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A Review Paper on Design, Analysis & Performance Evaluation of Semi-Active Monosuspension System for Two Wheelers

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Abstract— With the advent of high power super bikes the need for a comfortable ride has increased multi folds, hence the conventional passive suspension system will prove to be unfit. Hence there is a need of an active mono-suspension that will change as per road conditions to give optimal ride comfort to the rider. The project deals with design development of semi-active mono-suspension scaled prototype to to prove the operational benefits and evaluate the performance of the same under simulated conditions. The suspension parts will be duly developed using Unigraphix where as the analysis of the components will be done using Ansys work bench. The test and trial on the suspension will be done by arranging the suspension in regular swing arm configuration to find the measured vibration parameters of displacement (δ), velocity (ve) and acceleration and derived parameters of damping coefficient(ξ), at various drive conditions such as pitch, roll.

Index Terms— Mono-Suspension, Semi-Active, Regular Wing Arm, Velocity (Ve), Displacement (Δ), Damping Coefficient (Ξ), Pitch, Roll.

1 INTRODUCTION

SUSPENSION systems have been widely applied to vehicles, from the horse-drawn carriage with flexible leaf springs fixed in the four corners, to the modern automobile with complex control algorithms. The suspension of a road vehicle is usually designed with two objectives; to isolate the vehicle body from road irregularities and to maintain contact of the wheels with the roadway. Isolation is achieved by the use of springs and dampers and by rubber mountings at the connections of the individual suspension components. From a system design point of view, there are two main categories of disturbances on a vehicle, namely road and load disturbances. Road disturbances have the characteristics of large magnitude in low frequency (such as hills) and small magnitude in high frequency (such as road roughness). Load disturbances include the variation of loads induced by accelerating, braking and cornering. Therefore, a good suspension design is concerned with disturbance rejection from these disturbances to the outputs. Roughly speaking, a conventional suspension needs to be "soft" to insulate against road disturbances and "hard" to insulate against load disturbances.

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An automobile suspension system isolates to some degree the tires and wheels of the automobile from the occupant carrying body of the automobile. Mainly suspension system is divided into two system- active and passive suspension system. Passive suspension system consists of an energy dissipating element, which is the damper, and an energy-storing element, which is the spring. Since these two elements cannot add energy to the system this kind of suspension systems are called passive.

Active suspensions can be generally divided into two main classes: pure active suspensions and semi-active suspensions. Semi-active control has shown many advantages in vehicle suspension systems due to its low energy consumption with similar vibration control performance to the active control methods. Active or adaptive suspension is an automotive technology that controls the vertical movement of the wheels with an onboard system rather than the movement being determined entirely by the road surface. The system virtually eliminates body roll and pitch variation in many driving situations including cornering, accelerating, and braking. This technology allows car manufacturers to achieve a greater degree of ride quality and car handling by keeping the tires perpendicular to the road in corners, allowing better traction and control. Various attempts have been made to smoothen the ride comfort of two wheelers. Spring in spring type, mono suspension has shown considerable results. Yet no active or semi-active mono-suspension system has been tried on two wheelers to increase the ride comfort. Hence design and development of active or semi-active mono suspension system has become a need of hour.

1.1 Construction and Working

Geared motor is used to drive the worm which will rotate the worm wheel which will drive the damper disk to change damping hole dimensions

a) Deflection of the spring to change the spring rate as per condition of the road..ie, for large bumps spring length will be maximum and for short bumps but in series the spring length will be short. The up and down motion of the spring will be as per the road conditon.

b) To change the damping coefficient of the system by changing the damper hole size using the variable pitch disk. The rotation motion of the worm makes the disk to open the holes of damper thereby allowing oil to easily pass through system disks thus enable a smooth descent of the suspension in large bump where as the upward motion of the rack makes helical cam to close holes of the damper to allow reduded oil flo to provide better damping in case of short but series of bumps

The set-up is an innovation over the conventional Mc-pherson strut arrangement. The spring used in a helical compression spring with both end ground, the free length of the spring is adjustable. The Free length adjustment will adjust the ground clearance of the vehicle and at the same time make the suspension light thereby increasing the displacement ability of the shock absorber.

The free length adjustment is done using a precision linear actuator in the form of a12 V DC motor, coupled to re-circulating ball screw arrangement with precise displacement and accuracy of motion. The motor drive the re-circulating screw and thereby the nut displaces to adjust the free length of spring and also adjust the displacement of the piston of the hydraulic damper arrangement.

The second part of the hybrid system that is the hydraulic damper part, is coupled to the screw arrangement and it adapts it self as per the motion of the screw and nut arrangement. Thereby adjusting the damping coefficient.

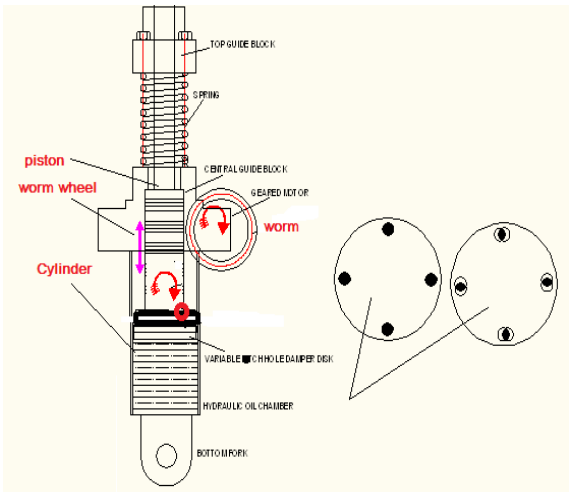

Fig1. Schematic view of semi-active suspension system

2 LITURATURE SURVEY

Y.M.SAM etal [1] presented a new mathematical model and control of the hydraulically actuated suspension system for the half model. The model presented takes into account all the pressure difference parameters inherent in the hydraulic cylinder. However, from the derived mathematical expression for the systems, it is found that the system may experience a mismatched condition problem due to the nature of the road disturbance which is not in phase with the control input. In order to achieve the desired ride comfort and road handling and to solve the mismatched condition, a proportional-integral sliding mode control (PISMC) technique is presented to deal with the system and uncertainties. Extensive simulations are performed for different road profiles and the results showed that the proposed controller performed well in improving the ride comfort and road handling for the half car model using the hydraulically actuated suspension system

Yunjun Li [2] did show the method of operating the active suspension system for a vehicle. The active suspension system receives information from one or more input sources; including both internal and external vehicle inputs, and uses that information to actively control the vehicle height. By doing so, the active suspension system can reduce aerodynamic drag on vehicle and improve the vehicles fuel economy ride comfort, handling and other aspects of operation. Some examples of external vehicle inputs that may be used include; short range road and vehicle information as well as long range traffic, road and route information. The active suspension may comprise of suspension control module electronically coupled to one or more internal vehicle input and one or external vehicle input; an actuator controlled by the suspension control module; a sprung mass mechanically coupled to the actuator. The suspension control module uses information from the internal and external vehicle input to drive the actuator and control a vehicle height.Sayel M Fayyad [3] presented a control system for active suspension systems which have been widely applied to vehicles, right from the horse- drawn carriages with flexible leaf springs fixed at the four corners, to the modern automobiles with complex control algorithms. This implementation includes constructing the transfer function of the control system then making a simulation using MATLAB software. It is found that active suspension system improves ride comfort even at resonant frequency. For step input the of 0.08 m, the sprung mass displacement has been reduced by 25 % which shows the improvement in ride comfort and sprung mass acceleration reduced by 89.93% .The suspension travel has been reduced by 74.64% and tire deflection has reduced by 89.73% .For the real application in vehicles, the proposed active suspension structure faces inevitably some challenges including the cost, the required space in vehicle and power consumption.Rajshree Taparia [4] showed the method to construct an active suspension control for a quarter car model subject to excitation from a road profile using an improved sliding mode control with an observer design. The sliding mode is chosen as a control strategy, and the road profile is estimated by using an observer design. The objective of a car suspension system is to improve the riding quality without compromising the handling characteristic by directly controlling the suspension forces to suit the road and driving conditions.

E.Venkateswarulu, N.Ramesh[5] presented the study of

model of active suspension in half car model. The idea of suspension has to improve the ride quality while maintaining good handling characteristics of three road disturbances bump and hole, sine and random. Then PID controller for active suspension of half car model has been simulated by using an analytical model within MATLAB SIMULINK Software. Based on three road surfaces the performances of passive and active suspension system were investigated. KYUHYUN SIM , HWAYOUNG LEE [6] study the advances that have been made to agricultural tractors to improve their ride comfort. In this paper, to improve the ride comfort of an agricultural tractor, a hydro-pneumatic suspension model with a semi-active suspension control is developed with computer simulation, and the effectiveness of the suspension is evaluated before the vehicle is equipped with the suspension and placed into production.Y.G.Srinivasa [7], we study that the ride dynamic performance of a high-speed tracked vehicle with active suspensions, and to compare it with that of a tracked vehicle having passive suspensions. Settee Thriveni, G Ranjith Kumar[7] titled "Design Evaluation & Optimization of Two-Wheeler Suspension System." Tells us about how a suspension system or 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.

3 METHODOLOGY

a) System design of semi- active suspension as for the component selection, geometry and profile selection, mounting & orientation.

b) Mechanical design of components under given system of forces to determine functional dimensions of the components to be used using various formulae and empirical relations.

c) Mechanical design of above components using theoretical theories of failure after selection of appropriate materials

- 3-D modeling of set-up using Unigraphix Nx-8.0
- Meshing using ANSYS.
- Validation of strength calculations of critical components using ANSYS.

d) Determination of mathematical model for correlating the results obtained from experimental validation.

e) Creation of Prototype: The selected mechanism and machine along with the damper will be designed using following machines:

- Centre lathe
- Milling machine
- Electrical Arc Welding
- DRO – Jig Boring machine

f) Experimental validation

4 CONCLUSION

From the literature survey of various papers following points can be highlightened- The need for semi-active mono-suspension in two wheeler is identified.Construction and working of semi-active suspension system is determined.

Various design calculations are identified to accomplish the project. Final result comparises of force vs velocity(ve), force vs displacement(δ), force vs acceleration analysis for various damping coefficients(ξ).

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