13th European ADAMS Users' Conference

Identification of Model Parameters with ADAMS/Design of Experiments (DOE) and ADAMS/Optimization

Dr. Bernd Weber
AUDI AG
I/EK-73, CAT/Technische Informationen Prozesskette Fahrwerk
D-85045 Ingolstadt

Tel: **0841 89-3378**
e-mail: **bernd.weber@audi.de**

Table of contents:

Paris, November 18-19th 1998

1. Introduction

A common problem encountered in simulations of vehicle dynamics is that specific system components cannot be modelled using their physical parameters because these parameters cannot be determined from the description of the system components.
Moreover, the aim of the automobile manufacturer is to obtain system components with a specified dynamic behaviour from its suppliers, but not to be concerned with how this behaviour is realised in practice.
For example, dynamic stiffness, phase angle, damper work, force-displacement curves and force-velocity curves are often specified for a given subsytstem.
Examples of system components are rubber mountings, hydraulic mounts, air suspension or shock absorbers.
In order to best support designers in the optimisation of these systems, methods are required that describe these system components in terms of these specifications as input and output parameters.

2. Mechanical Models and Parameter Identification

The above-mentioned system parameters, defined on a frequency domain, cannot be used as direct input data in multi-body dynamics. These systems can usually be modelled sufficiently with simple mechanical models, such as a combination of Kelvin and Gehmann models.
The parameters for these models can be uniquely determined by means of an identification process.
It is possible to distinguish between methods in the time domain and methods in the frequency domain without going into the details of identification processes. Here, identification processes that use measurement data from the time domain will not be considered, since these require measurements of exisiting components.
Identification processes that determine the system parameters as in test-bench experiments are most readily interpreted by designers and are therefore most easily accepted.

3. DOE and Optimisation

During the identification process, a sensitivity analysis (DOE) can be used to determine good initial conditions for optimisation, and to identify linear dependencies in the optimisation.
Additionally, the sensitivity analysis encourages the basic understanding of the system, thereby facilitating the subsequent design of the system component.
It is recommended that, for the optimisation process, the optimisation parameters are normalised, so that quantities of various orders of magnitude (displacements, forces) can be manipulated and so that the use of the optimiser can be standardised.
The number of simulations that are possible from within the ADAMS environment is currently rather limited, due to the fact that the memory allocated during a simulation is not or is only partially freed at the end of the run. Because of this, the constant use of the Output-Debugging function is recommended; this allows for recovery of the most recently calculated data after a program crash due to excessive memory requirements.

4. Example Hydraulic Mounts

Hydraulic mounts are used for the mounting of the powertrain (engine, transmission, differential) and in the suspension. They are used as mounts with distinctive mass effects in a narrow frequency range and as mounts with wide shock-absorbing effects without a distinctive mass effect.
The mass effects and the shock-absorbing properties are achieved by means of a channel between two oil chambers. For small amplitudes, an uncoupling of the oil channel is desired.
In order to describe the system in terms of physical parameters, both geometrical data (oil channel surface-area and length, oil channel geometry,...) as well as material properties such as oil viscosity are required; these are in general not available and are also not of interest to the automotive engineer.
The description of the system by the designer and the supplier takes the form of the dynamic stiffness and the phase angle as a function of the frequency at various amplitudes.
In this case, the simplest mechanical model is one with a rubber support-spring, rubber shock-absorber, membrane spring, decouple play, effective mass and a linear as well as a quadratic damping term (Figure 1). (In addition to these 7 parameter models, additional models with

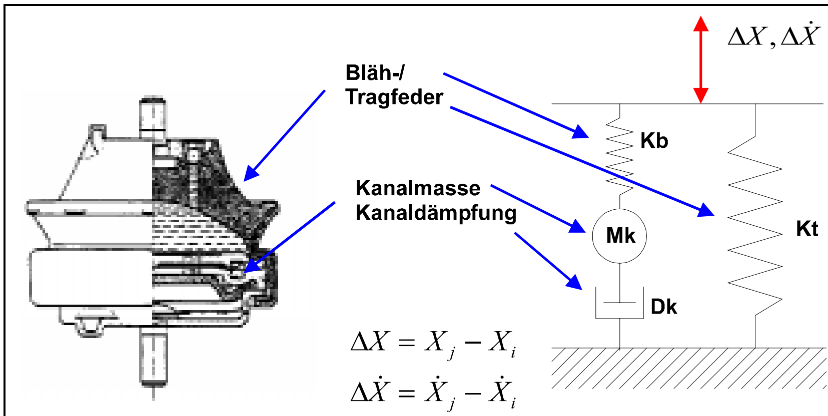

Figure 1: Hydro mount und Hydro mount model

more parameters for the description of the non-linearities in the stiffness curves are used).
In order to determine the model parameters, both a frequency sweep with a subsequent evaluation of the system response through a FFT analysis, as well as a simulated test-bench experiment can be used.
In the test-bench experiment, frequencies and amplitudes in a specified frequency-amplitude matrix are tested, and the values for the dynamic stiffness and phase angle are determined from the force-displacement curves. For sufficient accuracy, between 20 and 60 function evaluations or simulations have been necessary in the past.

5. Use of Optimisation for Model Validation

In addition to the optimisation of specific subsytem model parameters, preliminary trials have shown that optimisation can be used for the validation of simulation models.
Validation can often comprise more than half of the total time required for the entire simulation task. The definition of target functions in a mathematical form is often unfamiliar and cumbersome. Moreover, limits are imposed by CPU time and the number of model parameters that must be identified.
Nevertheless, current methods and computing capacity are sufficient to allow for the fitting of model parameters to expermimental results for systems that do not contain more than ca. 10 model parameters.

6. Summary

It has been shown that, with the use of DOE and optimisation, important identification tasks in multi-body simulation can be solved effectively without the use of other applications such as MATLAB.
For a large number of system components, the description of the dynamic behaviour in the frequency domain for determining the model parameters for multi-body dynamics in the time domain is sufficient.
After optimisation in the time domain, the ideal system component can then be described in the frequency domain, which is more familiar to the automotive engineer and the supplier.
Currently the fitting of simulation models to experimental data is very costly and time-consuming; in the future, optimisation will certainly play a key role, and the time requirements for simulation tasks will decrease.