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STUDY AND ANALYSIS OF DAMPERS USED IN LOCOMOTIVES.

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Abstract: *Aim of this seminar is to thoroughly study the dampers and its classification and my main focus is study of vibrational analysis of the GO KART vehicle before and after using dampers. The vibration is measured by using the FTT Analyzer. It is a plan to create 3D model using CATIA software. The analysis was carried out by using ANSYS Software. The factors that should be considered are load, material, size, dynamic characteristics, etc.*

Key Words: 1. vibrational analysis ,2. dampers, 3.FTT Analyzer ,4. material ,5. dynamic characteristics ,6. GO KART.

I. INTRODUCTION

The Dampers is a mechanical device designed to absorb and damp the shock pulses. It does this by converting the kinetic energy into heat energy which is then dissipated. Early vehicle manufacturer began finding solutions for steering and passenger comfort. The dampers previously were two arms connected to a bolt with a friction disc between them, over the years the suspension evolved into sophisticated design. Components and concepts changed and continue to change with the same basic objective to increase the comfort and steering stability with good handling.
Suspension system affects both the driver's control of the car and therefore the comfort of the occupants. The springs allow the vehicle to maneuver up to soak up bumps within the road and reduce jolting, while the dampers prevent bouncing up and down. Various mechanical links keep the vehicle in line. Springs deflect because the car goes over a bump then recover. The car would still bounce up and down if the energy stored within the springs weren't dissipated in how.

Dampers commonly called shock absorbers perform this function. A damper features a piston which moves inside a sealed, oil-filled cylinder with the up-and-down movement of the wheel. The upper mount of the shock connects to the frame (i.e., the sprung weight), while the lower mount connects to the axle, near the wheel (i.e., the unsprung weight). In a twin-tube design, one among the foremost common sorts of shock absorbers, the upper mount is connected to a rod, which successively is connected to a piston, which successively sits during a tube crammed with hydraulic fluid. The tube is understood because the pressure tube, and therefore the outer tube is understood because the reserve tube. The reserve tube stores excess hydraulic fluid. When the wheel encounters a bump within the road and causes the spring to coil and uncoil, the energy of the spring is transferred to the shock through the upper mount, down through the connecting rod and into the piston. Orifices perforate the piston and permit fluid to leak through because the piston moves up and down within the pressure tube. Because the orifices are relatively tiny, only a little amount of fluid, under great pressure, passes through. This slows down the piston, which successively slows down the spring. Shock absorbers add two cycles — the compression cycle and therefore the extension cycle. The compression cycle occurs because the piston moves downward, compressing the hydraulic fluid within the chamber below the piston. The extension cycle occurs because the piston moves toward the highest of the pressure tube, compressing the fluid within the chamber above the piston. A typical car or light truck will have more resistance during its extension cycle than its compression cycle. With that in mind, the compression cycle controls the motion of the vehicle's unsprung weight, while extension controls the heavier, sprung weight.

For example, if I kept a motor running at high speeds on the ground, and I stand next to it, I would be able to feel the vibrations near my feet. Now allow us to put a bit of rubber beneath the motor and you stay in just an equivalent place, you'd either feel nothing or feel the intensity of the vibrations reduced. The rubber here worked as the damper.
If the car didn't have a shock, the vehicle would originate and down till it lost all its energy. The shock, hence helps to avoid this by dissipating the energy of the spring as heat. (You can do an in depth reading on how Shocks work). On Automobiles we loosely use the word 'damper' in place of 'shock'. Although technically a shock is a damper, it will be more specific to use shocks when referring to the damper of the suspension system as damper can mean any other dampers use in the car.
In the coming session we will the see case study of GO-KART vehicle, the dampers used in the vehicle to reduce the vibration and increase the comfort. During this case study we will come across the types of dampers and will compare the vibration measured with FFT analyzer.

1.1 Literature Review

Grant A. Malmedahl

This research paper has reviewed the prevailing approaches of the estimation of the state of wear and tear of an automotive damper, with the aim of developing a strategy for a fast and effective diagnostic technique that would be administered in any repair facility. In this report it's that it's always been desirable to go away the shock in situ at the time of such testing, and there are three general procedures that claim to be an efficient method at determining damper wear. The general procedures are: to get rid of the shock and perform a dynamometer test, to go away the shock in situ and vibrate the tire at known frequencies, and therefore the last is to push on one corner at a time and observe the oscillations. This research investigates a way of controlling a brief drop of every corner of the vehicle while measuring the acceleration value. The acceleration values are then analyzed with the aim of estimating the decay rate of the resulting oscillation, which is known to be related to the damping ratio of the suspension system. The rate of decay, quantified by the damping ratio, is then used to infer the condition of the vehicle's damper. Multiple tests were conducted with shock absorbers of various degrees of wear and tear to assure the potential of this system. Also, tests were run to look at the consequences of spurious inputs to the test procedure, like low tire pressure and therefore caused a failed damper on the other end of the axle that has on the test results for a replacement damper. This thesis reviews the state of the art, defines the methodology and presents experimental validation of a replacement concept.

Jens Becker and Lothar Gaul

He has focused on Reduction of structural vibrations which is of major interest in mechanical engineering for lowering sound emission of vibrating structures, improving accuracy of machines and increasing structure durability. According to his theory besides design optimization and passive damping treatments, active structural vibration control can be applied to reduce unwanted vibrations. They become more and more important as lightweight constructions evolve. In this contribution, two semi-active control laws for control of friction dampers are derived and investigated. Purely semi-active control has the advantage to yield intrinsically stable closed-loop systems and low energy consumption compared to active vibration control. In the experimental implementation, the control makes use of piezoelectric stack actuators to apply adjustable normal forces between structure and attached friction damper elements. Roughly speaking, the normal forces are controlled accordingly to the measured structural vibrations in order to achieve optimal damping effect. The control algorithms make use of reduced finite-element models of the structural dynamics for the estimation of the not observable relative displacement beneath the normal force actuator based on acceleration measurements. Experimental results of the control algorithms for a beam test structure with an attached friction damper with one adjustable normal force show the effectiveness of the algorithms. The control laws are compared with respect to their effectiveness, need of actuator bandwidth, applicable frequency bandwidth and energy consumption.

Sondipon Adhikari

According to him the classical modal analysis is extended to deal with general non-viscously damped multiple degree-of freedom linear dynamic systems. The new method is similar to the existing method with some modifications due to non-viscous effect of the damping mechanism. The concept of (complex) elastic modes and non-viscous modes have been introduced and numerical methods are suggested to obtain them. It is further shown that the system response can be obtained exactly in terms of these modes. Mode orthogonality relationships, known for undamped or viscously damped systems, have been generalized to non-viscously damped systems. Several useful results which relate the modes with the system matrices are developed.

1.2 TYPES OF DAMPERS

1. Active Damper
2. Passive Damper
3. Semi-active Damper

1.2.1 Definitions

There are three types of Dampers as explained below:

- **Active Dampers**

The Active Damper System can adjust suspension stiffness changes in a split second, to both smooth the ride and sharpen handling according to driving conditions. Using sensor data, each damper incorporates a continuously adjustable valve which raises or lowers damper fluid pressure and thus the speed at which the fluid can flow from one end of the damper tube to the other. This varying flow rate allows quick and precisely measured stiffening or softening of the damper motion.

- **Passive Dampers**

Passive vibration control does not have any sensors or actuators and does not consume any power. Instead, it relies on the damping properties of materials used in its design. It could use pistons that move inside cylinders to force fluid through small holes to dissipate energy. This is what happens in shock absorbers in cars. The point is that it acts passively - without needing any external power supply.

- **Semi-active Dampers**

The semi-active damping control system for two-wheelers and power sports enhances the safety, comfort, and dynamics. The core component of the system is the semi-active damping unit. The unit is connected to the multiple sensors in the vehicle, which detect road surface conditions. Based on that feedback, the semi-active control unit increase stability, especially during off-road riding.

1.2.2 Application

1. Semi-Active dampers are used in Toyota Soared with Toyota Electronic Suspension system.

2. The Audi A8 is a fully active suspension car.

3. Passive dampers are mostly used in small scale i.e. for college level competition cars.

Case Study

1.Introduction

The GO-KART vehicle of Team Nemesis is a sport vehicle and has been participating in many competitions which are been organized every year. And their achievements are unstoppable. The legacy continues up till now. This vehicle does not contain suspension system as it is a sports vehicle. But Dampers are used to reduce the vibration of the engine.

2. Study of vehicle

Firstly, we will see the GO KART chassis which is mainly affected by the vibrations of the engine and the first part which transmits all the vibrations to the chassis is the engine mounting.

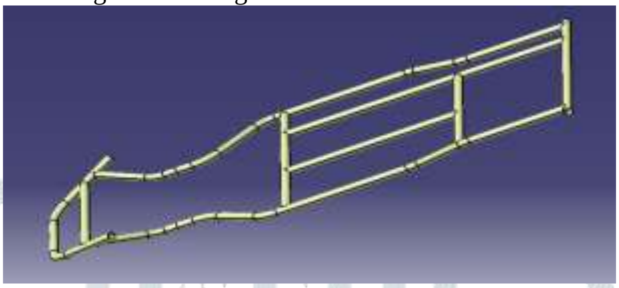

Fig.1.2 GO KART chassis

3. Engine Mounting

In the above fig1 we can see the CAD model of engine mounting. First the whole structure of vehicle is studied and the CAD model accordingly is prepared. To study the analysis of this mounting will be easier because the processing while meshing becomes difficult when we consider the whole chassis as our subject for analysis. The results we get after analysis will be greatly affected by the quality of meshing.

4.Material used

Component	Material	Cross section
Primary pipe	AISI 4130	O.D. 29.2 mm Thickness 0.5mm
Secondary pipe	AISI 4130	O.D. 25.4mm Thickness 0.5 mm
Engine mounting	AISI 4130	(Square) Outer 25.4, Thick 0.5 mm

5.Analysis of Mounting without damper

1. CAD model of engine mounting.
2. Frequency of vibrations.
3. The area of chassis which is constrained.

5.1Measurement of Vibrations

Different methods are used for calculation of vibration produced on the chassis due to engine. The FFT or Fast Fourier Transform spectrum analyzer is now a form of RF spectrum analyzer that is being used increasingly to improve performance reduce costs.

As the name suggests the FFT spectrum analyzer uses digital signal processing techniques implementing Fast Fourier Transforms or FFTs to provide spectrum analysis. The FFT spectrum analyzer is able to provide facilities that cannot be provided by swept frequency analyzers. They can provide fast capture and analysis of waveforms in a way that cannot be achieved with sweep / super heterodyne techniques alone.

We have used the FFT analyzer of magnetic probe type to calculate the frequency of engine mounting maximum engine RPM (i.e. 3600 RPM), To consider the most severe condition the mounts will have to face. The probe is connected to the engine mounting and readings are taken from minimum to maximum RPM. We can see the tachometer to find the engine RPM to understand at which RPM we are taking readings. We increase the RPM till 3600 is achieved. The obtained results are then stored in the device. The stored values are then observed in the MCME 2 software. The following results were obtained

5.2Measurement of Frequency

I have used the FFT analyzer of magnetic probe type to calculate the frequency of engine mounting maximum engine RPM (i.e. 3600 RPM)

5.3 Result of FFT Analyzer

The output of Analyzer is directly put on the Spectral Analysis Software and thus the result is obtained for the chassis of vehicle without damper. We can see that the maximum frequency obtained is 245 Hz (i.e. 196.44 dB). A graph is plotted between frequency verses time graph.

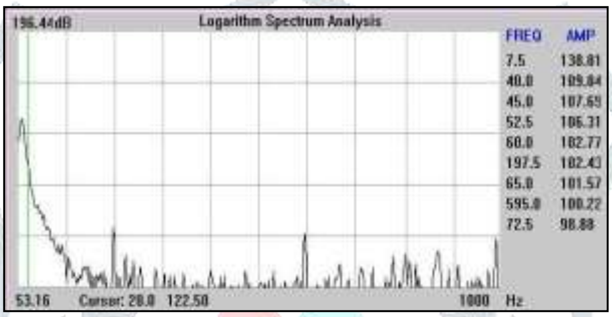

Fig.4.3-FFT Analyzer Graph

Constraints:

Third and most important input left for the analysis of engine mounting is the area of chassis which is to be constrained. As wheels are in contact with the ground and suspension connect the ground with the chassis. The area where the suspension arms are mounted on chassis will act as stationary area while we are studying the engine vibrations.

5.4 Analysis on Ansys

Firstly, the part which was going to remain stationary was selected made stationary, then the total weight acting on the body i.e. 900N was applied on part where engine and driver seat is located and then the results were obtained for total deformation and elastic deformation. Similarly, the same procedure will be done for the Analysis of chassis with dampers.

We have gathered now everything that is required to analyze the problem on software. As this is problem of vibrations we will go for the modal analysis of the engine mounting.

Stepwise procedure of modal analysis:

1. Define the material for chassis tubes as stainless steel.
2. Import the. igs file of engine mounting in ANSYS workbench
3. Now start the model edit mode in ANSYS.
4. Now the another window will be opened in this define the constraints first.
5. In analysis settings define the frequency range.
6. In solution icon select the total deformation as a required result.
7. Solve the problem and wait for solution.
8. Check the obtained results.

4.4 Analysis Result before dampers

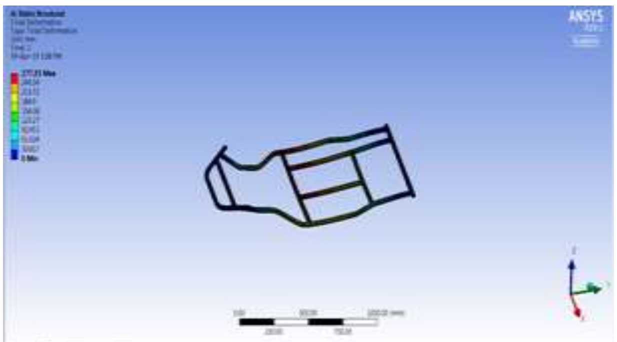

Fig.4.4-FFT chassis deformation before damping

5.5 Dampers to be used

Now dampers are to be used to reduce the vibration which decrease the chances of fatigue failure. The dampers absorb the vibration caused due to up down motion or engine vibration (i.e. kinetic energy) and convert it in potential energy.

In this case we are using **Passive dampers** i.e. Rubber Damper below the engine mounting so that it can absorb the engine vibration and dissipate it. Different types of Passive dampers are available in market according to the need of the customer and according to the application.

As shown in fig5.9 Rubber damper is used in the case of GO-KART.

Firstly, to calculate the frequency we will attach the rubber mounting between lower surface of engine and engine mounting. We will calculate the frequency again by same procedure and will store this data on device.

The obtained results are then brought to MCME 2 software and we will get the frequency at maximum engine RPM.

Rubber damper that are used in the case of GO-KART

5.6 Measurement of Frequency with Dampers

Now the dampers are placed below the engine and same procedure is followed and the vibration are calculated by FFT Analyzer and thus the graph is plotted.

As we can see in fig5.10 the frequency we got with rubber dampers is 208.375 Hz (ie 166.7 dB)

Thus the vibrations are reduced after using dampers. Now with this result we will keep our constraints and CAD model constant and change the input frequency and again perform the modal analysis and will get the new results for maximum deformation of engine mounting.

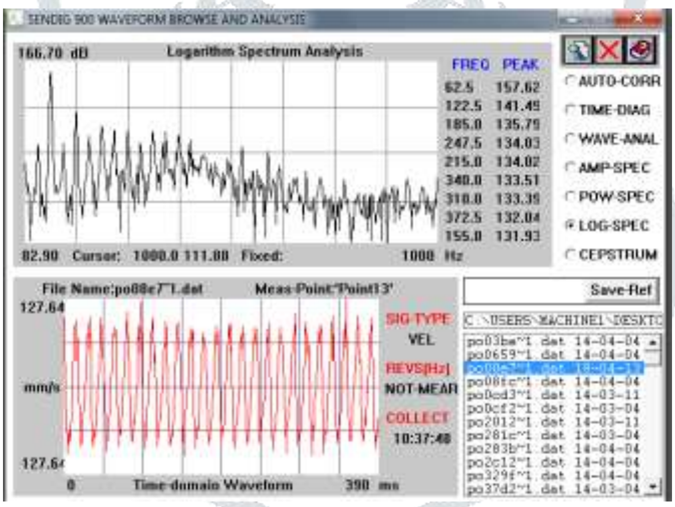

Fig.5.1-FFT Analyzer Graph

5.7Analysis result after damping

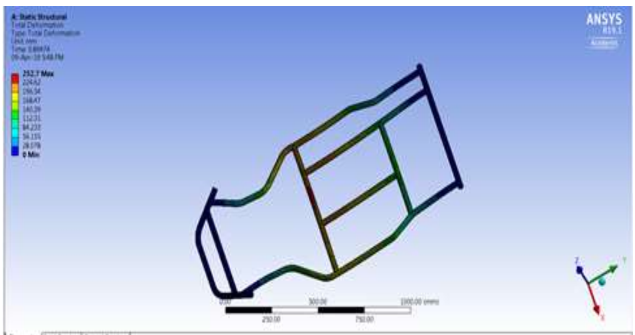

Fig.5.2-chassis deformation after damping

We can now observe the change in maximum deformation value that is 25.616 mm. After the dampers are placed a huge change is absorbed in the readings. The deformation has been reduced to a good extend. Thus making it more safe than previous values and thus the applied method for reducing the vibration is correct and further improvement can lead to more drastic change in vibrations

6. Comparison between the Frequency with and without Dampers

Parameter	Without mounting	With rubber mounting (Transmissibility 0.04)
Vibration frequency	245.55 Hz	208.375Hz
Maximum deformation	28.588 mm	25.116mm

7. CONCLUSIONS

1. The main aim of this seminar was to study the dampers used in locomotive and its types. Along with the most widely used dampers in present condition.
2. In this seminar we learnt that there are three types of Dampers used according to the application where it is to be used. According to the need, the type of Damper is selected.

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