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Combined Simulation, using a Hydrostatic Drive Train as an Example

Simulation is becoming more and more important in product development. New perspectives for computer simulation have become available through increased computer hardware capacity. Two possibilities had to be implemented in order to widen the scope of simulation programmes. The following article discusses the characteristics of these possibilities and their advantages for the user. Special focus is placed on coupling simulation programmes. The possibility of joint simulation, using the coupling of ADAMS and MatLab/Simulink as an example, is explained in detail. A hydrostatic drive train field sprayer is used to exemplify this.

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Literatur

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Simulation is an ideal aid to support development, due to the fact that accurate interaction can be created in an almost real situation. In this way development costs can be cut and development time saved. Due to the use of simulation programmes the number of prototypes required can be reduced, as can the testing thereof.

As the development of computer hardware advances so does the availability of improved and more sophisticated simulation programmes.

Market requirements have changed to keep pace with these developments. In the meantime simulation programmes are needed, which are not only specialised to show and simulate one module - i.e. the hydraulic component - but also for programmes, which include and calculate the interaction between modules and, for instance, electronic controls.

Possibilities for simulation software

Two possibilities have been achieved by the software developers to serve market requirements. One of these is to extend the tools for the simulation programmes in order to widen the scope. A specific advantage of this possibility is that only one programme is necessary, thus lowering the requirements of the computer hardware and avoiding communication problems with other programmes. However, one disadvantage is that the programme package can often only be utilised for the one specific purpose. As opposed to specialised programmes, this often means that the capacity of the additional tool boxes might be restricted or perhaps even less accurate.

The second possibility to extend the capacity is to couple different specialised simulation programmes with another. This can give varying results, which one divides into three different categories.

Co-simulation

The models are constructed and calculated in their respective simulation ambience. Specified input and output values are transmitted between the programmes, whereby one of the programmes functions as master and the other solvers as slaves. This method requires more calculation and more time, but is more accurate, as each part is solved by its own solver.

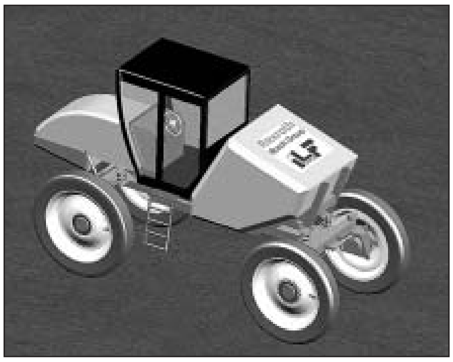

Fig. 1: Self propelled sprayer

Model integration

One simulation programme functions here as master into which all models to be coupled have been integrated. These are exported. The master calculates the complete model with its own solver, however, problems can occur due to the fact that the solver has not been optimised for individual part models.

Solver integration

The function of this coupling is similar to the model integration. However, in this case the solver is also exported. Due to the general legibility of the export formats not only the algorithms of the specific solver, but also company know-how is divulged. It can easily be seen that in general coupling method 1 and 2 are utilised

Many simulation programmes offer both possibilities discussed to expand the capability, additional toolboxes as well as coupling interfaces. It seems that of all the possibilities on offer for the development of a product, simulation packages are most interesting, due to the fact that far more detailed models can be constructed. The computer hardware can compensate the disadvantage of co-simulation (more calculation) so that co-simulation can be regarded as increasingly more viable.

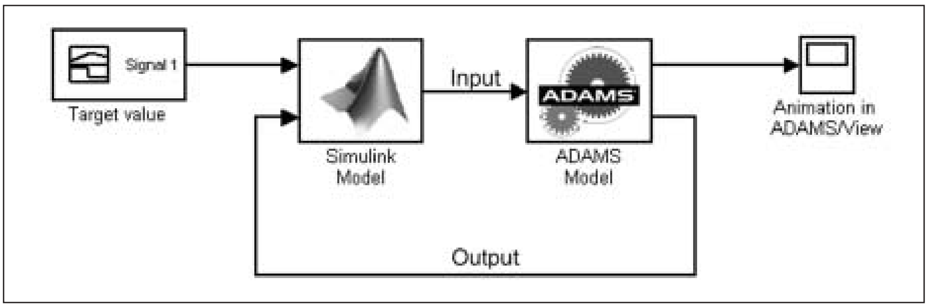

Fig. 2: Information flow between ADAMS and MatLab

Hydrostatic drive train

At the Institute for Agricultural Machinery and Fluid Technology (ILF), in cooperation with Bosch-Rexroth a co-simulation on a vehicle (ILF) with a hydrostatic drive (Bosch-Rexroth) was created. The model represents a drive train field sprayer, with a four-wheel drive, which is implemented by hydrostatic single wheel drives (*Fig. 1*).

The demands placed on the representation of the drive physics were particularly high. On the one hand the model should be as realistic as possible and only be manoeuvrable by the wheel torque (drive and braking torque) and steering angle. Free manoeuvrability of the vehicle should also be represented in the model and the drive torque is to be calculated by means of a simulation of the hydrostatic drive.

On the other hand, realistic representation of the vehicle reaction in all three translateral and rotational directions formed part of the simulation

Construction of the simulation

A co-simulation was chosen based on these requirements. The vehicle model was constructed in the multi body simulation programme ADAMS, the simulation of the hydrostatic drives with MatLab.

The construction of the model in ADAMS had several advantages. Due to the fact that the vehicle reactions were to be reproduced as accurately as possible, it was necessary to construct the model with almost identical physical characteristics, i.e. inertial torque. ADAMS, with its realistic construction, offers the possibility to calculate the physical characteristics with greater accuracy, so that these can be utilised to calculate the inertia, mass, etc. for the whole vehicle.

In addition ADAMS supplies a good and comfortable visualisation of the results, so that the model can also be used for presentations.

The utilisation of MatLab is advantageous for co-simulations, as MatLab - with Simulink - not only functions as simulation software for standard algorithms, but also as communication base. Bearing the subsequent simulation of the hydrostatic drive AMESim in mind, while AMESim offered an interface to MatLab, a direct interface to ADAMS is still in the development stage.

Therefore, MatLab has a dual purpose: firstly, the reproduction of control technological elements and secondly, for communication between ADAMS and AMESim. Before the planned hydraulic simulation can be implemented with AMESim, the hydraulic can be shown with MatLab.

Coupling of ADAMS and MatLab

The coupling with the valid version of ADAMS is very convenient. Using a suitable ADAMS tool box one obtains a prefabricated interface with which the necessary model data can be exported in the required format.

In MatLab there is a prefabricated interface which imports the exported data and creates a subsystem for Simulink (*Fig. 2*).

In the co-simulation by ADAMS and MatLab, MatLab is the master and ADAMS is the slave. This means that although both solvers are used, the ADAMS solver is controlled by the MatLab solver. The simulation parameter i.e. the step size is configured by MatLab.

Independent from all this, the in- and output variables are determined in ADAMS before the ADAMS model is exported, as these are the variables, in which the data is written, that is exchanged between ADAMS and MatLab. Due to the fact that each ADAMS calculation variable can be defined as an in- or output variable, the degree of freedom is considerable. In particular in control technology much research and testing can be carried out with Simulink. *Figure 3* shows an example of a simple cruise control function at a drive speed of 10 m/s. The drive speed and torque of a front hydro motor are shown for this duration. The diagrams clearly show the interaction between ADAMS and MatLab: The motor torque is sent as input from MatLab to ADAMS, where the drive speed is calculated as a reaction to the motor torque, and then sent to MatLab. This measurement is then used as standard measurement to calculate the required motor torque.

Experience with coupled simulation

Due to the fact that the co-simulation is the coupling form between ADAMS and MatLab, of course this results in the intended characteristics being those of the co-simulation: when results are to be considered within a short time frame, the requirements on the computer hardware are considerable for a complex model like the vehicle with hydrostatic drive, used here. This simulation necessitated a current processor with a sufficient working memory to enable a considerably fast calculation.

It should be mentioned here that the distribution of the calculation time among the respective solvers depends on the complexity of the model. For this model the solver from ADAMS required most of the calculation time, due to the fact that the drive dynamic correlation necessitated a considerable calculation requirement of the ADAMS solver.

It can be assumed that less complex models require less calculation time or less calculation capacity.

Apart from these model relevant demands on the computer hardware the coupling functions very well. Specific problems did not occur. The quality of the simulation is not affected by the interface, but is based on the models used.

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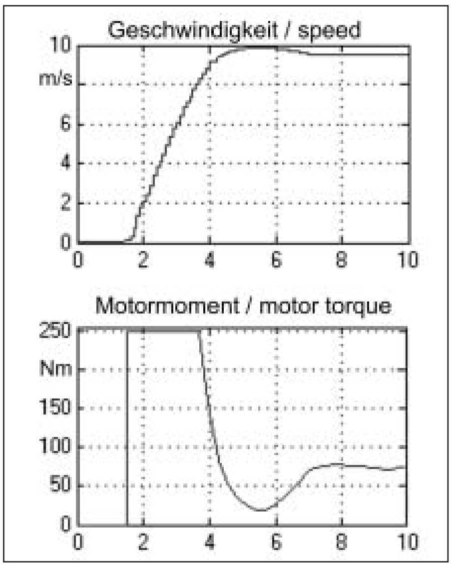

Fig. 3: Input and ouput-variables