THE USE OF ADAMS/FLEX ALLOWS SINGLE MODEL TO BE USED FOR SIMULATING HANDLING, STEERING, PRIMARY AND SECONDARY RIDE DYNAMICS

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ABSTRACT

ADAMS/Flex has allowed some very significant steps forward in the use of multi-body dynamics for automotive virtual prototyping. Simulating handling and secondary ride dynamics has previously required two distinct combinations of model and software and therefore two distinct data sets and assumptions.

This paper shows how Ricardo uses a correlated model of a passenger vehicle with a flexible representation of the vehicle structure to show how ADAMS can simulate the effects of a single component change in the areas of handling, steering, primary and secondary ride dynamics.

Introduction

The recent developments in the ADAMS software, such as ADAMS/Flex, has allowed models to be developed which represent vehicle behavior over a greater frequency band. This paper describes a model of a four wheel drive utility vehicle which includes a modal representation of the body structure and the chassis frame. This has lead to a full vehicle model that represents rigid body motions such as primary ride and extends into the secondary ride frequency range by representing the vehicle structure and it's interaction with vehicle chassis systems.

The automotive industry is seeing an increased number of vehicle products being based on a single platform, some of these are termed 'niche' products. For example, an alternative engine fitted into a current platform. In this case a full programme of analysis support is not required at concept if ADAMS is capable of highlighting problems with changes in engine position, mass and mounting and some structural change.

This project was completed over a period of 6 months, starting with ADAMS 8.2 and pushing the software releases to ADAMS 9.0.4 before completion. The project investigated ADAMS as a tool to predict changes in vehicle dynamics performance of a niche vehicle product before mule vehicles are built.

Typically a forced response software such as SDRC SYSTAN is used in parallel with ADAMS to investigate secondary ride effects. The two simulation methods are based on different theories and therefore require different assumptions to be made as shown in table 1.

However, for this specific problem, looking at the effect of the body stiffness on a secondary ride shake issue, ADAMS has been shown to successfully provide the required analysis support.

Problem definition

This vehicle is four wheel drive with a longitudinally mounted gasoline engine.

The body structure is mounted on a chassis frame by elastomeric mounts. The front suspension is independent, the rear suspension is a driven axle located by two leaf springs.

This vehicle exhibits a body structure mode at 16Hz (Figure 1) where the front end is seen to vibrate laterally. The FEA model of the body and chassis frame was based on an existing crash model and used Nastran eigenvalue solution.

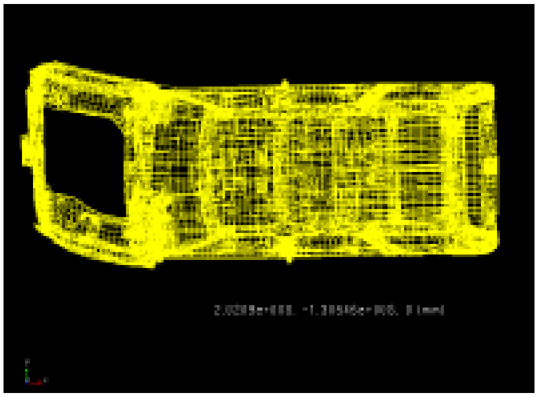

Figure 1 body structure mode at 16Hz

There is a second body mode (figure 2) which is vertical bending. The combination of vertical and lateral motions lead to a tyre model choice of the UATIRE. This was chosen for it's combination of lateral force and vertical ride force generation.

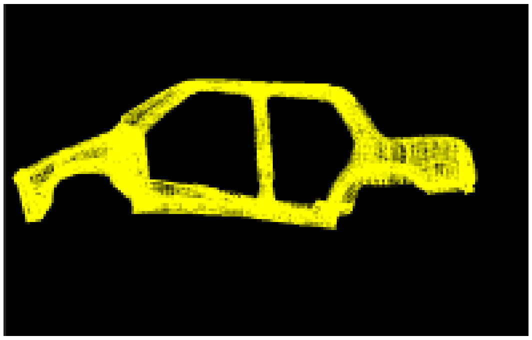

Figure 2 body vertical bending mode

The power unit and driveline modes of the vehicle interact with the suspension modes and first body mode. The vehicle exhibited lateral shake on rough roads. In particular it had significant aftershake from single events such as potholes.

ADAMS model

The vibration of the vehicle structure is readily represented as linear, indeed the theory of modal superposition assumes this. The importance of this simulation to be completed in a non-linear environment is to represent the inputs from the road to the structure as completely as possible. The model reflects this in many ways as shown in table 2. The model is shown in figure 3.

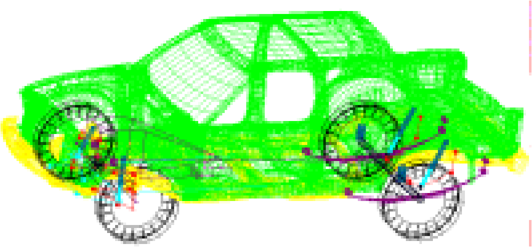

Figure 3 ADAMS model including FLEX body structure, closures and chassis frame

Simulation inputs

To show the model's capability the following analyses have been completed.

i) For primary ride, long wave pitch road definition

ii) For handling and steering, step steer input of 90 deg at 55 mph

iii) For secondary ride a rough road definition is used at 55mph

Model Results

This model was used to investigate the interaction of the systems, and used modal deactivation and a modified FLEX body to study the structure contribution.

The model was correlated for the rough road surface, where the surface profile was measured for this simulation. The correlation showed good agreement to a frequency above the first body mode. For the higher body modes the correlation was not acceptable.

The results presented in this paper will show how the model is sensitive to a single component change that has an effect across handling and ride areas. The modified model has reduced damping forces at each suspension corner.

Handling

The reduction in damping has increased the yaw response with a step steer, in particular it has reduced the response time by 5%. This is due to the increased roll rate and angle making the suspension oversteer more effective. The change has significantly effected the roll dynamics, causing residual roll velocity and roll acceleration long after the steering input as seen in figure 4.

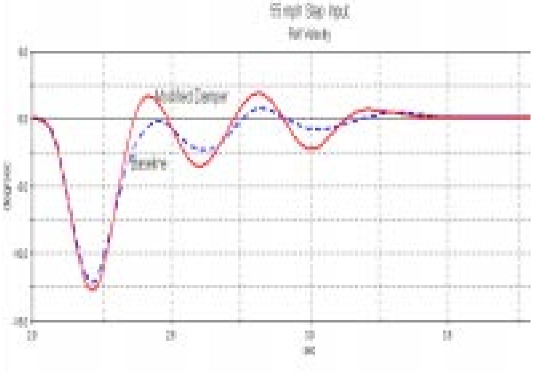

Figure 4 Roll velocity for step steer input

Primary Ride

For the longwave pitch simulation the reduced damper forces have lead to an increased vehicle pitch angle and engine vertical acceleration (figure 5), the increases of 17% are significant.

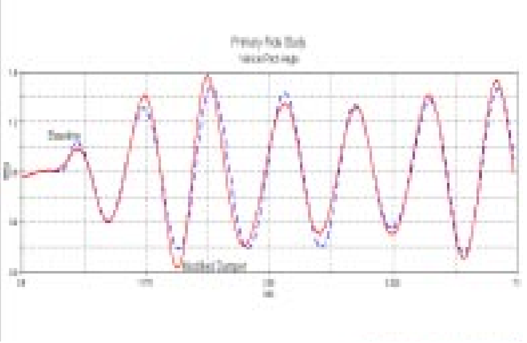

Figure 5 Vehicle pitch angle for long wave pitch road profile

Steering

The steering differences are found in the step steer simulation where the reduction in self aligning torque at high slip angles is more marked. This again is due to the oversteer nature of the suspension geometry

Secondary Ride

The accelerations calculated at the drivers seat rail are significantly improved with the reduced damping forces (figure 6). The hub accelerations of the front suspension are higher for the reduced damper force. This shows an improved ability of the vehicle to isolate the driver from the road surface.

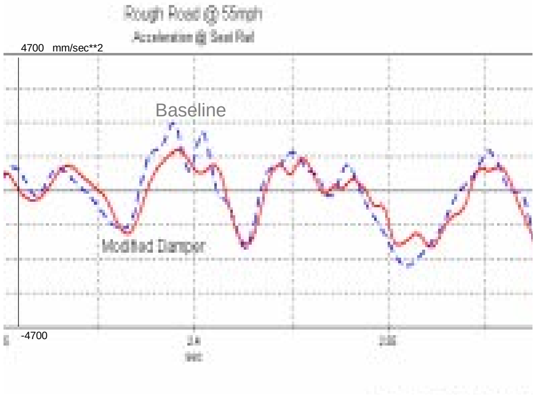

Figure 6 drivers seat rail vibration over a section of rough road at 55mph

Solution Time

The model in it’s final detail ran over the rough road taking approximately 70 hours of CPU time on a SGI Octane. The move to an NT platform has reduced the solution time down to 27 hours.

CONCLUSIONS

This modeling technique has extended the ability of ADAMS to simulate vehicle dynamics where the interaction of the vehicle body structural dynamics has a significant effect. The simulation shows sufficient accuracy to a level above the first body mode showing that this technique is suitable for specific secondary ride phenomenon.

Forced Response Model	ADAMS Model
Frequency domain calculations	Time based calculations
Linear structural elements	Linear structural elements
Point input at tyre	Nonlinear tyre road interface
Linear engine mounts / bushes	Snubbers / nonlinear effects on mounts
Linear damping	Complex nonlinear damper model
Linear geometry effects	Non-linear geometry effects
Linearised friction effects	Non-linear effect of friction

Table 1 Assumptions made in different analysis methods

Feature	Detail	Comments
Tire model	UATIRE	Combines ride and lateral forces
Front suspension	Double wish bone	Ball joint friction forces
Front damper	Non-linear viscous	Includes friction
Front spring	Torsion bar	Beam to FLEX chassis
Rear suspension	Live axle	Located to FLEX frame
Rear damper	Non-linear viscous	Includes friction
Rear spring	Leaf spring	10 beams / spring incl. Friction
Powerunit mounting	Non linear mounts	Includes snubbers
Exhaust system	Flexibility and mass	Beams and dummy parts
Driveline	4WD	Damped plunge at front diff
Road	Rough road	Up to 45Hz content
Body	FLEX part	Separate FLEX closures
Chassis frame	FLEX part	Non structural masses attached

Table 2: ADAMS Model Details