Tire dynamics research Application based on ADAMS/Tire

LIU Xi, LIU Fang-gang

***Abstract*— The mechanical properties of the tire are an important basis to optimize tire design and improve tire performance. However, the driving conditions of tires are complex and changeable which makes it hard to master the tires' mechanical characteristics. Using ADAMS/Tire can simulate a variety of driving conditions of the tire, and then calculate the mechanical parameters of automobile tires through mathematical model in all conditions. Through this process, the technical personnel can reduce the trial round of tests in the design process of tires, which can reduce the cost of tire test, and optimize tire design purpoee.el can make ca-responding adjustments to tire design and thus improve and optimize the vehic1e.**

***Index Terms*— ADAMS; tire dynamics model;simluation test ; mechanical properties**

I. INTRODUCTION

The tire is the important component of automobile, the contact surface that the tire and road interaction forms has provided all forces and moments that the motor sports and operation needed, six force component (as shown in Figure. 1) that produced in tire contact area are make the automobile to have the basic reasons to realize the movement such as starting, braking and turning. Six force components took the tire important external characteristics directly to affect the operation stability, the hide performance of as well as the brake vehicles actuate and other performance.[1]

Analysis of multi-body dynamics, tire six component is an important input of system simulation, get the tire six component numerical precision is guaranteed to vehicle dynamics analysis and reliable premise, the importance of the vehicle tire mechanics like aerodynamic on aviation. For tire six component description of the general in a standard coordinate system, used SAE tire coordinate system as shown in Figure.1. Therefore, research on tire mechanical characteristics is of great practical significance and broad application prospect[2].

The table below, Conventions for Naming Variables, and the figure, ISO Coordinate System, show the sign conventions for tire kinematic and force outputs.

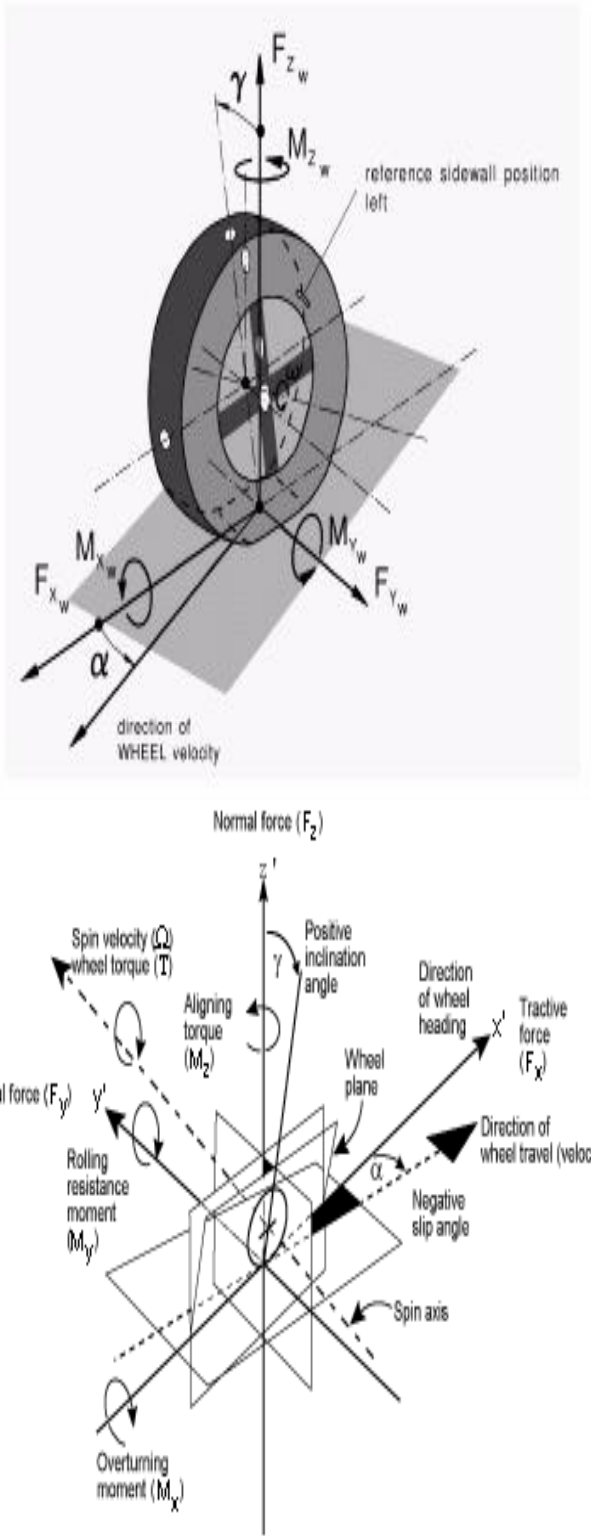

Figure 1. Six force components system and ISO coordinate system

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Table 1. Conventions for Naming Variables

Variable name and abbreviation:		Description:
Slip angle	α	The angle formed between the direction of travel (velocity) of the center of the tire contact patch and the ISO-W: x-axis. If the wheel-travel direction has a component in the ISO-W: +y direction, a is positive. This produces a negative lateral force (F_y). Note that the steer angle, or the vehicle attitude angle, plays no part in defining the slip angle.
Inclination angle	γ	The angle formed between the ISO-W: x-z plane and the wheel plane. If the wheel plane has a component lying in the direction of ISO-W, the inclination angle is positive.
Longitudinal slip	κ (ω_{actual} - ω_{free})/ ω_{free}	The ratio of the longitudinal-slip velocity of the contact patch to the longitudinal velocity of the wheel. The longitudinal slip is positive during acceleration of a moving tire and negative during braking. Longitudinal slip is limited to the range -1 to +1.
Longitudinal force at contact patch	F_x	The x-component of the force exerted by the road or tire.
Lateral force at contact patch	F_y	The y-component of the force exerted by the road or tire. Lateral force may be produced by one or any combination of the following: slip angle, inclination angle, conicity, or plysteer.
Normal force at contact patch	F_z	The z-component of the force exerted by the road or tire. The direction of this force is up.
Overturning moment at contact patch	M_x	The moment of the forces at the contact patch acting on the tire by the road with respect to the ISO-W: x-axis.
Rolling resistance moment	M_y	The moment of the forces at the contact patch acting on the tire by the road with respect to the y-axis.
Aligning moment	M_z	The moment of the forces at the contact patch acting on the tire by the road with respect to the z-axis.
Spin axis	Spin Axis	The axis about which the wheel rotates. Perpendicular to the wheel plane, not necessarily about the ISO-C: y-axis (only if inclination angle is zero).
The central plane of the tire and	Wheel plane	The wheel plane is normal to the wheel spin axis.

II. THE STUDY METHODS ON THE TIRE MECHANICS CHARACTERISTICS

In general, the research methods about tire mechanical characteristics including theoretical and experimental research: theory research, it is a description based on the physical model after simplified established on tire mechanical characteristics of mathematics, namely the theory model, the theoretical model can analyze the mechanical characteristics of the tire under different conditions the theoretical model for the mechanical properties, but the exact expression of the tire at different conditions, tend to use more parameters, which will increase the difficulty of parameter identification and experimental validation, the dynamics of real vehicle is not widely used in experimental study, is through the test measurement of tire under certain conditions of test data, fitting of experimental data, get the experience characteristics of tire mechanics expressions in some form, namely empirical model of $test by test bench for simulating driving conditions, tire different, then forecast the working situation of tire, experience model with only a formula to express mechanical characteristics of tire pure condition, mechanical characteristics description accurate and concise, very suitable for vehicle dynamics research.

III. BRIEF INTRODUCTION OF THE DEVELOPMENT OF VIRTUAL PROTOTYPE TECHNOLOGY AND ADAMS SOFTWARE

Virtual prototype technology, is a new method of the mechanical design field, is the extension of the development of system dynamics[3]. The use of software modeling of mechanical system, the system simulation, we can analyze and evaluate the system performance, so as to provide reference data for the detailed design of the physical prototype design, compared with the technology of virtual prototype technology and tradition, a very prominent feature is that it emphasizes the system point of view, can be as low as a full range of testing and evaluation of local products, based on the virtual prototype technology to the design, can easily modify the design error or defect in the computer, the design scheme of repeated tests of different, choose from the optimal design, so as to achieve continuous improvement and continuous optimization of the whole system, shorten the product development cycle, reduce test cost, the quality of ADAMS software product for the automobile industry, the digital simulation model of the whole vehicle virtual prototype technology, the whole vehicle as a system to analysis and research, will be able to discover the essential rules of the relationship between structure parameters and vehicle performance[4]. Before ADAMS in the physical prototype of certain models, we can realize the prediction on the overall performance of the vehicle, and the specific design process in the vehicle, but also through repeated simulation of design parameters of parts, so as to easily achieve the purpose of improving and optimizing the performance of vehicle and parts.

ADAMS software was developed by USA MSC. company used a mature software of virtual prototype analysis, at present has been for hundreds of the world's major large-scale manufacturers using ADAMS software is the world in the field of CAE the most widely used mechanical

system simulation software simulation, is a fusion modeling, solving, visualization technology analysis software[5].

ADAMS software can be used to simulate movement of mechanical system under actual working conditions through the establishment of functional digital prototype realistic, so as to help designers quickly from a variety of designs, and select an optimal design scheme. In practice, for the engineering designers, mechanical analysis can establish virtual prototype of mechanical system based on ADAMS the software, but also can be used as a development tool for analysis, two times the development of virtual prototype analysis.

IV. AUTOMOBILE TIRE MODEL AND ADAMS SOFTWARE COUPLING PROCESS

In the ADAMS software, research on the interaction between tire and road, is in the ADAMS/Tire module. Using. Using ADAMS software, the module, the user can conveniently calculate the longitudinal force of automobile tires of various stress due to road, combined with the ADAMS/Car module, vehicle equipped with a different tyre, can be in a variety of different road conditions, a group of road test, the calculation is convenient auto rotation, pitching and roll characteristics. Force and acceleration data output of the ADAMS/Tire can be used as the input load, finite element software package, on strength and fatigue properties should be the corresponding.

In the ADAMS/Tire module, integrated tire some classical models, including the magic model for simulation analysis of vehicle handling and stability, and the FTire model for simulation of vehicle durability[6].

In addition, the ADAMS software, also supports user-defined tire model. The simulation result data output and accuracy requirements of different model, tire model data, is not completely consistent, but the modeling accuracy of tire model, has a direct impact on vehicle modeling accuracy. Therefore, for the automobile tire model selection, must be consistent with the specific requirements of simulation.

You can use Adams/Tire to model tires for either vehicle-handling, ride and comfort, and vehicle-durability analyses:

• Handling analyses are useful for studying vehicle dynamic responses to steering, braking, and throttle inputs. For example, you can analyze the lateral accelerations produced for a given steering input at a given vehicle speed.

• Ride and comfort analyses are useful for assessing the vehicle's vibrations due to uneven roads with short wavelength obstacles (shorter than tire circumference), such as level crossings, grooves, or brick roads.

• 3D contact analyses are useful for generating road load histories and stress and fatigue studies that require component force and acceleration calculation. These studies can help you calculate the effects of road profiles, such as pothole, curb, or Belgian block.

Each tire model is valid in a specific area. Using a tire model outside this area can result in non-realistic analysis results.

The Handling Tire models can describe the first-order response of a tire, but do not take the eigenfrequencies of the tire itself into account. Therefore, the Handling Tire models are valid up to approximately 8 Hz. The PAC2002 can also use a more advanced transient method that extends the validity range up to 15 Hz. Beyond that frequency range, a tire model should be used that includes the dynamic effects of the tire belt. PAC2002 can offer also a basic approach of belt dynamics (rigid ring part) to increase validity up to 70 - 80 Hz; FTire is using a more complex approach with a more detailed
contact patch and a flexible ring approach, which allows simulations to higher frequencies and a wider range of applications.

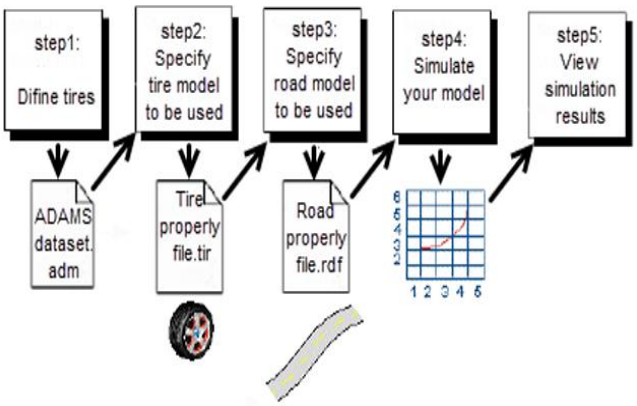

Figure 2. ADAMS/Tire Steps

In order to connect the tire model and ADAMS software, we must choose the right tire mechanics model, understand the interface specification of ADAMS software for automobile tire model is embedded in the reserved, familiar with. The ADAMS software process calls to the tire model, then write connection required program again.

The basic process includes: connected in a simulation time, acquisition of automobile tire model from the tire model interface currently used in the parameters, and these parameters are transmitted to the automobile tire model. Analytical calculation, then the output of the model of tire force and moment and other mechanical elements, back to the ADAMS software through the tire interface, to to compute the motion parameters of a simulation time, finally, through the analysis of the results of the simulation analysis, to assess how well the tire model and the actual situation.

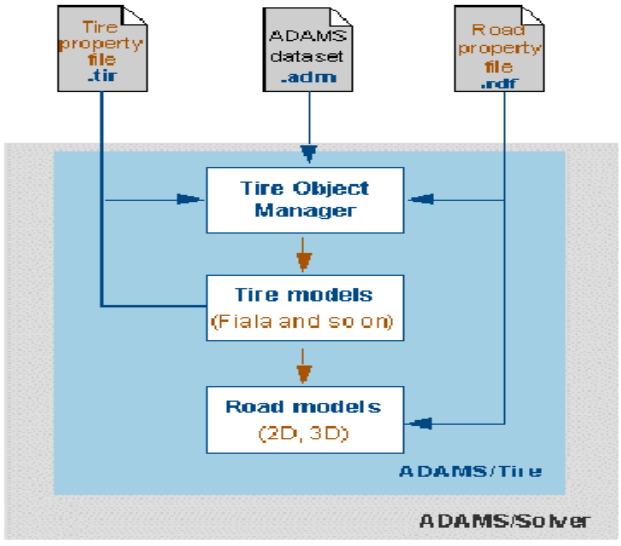

Figure 3. Flow of Information in Adams/Tire

V. FULL VEHICLE SIMULATION

Full vehicle simulation refers to the dynamic analysis of a series of simulations using the complete car model in the ADAMS software. But in the ADAMS software for vehicle, vehicle model is running in the virtual ground, control of vehicle model, also use the drive to achieve. In ADAMS software, in addition to the automobile model a series of standard test, also can easily realize the reality difficult or test is very dangerous.

For vehicle simulation using ADAMS software, the vehicle model including automobile operation stability and cornering ride comfort and a series of vehicle dynamics simulation, and get the operating characteristic curves under various conditions

According to the simulation results, the user can modify the components of the vehicle subsystem easily, also can through the type changing subsystem, to observe its effect on the performance of automobile.

In ADAMS software, vehicle simulation is divided into standard and custom simulation of two kinds of simulation. If users are standard simulation, only need to input various parameters can be in the corresponding software interface. If the tire parameters and road information, because its test methods are already provided good. If the user to customize the simulation, it is necessary to drive the control files and parameters, the test conditions and methods are defined.

VI. CONCLUSIONS

The development process of automobile tires, simulation experiment by using ADAMS software, can reduce the test design process in the round, in the course of the study, if the steam tire model has the forecast ability, must from less test data, to obtain accurate for automobile tyre mechanical characteristics description, so as to reduce the cost of tire test, and optimize the design of tire.

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