International Journal of Frontiers in
Engineering and Technology Research
Journal homepage: https://frontiersrj.com/journals/ijfetr/
ISSN: 2783-0497 (Online)

(RESEARCH ARTICLE)

Check for updates

Mathematical modeling and simulation of system operation: Power hacksaw

Ekeoma George Chukwuma [1] and Nwadinobi Chibundo Princewill [2,*]

[1] *Department of Mechanical Engineering, Abia State Polytechnic, Aba, Abia State, Nigeria.*
[2] *Department of Mechanical Engineering, Abia State University, Uturu, Abia State, Nigeria.*

International Journal of Frontiers in Engineering and Technology Research, 2022, 02(02), 013–019

Publication history: Received on 10 April 2022; revised on 21 May 2022; accepted on 24 May 2022

Article DOI: https://doi.org/10.53294/ijfetr.2022.2.2.0036

Abstract

The primary objective of this article is to develop a mathematical model of a power hacksaw operation mechanism. A MATLAB code was developed and implemented to run the simulation of the mechanism. The paper presents a MATLAB code implementation of the system using rotary to reciprocating motion to develop a mathematical model of the power hacksaw in a MATLAB software. The theory of rotary to reciprocating motion has been effectively used as an efficient approach to analyze the power hacksaw system and acceleration of the blade for two to three revolutions of the power hacksaw machine.

Keywords: Hacksaw; Motion conversion; MATLAB; Program; Model

1. Introduction

A model is a representation of the construction and working of some system of interest, while the process of producing a model is referred to as modelling (Nwadinobi and Ezeaku, 2018). A model is similar to but simpler than the system it represents. It assists the analyst to predict the effect of changes on the system under investigation. The model remains a close approximation to the real system and incorporate most of its salient features. A power hacksaw is a metal cutting machine useful for machining various other materials including wood and plastic (Kshirsagar, 2015). It cuts away large sections of materials such as of steel. The cutting job based on metal has quality blades of varied teeth ranging per inch. Typically, the blade with more thread per inch (TPI) will cut the material smoothly. It is even so powerful to cut rightly in detail that it has become the most common machine for cutting operations in many workshops.

1.1. Analysis of power hacksaw mechanism

Models act as communicators to others by providing information and impact in changing condition. It is also used to mimic the behavior of systems under different operating conditions (Dhirendra, 2016a; 2017b). Examples of the range of objectives can be explain to in terms of developing a scientific understanding through quantitative expression of current knowledge of a system, test the effect of changes in a system and as well as aid decision making.

However, modeling plays a role in understanding how the properties and performance of mechanical components and systems affect the overall physical system design such as power hacksaw. How well any particular objective is achieved depends on both the state of knowledge about a system and how well the modelling is done (Daniel and Glenn, 2008; Devendra, 2010; Wei, 2013). Hacksaw Machine is best for cutting large sections of metal pieces such as steel. This is achieved with the aid of an induction motor which is without doubt the most used electrical motor because of its unique characteristics (Sangeetha and Parthiban, 2014; Yashdeep, 2016). Most of its applications need fast and intelligent speed control system. It produces piece cutting in various materials of different thickness or diameters when handling

* Corresponding author: Nwadinobi Chibundo Princewill
Department of Mechanical Engineering, Abia State University, Uturu, Abia State, Nigeria.

work processes. It can be used with different grade saw blades matching the proper teeth per inch available in different models with variable cutting capacity. Power hacksaw type makes cuts in the structural materials in diameters of more than 10 to15 mm which would otherwise be hard to do with a normal hand held saw. Power hacksaw works on difficult and time consuming tasks. It has a feature of power saver; more proficient for cutting process. Some of its mechanical advantages include high speed steel teeth and vibration free cutting.

2. Material and methods

The schematic drawing of the power hacksaw mechanism was used to model the position, velocity and the acceleration.

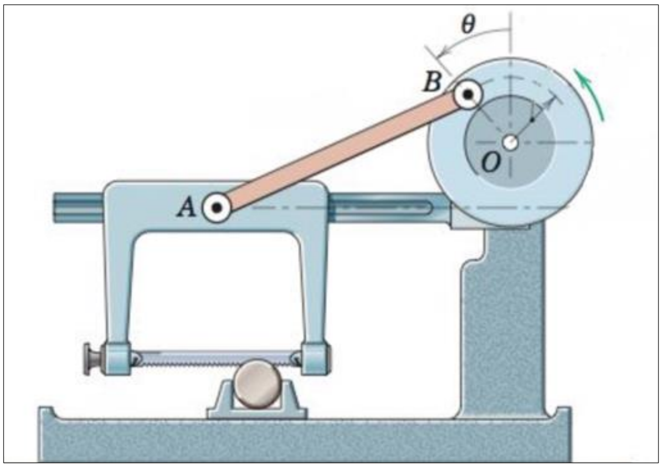

Figure 1 Power Hacksaw

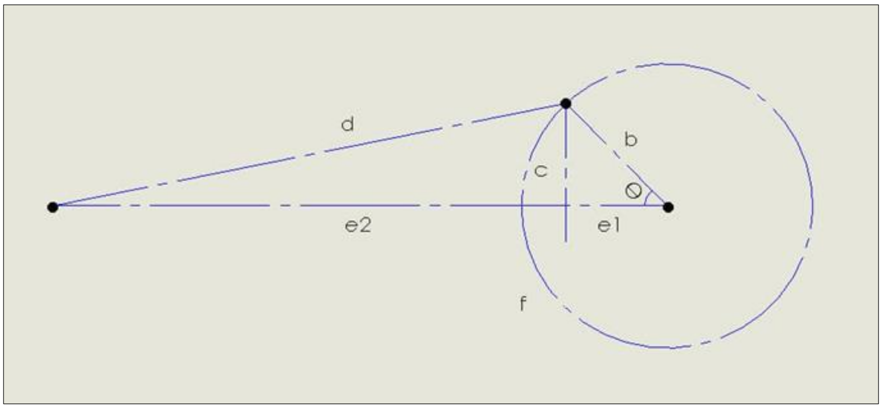

Figure 2 The power hacksaw motion system

The initial conditions for the power hacksaw machine were considered to be:

$t = 0, \theta = 0, \theta_1 = 0, \theta_2 = 0,$

Where

$$c = \text{the height of the crank at any given position}$$

$$b = \text{crank}$$

$$\theta = \text{the angle of the crank at any given position}$$

$$d = \text{connecting rod}$$

From fig. 2

$$e_1 = bcos\theta \quad (1)$$

$$c = bsin\theta \quad (2)$$

$$e_2 = \sqrt{d^2 - c^2} = \sqrt{d^2 - b^2sin^2\theta} \quad (3)$$

The displacement of the blade *(f)* at any given point is

$$f = e_1 + e_2 = bcos\theta + \sqrt{d^2 - b^2sin^2\theta} \quad (4)$$

The speed of the power hacksaw is given as the derivative displacement of the blade, hence

$$\frac{df}{d\theta} = \frac{d}{d\theta}\left[bcos\theta + \sqrt{d^2 - b^2sin^2\theta}\,\right] \quad (5)$$

$$= -b\theta_1 sin\theta + \frac{b^2\theta_1 sin^2\theta}{2\sqrt{d^2-b^2sin^2\theta}} \quad (6)$$

The velocity of the power hacksaw is given as:

$$x_1 = -b\theta_1 sin\theta + \frac{b^2\theta_1 sin^2\theta}{2\sqrt{d^2-b^2sin^2\theta}} \quad (7)$$

$where\ \theta_1 = 0$

The acceleration of the power hacksaw is the derivative of equation (7), where

$$\frac{dv}{d\theta} = \frac{d}{d\theta}\left[-r\theta_1 sin\theta + \frac{b^2\theta_1 sin^2\theta}{2\sqrt{d^2-b^2sin^2\theta}}\right] \quad (8)$$

$$= \frac{-b\theta_2 cos\theta + 4b^2\theta_1 cos\theta^2(d^2-b^2sin^2\theta) + \sqrt{b^2\theta_1 sin^2\theta}}{2\sqrt{d^2-b^2sin^2\theta}} \quad (9)$$

Hence, the acceleration is given as:

$$x_2 = \frac{-b\theta_2 cos\theta + 4b^2\theta_1 cos\theta^2(d^2-b^2sin^2\theta) + \sqrt{b^2\theta_1 sin^2\theta}}{2\sqrt{d^2-b^2sin^2\theta}} \quad (10)$$

$where\ \theta_2 = 0$

3. Results and Discussions

Matlab codes for power hacksaw for

```
% Matlab code for power hacksaw simulation for one, two and three revolutions

theta_one=400;                    % This is for revolution per minute

b=0.24;                     % m

d=0.50;                     % m

time=2*pi/theta_one;              % This is time for three revolution

t_v =linspace (0, time, 300);       % This is the time vector
```

```
theta=theta_one*t_v;              % This calculates theta at each time.
c=b*sin(theta);
e2s=d^2-b^2*sin(theta).^2;        % This calculates e2 square
e2=sqrt(e2s);
x=b*cos(theta)+e2;                % This calculates x for each theta
x_one= -b*theta_one*sin(theta)-(b^2*theta_one*sin(2*theta)./(2*e2));
x_two=-b*theta_one^2*cos(theta)-(4*b^2*theta_one^2*cos(2*theta).*...
e2s+(b^2*sin(2*theta)*theta_one).^2)./(4*e2s.^(3/2));
% Plotting for power hacksaw
subplot (2,2,1)
plot (t_v, x)                % This expression plots Position against time
xlabel('Time(s)')
ylabel('Position(m)')
subplot (2,2,2)
plot (t_v, x_one)            %This expression plots Velocity against time
xlabel('Time(s)')
ylabel('Velocity(m/s)')
subplot (2,2,3)
plot (t_v, x_ two)           %This expression plots Acceleration against time
xlabel('Time(s)')
ylabel('Acceleration(m/s^2)')
subplot (2,2,4)
plot (t_v, c)                %This expression plots c against time
xlabel('Time(s)')
ylabel('h(m)')
```

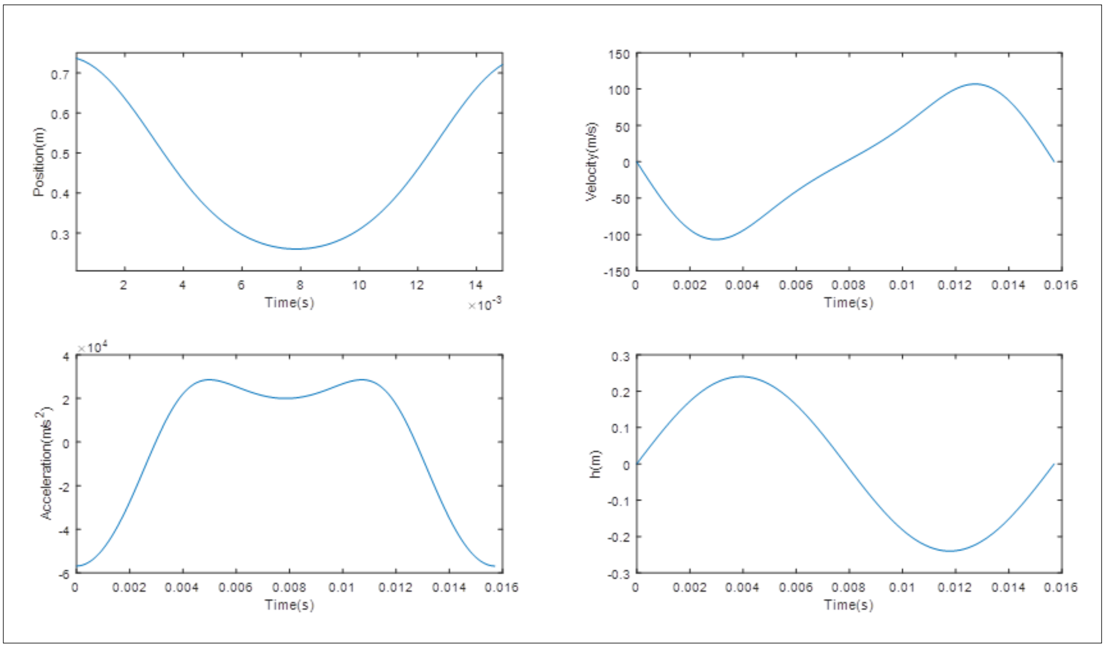

Figure 3 Simulation Result for one revolution

At one revolution of the hacksaw in Fig. 3. The velocity of the blade is zero at rest with a constant deceleration which is observed to be a slow down as the blade moves backwards, and at a point it assumes constant acceleration as the blade moves forward. The blade is zero at the end points (bottom dead center and top dead center) of the travel range where the blade changes the direction of motion. The acceleration is at maximum when the blade is at the left end and at minimum when the blade is at the right hand side.

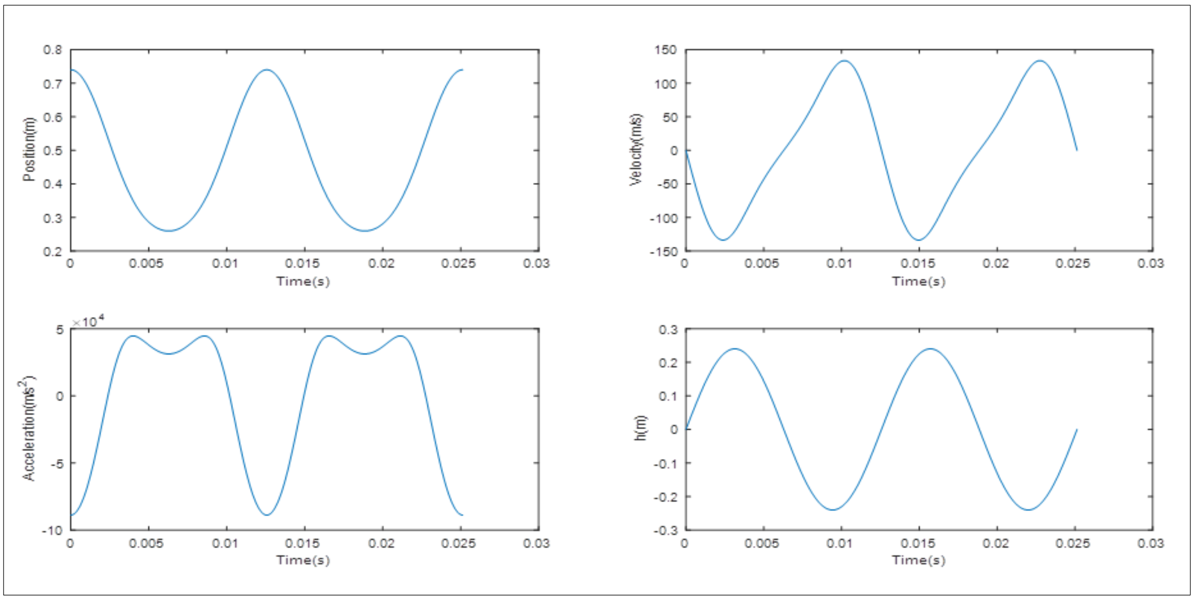

Figure 4 Simulation Result for two revolution

In Fig. 4, the velocity of the blade is zero at rest with a constant deceleration and a constant acceleration as the blade moves backwards and forward. The blade is zero at the end points (bottom dead center and top dead center) of the travel range where the blade changes the direction of motion. The acceleration is at maximum when the blade is at the left end and at minimum when the blade is at the right hand side.

It can be seen that changing the time from 2*pi/theta_one to 4*pi/theta_one increases the movement for two revolutions.

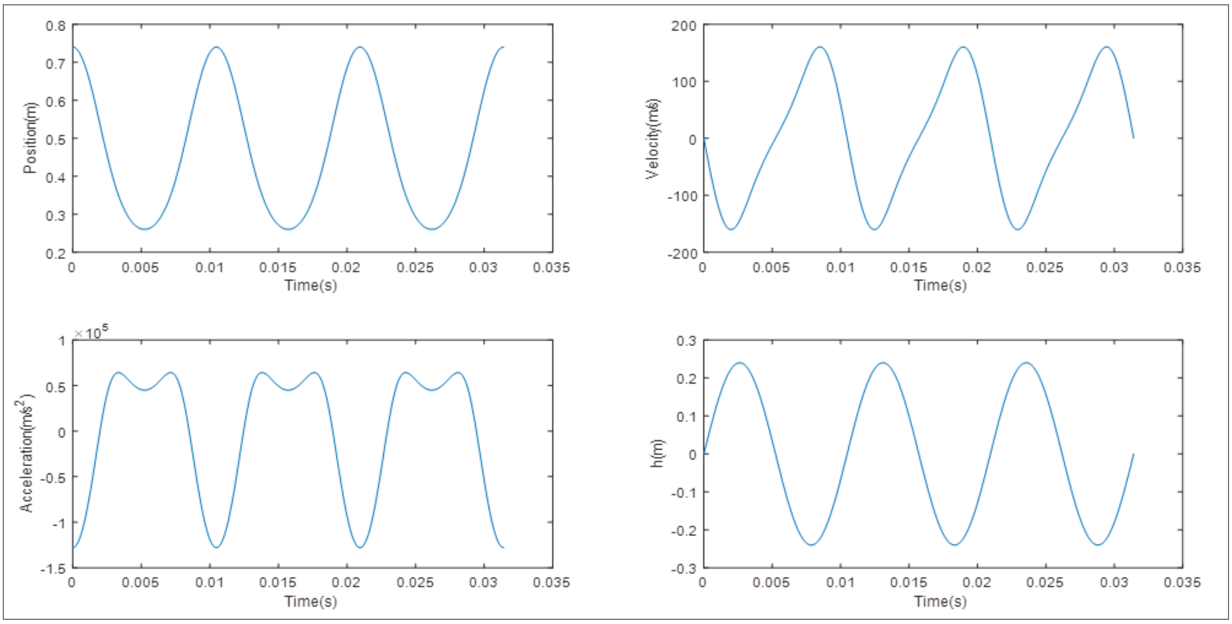

Figure 5 Simulation Result for three revolution

In Fig. 5 as well, the velocity of the blade is zero at rest with a constant deceleration and a constant acceleration as the blade moves backwards and forward. The blade is zero at the end points (bottom dead center and top dead center) of the travel range where the blade changes the direction of motion. The acceleration is at maximum when the blade is at the left end and at minimum when the blade is at the right hand side. It can also be seen that changing the time from 4*pi/theta_one to 6*pi/theta_one increases the movement for three revolutions.

4. Conclusion

MATLAB allows plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages. This allows to model and simulate the dynamic nature of the power hack saw. A developed mathematical model for a power hacksaw was used to generate a MATLAB code for implementation. The system used rotary to reciprocating motion was used to develop the model in a MATLAB software. The theory of rotary to reciprocating motion has been effectively used as an efficient approach to analyze the power hacksaw system and acceleration of the blade for two to three revolutions of the power hacksaw machine.

Compliance with ethical standards

Acknowledgments

The authors hereby acknowledge all that contributed to this research.

Disclosure of conflict of interest

The authors state that there are no conflicts of interest.

References

[1] Nwadinobi C. P., Ezeaku I. I. Review of Maintenance Scheduling and Optimization Models, International Journal of Scientific Research in Mechanical and Materials Engineering, 2018; 2(5): 23-35.

[2] Kshirsagar P. R. Theoretical Analysis of Multi-Way Power Hacksaw Machine International Journal of Research in Advent Technology. 2015; 3(4): 2321-9637.

[3] Dhirendra Singh. Modeling, Simulation and Implementation using MATLAB & Simulink. Matlab EXPO. 2016.

[4] Dhirendra Singh. Modeling mechanical and hydraulic systems in Simscape. Matlab EXPO. 2017.

[5] Daniel Lawson, Glenn Marion An Introduction to Mathematical Modelling Glenn Marion, Bioinformatics and Statistics Scotland. 2008.

[6] Devendra K. C. Modeling and simulation of systems using Matlab and Simulink. Taylor and Francis Group, LLC. 2010.

[7] Wei X. Modeling and optimization of wastewater treatment process with a data-driven approach. PhD (Doctor of Philosophy) thesis, University of Iowa. 2013.

[8] Sangeetha A, Parthiban B. Review of Modeling and Dynamic Analysis of Three Phase Induction Motor Using MATLAB Simulink. International Journal of Science, Engineering and Technology Research (IJSETR). 2014; 3: (3).

[9] Yashdeep N. Simscape Modeling of Motor-Generator Unit Components for Hybrid Electric Vehicle. A Thesis Presented to The Academic Faculty Georgia Institute of Technology. 2016.