International Journal of Mechanical Engineering (IJME)
ISSN: 2319-2240
Vol.2, Issue 1 Feb 2013 17-28

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

DESIGN AND DEVELOPMENT OF SHOCK ABSORBER TEST RIG

L.M. JUGULKAR[1], SHANKAR SINGH[2] & S. M. SAWANT[3]

[1]Reasearch Scholar , Department of Mechanical Engineering, Sant Longowal Institute of Engineering and Technology, Longowal, Sangrur (Punjab), India

[2]Associate Professor, Department of Mechanical Engineering, Sant Longowal Institute of Engineering and Technology, Longowal, Sangrur (Punjab), India

[3]Professor, Department of Mechanical Engineering, Rajarambapu Institute of Technology, Sakharale , Sangli, Maharashtra, India

ABSTRACT

Automotive vehicle performance has been a major focus of industrial research and development for nearly a century. While vehicle performance can be quantified in many ways like ride quality and handling is two aspects of performance directly related to suspension system. In a broader sense, vehicle's ride quality is characterized by suspension with low spring rate, low damping rate, resulting in large suspension travel. On the other hand, for achieving good handling characteristics suspensions with high spring rates and high damping rates, resulting in small suspension deflections are incorporated. Suspension system basically consists of different components like spring, shock absorber and linkages that isolates excitations from road to wheels and then to vehicle. So they perform a major role in obtaining desired ride and handling characteristics. Out of this, behavior of shock absorber (damper) significantly affects the performance of suspension system. This is difficult to achieve unless and until parts of the whole system performs their assigned task satisfactorily. For achieving this evaluation of performance of individual components of the suspension system is necessary. It raises need of a mechanism which will simulate different actual conditions that a vehicle is subjected. The mechanism or setup should be able to create a vehicular situation in which one end of the suspension test rig is subjected to jerks and bounce producing unsteady vibrations. While on the other side it should face loading conditions representing the weight of passenger and vehicle itself. So this paper encompasses the design and development of shock absorber test rig in which the above mentioned conditions are simulated and performance is evaluated.

KEYWORDS: Suspension System, Shock Absorber, Damping, Stiffness and Dynamic Characteristics

INTRODUCTION

The automotive suspension on a vehicle typically has the basic tasks

Provision Good Ride Quality

Ride quality in general can be quantified by the vertical acceleration of the passenger locations. The presence of a well-designed suspension provides isolation by reducing the vibratory forces transmitted from the axle to the vehicle body. This in turn reduces vehicle body acceleration. In this case of the quarter car suspension sprung mass acceleration 'Zs' can be used to quantify the ride quality.

Good Road Holding

The road holding performance of a vehicle can be characterized in terms of its cornering breaking and traction abilities. Improved cornering, breaking and traction are obtained if the variations in normal tire loads are minimized. This is because the lateral and longitudinal forces generated by attire depend directly on the normal tire load. Since tire can be directly related to vertical tire deflection. The road holding of the suspension can therefore quantified in terms of the tire deflection performance.

Provision of Good Handling

The roll pitch acceleration of vehicle during cornering, braking and traction are measures of good handling. Half-car and full-car models can be used to study the pitch and roll performance of vehicle. A good suspension system should ensure that roll and pitch motion are minimized.

Vehicle Static Weight

This task is performed well if the rattle space requirements in the vehicle are kept small. In this case of the quarter car model, it can be quantified in terms of the maximum suspension deflection (Zu-Zr) undergoes by suspension.

NEED OF PERFORMANCE MEASUREMENT SYSTEM

Suspension system is an important consideration as far as vehicle safety and comfort to the passengers is taken into account. It performs major role of isolating vehicle body from the road shocks which may be in the form of bounce, pitch, roll or sway. These tendencies give rise to an uncomfortable ride and also cause additional stress in the automobile frame and body. Thus in other words suspension system performs following functions:

- To prevent the road shocks from being transmitted to the vehicle components.
- To safeguard the occupants from road shocks.
- To preserve stability of vehicle in pitching or rolling while in motion.

Therefore it is really important to measure the efficiency or effectiveness of the system in order to ensure that whether the suspensions are performing their assigned job in a desired manner.

Following are some of the terms used in suspension performance measurement:

1. Spring rate: It is the force required for unit deflection.
2. Unsprung weight: It refers to weight of the vehicle components which are not suspended by the suspension system. It is desired to have least unsprung weight. The unsprung includes the wheels and tires, usually brakes plus some percentage of suspension, depending on how much of suspension moves with the body and how much with the wheels.
3. Transmissibility: Let us consider a machine operating at some working speed. Due to this it is creating some vibrations. Machine is equipped with isolators at its bottom side. Now the term ‘transmissibility’ comes into the picture.

Let, f_i = force induced due to vibrations.

f_t = force transmitted to the foundation.

Now, transmissibility (T_r) = f_t / f_i

It is said to have a good damping properties when system has less transmissibility. It means less vibrations are transmitted out of generated vibrations. In this performance measurement system we have mainly focused on transmissibility. Damper’s performance is evaluated on the basis of its transmissibility. For this acceleration is measured at the lower section of damper and then at the upper section.

SELECTION OF COMPONENTS

For experimental set up, required some components, some of them are designed and some of selected.

- Base.
- Sliding link.
- Pivoted link.
- Motor.
- Connecting link between motor shaft and pivoted link.
- Vertical columns.
- Accelerometer and control panel.
- Dimmerstat.
- Nuts and bolts.
- Bearing.

DESIGN OF COMPONENTS

Design of components is very important because set up must sustain against the fluctuating load. So that every component have sufficient strength rigidity. Design procedure for those components and basis for designing is mentioned below.

Base

Function:

- It gives firm support to the test set up
- It provides proper space for motor & rest of all the things consisting in the set up.
- It balances the system while the rig is in testing condition.

Consideration for Selection of Base:

- So as to get the rigid and firm support we have chosen the material for the base as mild steel..
- The C channel taken as a guide for the sliding link is with the available specifications in the market.
- The load bearing capacity of the material is suitable as per our requirement.

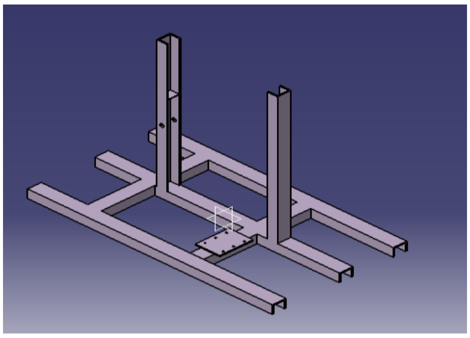

Fig. 1: Base

Sliding Link

Function:

- Function of the sliding link is to slide in the guide channel along with the load.
- Another function of this link is to support the suspension at upper side.
- It also provides the space and support for the loads to be acted on the suspension at the time of testing.

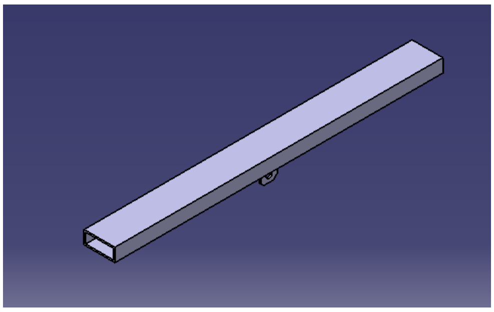

Fig. 2: Sliding Link

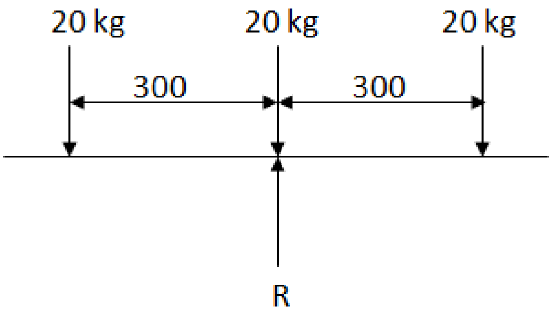

Fig. 3: Reactions on Sliding Link

Calculate the opposite reaction of loads i.e. R is given by,

R = 196.2+196.2+196.2

= 588.6 N

Now select the cross section of the sliding link, for calculate the bending moment and bending stress.

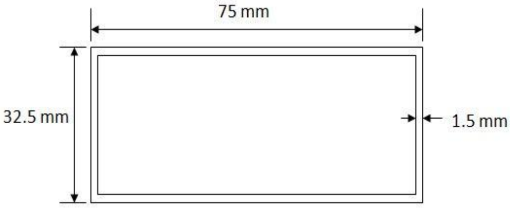

Fig. 4: Cross Section of Sliding Link

Where,

b = width of sliding link.

d = depth of sliding link.

t = thickness of sliding link.

Formula for bending moment is given by,

Mb = σb * Z

But,

$$I = \frac{b * d^3}{12}$$

$$= \frac{D^4 - d^4}{12}$$

$$= \frac{75^4 - 72^4}{12}$$

$$= 397230.75 \ mm^4$$

$$Ymax = \frac{d}{2}$$

$$= \frac{32.5}{2}$$

$$= 16.25 \ mm$$

$$Z = \frac{I}{Ymax}$$

$$= \frac{397230.75}{16.25}$$

$$= 24444.96 \ mm^3$$

Assume yield tensile strength for mild steel is 350 N/mm^2 and factor of safety is 3.

Therefore, $$\sigma b = \frac{Syt}{f.s.}$$

$$= \frac{350}{3}$$

$$= 116.66 \ N/mm^2$$

Then, $$Mb = \sigma b * Z$$

$$= 120 * 24444.96$$

$$= 2933395.2 \ N/mm$$

Now, calculate load per unit length for uniform distributed load W is given by,

$$Mb = \frac{W * L^2}{8}$$

∴ $$W = \frac{2933395.2 * 8}{800^2}$$

= 36.66 N/mm

= 3.74 kg/mm

Where,

Mb = bending moment.

σb = bending stress.

Z = section modulus.

I = moment of inertia.

W = load per unit length.

L = total length of sliding link.

Thus the designed of maximum uniform distributed load is greater than the actual load i.e. 0.73 Kg/mm acting on the system. Hence the design of the component is safe from failure.

Pivoted Link

Function:

- To compress the suspension to be tested with help of linked motor.
- It is pivoted at one end to the C-channel and another end is connected to link which is linked with motor.
- It provides support to the suspension at the lower end of the suspension.

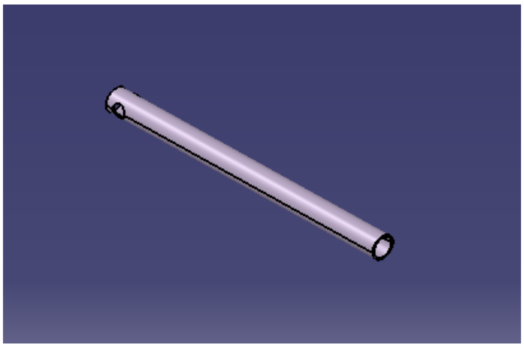

Fig. 5: Pivoted Link

Calculation of pivoted link

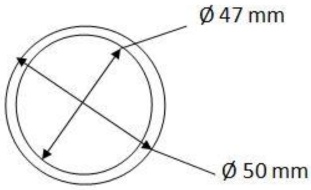

Fig. 6: Cross Section of Pivoted Link

Where,

D = outer diameter of pivoted link.

d =inner diameter of pivoted link.

We know,

$$I = \frac{\pi}{64} * [\, D^4 - d4 \,]$$

$$= \frac{\pi}{64} * [\, 50^4 - 474 \,]$$

$$= 67265.38 \quad mm^4$$

$$Ymax = \frac{d}{2}$$

$$= \frac{50}{2}$$

$$= 25 \quad mm$$

Section modulus is given by,

$$Z = \frac{I}{Ymax}$$

$$= \frac{67265.38}{25}$$

$$= 2690.622 \quad mm^3$$

Assume, yield tensile strength for mild steel is 350 N/mm^2 and factor of safety is 3. And our material is mild steel.

Therefore, $$\sigma b = \frac{Syt}{f.s.}$$

$$= \frac{350}{3}$$

$$= 116.66 \ N/mm^2$$

Then, $$Mb = \sigma b * Z$$

$$= 120 * 2690.622$$

$$= 322873.80 \quad N/mm$$

Now calculate point load W is given by,

$$Mb = \frac{W * L}{4}$$

$$\therefore \quad W = \frac{322873.80 * 4}{625}$$

= 2066.39 N/mm

= 210.64 kg/mm

Thus the designed maximum load is greater than the actual load i.e. 20 Kg/mm acting on the system. Hence the design of the component is safe from failure.

Connecting Link between Motor Shaft and Pivoted Link

Function:

- It provides link between pivoted link and motor shaft.
- It provides rigid support to the suspension while loading the suspension to the rig.
- It is provided with 2 DOF.

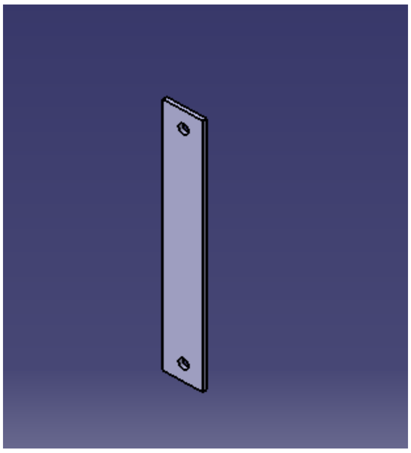

Fig. 7: Connecting Link

Accelerometer & Control Panel

Function:

- It measures the acceleration of the sliding link.
- It measures the acceleration of pivoted link also.
- We can draw the acceleration vs frequency with help of the results from this at varying speeds and voltages.

SHOCK ABSORBER TEST RIG

The construction and working of the shock absorber test rig is explained

The set up mainly consists of a rigid base which is rectangular in shape. On this base all other components are mounted. There is also provision made for the mounting of the motor which will act as source of excitation. Two vertical C-shaped channels are mounted on the base to provide support for different links like sliding link, pivoted link, etc. Sliding link is located horizontally at the upper portion of c-channels. Very small clearance is kept in the grooves of c-channel and sliding link so as to ensure the perfect sliding motion of the link. Small rectangular plates are welded at middle portion of c-channel inside the grooves. They are provided so as to restrict the motion of sliding link at lower side and provide resting position for link when not in operation. Three circular rods are provided at the upper face of the sliding link so as to apply desired weights uniformly. Bearings are provided at the side faces of sliding link to ensure its smooth motion inside the grooves of c-channels. At lower side a pivoted rod is provided which will carry the excitations from motor to the shock absorber. The rod is pivoted at one side with the help of a bolt-sleeve arrangement. By doing this, its oscillating motion can be achieved. This will ultimately result in alternate compression-tension of the shock absorber. At the middle portion of sliding link and pivoted rod, rectangular plates are given on which holes are made to accommodate the shock absorbers of different length. Two rectangular links are provided in between pivoted rod and motor shaft. They are coupled with the help of bolts.

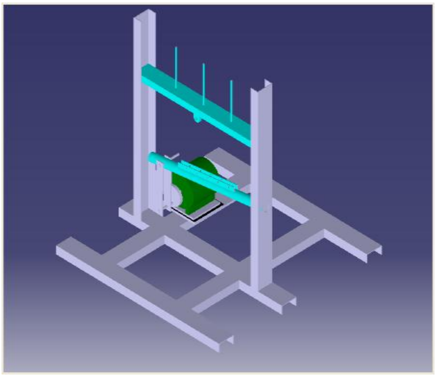

Fig. 8: Construction of Test Rig

When motor shaft rotates so the pulley attached to shaft. This motion is transferred to two rectangular links by using bolts where it is converted into oscillating motion at the pivoted rod. Now these oscillations will act as input excitations to the shock absorber and cause compression-tension.

This condition refers to actual vehicular condition in which jerks, bounce and vibrations are transmitted to suspension system. Loads are applied from upper side on the sliding link. Now this load will act on shock absorber as the shock absorber is attached to this link.

A provision is made that sliding link will not touch to the small rectangular plates inside grooves when it is at the lowest position when in operation. This loading condition refers to weight of vehicle chassis and the weight of the passengers which acts on the vehicle suspension system.

Now the shock absorber is loaded with the weights from upper side and due to the oscillations, it is also subjected to compression-tension. This perfectly simulates the actual vehicular condition. Now we can determine the transmissibility for the shock absorber by attaching accelerometers at the lower and upper sections.

By this, we can determine how the induced vibrations are damped by shock absorber. Also the proportion in which this damping is achieved can be predicted. This is how the performance of shock absorber is evaluated.

TESTING AND RESULTS

Testing includes the measurement of accelerations at input and output ends of the shock absorber. For this an accelerometer is used which will record the acceleration level at those locations.

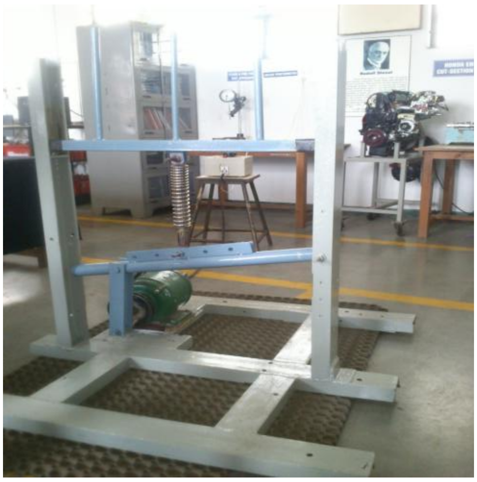

Fig. 9: Suspension Test Rig

RESULTS

A) Shock Absorber No 1:
Suspension results of Shock Absorber No 1

Sr. No.	Speed(rpm)	Acceleration Measured (g)		Transmissibility Factor
		Input End	Output End	
1	270	0.01378	0.01132	0.8214
2	300	0.2389	0.8021	0.3001
3	350	0.8103	0.5289	0.6527
Average				**0.5914**

B) Shock Absorber No 2
Suspension results of Shock Absorber No 2

Sr. No.	Speed(rpm)	Acceleration Measured (g)		Transmissibility Factor
		Input End	Output End	
1	270	0.1524	0.07620	0.50
2	300	0.5020	0.1089	0.2169
3	350	1.2900	0.7523	0.5831
Average				**0.4333**

From above results one can easily predict that shock absorber no. 2 has better damping characteristics since it prevents more vibrations from being transmitted.

CONCLUSIONS

The paper encompassed the erection of a setup or mechanism which will be able to develop the actual conditions those are faced by a suspension system and ultimately the components of the suspension system. After that the various concepts and available theories, practices adopted in industries by the experts are understood in order to approach towards the implementation. In the design of the various components of the system forces and stresses which are coming on the setup are calculated. By doing this it is ensured that the design is safe against any undesired consequences those may come while in operation. Also the major part of testing is done on the setup. For this use of different sensors and data acquisition system has been studied. Finally the tests are taken on the shock absorber and results are interpreted. Thus the performance of the different shock absorbers have been evaluated and compared.

REFERENCES

1. Oly D Paz "Design And Performance Of Shock Absorber", Cambridge University Press,(1997).
2. R. B. Goldner, P.Zerigian And J.R. Hull, "A Preliminary Study of Energy Recovery Vehicles by Using Regenerative Shock Absorber", Argonne National Laboratory, (2008).
3. John C. Dixon "Shock Absorber Handbook", Wiley Professional Engineering Publishing Series, 2nd Edition,(2007).
4. V.B. Bhandari," Design Of Machine Elements", TATA Macgraw Hill, 3rd Edition, (2010).
5. R.K. Bansal, "Strength Of Materials", Laxmi Publications, 4th Edition, (2007).
6. S. Ramamurtham "Strength Of Materials" Dhanpat Rai Publishing, 11th Edition, (2010).
7. N.K. Giri "Automobile Engineering", Khanna Publishers 3rd Edition,2005.
8. Newton ,Steeds, Garrett, "Motor Vehicle", Butterworth Heinemann,13th Edition.2004.
9. "Machine Design"; Robert L. Norton ;Pearson publication India ; 2nd Edition.