

ABS Braking with SIMAT Co-Simulation Interface

The Department of Automotive Engineering at the Czech Technical University in Prague are SIMPACK 8.5 users. In the field of multi-body systems dynamics, a number of dissertations have been written looking into various projects involving combustion engines, motor vehicles and rail vehicles. One of these projects was the ABS braking simulation of the Skoda Octavia vehicle. The mathematical model of the car was realised using the SIMAT Co-Simulation Interface, which is the interface between SIMPACK and MATLAB Simulink. The mathematical model of the Skoda Octavia was created in SIMPACK and the ABS control loop was created in MATLAB/Simulink.

MODEL OF VEHICLE

The model used was a multi-body system built-up with rigid bodies and kinematic joints. The car body and the straight track were connected with a 6 degree of freedom joint. The track contacts were modelled with tyre force elements, which supplied the tyre and track interaction. A database of slip characteristics for wet and dry surface was defined and the vehicle moved along a straight, flat road. The ABS braking initial velocity was set to 100 km/h.

Measured data of the Skoda Octavia was used to design the mathematical model. Some parameters were measured on the real vehicle. Other important mass and geometrical parameters were based on CAD models created in Pro/ENGINEER. The control process was optimised both for dry and wet surface using 185/60 R14 tyres and followed basic principles of ABS systems. The actuator in the mathematical model was powered by the braking torque obtained from the Simulink control loop. The braking torque was applied directly

to the wheel rim assuming that a constant friction coefficient was applied to the brake pads.

SENSORS

The communication between SIMPACK and MATLAB was realised using the SIMAT Co-Simulation Interface. The interface offered the data exchange through SIMPACK input and output vectors with the sensors situated on the vehicle model in SIMPACK. Measured data from the sensors was exported as a continual signal to Simulink.

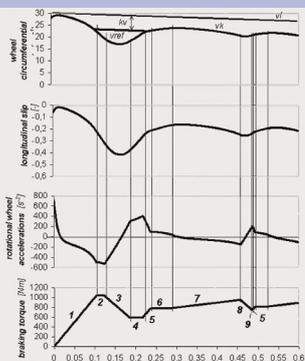
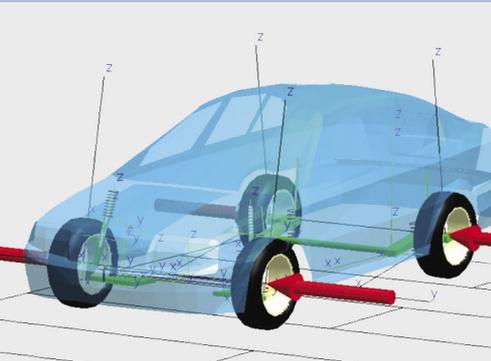
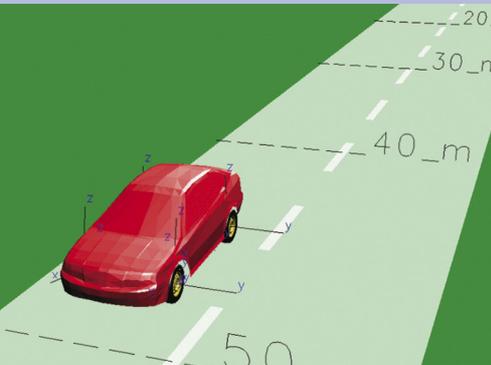
The most important input signals used in the control loop were values of wheel circumferential speeds and rotational wheel accelerations. The effect of the following variables was looked at: Longitudinal slip, consequential wheel braking torque, travelled distance, velocity of the vehicle, ABS braking time, longitudinal (braking) force and vertical force.

ABS CONTROL

The control loop was created in MATLAB Simulink with the instantaneous sensor values imported into Simulink through the SIMPACK Output vector.

Vehicle ABS systems are used to improve the stability of the vehicle. This is done by ensuring the wheel does not lock and, at the same time, keeping the longitudinal slip in the range of maximum adhesive force. This range is between the boundaries of the stable and unstable area for the longitudinal slip.

The rotational wheel acceleration was varied within the control loop and the cycle was split into 9 periods. The 1 – 4 periods acted only in the build-up time and in the ABS control initiation. Periods 5 – 9 created a closed loop during full braking. The control loop was in use until the vehicle velocity reached 7km/h, where for lower velocities,



First regulation cycle

the ABS was turned off and the braking torque increased till the vehicle stopped.

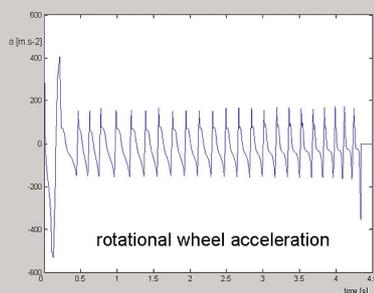
The acceleration thresholds for the ABS control loop were set up in relation to the measured car experiment, where pressure in the ABS regulated brake caliper was measured. The intention was to set-up thresholds within the optimal range so that the compared pressure curves of both real car and mathematical model have the same progression. The validation of the mathematical model enabled the real vehicle behaviour to be approximated during simulation. Finally the control thresholds were optimised to maximise braking efficiency. It was important to preserve other required values in their optimal ranges during the optimisation process. The efficiency of the optimisation process has been monitored by looking at the total braking distance required.

For this example, the SIMAT Co-Simulation Interface offered better performance than the standard SIMPACK control loop. The control algorithm was generated externally

from SIMPACK allowing easier modification of the parameters.

In Simulink it was possible to plot graphical outputs of the measured values during the time integration. It was also possible to modify the control algorithm without any changes to the SIMPACK vehicle model.

Wet surface



Dry surface

