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"INDEPENDENT SUSPENSION IN TRICYCLE": A Review

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ABSTRACT : A tilting preferably three wheel, vehicle is disclosed that has a tilting mechanism that allows the vehicle to have leaning characteristics substantially similar to those offered by an inline two wheel vehicle, but that does not require complex linkages or control system to operate effectively. A tilting linkage is operable secured to a frame to allow a pair of spaced apart wheel to remain substantially aligned with the plane of the vehicle throughout its range of movements while still allowing the steering axes of each wheel to intersect the vertical centre line of each wheel. The linkage also allows caster angle of each wheel's pivot axes can be optimized independently of the angle of vehicle's handle bar steering shaft. The main functions of suspension systems are to isolate the structure and the occupants from shocks and vibrations generated by the road surface. The suspension systems basically consist of all the elements that provide the connection between the tyres and the vehicle body.

Keywords: *Independent suspension, spring, tricycle*

I.INTRODUCTION

A three wheeled vehicle, with two steerable front wheels and a driven rear wheel by rider includes to the lower end of a column having a handle bar attached to its upper end's rear frame which supports the rider and includes the rear wheel. The handle bar, pivot shaft, a bearing housing and a mechanical connection for leaning the rear frame in the direction of a turn so as to compensate for centrifugal force encountered in turning the vehicle. The mechanical connection causes the rear frame to lean in a controlled relationship to the amount of rotation of the steering shaft, within rotational limits, to emulate the leaning action of a conventional vehicle when making a turn Suspension systems have been widely applied to vehicles, 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 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. Today, nearly all passenger cars and light trucks use independent front suspensions, because of the better resistance to vibrations. The main functions of a vehicle's suspension systems are to isolate the structure and the occupants from shocks and vibrations generated by the road surface. The suspension systems basically consist of all the elements that provide the connection between the tires and the vehicle body. The suspension system requires an elastic resistance to absorb the road shocks and this job is fulfilled by the suspension springs. Provide vertical compliance so the wheels can follow the uneven road, isolating the chassis from roughness in the road. Maintain the wheels in the proper steer and camber attitudes to the road surface Keep the tires in contact with the road with minimal load variations To accomplish all functions, the suspension system requires an elastic resistance to absorb the road shocks and this job is fulfilled by the suspension springs . A spring is defined as an elastic machine element, which deflects under the action of the load & returns to its original shape when the load is removed.

Types of Suspension System:

Generally, the suspension system is classified into two main types

- Dependent Suspension System
- Independent Suspension System

Dependent Suspension System:

This type of suspension system acts as a rigid beam such that any movement of one wheel is transmitted to the other wheel. Also, the force is transmitted from one wheel to the other. It is mainly used in rear of many cars and in the front of heavy trucks. Different types of dependent suspension system are,

- Leaf Spring Suspension
- Pan hard rod
- Watt’s Linkage

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

Out of all the above mentioned independent suspension systems, Double Wishbone Suspension System is the most common type of suspension system used in the passenger cars and most of the All-Terrain Vehicles.

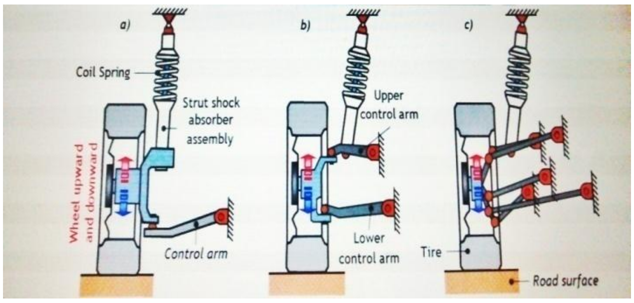

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Fig.1. Independent suspension system;
a) MacPherson strut b) double wishbone and c) multi–link suspension system

II.OBJECTIVE:

1. Keeps the vehicle balanced while it is traveling in turning and straight path.
2. Tilts the vehicle into a curve during cornering.
3. Reduces acceleration experienced by the driver Always maintains vehicle stability
4. To provide good ride and handling performance.
5. Vertical compliance providing chassis isolation.
6. Very little tire load fluctuation.
7. To ensure that steering control is maintained during manoeuvring.
8. Wheels to be maintained in the proper position with respect to road surface.
9. To ensure that the vehicle responds favourably to control forces produced by the tires during:-
   a. Longitudinal braking
   b. Accelerating forces,
   c. Lateral cornering forces and braking and accelerating torques
10. To provide isolation from high frequency vibration from tire excitation
   a. Requires appropriate isolation in the suspension joints
   b. Prevent transmission of ‘road noise’ to the vehicle body

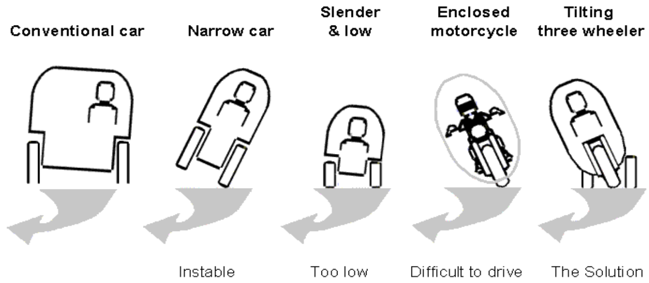
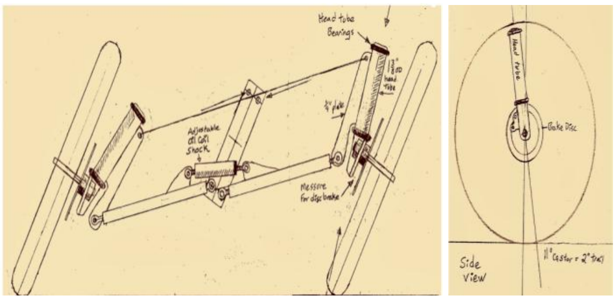


Fig. 2

III.STEERING TILT CONTROL:

Putting your feet down is a simple and straight forward action on a cycle, but once the rider is put inside an enclosed vehicle, the ‘feet down’ functionality has proven to be virtually impossible to replace by a mechanical system. The problem here is not the building of a mechanism that locks the vehicle in an upright position below a certain speed



Dig.1 The independent suspension system view

The present arrangement overcomes the cornering problems of vehicle by counteracting the centrifugal force exerted upon a vehicle and its rider during a turn. In the present invention the seat moving inward in relation to the amount of turn shifts the centre of gravity of the rider inward from a line between where the rear wheel and the outer front wheel contact the road so that the rider's weight has a greater anti-rotational force about the line to permit a greater centrifugal force on the rider without the vehicle tipping over or the rider falling out ward. Also, in the present invention centrifugal force acting on the rider moves him outward, causing the rear frame to rotate and the front wheels to swing back so as to lessen the sharpness of the turn and prevent the vehicle from rolling over.

A three wheeled vehicle comprising:

1) A right front steerable wheel and a left front steerable wheel disposed on respective sides of a central steering shaft having a handlebar attached there to wherein each of said right and left front steerable wheels has turning pivot;
2) A rider seat disposed intermediate said rear axle and said handle shaft, wherein said two front wheels including steering linkage disposed between their respective turning pivots and said central handle shaft;
3) A front frame coupled to and supporting said two front wheels, said steering shaft, and steering linkage and said handlebar;
4) A rear frame supporting a rider, said rear wheel, and a vehicle propulsion arrangement.

IV.MATERIAL SELECTION:

Material selection is one of the most important aspects of the design procedure of the product or the system. The materials are selected as per the required properties required for the satisfactory performance of the product. The material selected should exhibit these properties satisfactorily, while the product is in operation. The materials selected for various elements of the project depending upon their requirements are

PART	PROPERTIES	MATERIAL
Square bar	To sustain loadand high torque	M.S Black
Hub plate	Medium strength steel, good tensile strength.	EN 8
Steering Rod	Subjected to crushing load, high bending resistance.	M. S Bright Bar
Wheel	High tensile strength but should be economical.	M.S Black
Clamps	Ease in bending, fabrication and simple forming.	M.S Black
Frame	The material should sustain the compressive & shearing loads acting suddenly i.e. high compressive strength, economical, easily available.	Mild Steel

PLAN OF RESEARCH:

Selection of the entire system is done in mechanical system followed by the validation. Following steps were followed while selecting the material for the tricycle to making the independent suspension and steering mechanism in tricycle.

PART A: MECHANICAL

- Decide type of suspension system (Independent suspension).
- . Decide basic dimensions- wheelbase, height, wheels and other suspension parameters.
- Decide wishbones and knuckles.
- . Decide springs for suspension.

PART B: TESTING OF THE SYSTEM

- .Actual testing after assembling the system on vehicle and carrying out the actual run of vehicle on various parameters.

V. 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

4) **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.

5) 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.

VI.ADVANTAGES:

- It provides anti-skidding effect.
- It can be used for on road as well as for off road purpose.
- Assembly is reliable.
- Bolt on assembly gives redundancy to use vehicle as per requirement.
- Rider is safe while taking sharp turn on the road cause possibility of skidding or falling of tricycle is almost negligible.
- Normal people can take experience of off road biking.
- Always maintains vehicle stability
- Tilts the vehicle into a curve during cornering

VII.CONCLUSIONS:

1) The study of self-stability of the two-wheeled bicycle establishes conditions that minimize the critical velocity. We choose the position of the center of gravity of the front assembly as a control parameter, and find the optimal value of this parameter when the tilt angle of the front wheel is positive as well as negative.

2. Unlike the self-stability mode, the stability of the bicycle controlled by a rider is examined in the third section. Here, we assume that the rider acts to operate the handlebar such that a bicycle remains stable. To achieve this, we utilize an effect well-known to every bicycle rider: the stability is maintained when an oscillatory rotation is applied to the steering wheel.

VII. REFERENCES

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

3) R. A. Williams, " categorized suspension systems as adaptive suspensions, semi-active suspensions, low-bandwidth /soft suspensions, high bandwidth / stiff suspensions"

4) Kloiber Guido Koch and Boris Lohmann,, "presented new control approach for active vehicle suspensions based on modified optimal control problem,"

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