Air Ride Seat for Heavy Duty Vehicle

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Abstract
Riding comfort is one of important design features of the vehicle. Unlike to the passenger vehicle, commercial vehicles such as truck and bus often have their driver’s seat equipped with independent suspension system that mainly consists of air cell and shock absorber. The beneficial pneumatic pressure which is available particularly at commercial heavy duty vehicle enables to add the air cell into the seat suspension design for a better isolation of the vibration. The air cell is also commonly used at cabin and chassis suspensions of the heavy duty vehicle.

The design of seat system with air suspension in a heavy duty vehicle has multi-physical subcomponents. In order to put them effectively together in a virtual simulation, a co-simulation between 1D lumped network (SimulationX) and 3D mesh-based (VSS) solutions is proposed. The 3D finite element, i.e., mesh-based solution provides a precise and detailed mechanical interactions between various subcomponents and further with the occupied human body model. However the 3D FE solution is less suitable in early design phase, e.g., front loading stage to optimize the seat system design considering other relevant vehicle structure than the 1D lumped network solution due to its modeling complexity. On the other hand, the 1D lumped network solution is known to be quite effective for the modeling of pneumatic/hydraulic controllers together with a multibody link frame. However the mechanical interactions of the seat with the driver model via deformable upholstery need a 3D mesh based solution, the finite element analysis. Therefore the co-simulation of Functional Mockup Interface (FMI), in which the master and slave solutions are respectively 1D lumped network and 3D finite element analyses is performed to predicting the occupant kinematics for riding comfort simulation.

An extensive series of lab test have been performed to characterize the mechanical behavior of major components in air suspension seat such as hydraulic damper and pneumatic cylinder, the air cell. Two kinds of excitation signals, discrete sinusoidal and sine sweep were applied to the seat system to measure a transmissibility on dead weight and live human subject, respectively. The 1D lumped network (SimulationX) model is validated against this test result.

The verification and validation (V&V) of the 1D modeling scheme for a riding comfort virtual simulation
A case study is provided that simulated driving over a speed bump and assessed the associated riding comfort.