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Coil-Over Shock Absorbers Compared to Inherent Material Damping

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Abstract : Damping accompanies us daily in everyday life and is used to protect (e.g., in shoes) and make our life more comfortable (damping of unwanted motion) and calm (noise reduction). In general, damping is the absorption of energy which is either stored in the material (vibration isolation systems) or changed into heat (vibration absorbers). In case of the last, the damping mechanism can be split in active, passive, as well as semi-active (a combination of active and passive). Active damping is required to enable an almost perfect damping over the whole application range and is used, for instance, in sport cars. In contrast, passive damping is a response of the material due to external loading. Consequently, the material composition has a huge influence on the damping behavior. For elastomers, the material behavior is inherent viscoelastic, temperature, and frequency dependent. However, passive damping is not adjustable during application. Therefore, it is of importance to understand the fundamental viscoelastic behavior and the dissipation capability due to external loading. The objective of this work is to assess the limitation and applicability of viscoelastic material damping for applications in which currently coil-over shock absorbers are utilized. Coil-over shock absorbers are usually made of various mechanical parts and incorporate fluids within the damper. These shock absorbers are well-known and studied in the industry, and when needed, they can be easily adjusted during their product lifetime. In contrary, dampers made of – ideally – a single material are more resource efficient, have an easier serviceability, and are easier manufactured. However, they lack of adaptability and adjustability in service. Therefore, a case study with a remote-controlled sport car was conducted. The original shock absorbers were redesigned, and the spring-dashpot system was replaced by both an elastomer and a thermoplastic-elastomer, respectively. Here, five different formulations of elastomers were used, including a pure and an iron-particle filled thermoplastic poly(urethan) (TPU) and blends of two different poly(dimethyl siloxane) (PDMS). In addition, the TPUs were investigated as full and hollow dampers to investigate the difference between solid and structured material. To get comparative results each material formulation was comprehensively characterized, by monotonic uniaxial compression tests, dynamic thermomechanical analysis (DTMA), and rebound resilience. Moreover, the new material-based shock absorbers were compared with spring-dashpot shock absorbers. The shock absorbers were analyzed under monotonic and cyclic loading. In addition, an impact loading was applied on the remote-controlled car to measure the damping properties in operation. A servo-hydraulic high-speed linear actuator was utilized to apply the loads. The acceleration of the car and the displacement of specific measurement points were recorded while testing by a sensor and high-speed camera, respectively. The results prove that elastomers are suitable in damping applications, but they are temperature and frequency dependent. This is a limitation in applicability of viscous material damper. Feasible fields of application may be in the case of micromobility, like bicycles, e-scooters, and e-skateboards. Furthermore, the viscous material damping could be used to increase the inherent damping of a whole structure, e.g., in bicycle-frames.

Keywords : damper structures, material damping, PDMS, TPU
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