EXPERIMENTAL MECHANICS
New Trends and Perspectives

J.F. Silva Gomes, Mário A.P. Vaz
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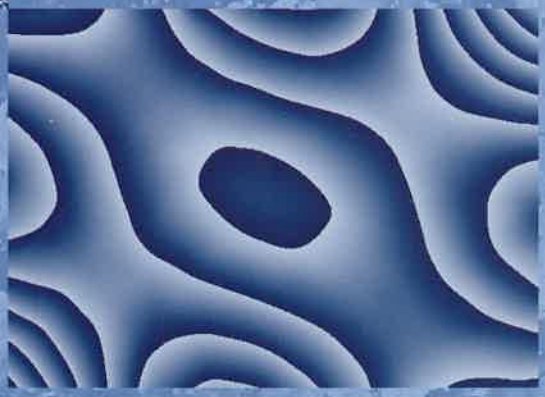

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(NEW TRENDS AND PERSPECTIVES)

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PAPER REF: 4050

PROPERTIES AND NUMERICAL MODELING OF MR DAMPERS

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ABSTRACT

Among the different strategies available to control engineering vibrations, the semi-active control based on Magnetorheological (MR) dampers have become a promising technology to be used in civil engineering structures. The ability of these devices to change the structural behavior without the need of large power sources is a major advantage that can be used to justify their potential application to this engineering branch. This paper reviews the basic concept of MR fluids and provides an insight of MR dampers dynamic behavior and the available numerical procedures to describe the damper response. In the first section an overview of the basic properties of the MR fluids and the fluid behavior under different flow regimes are presented. Then, a selection of numerical models to simulate MR dampers behavior will be presented based on the available literature.

INTRODUCTION

In the last years engineers began to use and developed the so-called "smart materials", i.e. materials in which at least one property can be changed in a controllable fashion by an external perturbation, in order to improve the behavior or to control the physical and mechanical properties of these materials. As is known, it is possible to obtain significant changes in some material properties like shape or viscosity when some external conditions like temperature or a magnetic field in order are changed. These properties allow the engineers to create "smart" devices some of them based on the use of fluids with controllable properties like Electrorheological (ER) and Magnetorheological (MR) fluids.

The initial discovery and development of MR fluids is credited to Jacob Rabinow at the US National Bureau of Standards in 1949 (Rabinow, 1948). Originally the research related with these fluids was focused in ER fluid, however in the last years MR fluids have been extensively studied due to their robustness for real-life engineering applications (Guglielmino *et al.*, 2008).

Basically, the main differences between ER and MR are related with operate temperature range, maximum yield stress and the sensitivity to impurities. The performance of MR fluids is less sensitive to temperature because the magnetic polarization mechanism remains unchanged over the operable temperature range. MR fluids can operate at temperatures from −40 to 150 °C with only slight variations in yield stress (Carlson and Weiss, 1994). Also, MR fluids behaviour is not affected by impurities, which means that is insensitive to contamination, while ER fluids are highly sensitive to moisture or impurities as result of manufacture and usage process.

RESULTS AND CONCLUSIONS

The Lord Corp. RD-1097-1 MR damper shown in Fig. 1 was tested in order to study its experimental response. This is a small sponge type MR damper with a conventional

cylindrical body configuration and an absorbent matrix saturated with an MR fluid in the piston rod. The enclosing cylinder is 32.0 mm in diameter and the damper is 253 mm long in its extended position with ±2.5 cm stroke. The device can operate within a current range from 0.0 A up to 1.0 A with a recommended input value of 0.5 A for continuous operation and can deliver a peak force of 100 N at a velocity of 51 mm/s with a continuous operating current level of 1.0 A. Thus, this damper can be used to control very small structural systems.

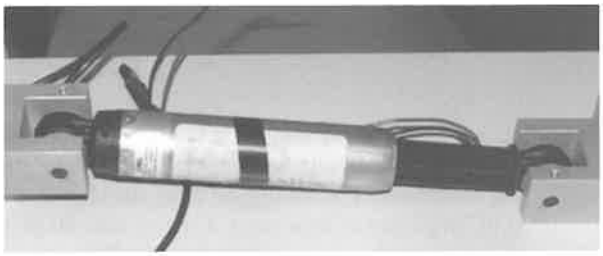

Fig.1 - Sponge type RD-1097-1 MR damper from Lord Corp.

A parametric study was carried out for several combinations of amplitudes, frequencies and input current were studied in order to obtain the required data to characterize the damper response to further develop a numerical model based on the experimental data. Hence, the damper was subjected to a series of predefined sinusoidal displacement excitations through a MTS actuator system working in displacement control mode. The excitation signals were automatically generated with the MTS controller and a regulated power supply unit was used to provide the constant current supply for each set of sinusoidal signals.

The work addresses the experimental characterization and numerical analysis of a small MR damper. Initially, the general properties of MR fluids and their ability to develop smart controllable devices are presented. Then, a brief review of the available parametric models is addressed. The small MR damper was tested to find the dynamic properties and two parametric models were developed to simulate its behaviour. Finally, an identification procedure was carried out to find the model parameters and was verified the viability of these models to simulate the MR damper response.

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