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Independent Suspension System in Cycle": A Review

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Abstract: The independent suspension is use in cycle for better performance. Main purpose is to suspension mechanism that fulfills requirements about stability, safety and maneuverability. Nowadays, as well as in the past, the development of the suspension systems of the vehicle has shown greater interest by designers and manufacturers of the vehicles. Research is focused to do a comprehensive study of different available independent suspension system (Mac Pherson, double wishbone, multilink) and hence forth develop a methodology to suspension system for a cycle. Few chosen suspension systems are analyzed into the very details in order to find out the optimal design of it. During development process of the suspension system should be considered design constraints and requirements provided in the check list. Afterwards the simulation results for kinematics analyses of suspension mechanism are performed in working environments. Achieved results are discussed in detail in order to find the best solution that will fulfill requirement from developed suspension system. All these investigations and reviews related to the suspension of cycle will be exploited in order to obtain the optimal suspension

Keywords: Independent suspension, suspension mechanism, spring, cycle.

I. INTRODUCTION

The primary function of the suspension system of the cycle should fulfill pretentious requirements about stability, safety and maneuverability. The suspension system of the vehicle performs multiple tasks such as maintaining the contact between tires and road surface, providing the vehicle stability, protecting the vehicle chassis of the shocks excited from the unevenness terrain, etc. The suspension system works together with the tires, wheels, frame, suspension linkages, breaks systems as well as steering to provide driving comfort, stability, etc.

This system is the mechanism that physically separates the vehicle body from the wheels of the vehicle. The performance of the suspension system has been greatly increased due to the continued advancements in automobiles in the recently years. The suspension system will consider ideal if the vehicle body isolate from uneven road and inertial

disturbances associated during situation of cornering, braking and acceleration. The design of the vehicle suspension system may be different for front and rear axis (independent or dependent suspension). The main aim in this research is to conceive and design the independent suspension for cycle to achieved great performance purpose. The independent suspension is designed to operate mostly in roughness as well as in paved roads environment.

Independent Suspension System:

This type of suspension allows any wheel to move vertical without affecting the other wheel. These suspensions are mainly used in passenger cars and light trucks as they provide more space for engine and they also have better resistance to steering vibrations. Different types of independent suspension system are

- Swing Axle Suspension
- Macpherson Strut Suspension
- Double Wishbone Suspension
- Trailing Arm Suspension
- Semi-trailing Arm Suspension
- Transverse Leaf Spring Suspension

II.LITERATURE REVIEWS

Review of basic fundamental studies, human comfort studies, techniques and classifications for suspension systems

1) **D. Hrovat of Ford Research Laboratory**, **surveys applications of "optimal control techniques to the design of active suspensions",** starting from simple quarter-car, ID models, which are followed by their half-car, 2D, and full-car, 3D, counterparts. While the main emphasis is on Linear–Quadratic (LQ) optimal control and active suspensions, the paper also addresses a number of related subjects including semi-active suspensions; robust, adaptive and nonlinear control aspects and some of the important practical consideration

2) **J. Watton** . **presented a car suspension incorporating "a Lotus actuator and a TVR suspension/wheel unit is studied both experimentally and analytically**."

An emphasis is placed on hydraulic modeling using a series of transfer functions linking the hydraulic and suspension components. This is significantly aided by the use of a Moog 2000 programmable servo controller (PSC) to equalize the extending and retracting low gains of the servo-valve in the Lotus actuator control loop, justifying the use of combined extending and retracting transient data for parameter identification. This then allows the system equations to be developed using linear state-space theory, and a suitable form is proposed for further design studies. It is shown that the hydraulic components significantly contribute to the system dynamics and hence cannot be neglected when control schemes are formulated. In particular, the significance of hydraulic bulk modulus on dynamic performance is evaluated, and the importance of accurately determining all components of velocity-type damping is highlighted.

3) R. A. Williams

has "categorized suspension systems as adaptive suspensions, semi-active suspensions, low-bandwidth /soft suspensions, high bandwidth / stiff suspensions"

It has been pointed out that good vibration isolation requires low resonance frequencies and modest damping, whereas load changes are reacted more effectively by stiff springs and high damping. Two state and continuously variable dampers for semi-active suspensions have been compared. It has been shown that, combining a semi-active damper with either a low bandwidth or a high bandwidth active suspension system has the benefit in terms of power requirements.

Review of theoretical investigations and modeling schemes. Exposure to the main potential\ benefits and limitations of different suspension systems: passive, semi-active and active systems

1) **Kloiber Guido Koch and Boris Lohmann**,

presented "new control approach for active vehicle suspensions based on modified optimal control problem"

which considers the nonlinear damper characteristic of a vehicle suspension setup. In this context a new method for the systematic construction of a control Lyapunov function is presented, that is applicable to a class of nonlinear systems. The states that are required by the controller are estimated from the available measurement signals using a nonlinear Kalman filter concept recently presented by the authors. In order to achieve the best possible performance with respect to the conflicting objectives passenger comfort, ride safety and suspension deflection, the controller parameters are determined by means of a multi objective genetic optimization algorithm. The potential of the controller is demonstrated by comparing it to a conventional linear quadratic regulator. The concept is validated one quarter-vehicle test rig using measurements of real road profiles as disturbance input.

2)B .Gao

proposed the "Control of a hydro-pneumatic active suspension based on a non-linear quarter-car model"

he states that it is extremely difficult to maintain simultaneously a high standard of ride, handling, and body control in a vehicle with a conventional passive suspension. However, it is well known that active suspensions provide a possible solution to this problem, albeit with additional cost and weight. This paper describes the design and analysis of a hydro-pneumatic slow active suspension. The design is based on hydro-pneumatic suspension components taken from a commercial system. A non-linear quarter-car model is developed, which includes a gas strut model developed in a previous study and a non-linear dynamic flow control valve model. A hybrid control strategy is proposed for the disturbance rejection and self leveling requirements. The disturbance rejection control is based on limited state feedbacks and the linear quadratic method plus a Kalman filter that is used to optimize the performance index. The self-levelling control employs a proportional, integral, and derivative (PID) control strategy. Practical issues, such as power consumption, controller robustness, and valve dynamics, are also investigated. Simulations show that the proposed system has good performance and robustness.

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5) **Fialho and Balas**

presents a novel approach to the "design of road adaptive active suspensions via a combination of linear parameter-varying control and nonlinear backs tepping techniques".

Two levels of adaptation are considered: the lower level control design shapes the nonlinear characteristics of the vehicle suspension as a function road conditions, while the higher level design involves adaptive switching between these different nonlinear characteristics, based on the road conditions. A quarter car suspension model with a nonlinear dynamic model of the hydraulic actuator is employed. Suspension deflection, car body acceleration, hydraulic pressure drop, and spool valve displacement are used as feedback signals. Nonlinear simulations show that these adaptive suspension controllers provide superior passenger comfort over the whole range of road conditions.

Investigation and development of actuation techniques for active suspensions

1)**Mache and Joshi**

have carried out theoretical and experimental "dynamic response analysis of a road vehicle suspension system using an electro-magnetic damper"

A two degree of freedom(DOF)quarter car model has been analyzed for frequency response analysis. The electromagnetic damper has been developed using a combination of permanent magnet (PM) and an electromagnet (EM) keeping an air gap between them. Linear aizing the magnetic damping force between PM and EM, the values of current and position stiffness have been obtained. It has been shown that the electromagnetic damper is effective in reducing the amplitude of vibration over a given range of excitation frequencies, in particular at resonant frequencies. Position and current stiffness have been experimentally determined by using the combination of operating curves of force vs current and force vs gap between PM and EM . It is shown that the electrical design of PM and EM combination with an air gap between them is crucial for the damper performance. well-known PID type. However, the requirement to implement advanced control strategies has led to an increased interest in the use of digital signal processors (DSPs) in this field. One design approach which merits special consideration is the use of computer simulation software to model the hydraulic plant and electronic servo-controller, and to generate and test embedded code for the target DSP. This application report discusses some of the issues involved in controlling linear hydraulic actuators, and the suitability of the TMS320C28x DSP for such systems.

2)**Zhang and Alleyne ,**

have introduced a novel reformulation of the "active suspension problem, based on prescribing a given displacement between the sprung and un sprung masses presents a hybrid control approach to circumvent the basic trade-off between performance and robustness from an individual controller."

This hybrid control strategy utilizes a robust controller for guaranteed robustness when the plant model is not well known, and employs an adaptive controller for high performance after sufficient plant information has been collected. To avoid a degraded transient after controller switching, a bump less transfer scheme is designed and incorporated into this hybrid control approach. This bump less transfer design is an extension from a conventional latent tracking bump less transfer design for a single input single-output (SISO) plant with 1 degree of freedom (DOF) controllers to either a SISO lightly damped zeros (LDZ) of the closed-loop system are the main source of performance limit, the closed-loop transfer functions of the two tracking problems (both force and displacement) analytically. The poles and zeros of the closed-loop transfer functions will then be analyzed. By doing so, the fundamental limits imposed by the LDZ will be clearly understood. It is shown that the displacement control problem also has its own pair of LDZ. Furthermore, while the natural frequency of the displacement control LDZ is a little higher, their damping ratio is lower. Therefore, switching to a displacement control problem is not a complete answer. Subsequently, remedies to reduce the adverse effect of the LDZ are studied. Four candidate approaches are analyzed—new actuator; suspension parameter optimization; add-on mode such as vibration absorbers; and advanced control algorithms. Analysis and simulation results are presented to show the effect of the proposed remedies.

Experimental analysis and modeling with simulation of the suspension strategy

1) **Senthikumar and Vijayarangan**

show with their experimentation that "active suspension system works better than passive suspension"

Also, they have found that, at higher frequencies (1 Hz and more) the performance of active suspension system deteriorates as force tracking at higher frequencies is difficult. The controller is designed to take necessary actions to improve the performance abilities already set. The controller amplifies the signals which are fed to the actuator to generate the required forces to form closed loop system (active suspension system) . The performance of this system is then compared with that of the open loop system (passive suspension system). The developed design allows the suspension system to behave differently in different operating conditions, without compromising on road-holding ability. The effectiveness of this control method has been explained by data from time domains. Proportional-Integral-Derivative (PID) controller has been developed. The Ziegle– Nichols tuning rules are used to determine proportional gain, reset rate and derivative time of PID controller. The experimental investigations on the performance of the developed active suspension control are demonstrated through comparative simulations.

10)**Megahed and Razik presented the "dynamic modeling and simulation of a proposed modified design of the vibration control of two degree of freedom primary systems. Lagrange formulation is used to obtain its dynamic model in an analytical form**"

This model, which is highly nonlinear, is used to develop a computational algorithm to study the absorber performance characteristics. This algorithm is programmed and simulated in MATLAB. The obtained results are numerically verified using software. The effect of mass and stiffness of the proposed design on its performance and tuning is discussed. An optimization algorithm is developed to select the best absorber parameters for vibration suppression of a specific primary system. The obtained results show a good agreement with those obtained using similar techniques. In addition, a linearised model of dynamics is developed, tested and simulated for the same data used in its nonlinear model

III. REFERENCES:

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