INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

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VIBRATION ANALYSIS OF A TWO WHEELER SUSPENSION SYSTEM

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Accepted Date: 05/03/2015; Published Date: 01/05/2015

Abstract: The suspension system consists of springs, dampers that connect a vehicle to its wheel. Its main purpose is to keep vehicle occupants comfortable and reasonably well isolated from road bumps, potholes, noise and vibration. As per the vibration analysis procedure, mathematical model is developed, derived equations of motion, then found out the solution of equation and finally interpretation of results and analysis. In this paper, an attempt is made to optimize the value of damping coefficient in order to provide better comfort.

Keywords: Mathematical model**,** Suspension**,** Damping coefficient, Optimization

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How to Cite This Article:

Sachin S. Channe, IJPRET, 2015; Volume 3 (9): 279-287

PAPER-QR CODE

INTRODUCTION

Suspension is one of the important component of an automobile. The main component of any suspension system is spring and damper. Generally in most of the two wheelers, passive suspension system is used. Now-a-days most of the research is going for active suspension system, but due to limitations, it is better to go for passive suspension system. So in passive suspension system one of the alternatives to improve the comfort level of passenger is to optimize the values of either stiffness or damping coefficient.

MATHEMATICAL MODELING

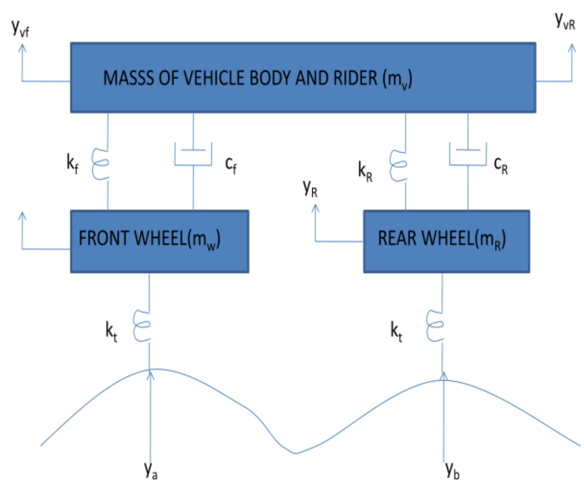

FIG 1: MATHEMATICAL MODEL OF A TWO WHEELER

Mathematical model having four degrees of freedom is considered. The displacement of vehicle is considered only in the vertical direction.

mf =mass of front wheel

mR =mass of rear wheel

kf =stiffness of front wheel

kR =stiffness of rear wheel

kta =stiffness of front tire

ktb=stiffness of rear tire

cf =damping coefficient of front wheel

cR =damping coefficient of rear wheel

yf =displacement of front wheel

yR =displacement of rear wheel

yv f=displacement of vehicle body due to front wheel

yvf =displacement of vehicle body due to rear wheel

1 Equation of motion

Equation of motion can be derived from the Lagrange's equation or from free body diagrams.

mf*ÿf - cf (ývf - ýf) - kf (yvf - yf) +kta (yf - ya)=0 (1)

mR*ÿR -cR (ývR-ýR) + ktb (yR-yb) – kR(yvR-yR) =0 (2)

mv*ÿvf + cf (ývf - ýf) + kf (yvf - yf) = 0 (3)

mv * ÿvR + cR (ývR-ýR) + kR (yvR-yR) = 0 (4)

INPUT PARAMETERS

The data of Hero Splendor is collected such as stiffness and damping coefficient of front and rear wheel.

Sr.no	Parameters	Values
1	m_f =mass of front wheel (kg)	6.150
2	m_R =mass of rear wheel (kg)	7.350
3	$m_{v\,=}$mass of vehicle body (kg)	235.5
4	k_f =stiffness of front wheel (N/m)	3920
5	k_R =stiffness of rear wheel (N/m)	18600
6	k_{ta} =stiffness of front tire (N/m)	201392
7	k_{tb}=stiffness of rear tire (N/m)	266252
8	c_f =damping coefficient of front wheel (N-s/m^2)	320
9	c_R =damping coefficient of rear wheel (N-s/m^2)	1492

ROAD PROFILE

The input road profile considered is sinusoidal as the actual disturbances are bumps and potholes. The amplitude is considered as 10 cm.

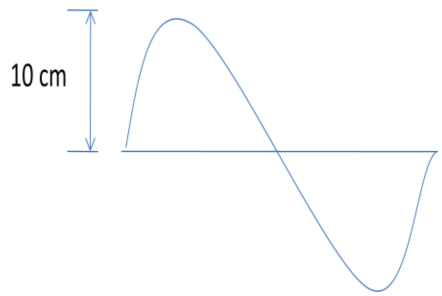

Fig 2. Road profile showing bumps and potholes

MATLAB PROGRAM

```
mf=6.150;  mR=7.350;   mv=235.5;   Cf=320;   CR=1490;   Kf=3920;  KR=18600;   Kta=201392;
Ktb=266252.7;  w0=20;

A = [0 1 0 0 0 0 0 0; -(Kf/mv)  -(Cf/mv) (Kf/mv) Cf/mv 0 0 0 0; 0 0 0 1 0 0 0 0; (Kf/mf) (Cf/mf) -Kf-Kta/mf -Cf/mf 0 0 0 0; 0 0 0 0 0 1 0 0; 0 0 0 0 -KR/mv -(CR/mv) KR/mv CR/mv; 0 0 0 0 0 0 0 1; 0 0 0 0 (KR/mR) (CR/mR) (-KR-Ktb/mR) -(CR/mR)]

B = [0;0;0;Kta/mf;0;0;0;Ktb/mR]

C = [1 0 0 0 0 0 0 0] % for vehicle body  displacement %

D = [0]

t=0:0.003:5;

r=0.1;

u=r*sin(w0*(t));

[Y,X] = lsim(A,B,C,D,u,t)

plot(t,Y)

ylabel('DISPLACEMENT')

xlabel('TIME')
```

RESULTS

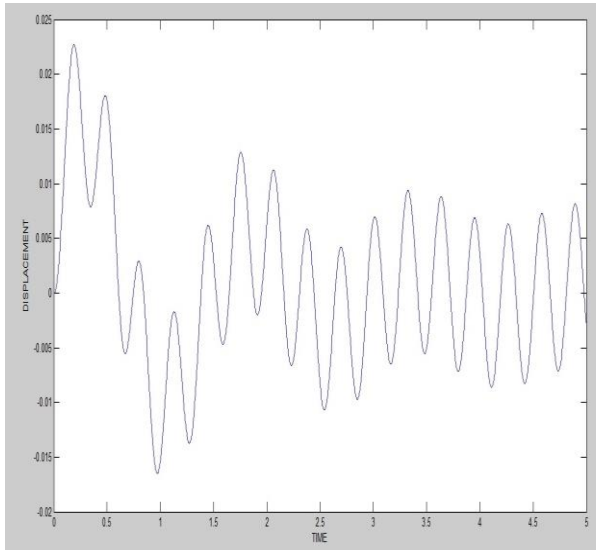

Fig 3. Displacement of front wheel vs time

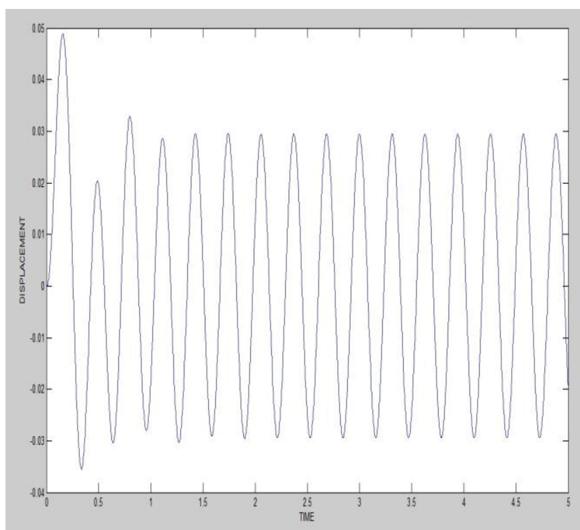

Fig 4. Displacement of rear wheel vs time

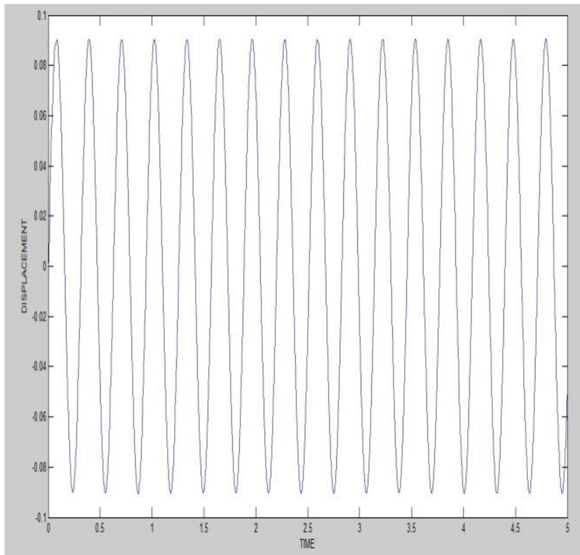

Fig 5. Displacement of vehicle body due to front wheel vs time

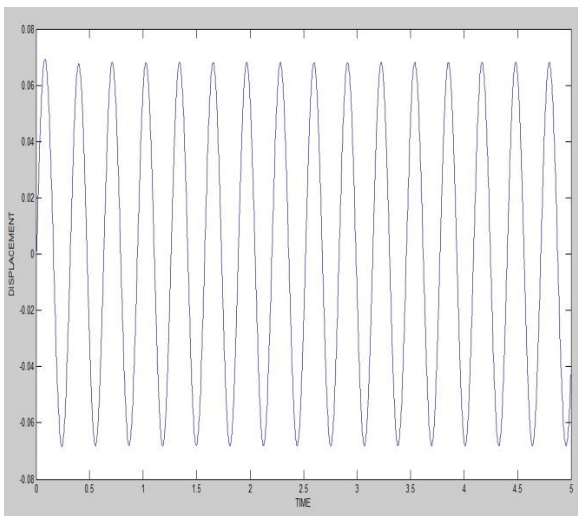

Fig 6. Displacement of vehicle body due to rear wheel vs time

The above graph shows the displacement of vehicle body. So in order to reduce the vibrations, values of damping factor is changed and resulting displacement is obtained with the help of graphs. Displacement for different damping values are shown in table 2.

Table 2.Displacement for different damping values

Damping factor	Displacement
360	0.0181
340	0.01808
320	0.01805
300	0.01801
280	0.01795
260	0.01798
240	0.01803
200	0.01805
180	0.01809
160	0.01815

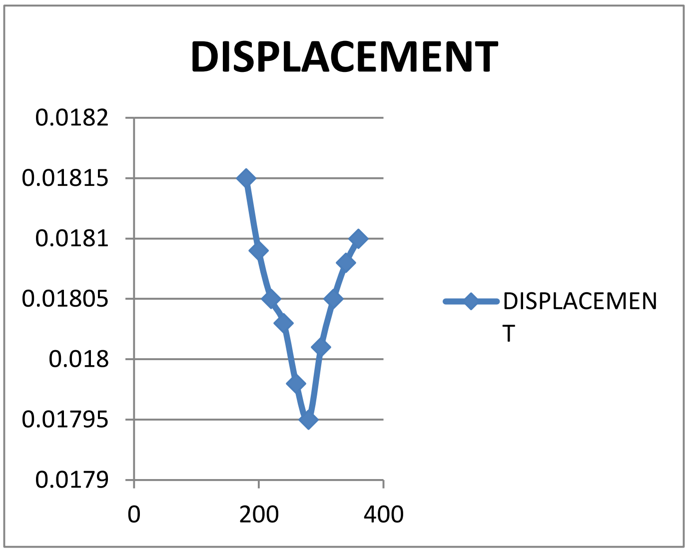

Fig 7.Graph of Damping Factor Vs Displacement

REAR WHEEL

TABLE 2: DISPLACEMENT FOR DIFFERENT DAMPING VALUES

Damping	Displacement
1490	0.047
1390	0.046
1290	0.046
1190	0.045
1090	0.044
990	0.043
890	0.042
790	0.042
690	0.041
590	0.04
490	**0.04**
390	0.04

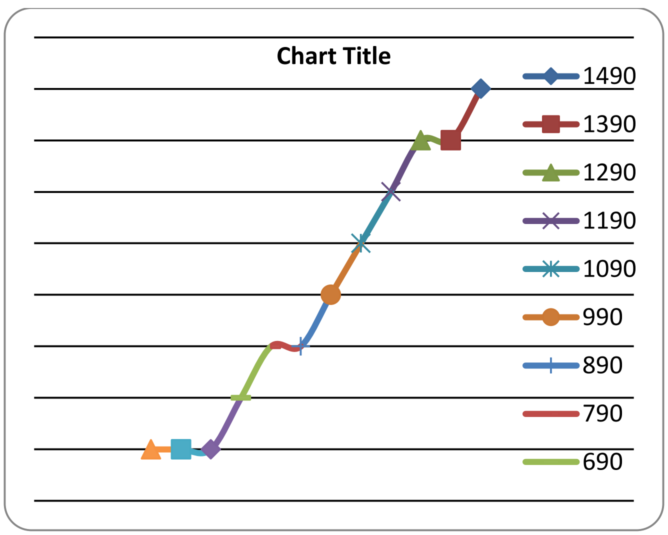

Fig 8.Graph of Damping Factor Vs Displacement

CONCLUSION

1. From the graph 7, We can see the minimum displacement 0.01795 m corresponds to a damping factor of 280 N-s/m2. So optimum value for the damping factor for front wheel is is 280 N-s/m2
2. From the graph 8, we can see that the minimum displacement 0.04 m corresponds to a damping factor of 490 N-s/m2. So the optimum value for the damping factor for rear wheel is 490 N-s/m2.

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