SELF-LOCKING MRF ACTUATORS FOR DAMPERS & LATCHES

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Short Abstract

The MRF actuators are new electromechanical components using Magneto Rheological Fluids (MRF). When submitted to a high enough magnetic field, MRFs switch from a liquid to an almost solid body. The purpose of the new developed MRF actuators is to reach three aims: to offer a blocking force at rest, which can be strongly reduced by applying a current, to provide an electrically- controllable resistive force over a stroke of 30 mm, to perform the control of the force in a very short time, typically in a few milliseconds. Thus, the MRF actuator can be used for two main applications : damper / latch - lock. Experiments on two versions of the actuator (a single piston rod / a feed through output axis) allows to get a blocking force of more than 100N, which is more than 10 times the actuator weight (its mass is 700gr). The required current and electric power required to cancel the blocking force are only 1.6A and 4W. The paper will further present the design and the electromechanical properties of the Self-breaking MRF Actuators for dampers & latches, as well as new results on the control of these actuators.

Summary

The MRF actuators are new electromechanical components using Magneto Rheological Fluids (MRF) [1]. These smart fluids are characterized by their ability to change their rheological properties versus applied magnetic field. With sufficient field, they can switch from a liquid to an almost solid body. This effect is reversible. It operates in few milliseconds. This effect can be used for generating controllable damping, smart shock absorption or braking capabilities, which can be used for making special electro-fluidic actuators. Most of MRF actuators (see for ex [2]) often a controllable breaking force but don not offer a blocking force at rest for offering a self-locking operation.

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- to perform the control of the force in a very short time, typically in a few milliseconds.

Thus, the MRF actuator can be used for two main applications : damper / latch - lock. In some cases, these two applications can be combined. For example in some embedded instruments, its is wise to damp vibrations when the lock / unlock operations occur. The self-looking feature has been obtained in the developed actuator thanks to a particular magnetic circuit designed with FLUX software [2] and knowledge acquired on MRF fluid magnetic and rheological properties.

The first application is the optimized damping which needs controllable energy dissipation. The device provides dissipated energy control in real time thanks to the current control. In a few milliseconds, the energy dissipation can be increased by 500%. A maximum damping can be maintained without power supply and so the fail safe operating can be guarantied in several applications. Vibrations damping and shocks absorption can be optimized thanks to a closed loop.

The second main application is the locking in position. The current control allows blocking the load in any positions along the stroke. The MRF actuator acts therefore as a linear electro-mechanical break without moving parts. Whatever the piston rod position, if the motion force is lower than the maximal force damping (@0A), the control of the current allows to get the lock of the rod.

Two architectures of the device are suggested: a damper with a single piston rod, the device allows damping a movement versus the frame or a damper with a double piston rod which allow transmitting the movement through the damper which operates in series with the motion line.

Damper with a single piston rod | *damper with a double piston rod*

Fig.1 – Two types of MRF damper / lock

As the devices much operate in all orientations and in both directions (Pulling & pushing) several physical limits were solved as the cavitations and the volume variation when the rod go in the damper or the sealing. For all these limitations, two specific solutions have been implemented and tested to validate the solutions (fig 1). Solutions are comparable as they use mostly the same parts.
A test campaign has been performed to assess the technologies vs the theoretical expectations. Force vs displacement at different currents, shows the achievement : looking at rest, controllable forces, pulling & pushing operations with similar properties for both actuators (fig 2) … Typical performances for the both actuator types are given in the table 1 and are very satisfying.

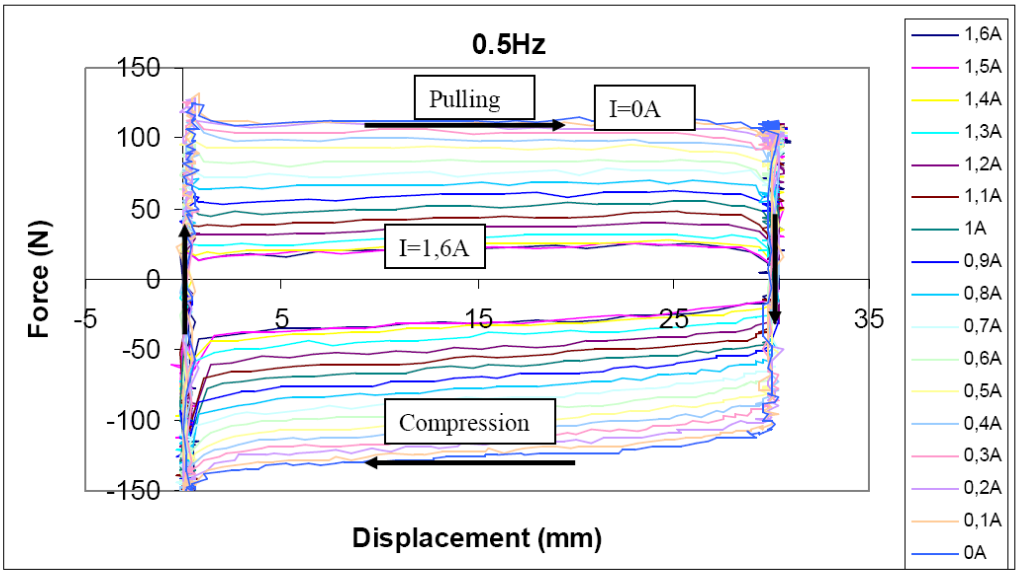

Fig.2 – Test results @ low frequency

References	Unit	A-MRF single piston rod	A-MRF double piston rod
Notes			
Stroke	*mm*	*30*	*28*
Damping force @ 0A	*N*	*120*	*90*
Damping force @ 1.6A	*N*	*25*	*16*
Dissipated energy pers cycle @ 0A	*Nm*	*7.2*	*5.04*
Dissipated energy pers cycle @ 1.6A	*Nm*	*1.5*	*0.72*
Total weight	*g*	*640*	*730*
Diameter	*mm*	*43*	*43*
Height (without stroke)	*mm*	*94*	*97*
Max current	*A*	*1.6*	*1.6*
Electrical interface		*1 coils = 2 wires*	*1 coils = 2 wires*
Winding resistance	*ohm*	*1.67*	*1.65*
Winding inductance	*mH*	*10.82*	*9.95*
Electric time response	*ms*	*6.5*	*6*
Electric dissipated power @1.6A	*W*	*4.3*	*4.2*

Fig.3 – MRF Actuators performances

The paper will further present the design and the electromechanical properties of the Self-breaking MRF Actuators for dampers & latches, as well as new results on the control of these actuators.

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