Design and Simulation of a Crash Energy Absorption System Integrated with Magneto-Rheological Absorber

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Abstract for Seminar 1

The global car crash fatalities are mostly due to the frontal collisions. The head-on collision of a car leads to the dangerous intrusion of the bumper and other frontal parts of the vehicle towards the passenger compartment. The frontal structure needs to have a proper adaptable crash energy absorption system to reduce the intrusion. A new crash energy absorption system combined with a Magneto-Rheological Absorber (MRA) has been proposed to meet the above requirements.

The design and modeling of the system based on magneto-rheological (MR) technology generally comprise of mathematical formulation, numerical simulation, and validation with a physical test. The current work focuses on lumped parameter modeling (LPM) of a light passenger car equipped with MRA in serial and parallel configurations. The modified Bouc–Wen model has been used in the design of MRA as it is the most standard form to model non-linear hysteretic systems. In this work, six new models are proposed by varying the position of MRA in the standard one degree of freedom (DoF) Kelvin–Voigt model and two-DoF model. The performance of the proposed models has been simulated in MATLAB–SIMULINK environment, considering various initial velocities of the vehicle by supplying different voltages to MRA.

The results show that three of the six proposed models exhibit better crash kinematic responses than the base models, which are experimentally validated and available in existing literature. Finally, the MRA behaviour has been captured to validate its effectiveness in the design of the crash energy absorption system. The proposed methods are also useful in the development of crash mitigation devices in electric vehicles (EVs). The results obtained would be utilized in design of a multi-stage crash energy absorption system.

Thus, the collision energy absorption system with add-on MRAs behaves as a semi-active system. It is efficient during various high-speed impacts and can be implemented practically.