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Double Wishbone Suspension Analysis for Elastic Center, Castor Trail and Standard Kinematic Analysis

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Abstract-Analysis and understand the performance characteristics of front double wishbone suspension system for sedan vehicle handling using low profile tire which gives good steering handling in term of high cornering and inclination stiffness characteristics. So it is essential to study the double wishbone suspension system for evaluating the elastic center while braking and isolation characteristics. This requirement for longitudinal compliance has an unfortunate side-effect on hub control when braking forces are applied. Consequently, the hub rotates when the suspension is subject is subject to braking forces. So this has to study in Multibody Dynamics considering the vehicle dynamics using ADAMS software. On the basis of vehicle dynamics analysis, it is conforming that the lower the longitudinal stiffness of the suspension, greater the associated hub rotation under braking. In the case of a front suspension, this gives potential for excessive castor trail loss and attendant steering instabilities.

Index Terms-Elastic Center, Caster, Multibody Dynamics, ADAMS, Vehicle Dynamics.

1. INTRODUCTION

Suspension framework in its least difficult structure may be considered as a linkage to permit the wheel to move in respect to the body and some versatile component to bolster loads while permitting that movement. It is astructural assembly of springs, shock absorbers (dampers) and control arms that connects a vehicle to its wheels. In a running vehicle, the suspension system keeps the passage comfortable and isolated from road harshness, bumps, and vibrations. It also provides the vehicle, good handling characteristic,permitting the driver to keep up control of the vehicle over harsh territory or in the event of sudden stops. Also, the suspension framework keeps the vehicle from harm. [1]

The Basically suspension framework comprises of spring, damper and auxiliary parts conveying the sprung mass (auto body). The springs retain effects and give padding when a wheel hits an obstruction. The springs additionally oppose the wheel's development and bounce back, pushing the wheel down, so to keep the control of vehicle by keeping the wheels in contact with the street. Shock absorbers (dampers) perform two functions. They absorb any larger than average shocks generated by bumps in the road so that the upward velocity of the wheel over the bump is not transmitted to the car subframe and eventually to driver or passenger. Secondly, they keep the suspension at full as much as possible during the travelling for the given road conditions, in brief, they keep the wheels planted on the road. Due to the criticality of suspension system performance related to ride comfort and vehicle control and passenger safety, the understanding of design variables and behavior of suspension system in severe or harsh loading cases should be well known and optimized. This report analyzes the characteristic model of wishbone type suspension system, with study the effects of low profile tier on ride and handling of vehicle, low profile tier provides very good high cornering performance and inclination stiffness characteristics. As passenger comfort is one of the prime criteria for performance evaluation of suspension.

King pin inclination is the transverse angle of the swivel axis of the front wheel and its stub axle. The effect of the inclination is usually discussed in terms of the king pin offset which determines the self-centering torque when the steering is turned for cornering. Although many cars have a positive value of offset which tends to return the wheel to the straight ahead position, some modern cars have a negative offset to improve stability when the tire blows or the brake fails on one front wheel.

Castor angle also introduces a self-centering torque when the car is traveling forward. This is achieved by the positive offset shown in the diagram where the

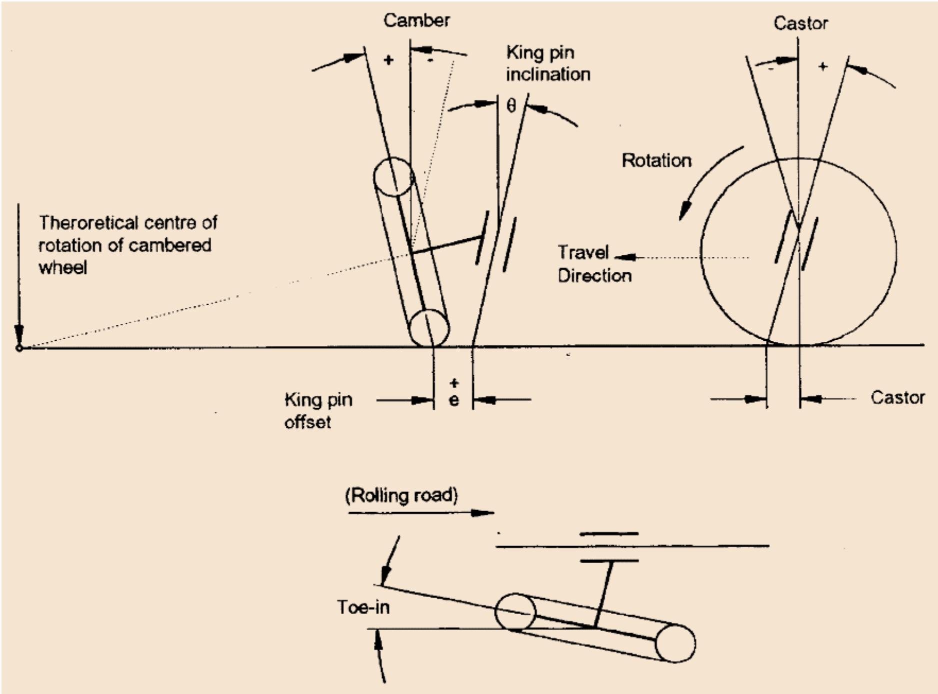

Fig. 1. Caster, Camber and Kingpin [7]

contact of the tire on the road trails behind the king pin axis [2].

With present day auto outline it has turned out to be more hard to see and grasp the connections of front wheel directing geometry. Subsequently there are favorable circumstances in using so as to consider the set-up by using a one third scale model which is as close as possible to the real construction found in a large car. Nevertheless, the needs of experimentation require some unusual variations like an adjustable stub axle [3,4].

2. PROBLEM DEFINITION, AIM AND OBJECTIVE

The demands on vehicle suspension performance – in terms of both accurate wheel geometry control and isolation – have increased steadily over the past decade as the requirements of steering, handling and styling have driven car makers toward ever-lower profile tire choices of a larger diameter.

The lower the longitudinal stiffness of the suspension, the greater the associated hub rotation under braking. In the case of a front suspension, this gives potential for excessive castor trail loss and attendant steering instabilities for sedan vehicle.

2.1. *Aim*

While using low profile tire for font double wishbone suspension system during braking reduce the castor trail at the contact patch of tier and road and minimize the hub rotation w.r.t wheel center for sedan vehicle.

2.2. *Objective*

Sections, sub-sections and sub-subsections are numbered in Italic. Use double spacing before all section headings and single spacing after section headings.

- To find the way for increase in longitudinal stiffness of the suspension
- Investigate the new design of double wishbone suspension system for effectively decoupling of castor and longitudinal stiffness
- Maintain the suspension geometry kinematics as same as traditional double wishbone suspension for front.
- A better solution would be a suspension whose longitudinal elastic center is moved verticallydown from the wheel center to the ground plane region.
- Analyze the new design by multibody dynamic software like ADAMS/CAR

3. INDEPENDENT WHEEL SUSPENSION – GENERAL.

The chassis of a passenger car must be able to take the installed engine power. Continually improving acceleration, higher peak and cornering speeds, and deceleration lead to significantly increased requirements for safer chassis. Independent wheel

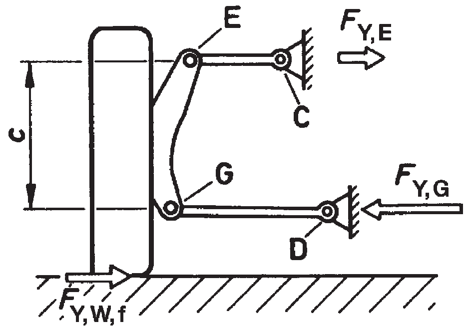

Fig. 2.Independent wheel suspensions [7]

suspensions follow this trend. Their main advantages are:

- A kinematic and/or elastokinematic toe-in change, tending towards understeering is
- Easier steerability with existing drive
- Low weight
- No mutual wheel influence

The last two characteristics are important for good road-holding, especially on bends with an uneven road surface.

Transverse arms and trailing arms ensure the desired kinematic behavior of the rebounding and jouncing wheels and also transfer the wheel loadings to the body (Fig. 2). Lateral forces also generate a moment which, with unfavorable link arrangement, has the disadvantage of reinforcing the roll of the body during cornering. The suspension control arms require bushes that yield under load and can also influence the springing. This effect is either reinforced by twisting the rubber parts in the bearing elements, or the friction. The lateral cornering force FY,W,f causes the reaction forces FY,E and FY,G in the links joining the axle with the body. Moments are generated on both the outside and the inside of the bend and these adversely affect the roll pitch of the body. The effective distance c between points E and G on a double wishbone suspension should be as large as possible to achieve small forces in the body and link bearings and to limit the deformation of the rubber elements fitted, which will impact on latral forces on wheel hub. [4]

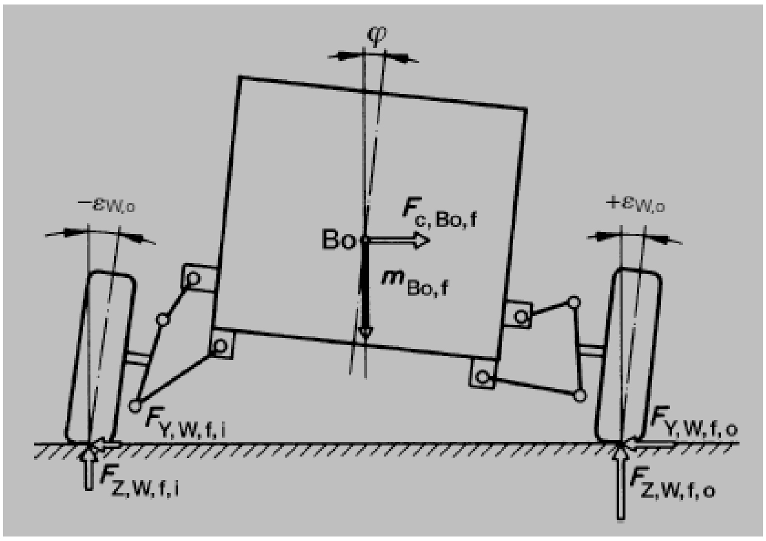

Fig. 3.Body inclines by the angle φ during cornering [7]

The outer independently suspended wheel takes on positive camber εw,o and the inner wheel takes on a negative camber εw,i. The ability of the tyres to transfer the lateral forces FY,W,f,o or FY,W,f,i decreases causing a greater required slip angle is the proportion of the weight of the body over the front axle and Fc,Bo,f , the centrifugal force acting at the level of the center of gravity Bo. One wheel rebounds and the other bumps, i.e. this vehicle has ‘reciprocal springing’, that is: FZ,W,f,o = FZ,W,f + FZ,W,f and FZ,W,f,i = FZ,W,f – FZ,W,f

Increases due to the parts rubbing together, and the driving comfort decreases. The wheels incline with the body (Fig.3). The wheel on the outside of the bend, which has to absorb most of the lateral force, goes into a positive camber and the inner wheel into a negative camber, which reduces the lateral grip of the tyres. To avoid this, the kinematic change of camber needs to be adjusted to take account of this behavior.

4. DOUBLE WISHBONE SUSPENSIONS

The last two characteristics above are most easily achieved using a double wishbone suspension (Fig.4). This consists of two transverse links (control arms) either side of the vehicle, which are mounted to rotate on the frame, suspension subframe or body and, in the case of the front axle, are connected on the outside to the steering knuckle or swivel heads via ball joints. The greater the effective distance c between the transverse links (Fig. 2), the smaller the forces in the suspension control arms and their mountings become, i.e. component deformation is smaller and wheel control more precise.

A cross-member serves as a subframe and is screwed to the frame from below. Springs, bump/rebound-travel stops, shock absorbers and both pairs of control arms are supported at this force center. Only the anti-roll bar, steering gear, idler arm and the tie-rods of the lower control arms are fastened to the longitudinal members of the frame. The rods have longitudinally elastic rubber bushings at the front that absorb the dynamic rolling hardness of the radial tires and reduce lift on uneven road surfaces.

The main advantages of the double wishbone suspension are its kinematic possibilities. The positions of the suspension control arms relative to one another – in other words the size of the angles α and β – can determine both the height of the body roll center and the pitch pole. Moreover, the different wishbone lengths can influence the angle movements

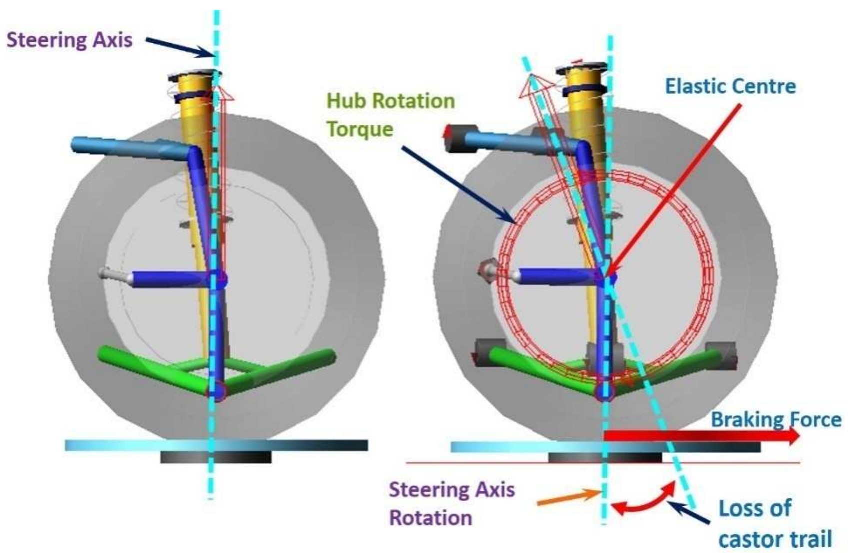

Fig. 5. Response of a double wishbone front suspension to braking forces [9]

Of the compressing and rebounding wheels, i.e. the change of camber and, irrespective of this, to a certain extent also the track width change. With shorter upper suspension control arms the compressing wheels go into negative camber and the rebounding wheels into positive. This counteracts the change of camber caused by the roll pitch of the body (Fig.3).

The response of a traditional double wishbone type front suspension to braking forces is depicted in (Fig 5); the hub and steering axis rotation, loss of castor trail and approximate elastic center location are all apparent [8,9]. The lower the longitudinal stiffness of the suspension, the greater the associated hub rotation under braking. In the case of a front suspension, this gives potential for excessive castor trail loss and attendant steering instabilities. Traditionally, because the castor and longitudinal stiffness are coupled.

So following are the designs already tried to achieving this goal and there shortcoming to achieve this goal, will discuss in brief only some actual production designs only.

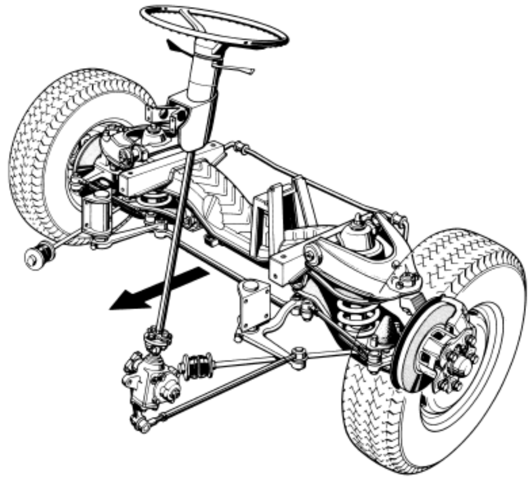

Fig. 4.Double Wishbone Suspension System [6]

5. SUMMARY

Figures are to be inserted in the text nearest their first reference. Figure placements can be either top or bottom.

5.1. *Advantage*

- Design simplicity and reduced cost
- Because of the relevant separation of body joints, forces exerted on the body are low in comparison for example a low double wishbone suspension.
- Higher suspension stroke than in other suspensions (a high double wishbone one for example, because of the limitation on upper arm length).
- Contained transversal dimension, due to the absence of the upper arm; this fact is quite beneficial for transversal engine installation.
- Possibility of designing with superior longitudinal flexibility, without greatly affecting the caster angle.
- Freedom in designing elasto-kinematic properties; camber recovery is limited only by viable positions for the upper pivot and lower arm fixed joint.
- The ratio between suspension and shock absorber stroke is near to one.Shock absorbers therefore work well with limited loads, low oil heatingand valve wear.

5.2. *Disadvantage*

- Lower performance in camber recovery. For example, the comparison between camber angle variation for a McPherson and a double wishbone suspension, shown in Fig. 6
- Suspension characteristic geometry causes a position for the upper pivot interface with the body, usually called dome, which is usually far removed from the stiffest structures of the body, the side beams. This causes significant problems with suppression of vibrations and noise from the road.
- Shock absorber piston rod deformation can increase friction and hysteresis.
- Notable height for the upper pivot, so that the spring and shock absorber are set over the wheel; this fact could degrade the vehicle’s aerodynamic shape and sporty body style.

6. CONCLUSIONS

The demands on vehicle suspension performance – in terms of both accurate wheel geometry control and isolation – have increased steadily over the past decade as the requirements of steering, handling and styling have driven car makers toward ever-lower profile tire choices of a larger diameter. Although the high cornering and inclination stiffness characteristics of these lower profile tires have benefited the steering and yaw responses of the modern vehicle. The associated increase in radial stiffness has reduced the tire's effectiveness as an isolator for ride comfort and harshness.

However, this requirement for longitudinal compliance has an unfortunate side-effect on hub control when braking forces are applied to the suspension system. The longitudinal elastic center of most suspension types generally lies somewhere in the region of the wheel center. Consequently, the hub rotates when the suspension is subject to braking forces, yet it remains relatively stiff when subject to impact forces, which are resolved at the wheel center. The lower the longitudinal stiffness of the suspension, the greater the associated hub rotation under braking. In the case of a front suspension, this gives potential for excessive castor trail loss and attendant steering instabilities [7].

All are above design show the wheel center is always in close proximity of wheel center of front wheel suspension system and co relation between longitudinal compliances and castor compliances, this will raise the need of the different suspension design close to double wishbone suspension which control the hub rotation and reduce castor trial

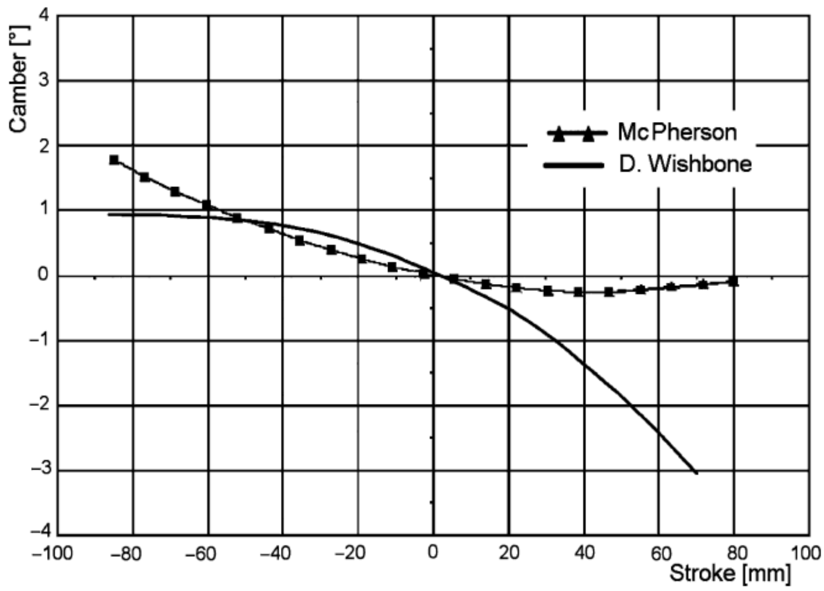

Fig. 6.Comparison between camber angle variation as a function of suspension stroke in a McPherson and a double wishbone suspension; the difference produces a better camber recovery in the double wishbone suspension. [5]

REFERENCES

[1] Wang, D. and Rui, Y, The Effects of Front Suspension Parameters on Road Wheel Toe Dynamics, SAE 2001 World Congress Detroit, Michigan, 2001. pp. 3-8.
[2] MB Gerrard, Kinematic Suspension Linkages - A Model for Their Behavior & a Procedure for Their Design, SAE Technical Paper 2002-01-0281, World Congress Detroit, Michigan. March 4-7, 2002. pp. 14-20.
[3] Pascali, L., Gabrielli, P., and Caviasso, G., Improving Vehicle Handling and Comfort Performance Using 4WS, SAE 2003 World Congress Detroit, Michigan March 3-6, 2003. pp. 4-9.
[4] Steven P. Fuja, Henry A. Schmid, and Joseph P. Ryan, Synthesis of Chassis Parameters for Ride and Handling on the 1997 Chevrolet Corvette, International Congress & Exposition Detroit, Michigan February 24-27, 1997. pp. 4-11.
[5] SAE, Surface Vehicle Recommended Practice-J670e, REV JUL76, pp. 11-24

[6] David A Croll, Automotive Engineering Powertrain, Chassis System and Vehicle Body, First edition, 2009, Butterworth-Heinemann Press
[7] Thomas D. Gillespie, Fundamentals of Vehicle Dynamics,2nd ed, SAE inc. pp. 25-76
[8] MSC Software Corporation Ltd,MSC Adams/Solver 2014 User Manual, pp 80-320
[9] MSC Software Corporation Ltd, MSC Adams/Car 2014 User Manual, pp. 1-206