Semi-Active Suspension for Two Wheelers

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Abstract

The Suspension of vehicle serves multi-purpose. It contributes to handling and provides comfort and safety. The most common form of front suspension for a modern motorcycle is the telescopic fork. The present telescopic suspension behaves in a similar manner at all road conditions. For example, a two wheeler with rigid suspension provides good handling and riding comfort on highways at high speeds. But it may not be suitable to rough road conditions. For such roads much softer suspension is preferred. It is clear that if the nature of the suspension can be varied according to the road conditions it will contribute to handling and riding comfort.The existing telescopic suspension in motorcycle is 'passive' in nature. In such a suspension the suspension characteristics are fixed by mass, spring and damper elements which are non-adjustable. They are effective only over a narrow range of disturbance inputs. A typical semi-active suspension is composed of a spring type element and a damper that is continuously adjustable. Thus the damper characteristics are continuously variable which makes it more preferable over passive suspension. In our work, we are developing an economic semi-active suspension system for two wheelers by modifying the existing telescopic suspension. Here we are varying the pressure of air column above the damping oil which changes the stiffness of the suspension. Thus the suspension characteristics can be varied by the rider according to the road condition and thus good handling and riding comfort can be achieved. The major advantage of this semi-active suspension is that it uses pressurized air for its functioning which is easily available and is of low cost. Also the rider has the provision to adjust the suspension according to his will which make it more flexible and user friendly.

Keywords: Suspension System, Telescopic Fork, Damper Characteristics, Semi-active Suspension

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I. INTRODUCTION

Suspension is the system of springs, shock absorbers and linkages that which connects a vehicle to its wheels and allows relative motion between the two. Suspension systems serve a dual purpose- contributing to the vehicle's road holding/handling and braking for good active safety and driving pleasure, and keeping vehicle occupants comfortable and reasonably well isolated from road noise, bumps, and vibrations. Isolation from the forces transmitted by external excitation is the fundamental task of any suspension system. The suspension has several important functions. They are:

1) Support the weight of the frame, body, engine, transmission, drive train, and passengers, also called sprung weight.
2) Provide a smooth ride with minimal body movement.
3) Keep the tires firmly planted on the road surface for maximum control at all times.
4) Prevent excessive body squat during acceleration.
5) Prevent excessive body dive during deceleration.
6) Allow the wheels to turn from side to side for steering.
7) Work with the steering system to help keep the wheels in correct alignment.

The typical motorcycle has a pair of fork tubes for the front suspension, and a swing arm with one or two shock absorbers for the rear suspension. The most common form of front suspension for a modern motorcycle is the telescopic fork. Other fork designs are girder forks, suspended on sprung parallel links (not common since the 1940s) and bottom leading link designs, not common since the 1960s.The forks can be most easily understood as simply large hydraulic shock absorbers with internal coil springs. They allow the front wheel to react to imperfections in the road while isolating the rest of the motorcycle from that motion. The top of the forks are connected to the motorcycle's frame in a triple tree clamp which allows the forks to be turned in order to steer the motorcycle. The bottom of the forks is connected to the front axle around which the front wheel spins.

Motorcycles commonly have passive suspension. In passive type suspensions the suspension characteristics are fixed by the mass, spring, and damper elements and are non-adjustable. The fixed setting of a passive suspension system is always a compromise between comfort and safety for any input set of road conditions. Therefore, they are most effective over a narrow range of disturbance inputs. This is the main drawback of passive suspension which is widely used today. In this work, we are developing a semi-active suspension system for two wheelers by modifying the existing passive telescopic suspension. In a semi-active suspension the damping characteristics are continuously adjustable. Here we are varying the pressure of air column above the damping oil which changes the stiffness of the suspension. Thus the property of the suspension can be varied by the rider according to the road condition and thus handling and riding

Comfort can be improved. By adding variable damper and/or spring, driving comfort and safety can be considerably improved compared to suspension setups with fixed properties.

A. Problem:

Motorcycles commonly have passive suspension. In passive type suspensions the suspension characteristics are fixed by the mass, spring, and damper elements and are non-adjustable. The fixed setting of a passive suspension system is always a compromise between comfort and safety for any input set of road conditions. Therefore, they are most effective over a narrow range of disturbance inputs. This is the main drawback of passive suspension which is widely used today. Semi active / active suspension systems try to solve or at least reduce this conflict. The mechanism of semi active suspension system is the adaptation of the damping and / or stiffness of the spring to the actual demands. Active suspension in contrast provide an extra force input in addition to possible existing passive systems and therefore need much more energy.

It is quite obvious that with increase in suspension stiffness there is improvement in quality of handling. But the ride quality is adversely affected. Existing suspensions in motorbikes uses much softer spring which provides better comfort but the handling is adversely affected. So a suspension which changes its stiffness will provide better handling and riding comfort at various road conditions. Semi-active suspensions such as Electro Rheological (ER) and Magneto Rheological (MR) are presently employed in four wheelers. But they are not feasible in two wheelers due to complex structure and high cost. So a low cost semi-active suspension which is simple and flexible has to be developed particularly for two wheelers.

B. Methodology:

The passive telescopic suspension is studied in detail & the various factors affecting suspension behavior are analyzed. Then the suspension model is created using MATLAB and analyzed for various air pressures. To test the performance of suspension by varying air pressure, an experimental setup is made on a motor bike (TVS star). Modified suspension is tested at different road condition and data acquisition is done using an accelerometer coupled with LABVIEW software. To assess the suspension behavior, subjective rating done by riders with varying air pressures through various road conditions.

II. OBJECTIVES

The objective of this work is to study and develop a semi-active suspension system for two wheelers by modifying the existing telescopic suspension. The major disadvantages of the existing semi-active suspension technologies are the complexity and high cost associated which makes almost impossible to implement them in a common motor bike. The proposed system is economical and provides good handling and ride quality at all road conditions. The system requires much less power, and is less complex and more consistent and can provide great improvement in ride quality.

III. DATA ACQUISITION

A. Experimental Set-up:

The idea is to develop a test set-up of semi-active suspension by modifying the existing telescopic suspension. For that a motorbike with telescopic front fork (TVS Star) is selected. It is made sure that the suspension is in good working condition and the fork oil is changed for better result. Initially the bolts on top of the inner fork tubes are removed and the nuts inside the fork tubes which mates with the bolt is drilled vertically. Thus a direct contact is made between the atmosphere and suspension oil. Then air valves that are commonly used in tires are gas welded to the top of the nuts without any air gap. This set-up provides the provision to supply air at any pressure above the suspension oil.

After that frames were made to fix the accelerometer to measure the vibrations of suspension. Two frames were made, one is fixed near the wheel hub and the other is fixed near the bracket as illustrated in Fig.1. The frames are placed in such a way that the accelerometer can be placed horizontally which in turn gives accurate results during testing. Data acquisition is done using an accelerometer and a data acquisition system coupled with LABVIEW software. Air is provided at different pressures to the suspension in order to find out the maximum pressure the oil seal can bear and it was found that the oil seal fails at a pressure of 85 kg/sq.cm. So the maximum pressure that can be supplied to the fork is 80 kg/sq.cm.

Fig. 1: Fixtures for Accelerometer

B. Governing Equations:

Stiffness of coil spring

KC = Gd4/8Nd3

Where G = Modulus of rigidity
d = Wire diameter
n = No: of active turns
D = Mean coil diameter

Stiffness of air column

KA = PA2/V

Where P = Pressure of air column
A = Cross sectional Area
V = Volume

IV. RESULTS AND DISCUSSIONS

A. Analytical Results:

The work presented here tries to analyze the effect of suspension on vehicle performance for a given road input using different approaches namely analysis by using state space equations in MATLAB and through physical modeling using Simscape blockset library. Here we simulate the output response for sudden change in road profile of 0.1 m height.

The results obtained by analysis done using MATLAB software are illustrated. Fig. 2 and Fig. 3 shows the Time vs displacement and time vs velocity graphs for sprung and unsprung mass respectively at normal pressure.

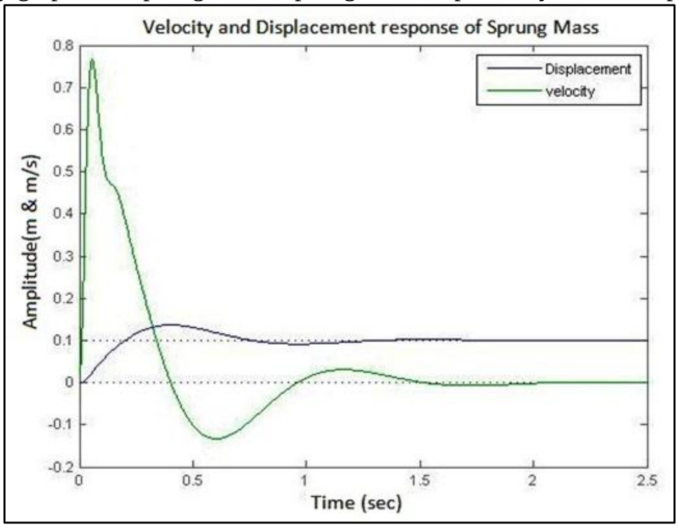

Fig. 2: Time vs Displacement & Time vs Velocity Graphs for Sprung Mass at Normal Pressure

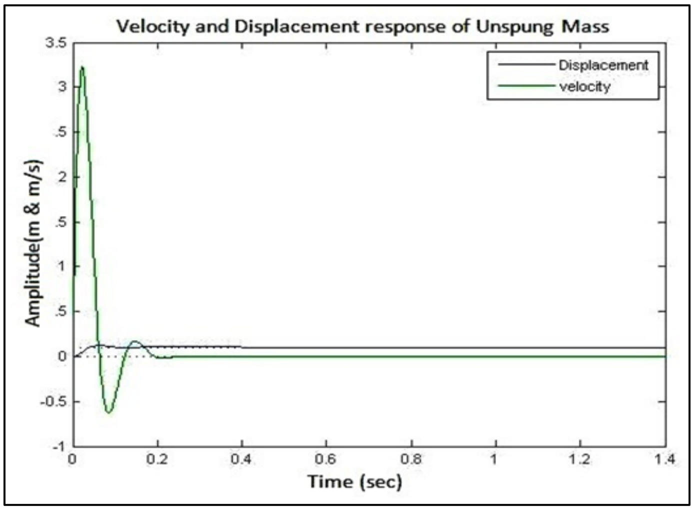

Fig. 3: Time vs Displacement & Time vs Velocity Graphs for Unsprung Mass at Normal Pressure

Consider the time vs velocity graphs. At atmospheric pressure, the relative velocity of sprung and unsprung mass is found to be 2.55m/s. At high pressure, the relative velocity of sprung and unsprung mass is found to be 2.1m/s. There is about 0.45 m/s reduction in velocity. The decrease in relative velocity indicates the reduction in suspension movement and confirms that the suspension has become stiff when air pressure is increased.

Fig .4 and Fig.5 illustrates the Time vs Displacement and Time vs Velocity graphs for sprung and unsprung masses respectively at a pressure of 80 kg/sq.cm for a road profile of 0.1 m height.

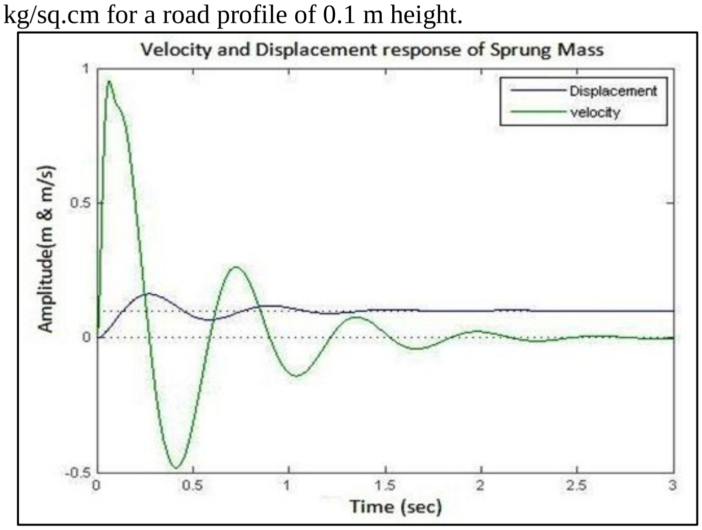

Fig. 4: Time vs Displacement & Time vs Velocity Graphs for Sprung Mass at 80 kg/sq.cm

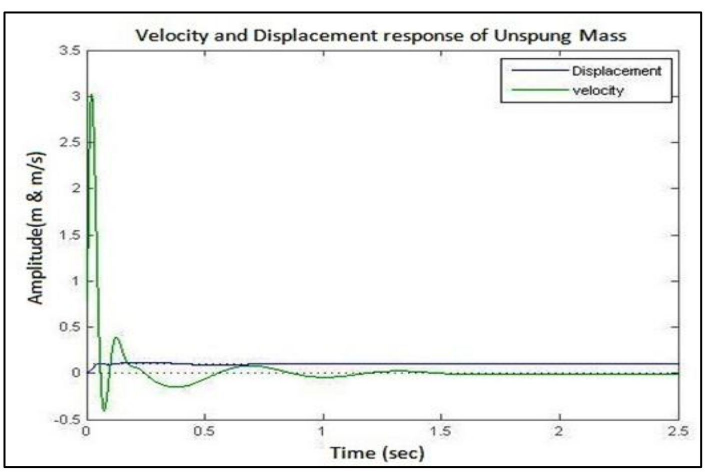

Fig. 5: Time vs Displacement & Time vs Velocity Graphs for Unsprung Mass at 80 kg/sq.cm

It is known that even a small decrease or increase in sprung mass velocity can affect handling. Consider the graphs 4 and 3. Here, in the time vs velocity plots the variation is about 0.45 m/s and it shows that variation of pressure has great effect on suspension behavior. The same can be inferred from the time vs displacement graphs

B. Experimental Results:

The result of objective assessment is plotted as PSD (Power Spectral Density) vs Frequency. The graphs show the behavior of the proposed suspension at various road conditions. Fig. 6 and Fig. 7 illustrates the graphs which shows PSD vs Frequency at smooth and rough road conditions respectively.

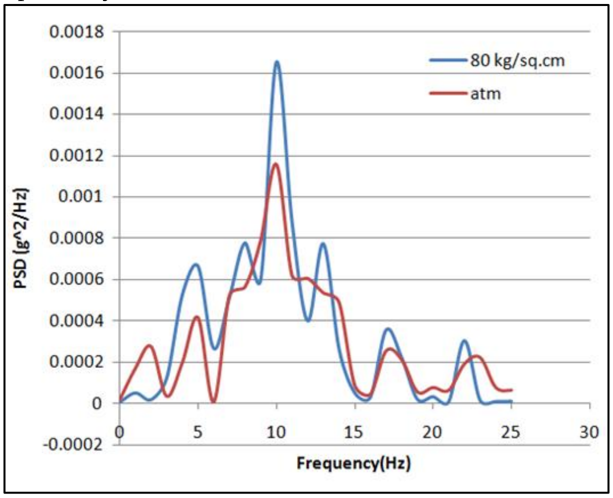

Fig. 6: PSD vs Frequency for Smooth Road at 80kg/sq.cm and Normal Pressure (At Sprung Mass)

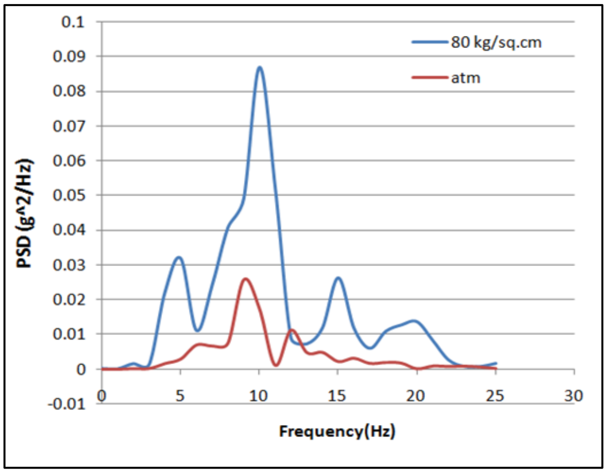

Fig. 7: PSD vs Frequency for Rough Road at 80kg/sq.cm and Normal Pressure (At Sprung Mass)

The area under the PSD vs Frequency graphs indicates the energy content. The energy content available at the sprung mass is increased in both cases which show that the suspension is becoming stiff. For smooth road the energy content almost remains same. But for rough road the energy content at the sprung mass is very high at 80 kg/sq.cm when compared with that at atmospheric pressure. This very high energy content at sprung mass indicates that the rider will feel uncomfortable when he rides the bike at high pressure through rough road.

V. CONCLUSIONS

The ride comfort and handling quality are two important aspects of the customer while choosing a motor bike. The nature of suspension system and motorcycle geometry is the major factors which affect the above mentioned qualities. In our work we are to optimizing these qualities at various road conditions. For an existing motorbike, it is almost impossible to vary the geometric parameters to have effect in the riding. So, the only way of controlling the ride comfort and handling is by varying the nature of the suspension system.

The existing telescopic suspension in motorcycle is 'passive' in nature. In such a suspension the suspension characteristics are fixed by mass, spring and damper elements which are non-adjustable. They are effective only over a narrow range of disturbance inputs. Also the common motorcycle suspensions are designed with much softer springs which will provide good riding comfort but handling becomes very difficult at certain conditions. This problem can be tackled by employing a semi-active suspension system. In semi-active suspension systems the damper characteristics is continuously variable which makes it more preferable over passive suspension. Even though there are many semi-active suspensions already present, they are meant for four wheelers and cannot be employed in a two wheeler-vehicle. Cost is another major factor which retards the implementation of semi-active suspensions in two-wheelers. In our work, we are developing an economic semi-active suspension system for two wheelers by modifying the existing telescopic suspension. Here we are varying the pressure of air column above the damping oil which changes the stiffness of the suspension. The stiffness of suspension can be varied by changing the pressure of air column above the suspension oil.

For smooth roads the air pressure inside the suspension should be increased so that handling can be improved without affecting comfort. But for rough road condition the pressurized air should be released from the forks so that the suspension becomes soft and thus improves the comfort which is the primary concern in such road conditions. While negotiating a curve the stiffer suspension provides good control. Another advantage is that it prevents excessive dive during sudden braking or deceleration and prevents excessive squat during acceleration.

The system is very economic as the primary requirement is air which is easily available. The rider has the provision to vary the suspension characteristics which makes the system more flexible. The robust nature of the system makes it easily adaptable for most two wheeler vehicles with telescopic forks.

REFERENCES

[1] A.H.Gupta, "A Review Study- Design And Analysis Of Suspension System", IJSRD - International Journal for Scientific Research & Development, Vol. 2, Issue 03, pp.1286-1289, 2014
[2] Hashmi Ayas Jameel Ahmed, M.G Rathi, "Effects Of Damping Parameters On Damping Force Of Two Wheeler Front Suspension", International Journal of Engineering Research & Technology, Vol. 2, Issue 7, pp.229-237, 2013
[3] Rijumon, Ajith Krishnan, "A comparison between passive & semi active suspension systems", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 6 ,pp. 2412 - 2416, 2013
[4] Pankaj Sharma, "Analysis of Automotive Passive Suspension System with Matlab Program Generation", International Journal of Advancements in Technology, Vol. 4, pp. 115-119, 2013
[5] Williamson M, "Design and Analysis of Two Wheeler Shock Absorber Coil Spring", International OPEN ACCESS Journal Of Modern Engineering Research (IJMER) , Vol. 3, pp.136-142 , 2012