International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 01,January-2015

Design of Secondary Suspension System for Two-Wheeler

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***Abstract*—The Suspension System has the function of protecting the driver and passengers from shock & to keep the tires of vehicle in continuous contact with ground providing for handling. The ride and handling are key parameters to be considered while evaluating any Suspension System. Attempts have been made to improve ride while controlling handling in vehicles. In case of Two Wheelers lot of research interest has been there in improving existing passive Suspension Systems. Displacement Sensitive shock absorption, Magneto-Rheological shock absorption, shock absorption with gas filled suspension are the technologies of interest in research in case of Two-Wheeler. Active and Semi-Active Suspension systems are now a days replacing passive Suspension Systems in case of Four-Wheelers, but cost point of view, Two-Wheelers have been kept improvising in passive Suspension Systems commercially. A secondary Suspension System is developed in this research for a Two-Wheeler by using gas springs. The Numerical model is prepared in ANSYS and it is validated experimentally. It was found that the Secondary Suspension System reduces the reaction forces drastically and Suspensions relative displacement reduces to negligible value. Gas springs have well known advantages. Those advantages are modified for Two-Wheeler Suspension System.**

Keywords—secondary suspension; gas springs; active suspension system; passive suspension system

I. INTRODUCTION

A suspension system or shock absorber is a mechanical device designed to smooth out or damp shock impulse, and dissipate kinetic energy. The shock absorbers duty is to absorb or dissipate energy. In a vehicle, it reduces the effect of travelling 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 un-sprung 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 torsional shocks as well. Ideal springs alone, however, are not shock absorbers as springs only store and do not dissipate or absorb energy [7].

Suspension system can be classified into three groups such as passive, semi-active and active based upon the performance delivered in the vehicle system during travelling period. Though the technology related to passive suspension system is simple and less costly but its performance is limited to certain frequency range due to the damping behavior of uncontrollable shock absorber. Active suspension systems can perform ride performance and vehicle handling related task in a wider frequency range making it an attractive choice for vehicle manufacturers. But certain requirements in terms of cost, high power demand for system working and many sensors and controllers makes this technology limited to certain costly vehicles. On the other hand, semi-active suspension system related technology offers a good solution in terms of enhanced performance compared to passive suspension system while requiring simple and cheap technology compared to active suspension system. Due to these favorable reasons, semi-active suspension related technology has attracted many researchers and industries in last few decades.

figures 1.1 & 1.2 [7] show classical suspension compromise & types of Shock Absorbers respectively

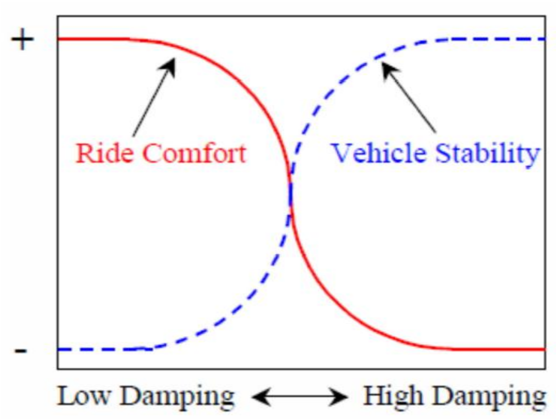

Fig. 1.1Classical Suspension Compromise

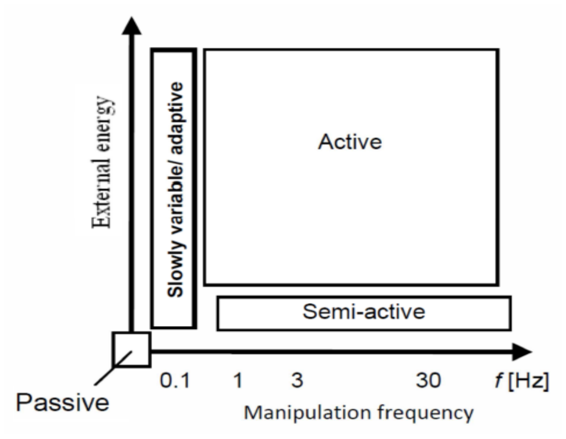

Fig. 1.2 Types of Shock Absorbers according to operation principle

The current research work focuses on using gas springs in suspension system. The gas spring is a hydro-pneumatic adjusting element with pressure tube, piston rod, & end fittings. It contains high pressurized Nitrogen.As compared to conventional coil springs, gas spring has an extremely flat, nearly linear characteristic curve which facilitates uniform comfortable adjustment or pivoting movement. Also, it has another advantage over mechanical springs is damping.When gas spring is installed piston rod facing downwards, during extension it first travels through gas portion & then through the oil portion. The oil dampens the movement & speed reduces considerably. The high pressure nitrogen acts with equal pressure on surfaces having different cross-sectional area of piston. This produces a force in extension direction. The force depends upon the charging pressure.

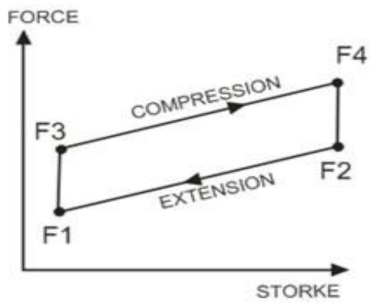

Fig. 1.3 Force Vs Stroke curve for a Gas-Spring

II. Mathematical Modelling

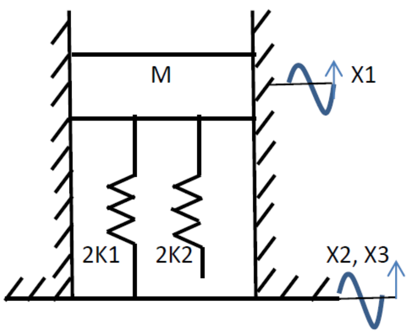

Fig. 1.4Mathematical Model of Secondary Suspension

$$M\ddot{X}1 + 2k1(X1 - X2) + 2k2(X1 - X3) = 0 \quad (1)$$

M - Sprung Mass on Secondary Suspension System
X1- Displacement of Mass M
X2- Displacement of Spring of stiffness K1
X3- Displacement of Spring of stiffness K2 [10]

III. Design

The Secondary Suspension System is designed for TVS Wego. Following factors were considered while designing gas-Springs

1.The size from dicky of TVS Wego to Seat at mid-span of is 235 mm.
2.The dicky can accommodate Suspension of size 100 mm in diameter.
3.The weight considered for design is 120 Kg
4.Two sets of gas springs are to be used with differentExtension forces to avoid proper contact between seat and dicky as well as to support full load of 120 kg .

Considering all parameters two sets of gas springs were selected. One with extension force 5 Kg and other with 50 kg.

IV. Finite Element Modelling

The finite element model was prepared in ANSYS Workbench. For the study, rigid body dynamic model was prepared. The geometry was prepared in ANSYS Design-Modeler. According to available test setup, sinusoidal loading was applied as input and transmitted force values at output as well as absolute displacement at output was computed by the ANSYS program. Two Loads with four speeds for each were simulated in ANSYS.

Table 4.1 Speeds for displacement input motion

<table>
<tr><th>Load(N)</th><th>S1(RPM)</th><th>S2(RPM)</th><th>S3(RPM)</th><th>S4(RPM)</th></tr>
<tr><td>500</td><td rowspan="2">60</td><td rowspan="2">120</td><td rowspan="2">180</td><td rowspan="2">240</td></tr>
<tr><td>441</td></tr>
</table>

V. Experimental Testing

Experimental testing was done on a test rig to evaluate force transmitted by the Secondary Suspension. The force transmitted is measured by shear beam load cell mounted at upper eye of Secondary Suspension. The input to Secondary Suspension system is Sinusoidal displacement input, which is given by the eccentric cam. Eccentric cam is attached to follower and driven by a permanent magnet DC motor. The speed of motor and hence cam motion can be varied with a knob on the test rig. The test rig had displays for voltage and current applied to the system. For placing weights, weight pallets were manufactured.

Figure below shows experimental setup with Secondary Suspension system

Fig. 5.1 Experimental Setup

The specifications of experimentation used is as follows

1. Load Cell

   Capacity- 100 Kg

   Sensitivity- 1.975 mV/V

   Excitation Voltage- 9-13 V
2. Load Cell Transmitter

   Input- 0-30 mV

   Power Supply- 24 VDC

   Output- 0-5 VDC
3. Voltage Data Logger

   Input Signal- 0-5 VDC

   Power Supply- 12 VDC, 1.2 Ah (Ampere Hour)
4. Potentiometer

   Output- 0-5 volt VDC

   Stroke- 80 mm

VI. RESULTS

Force transmitted by Secondary Suspension system with various loading conditions and speeds were plotted for both the methods, Experimental and Finite Element method. Absolute displacement at output was also plotted for various loading conditions. The comparative results are shown in figures 6.1 to 6.4 below

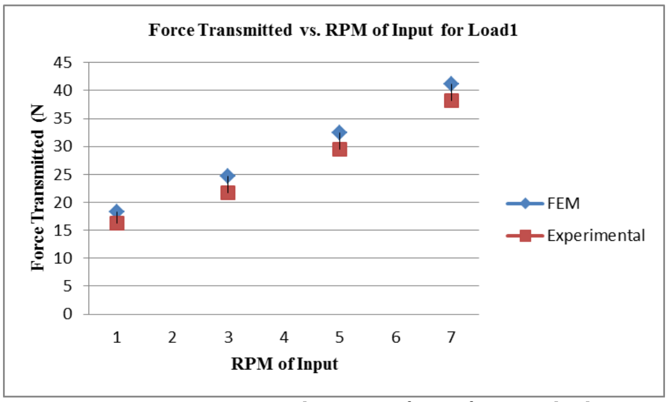

Fig. 6.1 Force Transmitted vs. RPM of input for 500 N load

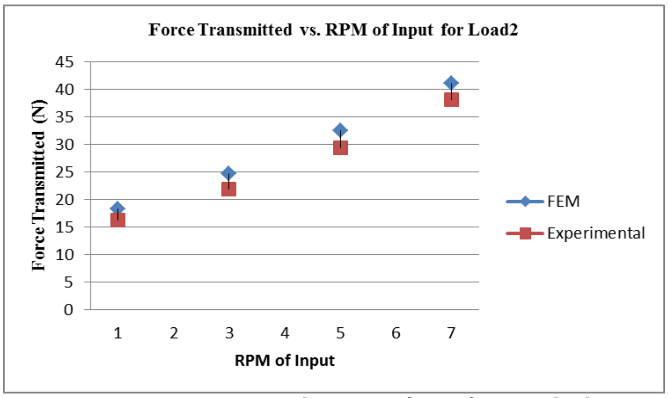

Fig. 6.2 Force Transmitted vs. RPM of input for 441 N load

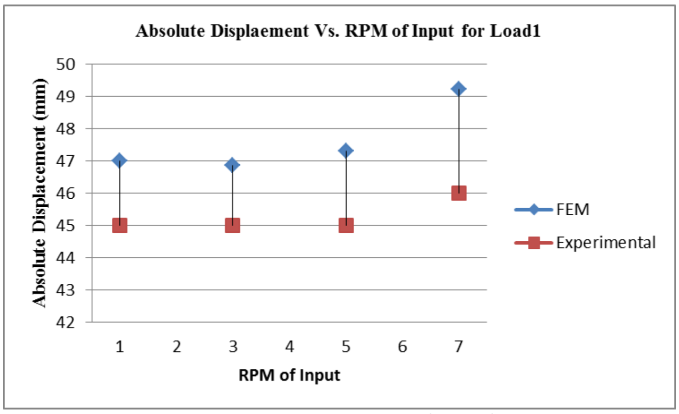

Fig. 6.3 Absolute Displacement Vs.RPM of input for 500 N load

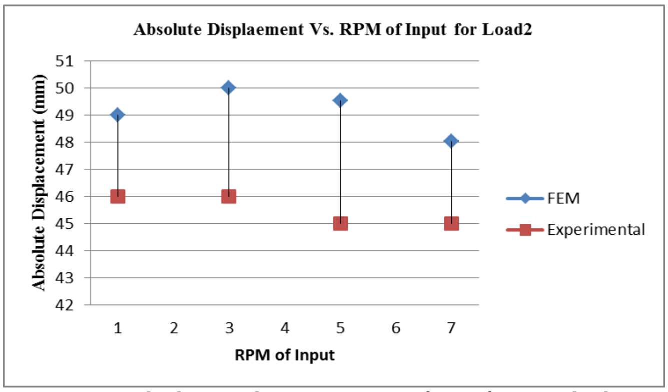

Fig. 6.4 Absolute Displacement vs.RPM of input for 441 N load

CONCLUSION

Absolute displacement and force transmitted values showed good agreement when compared for Finite Element Method and Experimentally. Absolute displacement and force transmitted values are reduced in case of Secondary Suspension. Secondary Suspension system improves performance in terms of comfort without affecting handling as the relative displacement is almost negligible.

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