

The Effect of Degraded Shock Absorbers on the Safety-Critical Stationary and Non-Stationary Lateral Dynamics of Passenger Cars

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Abstract : The average age of passenger cars is rising steadily around the world. Older vehicles are more sensitive to the degradation of chassis components. A higher age and a higher mileage of passenger cars correlate with an increased failure rate of vehicle shock absorbers. The most common degradation mechanism of vehicle shock absorbers is the loss of oil and gas. It is not yet fully understood how the loss of oil and gas in twin-tube shock absorbers affects the lateral dynamics of passenger cars. The aim of this work is to estimate the effect of degraded twin-tube shock absorbers of passenger cars on their safety-critical lateral dynamics. A characteristic curve-based five-mass full vehicle model and a semi-physical phenomenological shock absorber model were set up, parameterized and validated. The shock absorber model is able to reproduce the damping characteristics of vehicle twin-tube shock absorbers with oil and gas loss for various excitations. The full vehicle model was used to simulate stationary cornering and steering wheel angle step maneuvers on road classes A to D. The simulations were carried out in a realistic parameter space in order to demonstrate the influence of various vehicle characteristics on the effect of degraded shock absorbers. As a result, it was shown that degraded shock absorbers have a negative effect on the understeer gradient of vehicles. For stationary lateral dynamics, degraded shock absorbers for high road excitations reduce the maximum lateral accelerations. Degraded rear axle shock absorbers can change the understeer gradient of a vehicle in the direction of oversteer. Degraded shock absorbers also lead to increased rolling angles. Furthermore, degraded shock absorbers have a major impact on driving stability during steering wheel angle steps. Degraded rear axle shock absorbers, in particular, can lead to unstable handling. Especially the tire stiffness, the unsprung mass and the stabilizer stiffness influence the effect of degraded shock absorbers on the lateral dynamics of passenger cars.

Keywords : driving dynamics, numerical simulation, road safety, shock absorber degradation, stationary and nonstationary lateral dynamics.

Conference Title : ICVD 2025 : International Conference on Vehicle Dynamics

Conference Location : Sydney, Australia

Conference Dates : May 17-18, 2025