DESIGN OF SHOCK ABSORBER TEST RIG USING MECHANICAL EXCITER TO DETERMINE TRANSMISSIBILITY AND NATURAL FREQUENCY

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ABSTRACT:

Shock absorber is a very key element in an automobile system, which is also an example of under damped vibration system. The aim of a Shock absorber is to absorb maximum shocks and vibrations in terms of kinetic energy and sometimes in terms of potential energy as well. Mechanical vibration exciters are necessary for modal testing of large components like, chassis, Shock absorbers. In this research, a shock absorber test rig using mechanical exciter has been developed for shock absorber testing and modal testing of Go-kart chassis. A Scotch-yoke mechanism is used for design of mechanical exciter. FEA software is used for static and modal analysis of exciter for determining natural frequency and FFT analyzer to determine the transmissibility of shock absorber. Also to validate the results obtained from FFT analyzer FEA software is used. Natural frequency of exciter is mainly depends on its mass and stiffness properties. The results of natural frequency and mode shapes are obtained from FEA software. The results obtained from the FFT analyzer will in the form of a waveform which is used to find out the transmissibility at various loads and speeds. The natural frequency of mechanical exciter is obtained from FEA software. Further, the FEA and experimental results of Transmissibility and natural frequency of mechanical exciter are compared for necessary corrections in design parameters of the shock absorber behavior and chassis.

KEYWORDS: Mechanical Exciter, Transmissibility, Scotch-Yoke mechanism, FEA, FFT analyzer.

1. INTRODUCTION:

Shock absorber are used in every vehicle running in this world and since 1912 of its first discovery, it has become an integral part of the vehicle system. There have been many companies since then producing shock absorbers for different vehicles. Since the production took place the quality checks also were commenced and many types of test has been carried out to check the effectiveness of a shock absorber using destructive testing or non-destructive testing methods. Transmissibility has always been a very important dynamic characteristic of a shock absorber. In simple terms, transmissibility can be defined as the effectiveness of a shock absorber to absorb the shock absorber or any device which isolates the vibrations from the body.

Attempts have been made by [1] Nikhil kothawade and others to measure and analyzer the transmissibility of a shock absorber for which a shock absorber test rig is designed and developed. [2] research on damping characteristics of a shock absorber of heavy vehicles by Yongjie Lu and others have tested a shock absorber for damping characteristics and found that a typical shock absorber shows non-linearity, hysteresis. [3] H.R. Sapramer in his paper Test Rig Design for Measurement of Shock Absorber Characteristics has stated various dynamic characteristics of a shock absorber and their effect on damping properties.

Thus from the above literature, it can be observed that testing of a shock absorber is very crucial and that measuring the damping characteristics is the need of the hour. This paper mainly focuses on the design and development of a Shock absorber test rig to determine its effectiveness and natural frequency. Natural frequency of a body is the frequency of vibrating body which will continue to vibrate at certain frequency even after removal of external force. With the help of natural frequency, the behavior of a body can be determined. The transmissibility can be measured in two ways

a) FFT analyzer
b) FEA software

FFT analyzer will give the graphs and FEA software will be used to validate the results obtained by FFT.

2. PROBLEM STATEMENT:

Design and development of computerized shock absorber test rig for a shock absorber with stiffness and stroke length to determine transmissibility using FFT analyzer and FEA software as well as preparation of following graphs:

a) Speed vs Transmissibility
b) Load vs transmissibility
c) Speed vs time
d) Load vs time
e) Displacement vs time
f) Velocity vs time
g) Acceleration vs time

3. OBJECTIVES:

- To design and develop a shock absorber test rig.
- To design and develop a mechanical exciter.
- To design and manufacture suitable mechanism for exciter.
- To select bearing for shaft.
- To select coupling.
- To select prime mover for the whole system.

4. EXPERIMENTAL SETUP:

The shock absorber test rig works with the help of mechanical exciter. The mechanical exciter consists of a scotch yoke mechanism. The scotch yoke mechanism consist of three main components namely,

a) Crank.
b) Slotter.
c) Connecting rod.

The crank is connected to prime mover. When the prime mover is set in working mode, the shafted connected with the crank rotates, in return the crank also rotate. When the crank rotates, the pin in contact with the slot in slotter also moves into the slot and in turn generates the oscillatory motion of the connecting rod. To get the constrained oscillatory motion only in Y- direction, a guide way is proposed to reduce the deviation nearly up to zero. The Shock absorber test rig is divided into three main sections:

4.1 MECHANICAL EXCITER.

Consist of following core component

1) Electric motor.
2) Flexible coupling.
3) Journal bearing.
4) Shaft.
5) Scotch yoke mechanism.
6) Guide-way bush with frame.

4.2 MOUNTING AND UPPER FRAME:

It consists of two mountings bolted across the upper frame and the upper frame is mounted on the guide-way frame using nut and bolt to ensure flexibility in design. With the help of bolt assembly, it is possible to test different shock absorber of varying stroke lengths.

The base mounting is a bush with slot and arrangement for nut and bolt to trap the lower end firmly.

The upper end is trapped in the step shaft firmly to ensure there is no deflection along X-axis direction

4.3 ELECTRONIC COMPONENTS:

Load cell is used to measure the damping force exerted on the shock absorber for complete deformation.

Accelerometer is used to measure the acceleration of the moving or vibrating body.

FFT analyzer is a device which uses digital signal processing techniques to give in-depth wave form analysis. FEA process is an analysis process in which the infinite no of elements are converted into finite no of elements and analyze the stresses and strains and deformation.

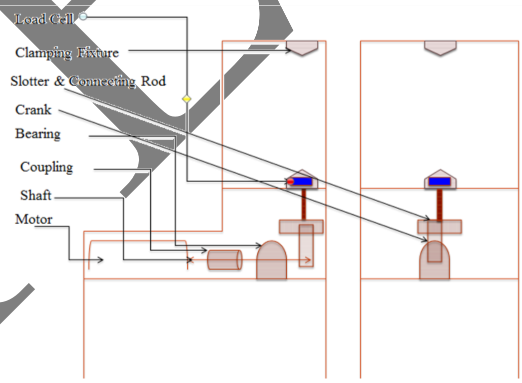

Figure 4: Block Diagram of Experimental Set-up

5. DESIGN OF COMPONENTS:

5.1. CRANK

We have selected
40C8 mild steel,
Having

S_{yt} = 250 MPA
S_{ut} = 400 MPA
T = 965.6 N-mm
F = 9.42 N
L = 20 mm
B = 15 mm
H = 64 mm

Based on the above data,

$\sigma_{allowable}$ = 125 MPA
Area = 1008.42 mm^2
σ_{design} = F/A
= 9.42/1008.42
= 9.34x10^{-3} N/mm^2 … Ans

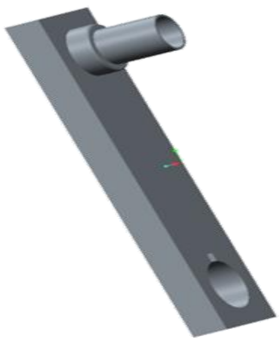

Figure 5.1: Crank with Crank Pin

5.2. SLOTTER AND CONNECTING ROD:

For Slotter,
Material selected is 40C8,
Having

S_{yt}	= 250 MPA
S_{ut}	= 400 MPA
$\sigma_{b(Max)}$	= 8.4373 N/mm^2
T	= 568.3 N-mm
F	= 9.42 N
M_b	= F*r
	=282.6 N-mm
I	=6.03x10^3 mm^4
σ_b	= M_b* Y / I
	=0.468 N/mm^2 … Ans

Figure 5.2: Slotter with Connecting rod

For connecting rod,
H = 150 mm
D = 10 mm

The connecting rod is provieded with threads for a length of 30 mm from the top so that the mounting bush can be adapted on the threads and the design will not be compicated.

5.3 LOWER END MOUNTING:

The lower end mounting is designed based on the dimensions of shock absorber. The shoch absorber haivng lower end dimensions as 25x15x35 mm And to lock the shock absorber bolt of dimensions M12 is used.

The dimensions are assumed based on the above data and they are:

D= 50 mm
H= 50 mm

The sides are faced to obtain the flat surface so that the nut and bolt gets clamped easily and tightly.

The lower end of the bush is gven a tap of 10 mm which will get clamped on the threaded connecting rod.

Figure 5.3: Lower End Mounting Bush

5.4 UPPER END MOUNTING:

The upper end mounting is a stepped shaft with following dimensions:

L = 30 mm
D_1 =30 mm (bigger end)
D_2 = 15 mm (smaller end)

The purpose is to clamp and eliminate the deflection in x & y direction. A hollow shaft with 15 mm thickness is and O.D of 30 mm is used to balance the stepped portion.

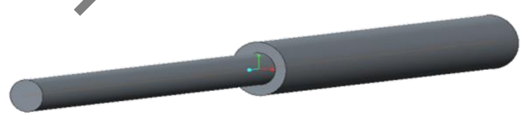

Figure 5.4: Upper End Mounting Stepped Shaft

5.5 THE SET-UP ASSEMBLY:

The figure shows the set-up assembly, in which all the deigned components are seen with their respective places.

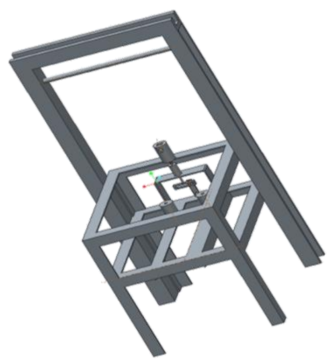

Figure 5.5: Set-up assembly

6. ANALYSIS OF COMPONENTS:

6.1 CRANK

The figures shown below are the static structural analysis of the crank and pin. The input shaft from motor is connected to the lower end of the crank which will cause it to rotate. Thus the torque acting at this end is 965.3 N-mm.

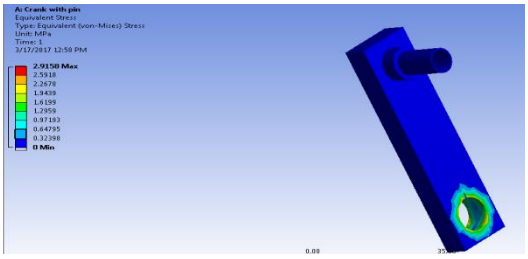

Figure 6.1: Static Structural analysis of crank

6.2 SLOTTER WITH CONNECTING ROD:

The slotter is connected by crank pin which accommodate in the slot of the slotter. So the force acts on the inside face of the slot and hence the deformation takes place on the inside face.

The force acting on the inside face is 9.42 N in –z direction. Thus stress and strains are shown in the analysis.

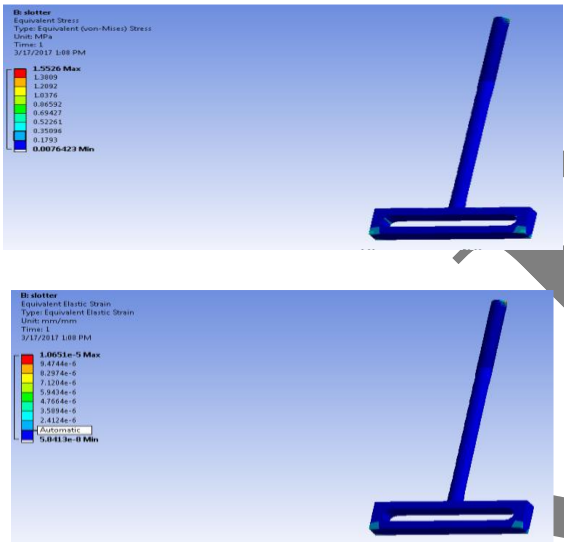

Figure 6.2: Static Structural analysis of slotter with connecting rod.

7. RESULTS AND DISCUSSION:

It is seen that from the above design and analysis, we are in position to validate the analytical and FEA results and on comparing both we can see whether designed components are safe or not.

Table 6.1: Results

Component	Analytical	FEA	% difference	Remark
Crank with pin	9.63x 10^{-3} N/mm^2	2.91 N/mm^2	99. 66	Recommended
Slotter and connecting rod	0.468 N/mm^2	1.522 N/mm^2	69. 25	Recommended

Thus from the above results it can be interpreted that the mechanism can take a load up to 15 kg with motor power of 1 HP and 2800 rpm. To increase the capacity of loading one needs to replace the motor with high capacity and modify dimensions accordingly.

8. CONCLUSION:

Thus the above paper shows the cad models, analysis of the designed parts which constitute for the development of a mechanical exciter. The present set-up is actually a scale down model of the Shock absorber test rig. So if the dimensions are scaled up, then it can be used for heavy duty applications as well. Also it can be used to test springs of various stiffness and shock absorbers of varying stroke length. Dimmer is recommended for smooth operation of a shock absorber test rig.

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