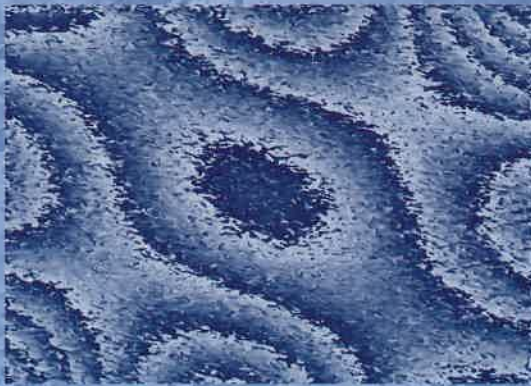


EXPERIMENTAL MECHANICS

New Trends and Perspectives

J.F. Silva Gomes, Mário A.P. Vaz
Editors



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Editors

J.F. Silva Gomes, Mário A.P. Vaz

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2963-IP	ANOMALOUS PLASTIC BEHAVIOR WITH LOCALIZED LATTICE ROTATION IN GUM METAL. Shigeru Kuramoto, Daigo Setoyama, Tadahiko Furuta, Elisabeth Withey, John W. Morris Jr. (Invited Paper).	1153
SYMP_22: EXPERIMENTAL METHODS IN THERMAL SCIENCES		1155
3007-IP	TECHNIQUES FOR MEASUREMENT OF AIR INFILTRATION IN SPACES AND FORCED VENTILATION IN AIR DUCTS. Clito F. Afonso (Invited Paper).	1157
3803	DEVELOPMENT OF A NEW DEVICE FOR HVAC AIR FLOW MEASUREMENT. António R. Silva, Clito F. Afonso.	1159
3179	COMPARATIVE STUDY OF THE PERFORMANCE OF A VARIABLE AREA RATIO STEAM EJECTOR. Szabolcs Varga, Armando C. Oliveira, Xiaoli Ma, Siddig A. Omer, Wei Zhang, Saffa B. Riffat.	1161
3108	MODELING AND SIMULATION OF COOLING OF A FOOD PACKAGED IN GLASS CYLINDRICAL GEOMETRY. Jesus Barrera, Hernán Estrada.	1163
3121	OPTIMIZATION OF A REFRIGERATION SYSTEM FOR COOLING DRAFT BEER. João Faria, Clito F. Afonso, Joaquim Gabriel, Armando Araújo, Jorge Pires, Cristina Silva, Armando Oliveira.	1165
2961	SHEET METAL FORMING USING HEATED STEAM ENERGY. Mohsen Saidi, Mohamed-Ali Rezgui, Mahfoudh Ayadi, Mourad Bouafia, Walid Nasri, Ali Zghal.	1167
3755-IP	CONTROLLING AIR TEMPERATURE VARIATIONS INSIDE REFRIGERATION CABINES BASED ON ANN AND EXPERIMENTS. Carlos C. António, Clito F. Afonso (Invited Paper).	1169
2991	HYDRAULIC PATHS FOLLOWED BY SOILS DURING SUCTION MEASUREMENT WITH DEW-POINT PSYCHROMETER. Rafaela Cardoso, Enrique Romero.	1171
SYMP_23: DYNAMICS, STABILITY AND CONTROL IN STRUCTURAL MECHANICS		1173
3011	EXPERIMENTAL VALIDATION OF A SIMPLIFIED NUMERICAL METHOD IN THE MODAL ANALYSIS OF THIN PIPES. Luisa Madureira, Francisco Q. Melo, Nuno V. Ramos, Jaime Monteiro, Mário A.P. Vaz.	1175
3114	LOAD TRANSMISSION TOWARD A PLASTIC RING VIA AN ELASTIC MEDIA WITH SEVERAL STIFFNESS. Jacinto Cortés, Fernando N. García, Francisco M. Sánchez, Alberto Reyes, Rodrigo J. Montalvo.	1177
2914	ANALYSIS OF STABILITY IN BORING OPERATION WITH SECONDARY EFFECTS. M.Raja Sekhara Rao, M.B.S.S. Reddy, K.Rama Kotaiah, Ch. Ratnam.	1179
3048	STABILITY OF A NONLINEAR 2 DEGREE-OF-FREEDOM VEHICLE SYSTEM WITH MULTIPLE TIME-DELAYS. Raghavendra D. Naik, Pravin M. Singru.	1181
3059	A STUDY ON THE DETERMINATION OF DESIGN LOAD FOR EXCAVATOR ATTACHMENTS FROM FIELD MEASUREMENT. Ju-Ho Kwak, Byung-Joo Kim, Jae-Ohk Lee, Hyun-Koo Cho.	1183
3083	NUMERICAL MODELLING OF TWO WAY REINFORCED CONCRETE SLABS STRENGTHENED WITH CARBON FIBER REINFORCED POLYMERS STRIPS. Dragos Banu, Rui C. Barros, Nicolae Taranu.	1185
2890	COMPLEX MODAL ANALYSIS OF A SLENDER VERTICAL ROTOR BY FINITE ELEMENTS METHOD. Cristiano E. Agostini, Edson A.C. Sousa.	1187
3084	NUMERICAL MODELLING OF STRUCTURAL RESPONSE OF REINFORCED CONCRETE PLATES WITH CUT-OUTS STRENGTHENED WITH CARBON FIBER REINFORCED POLYMERIC COMPOSITES STRIPS. Dragos Banu, Rui C. Barros, Nicolae Taranu.	1189

3085	DESIGN PROPERTIES OF COMPOSITE REINFORCEMENT BARS UNDER TENSILE LOAD. Catalin Banu, Nicolae Taranu, Rui C. Barros, Gabriel Oprisan, Oana M. Ionita.	1191
3002	RESIDUAL VIBRATIONS CONTROL FOR OPTICAL BEAM SHUTTING SYSTEMS. Sigita Navickaite, Ramutis Bansevicius, Viktorija Maciukiene, Vytautas Jurenas.	1193
3090	PRECISION EVALUATION OF ILLUMINATED MARKER POSITIONING WITH IMAGE PROCESSING. Takaaki Iizuka, Yasushi Niitsu.	1195
3839	MULTI-STAGE MODEL UPDATING WITH A SUBSTRUCTURE APPROACH. Yong Xia, Xiao-qing Zhou, Shun Weng.	1197
4050	PROPERTIES AND NUMERICAL MODELING OF MR DAMPERS. M. Braz Cesar, Rui C. Barros.	1199
4051	AN ESTIMATION OF DAMPING RATIO FOR THE NUMERICAL STUDY OF IMPACT FORCES BETWEEN TWO ADJACENT CONCRETE BUILDINGS, SUBJECTED TO POUNDING. Rui C. Barros, Seyed M. Khatami.	1201
	Author Index	1203

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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.

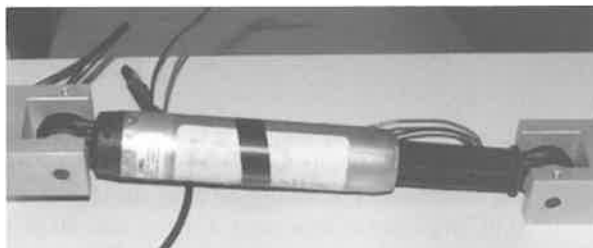


Fig.1 - Sponge type RD-1097-1 MR damper from Lord Corp.

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.

ACKNOWLEDGMENTS

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REFERENCES

- [1]-Carlson JD, Weiss KD. A growing attraction to magnetic fluids. *Machine Design*, 1994, 8, pp. 61-66.
- [2]-Guglielmino E, Sireteanu T, Stammers CW, Ghita G, Giuclea M. *Semi-active suspension control: improved vehicle ride and road friendliness*. Springer, 2008.
- [3]-Rabinow J. The magnetic fluid clutch. *AIEE Trans.*, 1948, 67, pp. 1308-1315.