Multibody Dynamic Analysis of The Suspension System Using Adams

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Abstract---In this paper, a review of past and recent developments in the field of Multibody dynamic system is presented. The objective is to review some of the basic approaches used in the computer aided kinematic and dynamic analysis of Vehicular Suspension Systems with the Multibody Dynamics approach and to identify future directions in this research area. Multibody dynamics is the subject concerned with the computer modelling and analysis of constrained deformable bodies that undergo large displacements, including large rotations. Here the aim is to show how Multibody dynamics is associated with the different type of suspension systems and their analysis is based on it. Softwares like ADAMS, DADS and other Multibody codes help in the analysis of the suspension systems. By using ADAMS software package analysis like baseline parallel wheel travel and brake pull analysis can be easily done. Also systems like Macpherson and Double wishbone suspension system modeling and analysis is done and the simulation results are shown in the form of graphs. The alterations are based on the positions of the joints. For better ride and handling performance this analysis is done.

I. INTRODUCTION

A multibody system is a group of interconnected rigid and deformable components, each of which may undergo large translational and rotational motions. Dynamics as a discipline, as a science and as it is understood today has its roots rather coincidentally but aptly in the fundamental understanding of its origins, in the motions of heavenly bodies [1]. In machine dynamics, multibody can be widely used in the analysis, design, and control of many practical systems such as: ground, air, and space transportation, vehicles, automobiles, trains, airplanes, and spacecraft, manufacturing machines, manipulators and robots, mechanisms, articulated earthbound structures such as cranes and draw bridges, and biodynamical systems in human body, animals, and insects.

The very first application of rigid body dynamics was described by Euler in his masterly derivation of kinematic relations for a single gyroscope, followed by the dynamic equations of motion. Lists and reviews of the many contributions on the subject are given in survey papers on FMD (Flexible Multibody Dynamics) [3] and on the general area of Multibody dynamics, including both rigid and flexible multibody systems [3].A number of books on FMD been published. In the last few years, there have been a number of conferences, symposia, and special sessions devoted to MBD. Two archival journals are devoted to the subjects of rigid and flexible multibody dynamics: ''Multibody System Dynamics'' published by Kluwer Academic Publishers, and ''Journal of Multibody Dynamics'' published by Ingenta Journals. There are a number of commercial codes for flexible Multibody Dynamicse.g., ADAMS from Mechanical Dynamics Inc., DADS from CADSI Inc, MECANO from Samtech, and SimPack from INTEC GmbH as well as many research codes developed at universities and research institutions. A survey of multibody dynamics software up to 1990 with benchmarks was presented in Schiehlen[1].

In 1977 Orlandea et al. presented the first practical solution methodology for large rigid Multibody dynamic systems, based upon Lagrangian dynamics for constrained systems. Their work culminated in the development of ADAMS, an acronym for Automatic Dynamic Analysis of Mechanical Systems, the spread and increasing use of which in industry has acted as the main driving force for many developments that have since taken place. Vehicle ride and handling analysis has received the most attention and represents the largest growth area in the application of multibody dynamics as described by Kortuem and Sharp, Kortuem and Schiehlen, Sharp, Schiehlen and Schafer, Kuebler and Schiehlen, Abe and Evans [3]. There has been a gradual trend towards the inclusion of flexible elements in the analysis of Multibody systems. These include, for example, vehicle suspension analysis, active elements in suspension roll and vehicle yaw control and consideration of structure interactions as in aerodynamic effects and fluid sloshing within the vehicle and their effects upon the roll-over characteristics of vehicles.

II. MULTIBODY DYNAMICS AND THE SUSPENSION SYSTEM OVERVIEW

Most vehicle dynamic analyses deal with the ride and handling issues. There has been a gradual trend towards the inclusion of flexible elements in the suspension roll and vehicle yaw control and consideration of fluid structure interactions as in aerodynamic effects and fluid sloshing within the vehicle and their effect upon roll over characteristics of vehicles.

General purpose MBS programs are able to do the virtual prototyping and are also able to address a large set of problems of the vehicle dynamics. This MBS program has lots of analysis codes and the code consists of a number of integrated programs that perform three-dimensional kinematic, static, quasi-static or dynamic analysis of mechanical systems. These programs helps for better ride and handling performance for the next generation vehicles to the automotive industry by simulating the performance of the vehicle and its sub-system.

- Suspension kinematics and their effects on vehicle dynamics and stability:

As one of the main elements of vehicle: a suspension system the analysis of its kinematics, their effects on vehicle dynamics and stability has attracted very small concerns from the little technical literature. Such topics should be conducted so as to provide some general guidance for automotives R&D for more effective vehicle dynamics tuning and refinemen

- Road Vehicle Dynamics

Characterization of potholes and bump rebound dynamically response to road vehicles to provide a general framework for evaluating shock-isolation properties of alternative suspension designs/tunings, as well as controlled suspensions.

A. Research Areas In MBD: The growth of Multibody Dynamics includes the following aspects:

– Theoretical and computational methods
– Flexible Multibody Systems
– Large Deformation Phenomena
– Contact and impact problems
– Control and mechatronics
– Non-holonomic systems
– Multi-Physics problems
– Machines and mechanisms
– Robotics and walking machines
– Biomechanical problems
– Algorithms, integration codes
– Simulations and virtual reality

III. TYPES OF SUSPENSION SYSTEM CAN BE ANALYZED IN ADAMS:

– Macpherson strut system
– Double wishbone suspension system
– Trailing arm axle
– Multilink suspension system
– Twist beam axle etc.

IV. LITERATURE SURVEY :

Hazem Ali Attia [5] 2001 in his paper the dynamic analysis of the double wishbone motor-vehicle suspension system using the point-joint coordinates formulation is presented. The mechanical system is replaced by an equivalent constrained system of particles and then the laws of particle dynamics are used to derive the equations of motion. Due to the presence of large number of geometric and kinematic constraints the velocity transformation approach is used to eliminate some constraints. The equations of motion in terms of the Cartesian coordinates of the particles are transformed to a reduced set in terms of relative joint variables by defining differential algebraic equations in terms of the joint variables are equal to the number of degrees of freedom of the whole system plus the number of cut-joint constraints corresponding to cut of kinematical closed loops. Use of both the Cartesian and relative joint variables produces an efficient set of equations without loss of generality.

M.S. Fallah, M.Mahzoon, and M.Eghtesad [6] described about a spatial model of the Macpherson suspension system to conduct the kinematic and dynamic analysis was formulated in this paper by the researchers. In order to improve the ride quality and optimize the performance of the kinematic parameters subjected to a ride control force at the same time, a comprehensive model of the Macpherson system was presented in this paper. The model considers the kinematic properties, the vertical acceleration of the sprung mass and the motions of the unsprung mass subjected to control arm connection. In addition, it includes physical characteristics of the spindle, such as mass and inertia moment. With that model, it is convenient to observe the improvement of ride quality and the variation of suspension kinematic parameters, such as camber angle, castor angle and track subjected to control actuation force.

V Cherian, N Jalili*, and V Ayglon[7], This paper describes the non-linear modelling of a double wishbone suspension developed to investigate the non-linear kinematics and dynamics in the closed, spatial kinematic chain configuration. Analytical and ADAMS models are generated and kinematic and dynamic characteristics of the models are investigated. The analytical model of the suspension mechanism is an idealized four degree-of-freedom (DOF) model, with suspension members considered as rigid links and bushings taken as linear spring–damper elements. The simulation results of the model subjected to a virtual kinematics and compliance (K&C) test are compared with results generated by an ADAMS model, developed based on parameters obtained from the vehicle manufacturer, subjected to the same virtual test. The experimental K&C testing on the test vehicle presents a method of capturing the kinematic characteristics of the suspension mechanism. The comparison of the simulation and experimental results presented shows that the models are capable of simulating the characteristics of the pre-existing suspension configuration of the test vehicle.

These are the papers describing about the future suspension system that providing the best ride and handling performance on the roads. For that we have to analyze the suspension system in different conditions like driving car on the bump and potholes, while steering, while braking or combination of all these. By doing this analysis we can obtain the alterations in different kinematic parameters which influence the change in the dynamics of the suspension system. For doing this analysis the software named ADAMS is very helpful by providing the templates of all the required suspension systems.

Here, in this paper mainly two most used suspension systems Macpherson and Double wishbone suspension system's analysis is shown by using the ADAMS software and also comparison of them by the results obtained from the ADAMS/Postprocessor.

V. ANALYSIS OF MACPHERSON AND DOUBLE WISHBONE SUSPENSION SYSTEM BY ADAMS

A. Modeling Of The Macpherson Suspension System: Steps for creating the suspension system

1) Co-ordinate system and direction of gravity choosing for the modeling
2) Building the suspension sub-system by using the template available in the ADAMS.

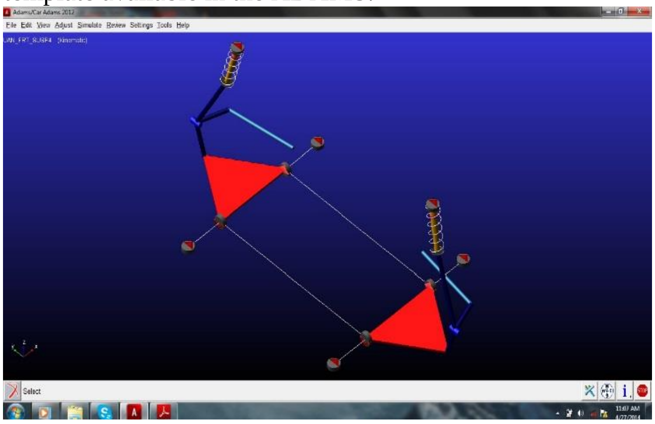

Fig. : 1

3) Adding steering sub-system and assembling for the final analysis

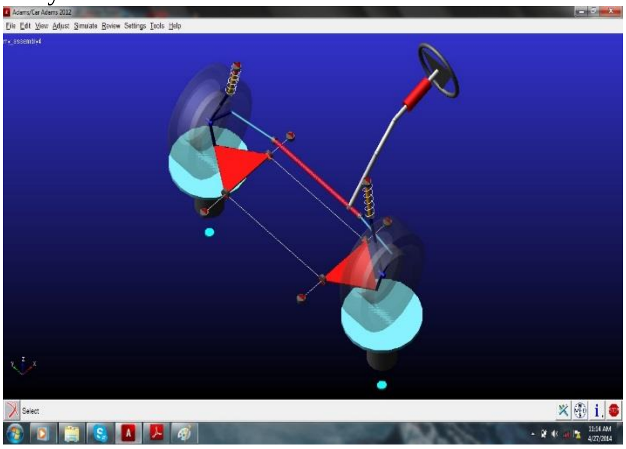

Fig. 2:

4) Analyzing the suspension system for the bump length of 100mm and simulating the system for it.
5) Animating the system for the bump length of 100mm
6) Results for the analysis by ADAMS/Postprocessor.

B. Modeling Of The Double Wishbone Suspension System:

Steps for creating the suspension system

1) Co-ordinate system and direction of gravity choosing for the modeling
2) Building the suspension sub-system by using the template available in the ADAMS

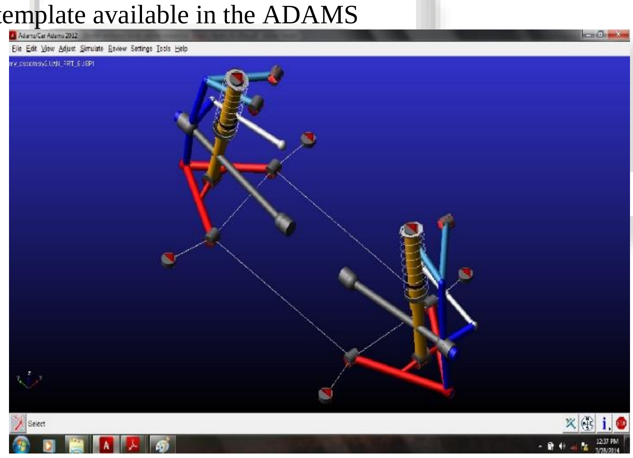

Fig. 3:

3) Adding Steering Sub-System And Assembling For The Final Analysis

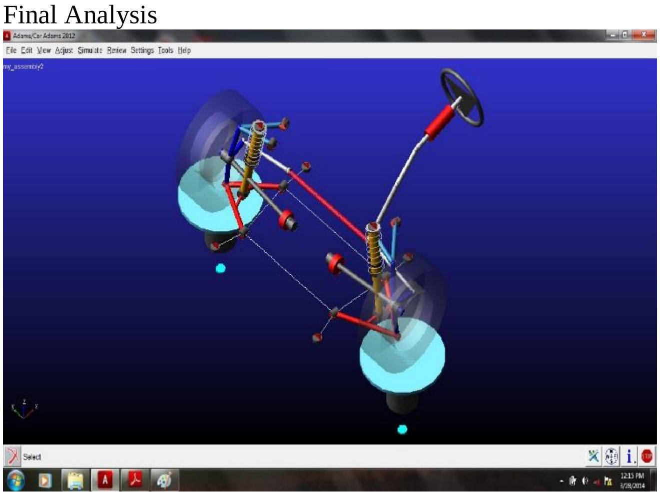

Fig. 4:

4) Analyzing the suspension system for the bump length of 100mm and simulating the system for it.
5) Animating the system for the bump length of 100mm
6) Results for the analysis by ADAMS/Postprocessor.

VI. RESULTS, DISCUSSION AND COMPARISON FOR THE SYSTEMS.

Here, mainly four kinematic parameters camber angle, toe angle, Kingpin angle and caster angle alteration is shown with the scrub radius change. All the parameters vary from the bump and rebound positions.

A. Results For The Double Wishbone Suspension System :

1) Bump Length Vs. Camber Angle

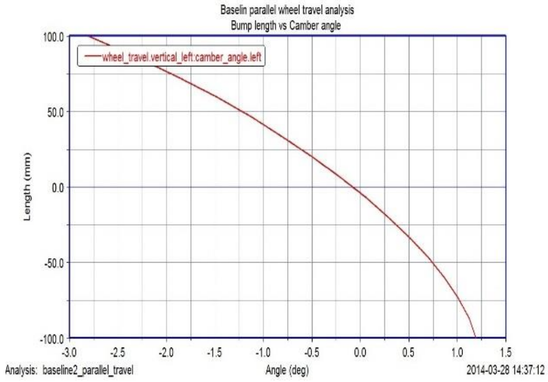

Fig. 5: Bump length vs. Camber angle

2) Bump Length Vs. Caster Angle:

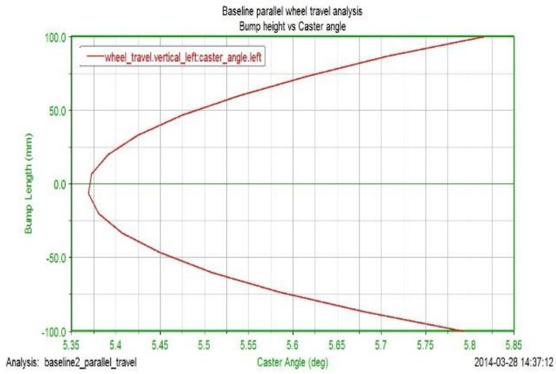

Fig. 6: Bump length vs. Caster angle

3) Bump Length Vs. Toe Angle:

Fig. 7: Bump length vs. Toe angle

4) Bump Length Vs. KPI Angle :

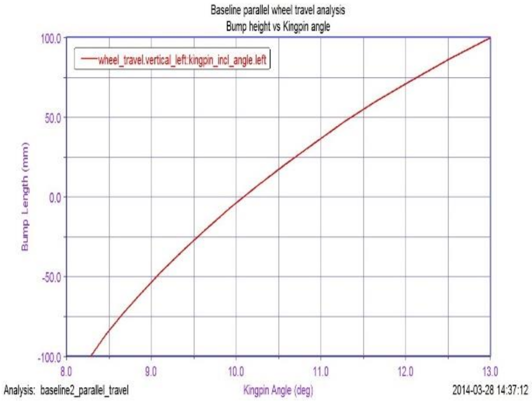

Fig. 8: Bump length vs. KPI angle

B. Results For The Macpherson Strut Suspension System:

1) Bump Length Vs. Camber Angle :

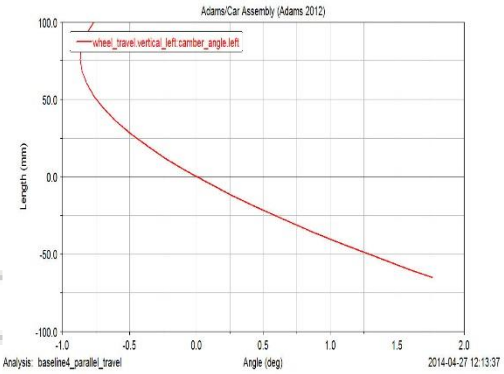

Fig. 9: Bump length vs. Camber angle

2) Bump Length Vs. Caster Angle :

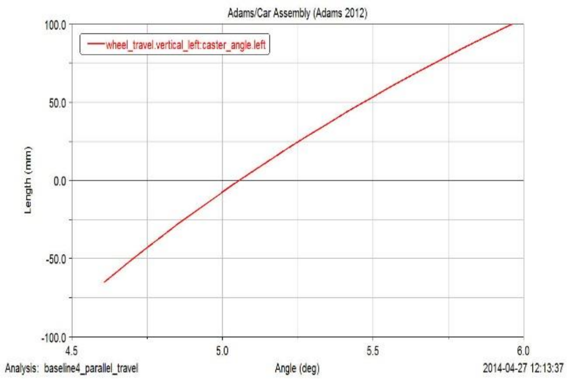

Fig. 10: Bump length vs. Caster angle

3) Bump Length Vs. Toe Angle

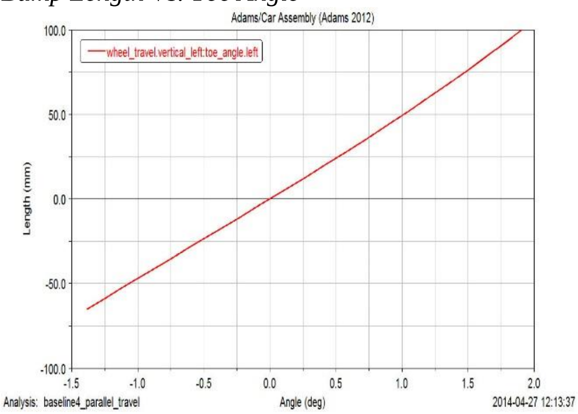

Fig. 11: Bump length vs. Toe angle

4) Bump Length Vs. KPI Angle :

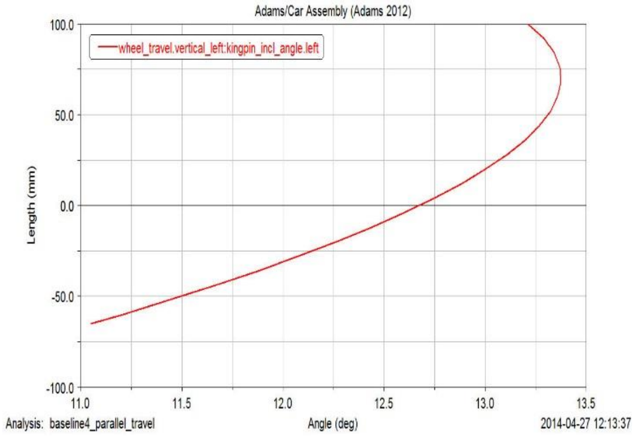

Fig. 12: Bump length vs. KPI angle

C. Plot Examination Results :

Table. 1:

Parameters	**Macpherson system**		**Double wishbone suspension system**	
	Bump length		**Bump length**	
	-80mm	**+80mm**	**-80mm**	**+80mm**
Camber angle (deg)	1.76	-0.76	1.19	-2.23
Caster angle (deg)	4.61	5.96	5.68	5.71
Toe angle (deg)	-1.38	1.9	4.63	-1.61
Kingpin angle (deg)	11.05	13.21	8.46	12.52

VII. Conclusion

The results show variations in all the kinematic parameters of the both suspension systems. All the kinematic parameters affect the dynamic performance of the suspension system. It is noticeable with the front suspension that the plots begin to deviate when approching the full bump and full rebound positions This is due to bump stop and rebound stop generating forces that are then back to the suspension through the bushes. The reaction forces at the bushes leads to distortions that produce the changes in the geometry as shown in plots. This geometry changes are entirely dependent on the positon and orientation of the joints.Camber angle generates camber thrust and positve camber thrust for the lateral force and negative camber thrust for the undesteer. So, for best ride and handling experience accurate positioning of the joints are needed and also from the results we can tell that Double wishbone has less alteration then Macpherson so use of the double wishbone is better than the Macpherson. But at the time it is more complex than the Macpherson so according to the requirements the suspension system should be use for the best ride and handling without any noise.

VIII. References

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