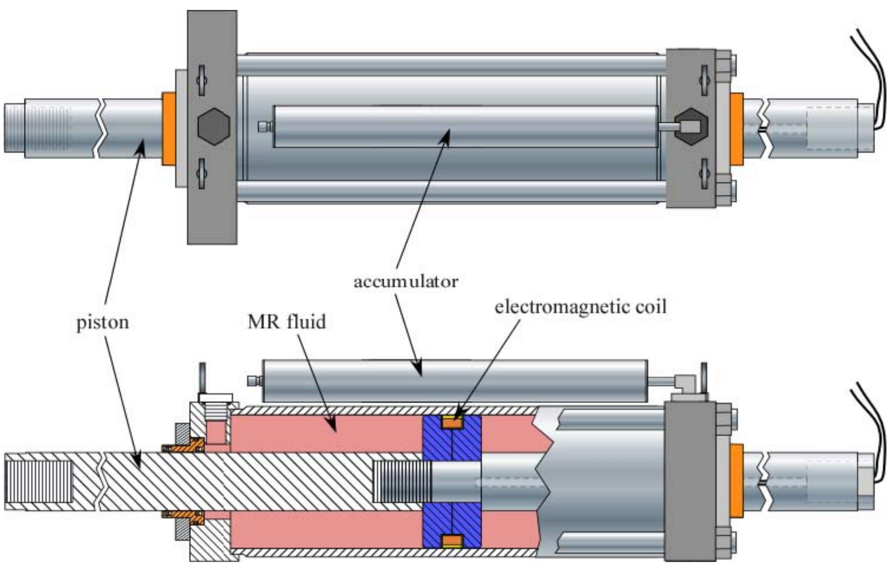
The Magneto-Rheological (MR) fluid damper is a promising type of semi-active device for civil structures due to its mechanical simplicity, inherent stability, high dynamic range, large temperature operating range, robust performance, and low power requirements. The MR damper is intrinsically nonlinear and rate-dependent, both as a function of the displacement across the MR damper and the command current being supplied to the MR damper. As such, to develop control algorithms that take maximum advantage of the unique features of the MR damper, accurate models must be developed to describe its behavior for both displacement and current.

The "Hyperbolic Tangent Model (Version 1) for 200 kN Large-Scale Magneto-Rheological Fluid (MR) Damper" includes a model of the pulse-width modulated (PWM) power amplifier providing current to the damper and a hyperbolic tangent model of the controllable force behavior of the MR damper.

The physical counterparts of this model are the large-scale 200 kN MR damper that were manufactured by the Lord Corporation. The damper is 1.47 m in length, weighs approximately 2.734 kN, and has an available stroke of 584 mm. The damper's accumulator can accommodate a temperature change in the fluid of 80^{o}F. The damper can provide control forces of over 200 kN. A schematic of the large-scale MR damper is shown below.



Large-Scale Semiactive Damper Schematic.

The MR damper is controlled with a low voltage, current driven command signal. An Advanced Motion Controls pulse-width modulated (PWM) Servo-Amplifier is powered by an 80 volt DC, 5 amp unregulated linear power supply. The servo-amplifier is used to provide the command signal that controls the electromagnetic field for each damper. The PWM Servo-Amplifier is controlled by a 0-5 volt DC signal and utilizes pulse width modulation for current control. The input control signal can be switched at a rate of up to 1 kHz. Each damper has been fitted with a 1.5KE75A transient voltage suppressor to protect the MR damper electromagnetic coils from unintended and damaging voltage peaks, limiting the peak voltage to 75 volts.

This model has been validated through experimental testing which were conducted on two 200 kN large-scale MR dampers located at the Smart Structures Technology Laboratory (SSTL) at the University of Illinois at Urbana Champaign and the Lehigh University Network for Earthquake Engineering Simulation (NEES) facility. Comparison with experimental test results for both prescribed motion and current and real-time hybrid simulation of fully semiactive control of the MR damper shows that the proposed MR damper model can accurately predict the fully-dynamic behavior of the large-scale 200 kN MR damper.

Besides the developed MR damper model, a sample code is included to show as an example on how to run the model. Please refer to HT_SampleRun.m for details.

Please note the following:

1. The attached HT_Params_V1.m needs to be run before the HT_Model_V1.mdl.

2. This model was developed using Matlab 2011 and was tested in Matlab R2013a.

3. A newer version (Version 2) of the HT model which includes a model of the pulse-width modulated (PWM) power amplifier providing current to the damper, a model of the inductance of the large-scale 200 kN MR dampers coils and surrounding MR fluid - a dynamic behavior that is not typically modeled, and a hyperbolic tangent model of the controllable force behavior of the MR damper is developed and made available through NEEShub.

Details regarding the attached model can be found in the following publications:

1. Z. Jiang and R. Christenson (2012), “A Fully Dynamic Magneto-rheological Fluid Damper Model”, Journal of Smart Materials and Structures 21 065002.

2. Z. Jiang and R. Christenson (2011), “A Comparison of 200 kN Magneto-rheological Damper Models for Use in Real-time Hybrid Simulation Pretesting”, Journal of Smart Materials and Structures 20 065011.

3. B. Bass and R. Christenson (2007), "System identification of a 200kN magneto-rheological fluid damper for structural control in large-scale smart structures", Proc. American Control Conf. (New York) pp. 2690-5