# A Review of Design of Shock Absorber Test Rig

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**Abstract -** *Shock absorber device is generally used in all automobiles. It is an example of under damped vibration system which absorbs maximum amount of kinetic energy and sometimes potential energy. Main purpose of our research is to measure transmissibility of shock absorber and to analyze it for different loads and speeds. Effectiveness of the vibration absorber can be measured by transmissibility. And for measurement of transmissibility shock absorber test rig is designed and developed. an experiment on test rig is carried out at various loads and speeds which results to output in the form of sinusoidal waveform on paper by using stylus. The waveform is used to find out the transmissibility at various load-speed combinations. It gives the behavior of shock absorber at various speeds and loads.*

***Key Words*: Amplitude, Displacement, Velocity, acceleration, Transmissibility, accuracy of shock absorber.**

## 1. INTRODUCTION

Shock absorber is the necessary element of every automobile. It absorbs some amount of force and motion and transmits remaining force and motion to the person who is sitting on vehicle. Input force and motion is given by due to uneven path like speed breakers, ditches etc. The shock absorber testing rig estimates that how much force that shock absorber absorbs and how much motion it transmits. To control the vibrations of suspension system of every automobile Shock absorber is used. If this vibrations are uncontrolled can lead to apocalyptic results like Excessive stresses, Undesirable noise, Looseness of parts, probability of happening accidents increased in very big extent, to minimize these effects proper testing of shock absorber is necessary.

The main objectives behind the design of shock absorber are: To determine dynamic characteristics like displacement, vibration etc. of automotive shock absorber system, to test and indicate the condition of shock absorber in automotive vehicle, to calculate accuracy of shock absorber.

## 1. TERMINOLOGY AND DIMENSIONS

1. Time Period:
In the both rectilinear & torsion types of vibration analysis, a steady state mechanical vibration is the motion of system repeated after an interval of time known as the time period.
2. Cycle:
The motion completed in any one period of time.
3. Frequency:
The number of cycles per unit time is called frequency.
4. Amplitude:
The maximum displacement of vibrating body from the mean position.
5. Natural Frequency:
Frequency of free vibration of the system. It is a constant for a given system.
6. Resonance:
The vibration of the system when the frequency of external force is equal to natural frequency of the system.
7. Damping:
Damping is nothing but resistance to motion of vibrating body.
8. Degree Of Freedom:
A system is said to be n-degree of freedom system if its needs 'n' independent co-ordinates to specify completely the configuration of the system at any instant. A mass is supported by a spring & constrained to more in one direction without rotation in a single degree of freedom system. The same is true for a simple pendulum oscillation in one plane. A crank slider mechanism is also a single degree of freedom system since only the crank angle sufficient to define the illustrated On the other hand a spring supported rigid mass which can move in the direction of the spring & can also have angular motion in one plane has two degree of freedom. A body in a space has degree of freedom three

translational & three rotational. A flexible beam between two supports has an infinite number of degree of freedom.

9. Phase Difference:

It is the angle between two rotating vector representing simple harmonic motions of same frequency.

10. Simple Harmonic Motion:

A periodic motion of a particle whose acceleration is always directed towards the mean position & is proportional to its distance from the mean position.

11. Modes of Vibration:

The word relates to the shape or form of motion, e.g. linear or translation, angular or torsion, flexural, transverse or lateral.

12. Nodes:

The word "Node" applies to any point on line, which is stationary at all times in a vibrating or oscillating system.

## 2. Classification of Vibration

1. According to actuating force:
   i. free vibration
   ii. force vibration
2. According to external resistance
   i. undamped vibration
   ii. damped vibration
3. According to motion of system w.r.t. axis
   i. longitudinal vibration
   ii. transverse vibration
   iii. torsional vibration
4. according to behavior of vibrating system
   i. linear vibration
   ii. non-linear vibration
5. according to magnitude of actuating force at a given time
   i. deterministic vibration
   ii. random vibration

## 3. Transmissibility:

Force transmissibility is defined as the amplitude ratio of the transmitted force to the impressed force. In order to reduce as much as possible the amount of force transmitted to the seat of the vehicle due to the vibration of the vehicle because of interaction with the roads, vehicles are usually isolated from the roads by means of wheels and suspension system which involves the shock absorber and the spring damper system in it. As a result the force transmitted to the seat of vehicle is the sum of the spring & the damper force of the shock absorber. i.e. Ft = kx + cx

Force transmissibility is defined as the amplitude ratio of the transmitted force to the impressed force. The formula for the force transmissibility is given as per equation 1

$$Tr = [1+(2\xi\omega/\omega_n)^2 /[1-(2\xi\omega/\omega_n)^2]^2+[2\xi\omega/\omega_n]^2]^{1/2}$$

Where, $r = (\omega/\omega_n)$ = frequency ratio, $\xi$ = damping factor

The transmissibility curve of the fig gives us a lot of useful information. The first thing is that, we see is that all the curve starts from unity value of transmissibility, pass through the unit transmissibility at $(w / w_n) = 2$ & after that they tend to zero as $(w / w_n)$.

These curves can be divided into the three distinct frequency region as shown in the lower part of the fig. (1.3.a).

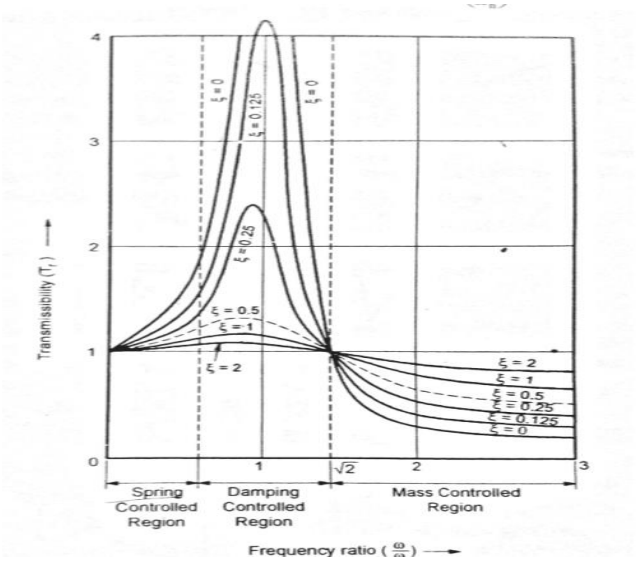


**Fig 1.3.a.** Transmissibility Vs Frequency ratio[7]

These regions are respective control by the three parameters of the system, mass, damping & stiffness. The region where the isolation is really effective is when $(w /w_n)$ is large. These are the mass controlled region. Larger mass gives low natural frequency & consequently higher value of $(w /w_n)$. Damping in this region deteriorates the performance of the system. This is controlled region. Larger stiffness gives high value of natural frequency & consequently low value of frequency ratio. The middle region always to be avoided is the damping control region.

## 4. ELEMENTS of A VIBRATORY SYSTEM:

The elements that constitute a vibratory system are shown in fig. They are idealized & called the mass, the spring, the damper θ& the excitation.

The mass 'm' is assumed to be a rigid body. It executes the vibration can gain or lose kinetic energy in accordance with the velocity changes of the body.

The spring 'k' possesses elasticity & is assumed to be the negligible mass. Spring forces exist if the spring is deformed, such as the extension or a compression of a coil spring. Therefore, the spring force exists only there is a relative displacement between the two of the spring.

The damper 'c' has neither mass nor elasticity. Damping force exist only if there is a relative motion between the ends of the dampers. The work or the energy input to the dampers is converted into heat. Hence the element is neoconservative. Energy enters in a system through the application of the excitation. An excitation force may be applied to mass or motion applied to the spring & the damper.

## 5. CAUSES of VIBRATION:

The main causes of vibration are as follows:-

1. Unbalanced force in the machine: These forces are produced from within the machine itself.
2. Dry friction between the two mating surfaces: This produces what are known as self excited vibration.
3. External excitation: These excitation may be periodic random, or of the nature of an impact produced external to the vibrating system.
4. Earthquake: These may cause of vibration of transmission & telephone lines under certain conditions.

## 6. EFFECT of VIBRATION:

Vibrations having some desirable effects as well as undesirable effects. They are as follows:

### 6.1 Undesirable Effect Of Vibrations:

Vibration occurs in many common engineering systems & if uncontrolled can lead to apocalyptic results, e.g.

a. Excessive stresses: Vibrations of the structure induced during an earthquake lead to large stresses & can result in structural failure.
b. Undesirable noise : Excessive vibration of industrial compressor or pumps increases the noise level in the machine surrounding con induce vibration of the surrounding structure & cause inefficient operation of the machine.
c. Looseness of parts: Vibration resulting from the rotating unbalanced in a helicopter blades can lead to the pilots loosing controlled of helicopter & crashing. 4. Vibration of machine tools leads to improper machining of the parts.

### 6.2 Desirable Effect Of Vibration:

In spite of harmful effects the vibration phenomenon does have some uses also, e.g.

i. The suspension system of an automobile protects the passenger & automobile from terrain.
ii. Cushioning is used in the packaging fragile items to prevent breakage when dropped.
iii. In musical instruments.
iv. Vibrating screens.
v. Shakers.
vi. Stress relieving.

## 7. CONTROL of VIBRATIONS:

Mechanical vibrations can be controlled by several techniques which are as follows:

1. Removing the cause of vibration.
2. Putting the screen if noise is the objection.
3. Resting the machinery on proper type of isolate.
4. Shock absorbers.
5. Dynamic vibration absorber.

## 8. TYPES of VIBRATION TEST:-

The purpose of vibration test in general is to know the system characteristics. We shall consider, here only a linear system with small amplitude of vibration. System characteristics of interest are natural frequencies, the corresponding mode shaped & nature & amount of damping. Different testing procedure adapting can be categorized according to basic nature of the test.

**8.1 Free Vibration Test:** - This is simplest of all the different testing procedures adapted. The system is displaced from its mean position & then released. The resulting free vibrations are recorded, from which information regarding the natural frequency & damping can be obtained. In practice the mechanical system under test is rapped by impact form a digit hammer to

induced free vibration. A storage oscilloscope can be used to capture the response of further analysis.

**8.2 Forced Vibration Test:** - The system is subjected to known unidirectional harmonic forces at a desired frequency with the help of suitable shaker, such as an electrodynamics shaker with aid of instruments shown schematically in fig. The steady state response of the system recorded with help of the accelerometer as shown in fig. The frequency of excitation is varied as suitable intervals in given range of interest of steady state response thus obtained in is plotted as a function for a constant excitation force. The difference of phase between the excitation responses may also recorded with the aid of phase meter or an oscilloscope. The data thus obtained can be used study the performance & identify its parameters. A servo controlled shaking system can be used to conduct these system automatically & reduce the testing time. Such a test is called 'Sweep Test'. The excitation frequency is varied continuously & the response amplitude is recorded with a suitable recording device. When only the natural frequency are of interest the excitation force need not to be controlled. The frequency can be simply varied with sufficient excitation force to record peak amplitude which gives natural frequencies.

## 9. CONCEPTUAL DESIGN:-

Conceptual design is a design which is done without any mathematical calculations. It is totally based on assumption and logics of technical backgrounds.
Conceptual design is done where it becomes difficult for a person to go for mathematical design.
In this project following parts are conceptually designed:-

1. Motor: - This motor does not require any mathematical design because it is required to produce necessary torque to rotate the circular plates through a gear box at certain r.p.m.
2. Gear box: - Gear box of reduction ratio 1:10 is used to slow down the r.p.m. of circular plate and to eliminate the force acting on the motor.
3. Circular plate: - the plate is used to support cam and shock absorber. It is used to transmit force from motor shaft to shock absorber. Circular plate is given a particular thickness to support large loads and diameter is selected to ensure easy movement of bushes. If diameter of plate increased beyond the certain limits, this will increase the distance between pillars. This will give resistance to the easy movement of bushes.
4. Cam: - The main purpose of cam is to give shock to the shock absorber. Cam is having the exactly the radius of curvature for the easy lifting of shock absorber. Particular height is given to cam so as to get sufficient measurable displacement at output. The length of the cam is 20-30 percent of the diameter of plate for easy lifting of shock absorbers. The thickness of bearing is to avoid sleeping.
5. Bush: - Inner diameter of bush is approximately same as that of outer diameter of pillar with permissible tolerances for easy movement. Outer diameter is selected in such way that welding should not affect the inner diameter of inner surface of bush. Height of the bush is in the required limits. If the height is larger than the initial load on the shocker/plate will be more and also the friction between the pillars & bushes will be more. If the height is not sufficiently large, problem to hold shock absorber may occur.
6. C-channels (base of set up): - Selection of C-channel is decided on the basis of weight of the machine (mainly two large heavy pillars). The standard size of C-channel is selected from the steel table.
7. Indicator mechanism: - This set up is totally mechanically operated, so as it is provided with a mechanically operated indicator mechanism.
8. This mechanism is cheap as well as light in weight. It consists of graph-paper or paper/scale pen/ pencil, connecting rod, pen / pencil holder etc.
9. Weights: - Shock absorber of vehicle is used to set up, so the scientific weights (around 50 kg) are used (which are equivalent to an average weight of a man).

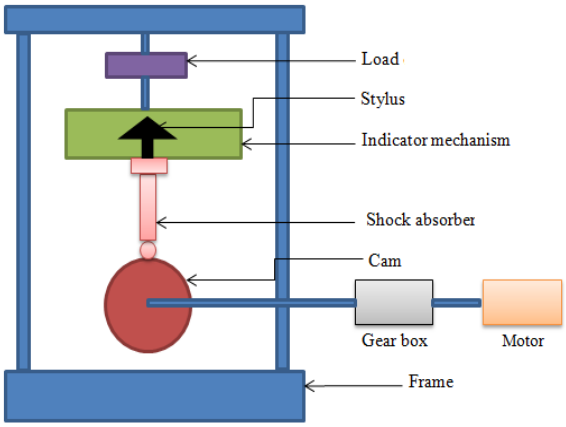


**Fig. 1.9.a.** Conceptual design of shock absorber test rig

## 10. CONCLUSION:

This mechanism converts rotary motion of the circulating disc into the linear motion of the shock absorber. At various

loads and speeds combinations the readings on the test rig can taken with the help of stylus mounting on test rig and by using the data, characteristics of shock absorber can calculate. Thus the shock absorber test rig design is very important for characteristics of shock absorber and to find effectiveness. It is done by conceptually.

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