Modal Analsis of Shock Absorber With Different Materials

Sangamesh B. Herakal [1], MalleshJakanur [2], Rohan[3]
[1, 2, 3] Asst Prof
[1, 2, 3] Holy Mary Institute Technology and Science

Abstract- *Shock absorber is a mechanical device designed to smooth out or damp shock impulse, and dissipate kinetic energy. In a vehicle, it reduces the effect of traveling over rough ground, leading to improved ride quality, and increase in comfort due to substantially reduced amplitude of disturbances. In this work suspension system is designed and a 3D model is created using CATIA V5 R21. The model is also changed by changing the thickness of the spring. Structural analysis and modal analysis are done on the shock absorber by varying different spring materials. Spring materials are Spring Steel, Phosphor bronze, Beryllium Copper and Titanium alloy. To validate the strength of the model, the structural analysis on the helical spring was done. The analysis is done by considering loads, bike weight, and single, double riding. Modal analysis is done to determine the displacements for different frequencies for number of modes. Finally comparison is done for different materials to verify best material for spring in Shock absorber. Modeling is done in CATIA and analysis is done in ANSYS.*

Keywords- Static, Transient Dynamic, Buckling, CATIA V5 R21, ANSYS.

I. INTRODUCTION

A shock absorber or damper is a mechanical device designed to smooth out or damp shock impulse, and dissipate kinetic energy. Pneumatic and hydraulic shock absorbers commonly take the form of a cylinder with a sliding piston inside. The cylinder is filled with a fluid (such as hydraulic fluid) or air. This fluid-filled piston/cylinder combination is a dashpot. The shock absorbers duty is to absorb or dissipate energy. These are an important part of automobile suspensions, aircraft landing gear, and the supports for many industrial machines. Large shock absorbers have also been used in structural engineering to reduce the susceptibility of structures to earthquake damage and resonance. A transverse mounted shock absorber, called a yaw damper, helps keep railcars from swaying excessively from side to side and are important in commuter railroads and rapid transit systems because they prevent railcars from damage station platforms. In a vehicle, it reduces the effect of traveling over rough ground, leading to improved ride quality, and increase comfort due to substantially reduced amplitude of disturbances. Without shock absorbers, the vehicle would have a bouncing ride, as energy is stored in the spring and then released to the vehicle, possibly exceeding the allowed range of suspension movement. Control of excessive suspension movement without shock absorption requires stiffer (higher rate) springs, which would in turn give a harsh ride. Shock absorbers allow the use of soft (lower rate) springs while controlling the rate of suspension movement in response to bumps. Damp the motion of the upspring weight up and down on the springiness of the tire. Since the tire is not as soft as the springs, effective wheel bounce damping may require stiffer shocks than would be ideal for the vehicle motion alone. Spring-based shock absorbers commonly use coil springs or leaf springs, though torsion bars can be used in tensional shocks as well. Ideal springs alone, however, are not shock absorbers as springs only store and do not dissipate or absorb energy. Vehicles typically employ springs and torsion bars as well as hydraulic shock absorbers. In this combination, "shock absorber" is reserved specifically for the hydraulic piston that absorbs and dissipates vibration. There are a number of different methods of converting an impact /collision into relatively smooth cushioned contact.

- Metal Spring
- Rubber Buffer
- Hydraulic Dashpot
- Collapsing safety Shock Absorbers
- Pneumatic Cylinders
- Self compensating Hydraulic

In a vehicle, suspension system reduces the effect of traveling over rough ground, leading to improved ride quality, and increase in comfort due to substantially reduced amplitude of disturbances. Without shock absorbers, the vehicle would have a bouncing ride, as energy is stored in the spring and then released to the vehicle, possibly exceeding the allowed range of suspension movement. Control of excessive suspension movement without shock absorption requires stiffer (higher rate) springs, which would in turn give a harsh ride. Shock absorbers allow the use of soft (lower rate) springs while controlling the rate of suspension movement in response to bumps. They also, along with hysteresis in the tire itself, damp the motion of the unsprung weight up and down on the springiness of the tire. Since the tire is not as soft as the springs, effective wheel bounce damping may require stiffer shocks thanwould be ideal for the vehicle motion alone. Spring-based shock absorbers commonly use coil springs or leaf springs, though torsion bars can be used in torsional shocks as well. Ideal springs alone, however, are not shock absorbers as springs only store and do not dissipate or absorb energy. Vehicles typically employ springs and torsion bars as well as hydraulic shock absorbers. In this combination, "shock absorber" is reserved specifically for the hydraulic piston that absorbs and dissipates vibration.

For a car suspension system, shock absorber can have a huge impact on the comfort level of driving experience. According ISO 2631-1, ride comfort can be affected between 0.5 Hz and 80 Hz [4]. In order to analyse the suspension system, mathematical model can be used such as quarter-car, half-car and full-car models. The models can be generally defined with the governing equation. Mathematical modelling can be used to analyse the car suspension system. A car suspension system can be expressed as spring-damper-mass system which means the system consists of these three main components: spring, damper and mass. Different car model can be used for the analysis such as quarter-car model, half-car model and full-car model. Quarter-car model offers simplicity by defining the system solely in vertical motion. Bhargav et al. also stated that quarter-car model is easily understandable as it only described the suspension system in vertical motion [5]. Half-car model, unlike quarter-car model, it takes into account rotational motion which is one of the important element that could has direct impact on the ride comfort [6]. Another study, Gang Wang et al. stated that halfcar model is normally used due to its symmetry which analysis of both front wheel and rear wheel can be viewed [7]. Full-car model is the most complex model among the other two models which showed the suspension system for both front wheels and rear wheels. Full car model can either be seen as four quarter-car models which could be considered an approach to analyse or direct analysis on the model [8]. Full-car model has better accuracy than the other two models which are quarter-car model and half-car model because full-car model can analyse if in a case where asymmetry exist such as uncertainties of road.

II. METHDOLOGY

In this study, there are two phases of analysis which are mathematical modelling and vibration analysis. Mathematical modelling is used to define the suspension system. Mathematical modelling used in this study is quarter-car model which represent one-quarter of the suspension system. Derivations of the equations are developed in phase 1 to obtain the theoretical result. Phase 2, the simulation, by using finite element analysis (FEA) based software – ANSYS to conduct the modal analysis on the suspension system. To import 3D model to ANSYS, a model is created using CATIA.

III. MATERIAL PROPERTIES

Spring Steel

Young's Modulus (EX): 2.1×105 N/mm2 Poisson's Ratio (PRXY): 0.29
Density: 7.85×10-6 kg/mm3
Load: 2943N

Beryllium Copper

Young's Modulus (EX): 2.8×105 N/mm2 Poisson's Ratio (PRXY): 0.285
Density: 1.85×10-6 kg/mm3
Load: 2943N

IV. RESULTS AND DISCUSSIONS

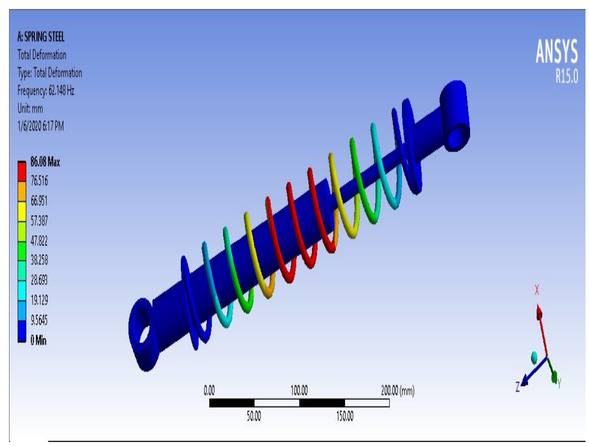

Fig 1: First mode shape of Spring steel

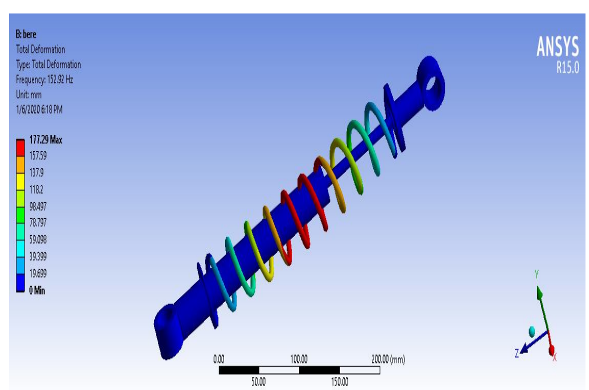

Fig 2: First mode shape of Berelium Copper

Table 1: Comparison of frequency for both materials

S. No	Spring steel Hz	Berelium Copper Hz
1	62.178	152.92
2	62.631	154.11
3	98.799	242.85
4	104.64	257.21
5	108.08	266.19
6	119.39	293.51

V. CONCLUSION

1. In this project we have designed a shock absorber used in a 150cc bike. We have modeled the shock absorber by using CATIA V5.
2. To validate the strength of our design, we have done structural analysis on the shock absorber by using ANSYS Mechanical APDL.
3. We have done analysis by varying spring material: Spring Steel and Beryllium Copper.
4. By comparing the results for materials, total deformation value is more for Spring Steel than Beryllium Copper. So stiffness is less for Spring Steel.
5. So we can conclude that as per our analysis, using Beryllium Copper as material for spring is the best option.

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