Transmissibility Investigation of Shock Absorber of Honda-Splendor/Shine Two Wheeler

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Abstract- *Shock absorber is very important term in automobile industries. They are used for the driving comfort and driving safety. This paper presents performance characteristics of the shock absorbers under real conditions. Dynamic behaviors of the absorber are studied by computer simulation and experimental testing and are validated with MATLAB results. The road disturbance is generated in the model by giving speed brakes fixed on drum which is rotated by using motor. In this paper study and analysis of single DOF spring-mass-damper system (Hero Splendor Rear Shock Absorber) and plotted its dynamic characteristics curve for different values of spring stiffness for different oils.*

Keywords- Shock Absorber, MINITAB, MATLAB, Optimization-Fuzzy Logic.

I. INTRODUCTION

The Shock absorber is a Suspension system which designed mechanically to control shock impulse and dissipate kinetic energy. It reduces the amplitude of disturbances leading to increase in comfort and improved ride quality. Shock absorber minimizes the effect of traveling on a rough ground. Now-a-days Modern vehicles come along with strong shock absorbers to tolerate any type of bouncy conditions. If supposedly shock absorber is not used then to control excessive suspension movement, stiffer springs will be used. The suspension system of an automobile is one which separates the wheel assembly from the body.

The primary function of the suspension system is to isolate the vehicle structure from shocks and vibration due to irregularities of the road surface. The Suspension system is used to support weight, absorb and dampen road shock, and help maintain tire contact as well as proper wheel to chassis relationship. A vehicle in motion is more than wheels turning. As the wheel revolves, the suspension system turns in dynamic state of balance, continuously compensating and adjusting for changing driving conditions according to road profile. Suspension of vehicle need to analyze before the manufacturing. This is because to make sure components in shock absorber system remain in good conditions. The Shock absorber system need to analyze how shock to see how they are going to perform in worst case scenario. A safe vehicle must be able to stop and maneuver over a wide range of road conditions. The Good contact between the wheel tires and the road will able to stop and maneuver quickly.

Suspension is the term given to the system of springs, shock absorbers and linkages that connects a vehicle to its wheels. Shock absorber with its whole assembly is an important part of automotive suspension system which has an effect on ride characteristics. Shock absorbers are also critical for tire to road contact which to reduce the tendency of a tire to lift off the road. This affects on braking, steering, cornering and overall stability of the vehicle. The removal of the shock absorber from suspension can cause the vehicle bounce up and down. It is possible for the vehicle to be driven, but if the suspension drops from the driving over a severe bump, the rear spring can fall out. Basically, the shock absorbers must be replaced after driving exceeds certain distance. But this actually not should have been followed if there are no defective.

II. PROBLEM SPECIFICATION

The aim of the project is to study and analyze single degree of freedom spring-mass-damper system and plot its dynamic characteristics curve for different values of spring stiffness for various speed conditions using FFT Analyzer validation with Matlab Results.

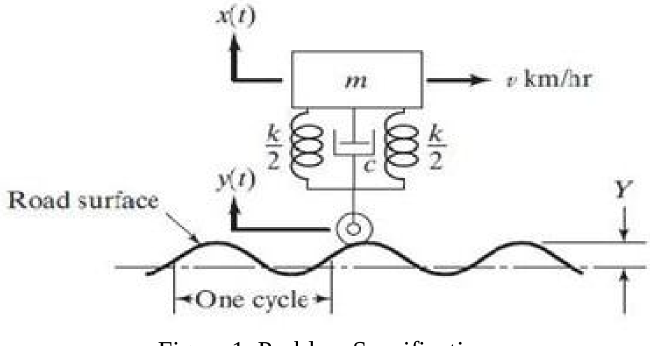

Figure 1. Problem Specification

III. OBJECTIVES

a) To test suspension on different types of oils and stiffness to find out optimum motion transmissibility using DOE
b) To determine dynamic characteristic of shock absorber.
c) Suspension will be test for multiple stiffness by varying loads, speed and different oils.
d) Motion transmissibility develop suspension testing set up for testing a various suspensions.

IV. METHODOLOGY

Using the knowledge from literature review, we can know how the CAD model is to be prepared. The conditions required for applying various constraints and how the loads are applied is briefed about in the technical papers referred.

CAD Model Generation

- Getting input data on dimensions shock absorber test rig.

Determination of loads

- Determination of different loads and boundary condition acting on the component by studying various reference papers and different resources available.

Testing and Analysis

- Testing is done by using FFT analyzer & Matlab software

Re-Design, Analysis and Results

- Making changes in model for optimization.
- Analyze this new model.
- Check the transmissibility ratio by using MINITAB.

Fabrication, Experimental validation and Result

- Fabrication of prototype.
- Suitable experimentation and comparison with present model.
- Validation of result by comparing with software results.

V. DESIGN AND ANALYTICAL CALCULATIONS

1. SPRING STIFFNESS CALCULATION

Figure 2. Spring Stiffness Measurement

As initially we don't have spring stiffness value for two suspensions those are used for experimentation .For this one small experiment is done to calculate the stiffness. Initial length of the spring is measured with scale. Then 60 Kg load is applied on spring of one of the shock absorber. Thus spring gets compressed and now again spring length is measured. Now by using the formula for calculating spring stiffness,

$K= (F/X) \times 9.81$ N/mm
Where,
K-Spring stiffness in N/mm F-Load applied in Kg
X-Displacement due to loading=
(Free length -Compressed length) in mm. Sample Calculation
For Splendor,
$K= (60 \times 9.81)/ (230-205)$
$K= 23.54$ N/mm

Table 1. SPRING STIFFNESS OF SPLENDOR AND HONDA SHINE SHOCK ABSORBER

Sr. No	Shock Absorber	Load on Spring Kg	Length mm		Spring Stiffness (K) N/mm
			Free Length	Comp. Length	
1	Splendor	60	230	205	23.540
2	Honda Shine	60	240	206	17.310

2. Shaft material and Calculation

EN 19 Alloy Steel used for shaft. It is a high quality, high tensile steel usually supplied readily machineable in any temperature condition, giving good ductility and shock resisting properties combined with resistance to wear.

A. Applications:

EN19T was originally introduced for the use in the machine tool and motor industries for gears, pinions, shafts, spindles and the like. Later its applications became much more extended and it is now widely used in areas such as the oil and gas industries. EN19T is suitable for applications such as gears, bolts, studs and a wide variety of applications where a good quality high tensile steel grade is suited.

B. Calculation

Perimeter of Drum

$P=2\pi r$
$P=2\pi \times 0.305$ $P=1.91637$ m

volume of drum
$V=2\pi r^2 h$ $V=2\times 3.14\times 0.305\times 0.305\times 0.005$ $V=0.00292246$ m3

Mass of Drum $M=V\times\rho$ $M=0.00292246\times 7860$ $M=22.98$ kg

WEIGHT OF DRUM
$W=m\times g$ $W=22.98\times 9.81$ $W=225.48$ N

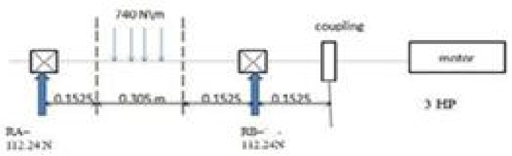

Figure 3. Force Diagram

By maximum shear stress theory
Support reaction (RA, RB)
$\sum MA=0$
$[(-RB\times 0.6096) + (740\times 0.305\times 0.15252)]=0$ $RB=112.74N$
$RA= -RB+ (740\times 0.305)$ $RA=112.74$ N
Bending Moment (M) $M=RA\times x- w \times (0.15252)/2$
$M=112.74\times 0.305-740\times (0.1525) 2/2$ $M=25.78$ N-m
Torque $T=F\times r$
$T= (149\times 9.81) \times 0.405$
$T= 592$ N-m

Equivalent Torque $Te = \sqrt{(M2+T2)}$
$Te = \sqrt{(25.782 + 5922)}$
$Te = 593$ N-m

Diameter of Shaft

$d= \sqrt[3]{(16\times Te/ \pi \tau)}$
$d = \sqrt[3]{[(16\times 593\times 1000)/ (\pi\times 45)]}$
d=40.69 mm~50 mm
By maximum principal stress theory

Equivalent Moment $Me= [M +\sqrt{(M2+T2)}] /2$
$Me= [25.78+\sqrt{(25.782+5922)}] /2$
Me=309.17 N-m

Diameter of Shaft $d= \sqrt[3]{(32\times Me/\pi\sigma)}$
$d=\sqrt[3]{((32\times 309.17)/(\pi\times 75))}$
d=41 mm
Selecting maximum diameter & after select the roller bearing
Find Te < T
$T= (60\times 1000\times P/2\pi N)$
$T= (60\times 1000\times 2.238/2 \pi\times 240)$ T=89.047 N-m

Velocity
$V= \pi DN/60$ $V=\pi\times 0.05\times 240/60$ V= 628.31 m/s V=2.2611 Kmph

3. Bearing

Bearing is mechanical element which locates two machine parts relative to each other and permits a relative motion between them. It has two or more contacting surfaces through which a load is transmitted. UCP210 bearing is used for shaft.

According to required torque of 89 Nm & internal diameter of 50mm bearing selected is Plummer block.

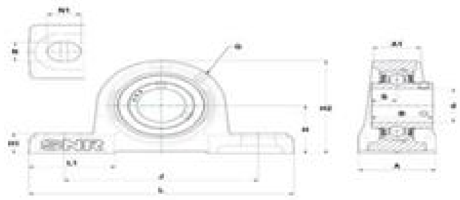

Figure 4.Bearing UCP210

4. Key

Key is a mechanical element used on shafts to secure rotating elements like gears, pulleys, or sprocket and prevent relative motion between two. The key transmits torque fromthe shafts to shaft supported element or vice versa. It is always inserted parallel to the axis of shaft.

Carbon steels have carbon as the key alloying element in their composition. They also contain up to 0.4% silicon and 1.2% manganese. In addition, the residual elements such as copper, molybdenum, aluminum, chromium and nickel are present in these steels.

A. Calculations

$TMax=1.25\times 593$ $TMax=741.25$ N-m $741.25\times 103=(\pi/16)\times d3\times 45$
d=50 mm $w=h=50/4\approx 13$mm l=75mm

Shear Stress
$TMax= w\times l\times (d/2) \times (\tau\ per)$ Key
$741.25\times 103= 13\times l\times (50/2) \times 45$
l= 50.68 mm

Crushing Stress
$TMax= (h/2) \times l\times (d/2) \times (\sigma\ per)$ Key
$741.25\times 103= (13/2) \times l\times (50/2) \times 80$

l=57mm

Thus key dimensions should be taken as 13mm, 13mm, and 75mm in breadth, width and length respectively.

VI. EXPERIMENTAL SETUP

Figure 5. Experimental Setup (CAD Model)

1. ABOUT SETUP

A. FRAME

It is Base structure of setup. It is made of MS bars in C-Section. Total material used is about 35 Feet. Frame gives the support to all the assembly components.

B. DRUM

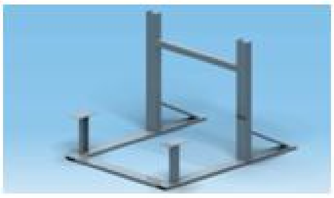

Figure 6. Frame

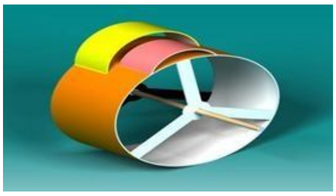

Figure 7. Drum

It is made of MS sheet having thickness 4mm. It is manufactured by rolling of sheet metal. Standard speed breaker profiles are also made by sheet metal by giving radius and welded to drum. Drum is supported by 3 spokes.

C. WHEEL ASSEMBLY

Figure 8. Wheel assembly

It is wheel assembly of Hero Splendor Bike. Wheel is fitted in swing arm. Shock absorbers lower point is mounted on swing arm. Swing arms are assembled to Frame.

D. MOTOR

1440 RPM 3 HP single phase motor is coupled to shaft. It rotates drum and ultimately drum

E. DIMMERSTAT

Dimmerstat is auto transformer having continuously variable voltage. It has simple construction and variation of output voltage is smooth, continuous and breakless. It has high efficiency and excellent overload capacity for short time. 20ampere dimmerstat is used to control the motor speed.

F. FFT Analyzer

FFT-Fast Fourier Transform. It is a noise & vibration measurement instrument. Time domain data is converted into frequency domain. We will take reading by using accelerometer. DEWEsoft is used to display the results.

Figyre 9. FFT Analyzer

SPECIFICATION

- Small USB- based system
- 8 analogue input channels (strain, voltage; with MSI adapters any input)
- 200 kS/s aliasing-free 24bit-ADC
- 8 precise real time counters
- 2 CAN bus ports isolated

G. ACCELEROMETER

Accelerometer is a Piezo-electric accelerometer and it is considered as the standard vibration transducer for machine vibration measurement. The accelerometers consist of a piezoelectric crystal which has a mass attached to one of its surfaces. When the mass is subjected to a vibration signal, the mass converts the vibration (acceleration) to a force, this then being converted to an electrical signal. This is the basis of the "accelerometer".

H. THE DEWESOFT SOFTWARE

The analysis is carried out in DEWESoft Software. Various methods of dynamic signal analysis are present in the software such as Sound level, Torsional vibration, Human Vibration.

2. WORKING

- Shaft is mounted in bearing on which drum is mounted. Speed breaker profiles are welded on drum.
- On drum wheel assembly is mounted.
- Shaft is coupled to motor. Motor shaft rotates the Drum shaft which simultaneously rotates the wheel which in on drum.
- Motor speed is controlled by using Dimmerstat.
- As wheel and drum rotates wheel reaches to speed beaker profile it create bump on shock absorber.

Figure 10. Actual Experimental Setup

- Shock absorber will get compress.
- FFT analyzers sensors will attached to Upper and lower point of shock absorbers and readings displayed on computers screen.

VII. RESULTS AND DISCUSSION

1. EXPERIMENTAL RESULTS

Table 2. SPLENDOR SUSPENSION (OIL 1)

S.N	Spring Stiffness (K)	Load (Kg)	Peak(RMS) m/s^2		Transmissibility T_R=(A/B)
			Top (A)	Bottom (B)	
1	23540	27	17.085	23.347	0.7317
2	23540	32	14.420	24.23	0.6073
3	23540	37	11.71	22.955	0.4932
4	23540	42	10.59	23.544	0.4147

Table 3. HONDA SHINE SUSPENSION (OIL 1)

S. N	Spring Stiffness (K)	Load (Kg)	Peak(RMS) m/s^2		Transmissibility T_R=(A/B)
			Top (A)	Bottom (B)	
1	17310	27	13.34	24.32	0.5485
2	17310	32	11.54	25.66	0.45
3	17310	37	10.73	26.19	0.41
4	17310	42	10.30	28.61	0.36

Table 4. SPLENDOR SUSPENSION (OIL 2)

S. N	Spring Stiffness (K) (N/m)	Load (Kg)	Peak(RMS) m/s^2		Transmissibility T_R=(A/B)
			Top (A)	Bottom (B)	
1	23540	27	18.774	25.407	0.7371
2	23540	32	14.469	24.525	0.6045
3	23540	37	11.375	21.876	0.52
4	23540	42	9.809	21.876	0.4484

Table 5. HONDA SHINE SUSPENSION (OIL 2)

S. N	Spring Stiffness (K) (N/m)	Load (Kg)	Peak(RMS) m/s^2		Transmissibility T_R=(A/B)
			Top (A)	Bottom (B)	
1	17310	27	13.791	25.898	0.5325
2	17310	32	12.24	27.664	0.4427
3	17310	37	9.4176	24.721	0.3809
4	17310	42	7.651	23.093	0.33134

2. FFT RESULTS

1. Splendor Suspension Bottom for weight 32Kg for Oil 1

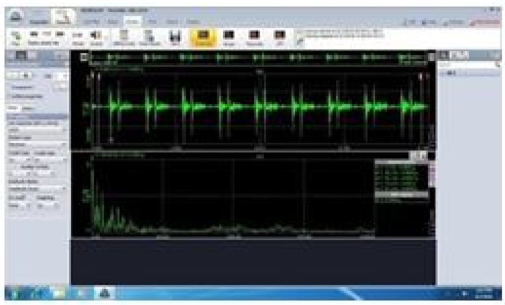

Figure 11.Graph 1

2. Splendor Suspension Top for weight 32Kg for Oil 1

Figure 12.Graph 2

3. Splendor Suspension Bottom for weight 32 Kg for Oil 2

Figure 13.Graph 3

4. Splendor Suspension Top of weight 32Kg for Oil 2

Figure 14.Graph 4

VIII. RESULTS AND DISCUSSION

1. Transmissibility comparison

Now we can compare the transmissibility calculated from experimental readings and MATLAB solution. The percentage error in transmissibility is shown in following table

8.1.1 Splendor Suspension (K=23540N/m and Oil 1)

Table 6. Transmissibility comparison of Splendor suspension with Oil 1

Load (Kg)	ω/ ωn	Transmissibility		% Error
		Experiments	MATLAB	
27	1.524	0.7317	0.7859	6.896
32	1.659	0.5951	0.6073	2.009
37	1.784	0.51	0.4932	3.406
42	1.901	0.45	0.4147	8.512

2. Honda Shine Suspension (K=17310N/m and Oil 1)

Table 7. Transmissibility comparison of Honda Shine suspension with Oil 1

Load (Kg)	ω/ ωn	Transmissibility		% Error
		Experimental	MATLAB	
27	1.777	0.5485	0.5203	5.419
32	1.9348	0.45	0.4149	8.459
37	2.08	0.41	0.3445	19.013
42	2.21	0.36	0.2943	22.324

3. Splendor Suspension (K=23540N/m and Oil 2)

Table 8. Transmissibility comparison of Splendor suspension with Oil 2

Load (Kg)	ω/ ωn	Transmissibility		% Error
		Experimental	MATLAB	
27	1.524	0.7371	0.7837	5.946
32	1.659	0.59	0.6045	2.398
37	1.784	0.52	0.4906	5.993
42	1.901	0.4484	0.4123	8.756

4. Honda Shine Suspension (K=17310N/m and Oil 2)

Table 8. Transmissibility comparison of Honda Shine suspension with Oil 2

Load (Kg)	ω/ ωn	Transmissibility		% Error
		Experimental	MATLAB	
27	1.777	0.5325	0.5159	3.218
32	1.9348	0.4427	0.411	7.713
37	2.08	0.3809	0.3411	11.67
42	2.21	0.33134	0.2913	13.745

3. Result of MATLAB

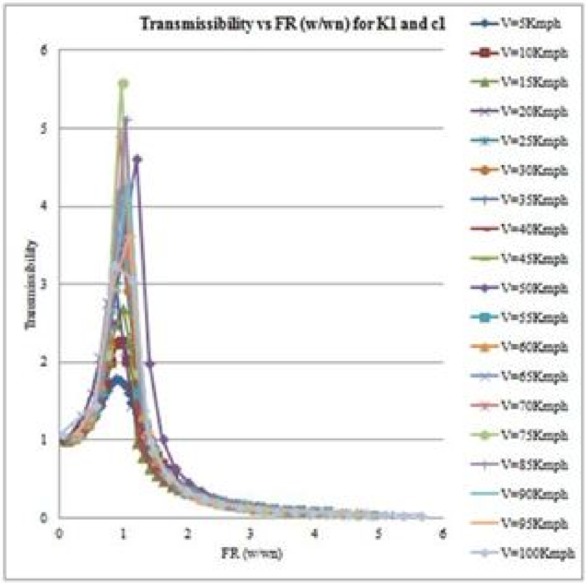

Figure 15. Transmissibility Vs FR (ω/ ωn) for K1 and c1

IX. CONCLUSION

From this Suspension testing setup we can test multiple numbers of suspensions at different loads and different speeds. Also we can use suspensions of different height.

By changing different suspensions and oils we can find out optimum motion transmissibility. With ultimate objective of studying and plotting dynamic characteristics for Hero Splendor suspension and Honda Shine suspension using single wheel model of suspension analysis to produced large number of results. However it concludes the project work with following points:

1. The suspension system gives best performance when designed to be slightly under-damped.
2. From experimental results and graphs we can conclude that for good ride, transmissibility should be as low as possible and this can be attained by using low damping constant and high spring stiffness and Honda Shine suspension gives the better results as compared to Splendor suspension

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