Semi-active Control of Structures Using Current-Controlled MR Fluid Damper

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CERTIFICATION OF AUTHORSHIP/ORIGINALITY

I certify that the work in this thesis has not previously been submitted for a similar degree nor has it been submitted as a part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any assistance that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all the information sources and literature used are referenced in the thesis

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Acknowledgements

At last, I come to my single unedited part of the thesis. It may appear in the first page, but it was actually the last to be written. It is meant to acknowledge all the wonderful people who made it possible for me.

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Abstract

A critical aspect of the design of smart structures for buildings and other civil engineering infrastructure is the reduction of vibrations, deflections and forces induced by external disturbances such as earthquakes, strong winds or heavy dynamic loads. This research work focuses on the design of a second-order sliding mode controller for vibration control using Magneto-rheological fluid (MR) dampers integrated in smart structures to sustain external earthquakes or dynamic loadings. Following comprehensive surveys on structural control and recent earthquakes scenarios around the globe, this work presents an effective control system for suppression of structural vibrations. The advantages of these structures come from the use of semiactive devices for the fail safe operations and low energy consumption.

MR dampers are increasingly employed in structural control applications owing to many feasible advantages for mitigation of dynamic effects caused by external disturbances. However, the control of MR dampers is hindered by their nonlinear force-displacement and hysteresis force-velocity responses which usually affect controllability. On the other hand, the required yielding force to suppress structural vibrations results from the magnetisation of the fluid particle suspension in the damper housing via the controlled current. To robustly control the dampers' magnetisation current, the sliding mode methodology is adopted. In the context of structural control, a sliding mode controller is an attractive candidate for semiactive control of quake-induced structures in face of uncertainties.

In most of MR damper controllers developed so far, the damping force is quite often derived as the control signal, while the damper current is obtained via a secondary current-control loop. In this study, the controlled current for MR-dampers is directly generated by using second-order sliding mode controllers with the aims to satisfy the control constraints, retain strong robustness and remove chattering. The higher-order sliding mode idea is to drive to zero not only the sliding function of the state variables but also higher-order time derivatives of the sliding function. The effectiveness of the second-order sliding mode controller is verified, in simulation, on a benchmark three storey building models subject to excitation of various scaled earthquake records.

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