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Modeling and control of a shock absorber with tunable inertance and damping

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Inerter is a two-terminal mass element and the forces applied at its two terminals are proportional to the relative acceleration between the two terminals. The proportional coefficient is called the inertance. The topic of the inerter has received extensive attention because of its unique advantages, such as small weight and no ground restriction of the capacitor in the corresponding circuit system counterpart as compared to the conventional mass element. Inerter has been applied or studied as a passive device in various vibration isolation systems. Aiming at further improving the vibration isolation performance of the systems, the topic of controllable inerter has received much attention. The vibration isolation system with controllable inertance and/or controllable damping has shown obvious advantages compared with the conventional passive inerter-spring-damper system.

Based on the structural design concept of "functional integration", we proposed and designed a shock absorber with both controllable inertance and damping. The proposed shock absorber is composed of a magnetorheological (MR) damper, a MR clutch, a flywheel, a ball screw mechanism, a spring and a housing. The controllable inertance is realized by the coordination between the MR clutch and the flywheel. The ball screw drives the flywheel to rotate together when a certain current is applied to the MR clutch, that is, the inerter works. The ball screw is disengaged from the flywheel when applied no current and the inerter stops working. Thereby, the switching of the working state of the inerter (inertance) is realized by the applied current. In this paper, the shock absorber is modeled, including the controllable inertance of the MR inerter and the controllable damping force of the MR damper. The controllable mechanical properties of the shock absorber are analysed and evaluated. Nonlinear controller for a 1/4 car system using the shock absorber is proposed and verified.

Biography

An-Ding Zhu and Li-Jun Qian, currently working at Hefei University of Technology, China. This presentation is part of a collaboration they continued with Xian-Xu Bai who joined Hefei University of Technology in 2013 and founded Laboratory for Adaptive Structures and Intelligent Systems (LASIS) in 2016. His research interests are focused in two areas. (i) Design, optimization, dynamics, and control of smart structures based on smart materials, including magnetorheological fluids/elastomers and magnetostrictive materials, applied to automotive and aerospace systems, and (ii) New mechatronics-based vehicle dynamics and control in emphasis on intelligent/unmanned vehicles. He has authored over 50 international journal and conference articles. He is an inventor on 16 issued Chinese patents and 2 PCT US patents (pending). Currently, he serves as an Associate Editor of Journal of Intelligent Material Systems and Structures. He is a Committee Member of Adaptive Structures and Materials System Branch of Aerospace Division of ASME. He is a peer reviewer of over 30 international journals. He is a member of ASME, SAE China and IEEE.

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