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Modelling and Simulation of Full Vehicle for Analysing Kinematics and Compliance Characteristics of Independent (Macpherson strut) and Semi Independent (Twist Beam) suspension system

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ABSTRACT : *A number of researcher projects have been conducted to determine which physical motion parameters are actually perceived by humans during vehicle operation and which are judged undesirable or poor on the basis of their intensity. All of these investigations have endeavoured to find the best possible correlation between driver evaluation and measured parameters in specific driving manoeuvres. These relationships are examined in greater detail in this work. In this way, it will be possible to describe objectively a large range of vehicle ride & handling properties, which in turn will generate continuous improvement in systematic methods for suspension development, and to apply these advancements toward satisfying demands for continued progress. The main objective of this work is to quantify automobile ride & handling characteristics and to do sensitivity analysis of various hardpoints of Independent (Macpherson strut) suspension and Semi independent (Twist Beam) suspension.*

Keywords *- Ride, handling, Suspension Parameter and Variation.*

1. Introduction

Computer Simulations of mechanical systems is becoming increasing important in many areas of engineering. The power of such programs lies in their ability to accurately simulate real world mechanical systems using computer code and equations. This eliminates much iteration of the prototype fabrications, lab testing and model revision. This reduction in hardware constructions saves time and money. Because of this and other benefits offered by such digital simulation programs, their use is becoming more and more widespread. One of the dominant users of these programs is the automotive industry which is using ADAMS (Automatic Dynamic Analysis of Mechanical systems) and other similar programs to do many types of studies, such as vehicle dynamics

1.1. WHAT IS VEHICLE DYNAMICS?

Vehicle Dynamics is the study of Vehicle whole body motion. The total vehicle system is subjected to many different degrees of free motion. The interaction of these movements, each with its own velocity, acceleration, and frequency, makes a road vehicle one of the most complex systems in the field of dynamics.

These vehicle dynamics interactions are shown in figure .

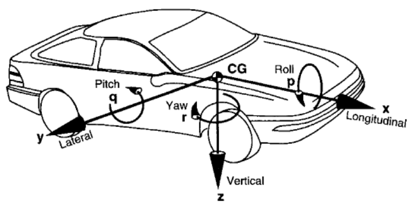


Fig 1. Vehicle Dynamics Definition

Analysis of what takes place during a complex manoeuvre, such as coincidental roll, pitch and yaw. During the analysis additional variables must be considered, such as body flexibility, suspension link deflections, compliance in the attachment bushes, and geometry changes caused by torque inputs to the wheels and by suspension movement.

1.2. METHODS OF VEHICLE DYNAMIC STUDY

1.2.1. Classical Methods:

In the classical methods the study of two degree of freedom model gives a useful insight. With the reasonable increase in sophistication but well worth the effort is the elaboration to the three degree of freedom to include the influence of suspension roll. Such classical models help the analyst discern 'the woods for the trees' – they easily bring forth, for example, the influence of suspension steer derivatives on straight line stability.

1.2.2. Computational Methods:

Whether the equations of motion have been derived by hand or delegated to a commercial software package, the primary goal when considering vehicle dynamics is to be able to predict the time domain solution to those equations. Once the equations of motion are assembled they are integrated numerically. This is a specialized field of its own right. The equations can be solved in a fairly direct fashion as assembled by the commercial package pre-processor or they can be subjected to further symbolic manipulation before numerical solution.

1.2.3.Commercial Computer Package:

MSC.ADAMS program is typical of the range of multi-body analysis software described as numeric where the user is concerned with assembling a physical description of the problem rather than writing equations of motions. Here, the equations are generated in numerical format and are solved directly using numerical integration routine embedded in the package.

2. Theory of MBD Software

2.1. What is Multibody Dynamics ?

Multibody system is the group of bodies interconnected by joints, influenced by forces, and restricted by constraints. And the field of studying the classical mechanical properties (especially motion) of these systems is known as Multibody dynamics. A Multibody system is used to model the dynamic behavior of interconnected rigid or flexible bodies. The key feature of a system that makes it suitable for Multibody treatment is the observation that the motion is localized, that is, it is well described as a set of composite parts, which undergo large motion with respect to one another, but are themselves nearly rigid.

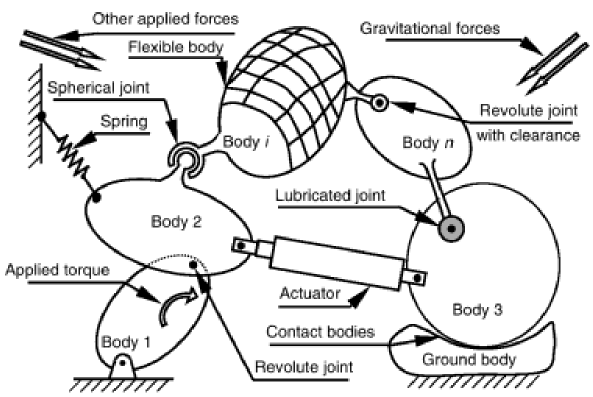


Fig 2. Schematic representation of general Multibody system.

Figure shows schematic representation of general Multibody system made of rigid bodies interconnected by kinematics joints and acted on by applied forces .Some examples of the breadth of applicability of Multibody dynamics, which has been used effectively to model machines, skeletal motion and gait, coarse-grained biopolymers, and many other systems relevant to a wide variety of scientific and engineering disciplines. Multibody dynamics is a generalization of several more-familiar modeling methods. It includes as special cases, for example, systems of point masses represented in Cartesian coordinates (e.g. molecular dynamics models) and systems of freely moving extended bodies (typically, rigid bodies). Multibody dynamics should be viewed as a basic numerical capability fundamental to any simulation system. It is in the same category as, say, a linear algebra library, not an end-user application.

3. Validation Detail

3.1. SUSPENSION ANALYSIS USING ADAMS/CAR

In Adams/Car, a steering subsystem and a front suspension subsystem, plus a suspension test rig, form the basis of a suspension assembly that is analyzed for kinematic behavior.

3.1.1. Setting Up Suspension And Steering Subsystems

The Front Suspension and Steering Subsystems are integrated on the MDI Suspension test rig as shown in figure .

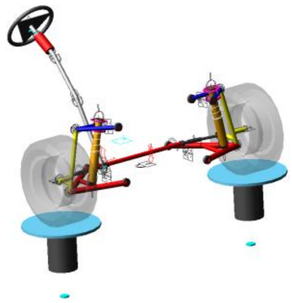


Fig 3. Adams/Car MDI Suspension Test Rig

3.1.2. Performing Suspension Analyses

Before performing a suspension analysis, several parameters about the vehicle are specified. These parameters include the vehicle's wheel base and sprung mass, whether or not the suspension is front- or rear-wheel drive, and the braking ratio. For this analysis, parameters to indicate front-wheel drive and a brake ratio of 70% front and 30% rear are assigned.

3.1.2.1. Parallel wheel travel:

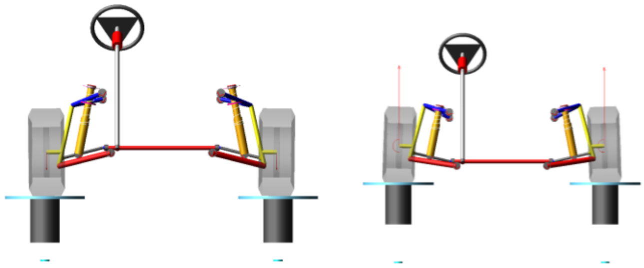


Fig 4: Parallel Wheel Travel Analysis Using MDI Test Rig

After defining the vehicle parameters, the parallel wheel travel analysis is done. During the analysis, the test rig applies forces or displacements, or both, to the assembly, as defined in a loadcase file. For this analysis, ADAMS/Car generates a temporary loadcase file based on the inputs specified. This parallel wheel travel analysis moves the wheel centers from -75 mm to +105 mm relative to their input position, while holding the steering fixed. During the wheel motion, ADAMS/Car calculates many suspension characteristics, such as camber and toe angle, wheel rate, and roll center height.

3.1.2.2.Opposite wheel travel:

On similar lines of above analysis, opposite wheel travel analysis was conducted. In this analysis, when one wheel goes in bump the other wheel simultaneously goes in rebound. This analysis is performed to simulate roll behavior of the vehicle. This opposite wheel travel

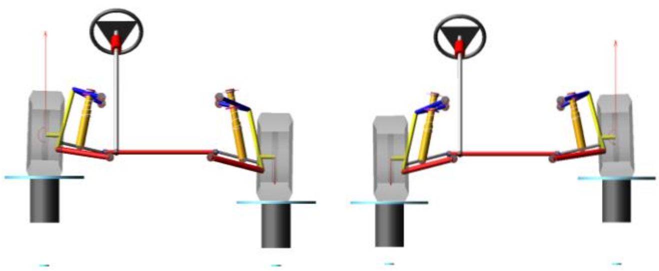


Fig 5: Opposite Wheel Travel Analysis Using MDI Test Rig

analysis moves the wheel centers from -75 mm to +105 mm relative to their input position, while holding the steering fixed.

3.2. SUSPENSION ANALYSIS USING K&C RIG

The standard Suspension Parameter Measuring Machine is designed to measure the quasi-static suspension characteristics that are important to a vehicle's ride and handling. The machine applies forces slowly, so as not to excite dynamic forces emanating from inertias, dampers or elastomeric components. The SPMM also enables some tests to be performed at higher frequencies to allow some dynamic properties to be characterized.

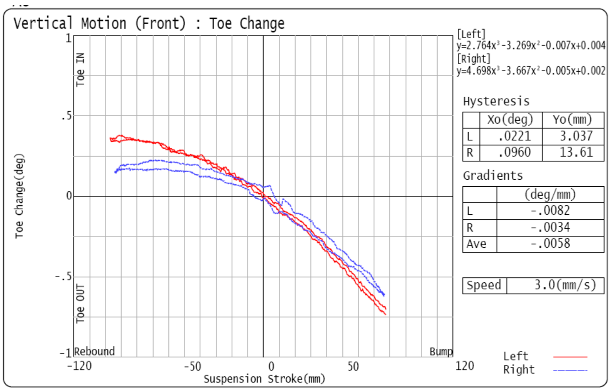
A wide range of parameters may be evaluated, the principal ones being suspension stiffness and hysteresis, bump-steer, roll-steer, roll stiffness distribution, longitudinal and lateral compliance-steer, and steering system characteristics. Knowledge of these parameter values and characteristics is an essential tool to a thorough understanding of a vehicle's performance in terms of ride, impact isolation, steering and handling. The machine can impart a wide variety of displacements, forces and moments to the suspension system and can quantify a wide range of suspension characteristics. Any of the rig's axes can be moved in combination with any other axis, either in phase or in anti-phase. In this way, complex combined loadings can be generated. Axes may be moved under servo control to maintain the relevant forces or moments at the required test values.

Fig 6. Suspension Parameter Measuring Machine (SPMM)

4. Comparing of Results

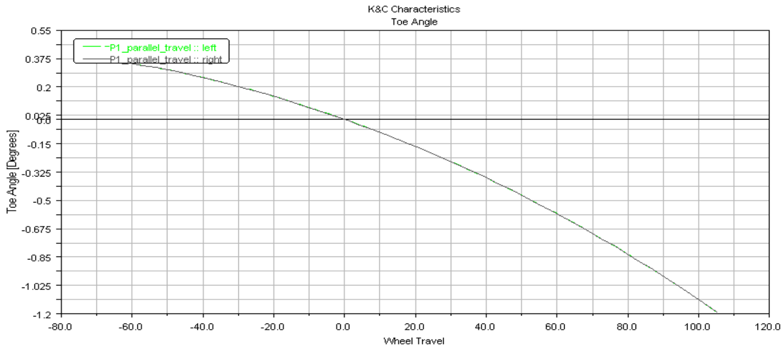
A prototype of actual the Passenger Car under development is mounted on SPMM. The wheels are subjected to vertical displacement and roll displacement. A similar exercise is conducted on the ADAMS virtual (MDI) suspension test rig, wherein only front suspension with steering is mounted on the MDI test rig. Parallel wheel travel and opposite wheel travel analysis are performed and results are plotted in ADAMS/ post-processor. The plots are evaluated based on the three criteria, viz. nature of curve, values obtained and gradients of the curve.

4.1. Vertical Motion
Measured Parameter: Toe angle
SPMM Results:



Graph 1. Toe change Vs Susp. stroke (Vertical motion analysis)

Adams/Car Results:



Graph 2. Toe angle Vs wheel travel (Parallel wheel travel analysis)

Correlation:

Criteria	Observation
Nature of curve	Similar nature
Values	Approximately 90% matched
Gradients	0.005 (SPMM) / 0.007 (ADAMS)

5. Conclusion and Scope of Future Work

5.1. CONCLUSION

By following the comparison made between Adams/Car and SPMM results, conclusion can be drawn that Adams/Car results match very well with the corresponding SPMM results. On an average the co-relation obtained in the values is 75%.

6. Acknowledgement

After beginning my career for post graduate in Mechanical Engineering at D.Y. PATIL COLEGE OF ENGINEERING, AKURDI, PUNE-44 OF Pune University, well known as “oxford of east”. I have great pleasure to present Seminar entitled **“MODELLING AND SIMULATION OF FULL VEHICLE FOR ANALYSING KINEMATICS AND COMPLIANCE CHARACTERISTICS OF INDEPENDENT (MACPHERSON STRUT) AND SEMI INDEPENDENT (TWIST BEAM) SUSPENSION SYSTEM ”**

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