with the help of a movable dead weight where as in the conventional hacksaw machines variable cutting speeds and variable cutting forces are not possible. This attachment is most useful for small workshops where there is not enough space for accommodating both Lathe and Hacksaw machines. This Hacksaw attachment on a Centre Lathe uses a simple four-bar mechanism where the link adjacent to the smallest link is fixed and we get a Crank-Rocker mechanism. We can use the coolant mechanism available on the Lathe for cooling and lubrication. We can cut a variety of materials using this hacksaw attachment as variable cutting forces are available. We have designed each of the components in Unigraphics Nx-8.5, assembled and simulated the motion. We have manufactured the required components and purchased the standard components available in the market. We have calculated the cutting force and the force obtained from the attachment is more than sufficient for cutting. We have also found out the temperatures during cutting of different materials such as Aluminum and Mild-Steel bar stocks using a Laser gun temperature measuring device.

Keywords— Center Lathe, Power Hack Saw, Designing, Manufacturing, Force Analysis, Tests performed, Cutting force.

INTRODUCTION

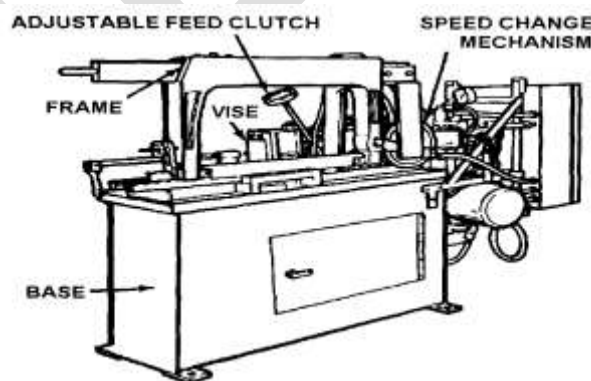
1. Sawing Machines:

Purpose:

The sawing machine is a tool designed to cut material to a desired length or contour. It functions by drawing a blade containing cutting teeth through the workpiece. The sawing machine is faster and easier than hand sawing and is used principally to produce an accurate square or mitered cut on the workpiece.

Types:

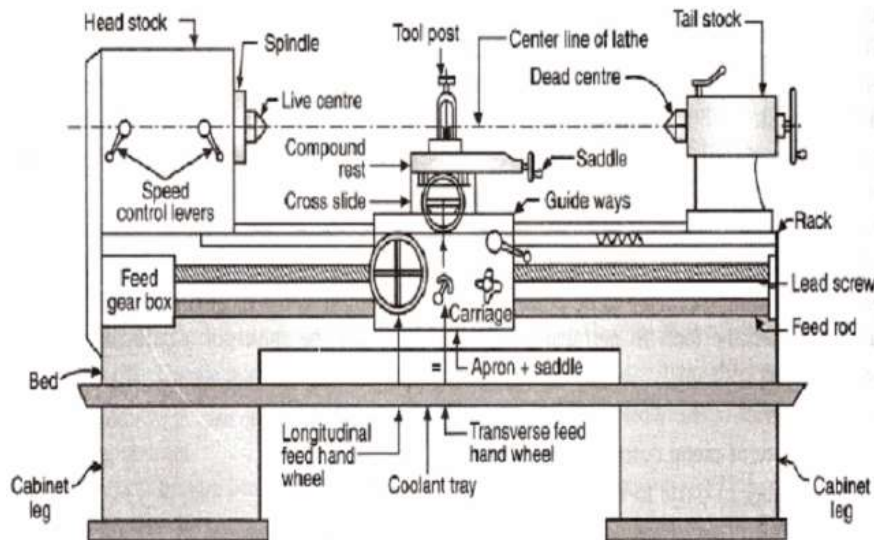
The power hacksaw and the bandsaw are two common types of sawing machines used to cut metal in the machine shop. The power hacksaw uses a reciprocating (back and forth) cutting action similar to the one used in a hand hacksaw. The power hacksaw is used for square or angle cutting of stock. The band saw uses a continuous band blade. A drive wheel and an idler wheel support and drive the blade



2. Lathe

The lathe is a machine tool used principally for shaping articles of metal (and sometimes wood or other materials) by causing the workpiece to be held and rotated by the lathe while a tool bit is advanced into the work causing the cutting action. The basic lathe

that was designed to cut cylindrical metal stock has been developed further to produce screw threads, tapered work, drilled holes, knurled surfaces and crankshafts. The typical lathe provides a variety of rotating speeds and a means to manually and automatically move the cutting tool into the work piece. Machinists and maintenance shop personnel must be thoroughly familiar with the lathe and its operations to accomplish the repair and fabrication of needed parts.



MECHANISMS USED IN POWER HACK SAW ATTACHMENT

We use a Crank-Rocker mechanism for the Power Hacksaw Attachment on a Center Lathe.

Gruebler's equation

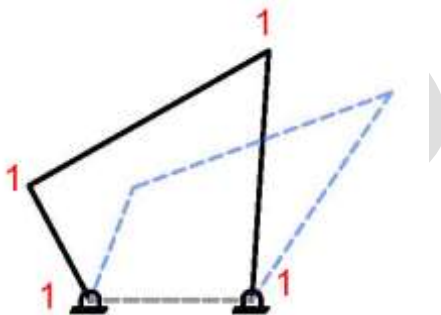
This equation is used to find the Degrees of freedom of a mechanism.

N = Number of Links (including ground link).

P = Number of Joints (pivot connections between links).

- Each link has 3 degrees of freedom.
- Each pivot subtracts 2 degrees of freedom.

$$DOF = 3(N-1) - 2P$$



$$N = 4$$

$$P = 4$$

$$DOF = 3X(4-1)-(2X4) = 1$$

WHAT IS TO BE ACHIEVED

A. Objective

- To design and fabricate a Power Hack saw attachment on a Heavy Duty Lathe.
- NX software shall be used to design the power saw. Analysis of links will be carried out using ANSYS.
- Design of the mechanism will be carried out based on the forces acting on the links.
- To make the Power Hack saw machine affordable for small workshops.
- To utilize Lathe even for cutting bar stocks.

B. Specifications of Heavy Duty Center Lathe

- Admits between centers = 1035 mm.
- Centre height = 235 mm.
- Swing over Cross slide = 255 mm.
- Lead screw = TPI: 4
- Motor details: 3HP at 1440 RPM AC. 50 Hz, 3 phase.

C. Problem Definition

- Generally the conventional Power Hack Saw costs about Rs 60,000.
- Space is very important criteria for the small workshop. The conventional Power Hack Saw needs more space for its installation.
- Variable cutting speeds and variety of cutting speeds cannot be attained from the conventional Power Hack Saw.
- Variable cutting strokes cannot be attained in conventional Power Hack Saw.

D. Problem Solution

- This attachment costs around Rs15, 000-20,000 only.
- Already available Lathe can be used for cutting of bar stocks by using this attachment thereby saving the space.
- Variable cutting speeds can be obtained.
- Variable cutting strokes can be obtained.

E. Procedure Followed

- Designing of each component in Unigraphics NX8.5 software.
- Obtaining the dimensions of each component based on the available space limitations.
- Assembling the designed components in NX8.5 software.
- Giving motion to the assembly in NX8.5 software and obtaining the simulation.
- Calculation of force required for cutting.
- Calculation of force obtained from the Lathe and checking whether it is sufficient to cut or not.
- Manufacturing the components.
- Purchasing the standard components.
- Assembling of the manufactured components.
- Performing certain tests such as Finding the temperature in the cutting zone for different materials, Finding the cutting time for different materials.

WORKING

The mechanism is similar to the Crank-Rocker mechanism. The Face plate is connected to the chuck in the Head stock with the help of Spindle and draws the power from the Lathe. This rotatory motion of the Face plate is converted to the angular motion of the Rocker arm.

From here the angular motion is converted to the translatory motion of the frame with the help of an extension from the Rocker arm and the connected to the Hacksaw frame.

The feed is provided with the help of a movable dead weight which is provided on the top of the frame with the help of Screw rod and Dead weight.

With the help of this movable dead weight we can get variable cutting forces for different materials. This dead weight can be moved along the frame length from the pivot point to the end of the frame on a screw rod, its position can be locked at any position with the help of lock nuts, and hence different forces can be obtained.

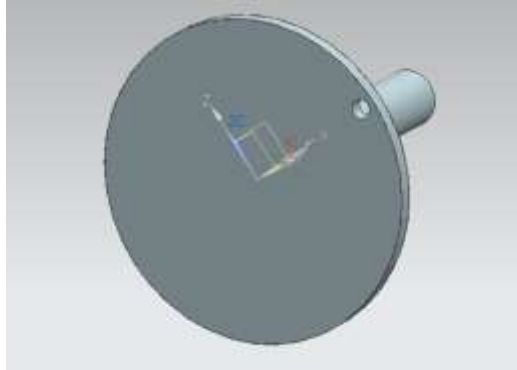
PARTS

- Face plate or Crank.
- Connecting rod.
- Rocker arm.
- Hack saw frame.
- Hacksaw Blade
- Vice for holding the work piece.

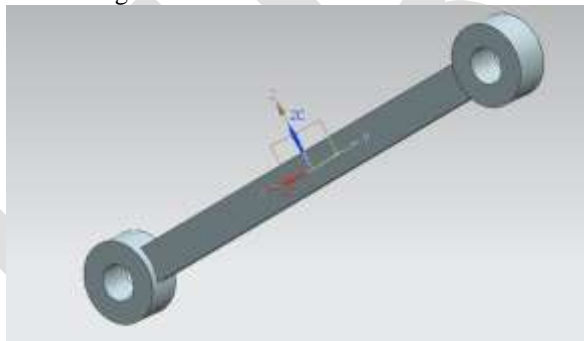
- Carriage.
- Bearings used in all joints (I.D = 10mm, O.D = 30mm)..
- Clamps for holding Carriage.
- Movable Dead Weight along with Screw rod.

A. Parts Description

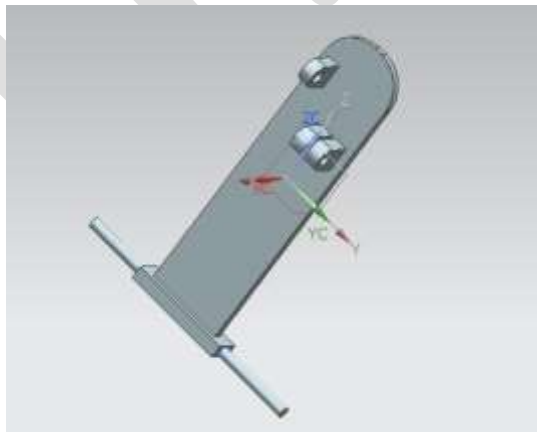
i. Face Plate or Crank



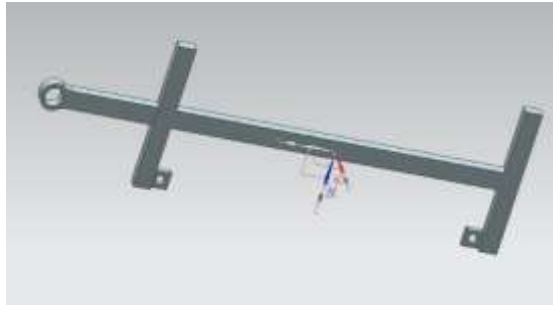
ii. Connecting rod



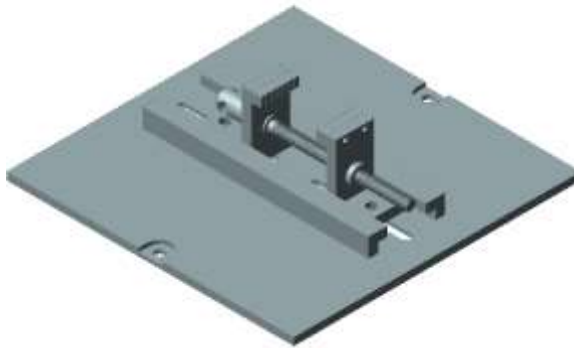
iii. Rocker Arm



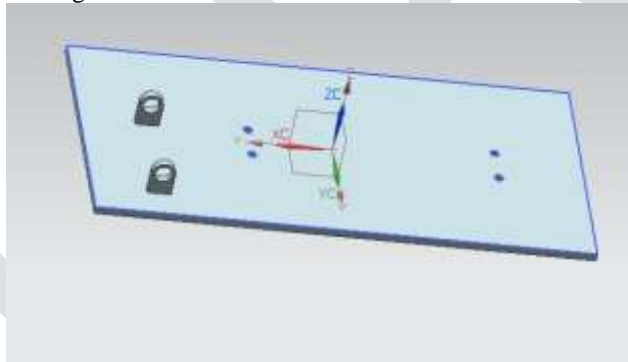
iv. Hacksaw frame



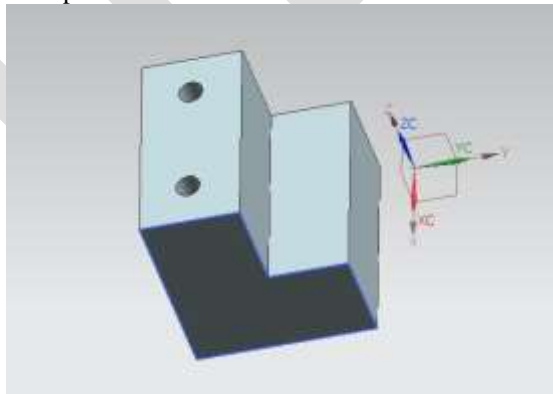
v. Vice For Holding The Work Piece



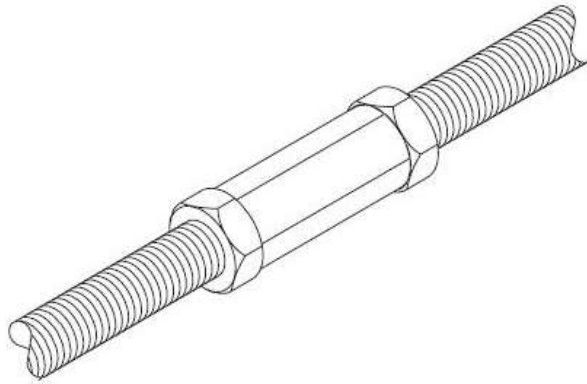
vi. Carriage



vii. Clamp

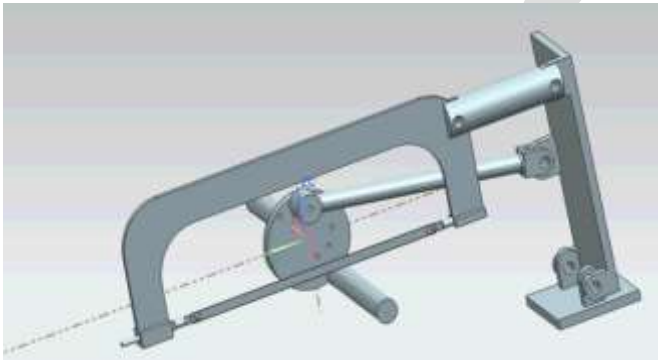


viii. Movable Dead Weight Along With Screw Rod

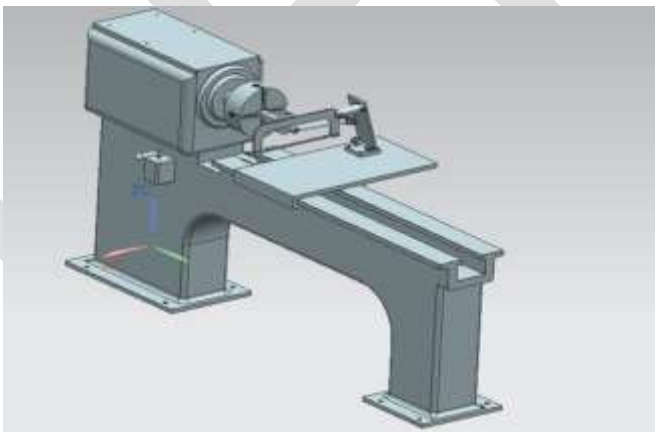


ASSEMBLY

The following figure shows the assembly of the designed parts



The final Assembly is as follows



CALCULATIONS

1. Link Lengths:

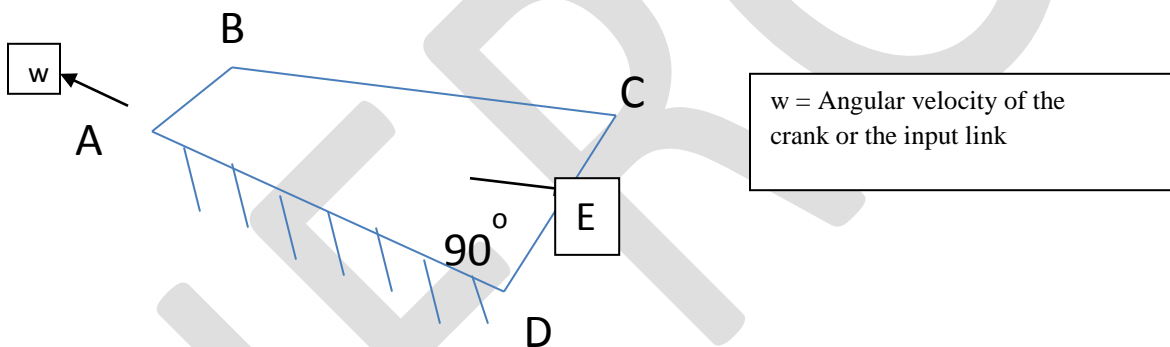
- Diameter of the Face Plate= 200 mm (Obtained from the space limitations)
- Connecting rod length= 295 mm (Obtained from the limitation of the space between Rocker Arm and Face Plate)
- Rocker Arm length= 195 (Based on the length constrain of the standard Hacksaw Blade of 10 TPI)
- Carriage Dimensions= 640mm x 330mm x 10mm (Based on space required to accommodate all the parts and the work piece).

2. Velocity Analysis:

- Optimum speed for cutting from the lathe for cutting mild steel = 75 Rpm.
- Speed of the crank $w = 7.85 \text{ rad/sec}$ $v = 0.746 \text{ m/sec}$.
- Using Graphical method velocity of the rocker arm where the frame is pivoted = 0.346 m/sec.

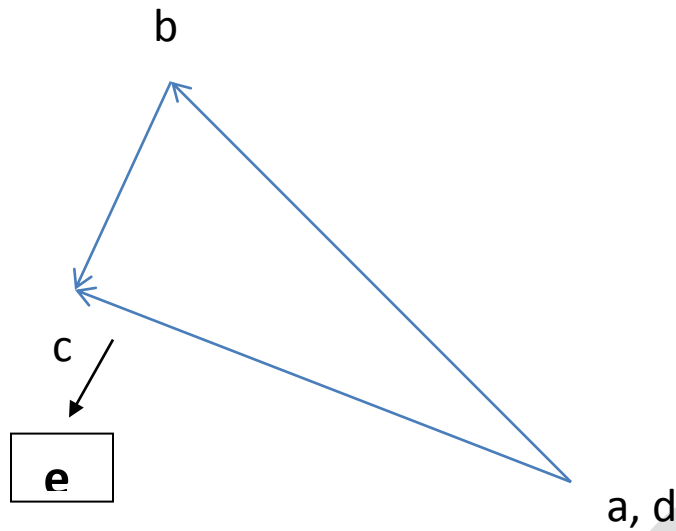
Consider for the position shown below

Position Diagram



Where Link lengths

AB = 95 mm, AD = 320 mm, BC = 295 mm, CD = 195 mm.



Velocity Diagram

From the above velocity diagram

$$dc = 500,$$

We know that 'dc' and 'de' are in the same ratio of lengths DC and DE

$$\text{Therefore } \frac{de}{135} = \frac{500}{195}, \text{ then we get } de = 346.15 \text{ mm/sec.}$$

$$\text{Hence 'de' = Velocity of the pivoted point of frame on the Rocker} = 0.346 \text{ m/sec.}$$

3. Calculation of Cutting Force Required:

From the modified second law of cutting force,

$$P_z = (p_o \div a^m) \times A$$

Now,

$$A = a \times (\sum^Z b)$$

And a = rise per tooth

$$\sum^Z b = b \times Z_c$$

Where Z_c = Number of Cutting Teeth.

and b = Width of the teeth in 'mm'.

The value of $K_s = (p_o/a^m)$ is shown in the following figure 13.3.1 from which the force is evaluated.

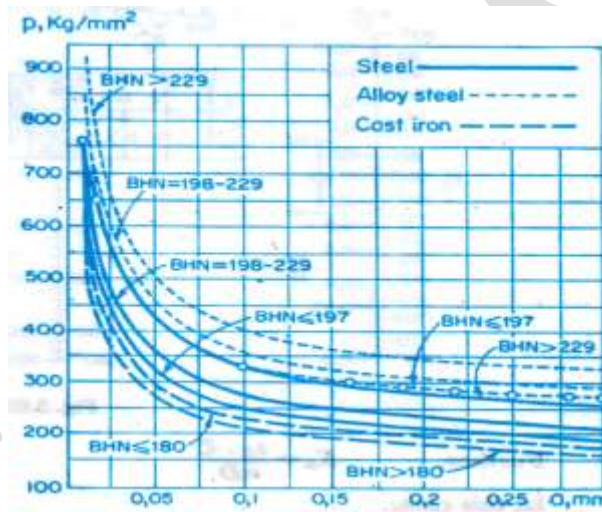


Fig3.1

$$P_z = K_s \times a \times (\sum^Z b)$$

The force P_z can be expressed in Granovsky's form derived from First Law of Cutting Force, then

$$P_z = C_z \times s^u \times (\sum b) \times K_H \times K_\gamma \times K_a \times K_w \times K_c, \text{ Kg.}$$

The values of constants C_z , u , v can be determined from the Table 3.1 and the values of K_H , K_γ , K_a , K_w and K_c can be determined from the tables 3.2, 3.3, 3.4, 3.5 and 3.6.

Material	Broach Type								
	Round			Spline			Single Keyway		
	C_z	U	V	C_z	u	v	C_z	u	v
Carbon Steel $\sigma_u=75 \text{ kg/mm}^2$	762	0.85	1	230	0.85	1.0	202	0.85	1.00
Grey Cast Iron BHN = 190	300	0.73	1	152	0.73	1.0	115	0.73	1.00

Table 3.1

Values of K_H

Material	Cutting of (Broaching of)		
	Round Holes	Splined Holes	Tooth Spaces
Carbon Steel, $\sigma_u < 70 \text{ kg/mm}^2$	0.92	0.92	0.88
Carbon Steel, $\sigma_u = 70-80 \text{ kg/mm}^2$	1.00	1.00	1.00
Carbon Steel, $\sigma_u > 80 \text{ kg/mm}^2$	1.10	1.24	1.24
Alloy Steel, $\sigma_u > 80 \text{ kg/mm}^2$	1.20	1.11	1.12
Cast Iron, BHN ≤ 200	1.00	1.00	1.00
Cast Iron, BHN > 200	1.20	1.40	1.20

Table 3.2

Values of K_γ

γ	12	8	2
K_γ	1	1.13	1.15

Table 3.3

Values of K_α

	$\alpha = 2 \text{ to } 3^\circ$	$\alpha \leq 1^\circ$
Steel	1	1.2
Cast Iron	1	1.12

Table 3.4

Values of K_w

Wear	Sharp Tool	Partly Worn	Worn
K_w	1	1.18	1.35

Table 3.5

Values of K_c

	With Coolant	Dry
K_c	1.00	1.33

Table 3.6

Here $C_z = 202$, $u = 0.85$, $v = 1$

$K_H = 1$, $K_\gamma = 1$, $K_a = 1$, $K_w = 1$ and $K_c = 1.33$

Feed $S = 0.34615$ m/sec = 5.769×10^{-3} m/min

(From cutting speed obtained in Velocity Analysis).

Required Cutting Force $P_z = 170.609$ kg

$P_z = 1671.88$ N.

4. Force Obtained from the Lathe

Power of the Lathe = 3 H.P

We know that 1 H.P = 750 W.

Hence the power obtained from the Lathe $P = 2250$ W.

Optimum speed $N = 75$ R.P.M

We know that power $P = 2 \times \pi \times N \times T/60$ watts.

Where T = Torque in N-m.

At $P = 2250$ W, $N = 75$ R.P.M

We get Torque $T = 286.487$ N-m.

We know that Torque $T = F \times r$ N-m.

where F = Force in newton, r = Radius from the pivot in metre.

At $T = 286.487$ N-m and r = radius of the crank = 0.095 m.

We get Force $F = 3015.55789$ N.

Considering the Overall Efficiency (Including Transmission and Mechanical losses) = 90 %

Total Force available for cutting from the Lathe to the Hacksaw = 0.9×3015 N

$F_t = 2714$ N.

This Force $F_t = 2714$ N is greater than the required force for cutting $P_z = 1671.88$ N.

Hence the Lathe can provide the cutting force and we can use the Power -Hacksaw attachment on the Lathe.

TESTS PERFORMED

To find out the Temperature in the cutting zone during cutting for different materials:

An Infrared Thermometer is used to find out the Temperature in the cutting zone

Temperature obtained while cutting Aluminium pipe $T_1 = 260^\circ\text{C}$

Temperature obtained while cutting Mild Steel Stock $T_2 = 560^\circ\text{C}$.

RESULT

- Designed each component and the dimensions were obtained successfully according to the Lathe specifications.
- Simulated the motion to the assembly in the Nx software and the design was correct.
- Identified which parts are to be manufactured and which parts are standard parts.
- Fabricated the Face Plate, Connecting rod, Carriage, Rocker-Arm, Clamps and assembled them.
- Bought the standard parts such as nuts and bolts, vice etc. and assembled them. Fabricated the Power Hacksaw Attachment for a Heavy Duty Centre Lathe and the motion is successful. The entire assembly is shown in the following figure.



ACKNOWLEDGMENT

Thanks to Dr. K. Kishore for providing technical assistance in calculating the cutting force and also for providing help in researching on Power Hack Saw.

CONCLUSION

- The Gruebler's criterion for the Linkages is satisfied.
- Granovsky's equation is satisfied and used to find the cutting force.
- Lathe is able to provide the required cutting force to cut the work piece.
- Found the temperature in the cutting zone for different materials during cutting.
- Able to obtain the required motion of the Hacksaw frame after fabrication.
- Able to get variable cutting forces with the help of a movable dead weight.
- Design, Manufacturing and Analysis of Power hacksaw attachment is completed successfully.

REFERENCES:

- [1] Metal Cutting Theory and Practice by A. BHATTACHARYA – Pg. 288 to 294.
- [2] Simple Power Hacksaw - Popular Mechanics Magazine 1936.
- [3] A theoretical study of the cutting action of power hacksaw blades- International Journal of Machine Tool Design and Research 01/1974
- [4] International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, Issue 6, June 2013.
- [5] Fundamentals of Metal Cutting and Machine Tools by B.L.Juneja- Pg. 81.
- [6] Fundamentals of Machining and Machine Tools by R.K. Singal- Pg. 73, Pg. 202.
- [7] Analysis of Machining and Machine Tools by Steven. Y. Liang, Albert J. Shih.
- [8] Theory of Machines by R.S. Khurmi and J. K. Gupta.
- [9] Theory of Machines by Rattan S.S - Pg.6, Pg. 68.
- [10] A Textbook of Machine design by R.S. Khurmi.
- [11] Theory of Machines and Mechanisms by Uicker J.J., Pennock G.R. and Shigley J.E.
- [12] Metal Cutting Theory and Practice, Third Edition by David A. Stephenson, John S. Agapiou- Pg. 502.