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Force tracking control of MR damper and controller parameter optimization using sensitivity analysis method

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ABSTRACT - The objective of this paper is to optimize the control parameters of Magnetorheological (MR) damper under harmonic motion. The MR damper is modeled using parametric approach and Bouc-Wen model is chosen to represent MR damper model. Next, a control strategies using continuous state feedback controller is used to track the desired and actual force through B and G parameter. An optimization tool (sensitivity analysis) is used to determine the selection of controller parameter. Lastly force tracking control used to evaluate the performance of control strategies.

1. INTRODUCTION

Magnetorheological (MR) fluid is smart materials that change its behavior due to responds from the applied magnetic field [1]. The ability to change its state reversibly from viscous liquid to semi solid in milliseconds when exposed to magnetic field make it more flexible [2]. Since MR damper can reversibly change its state, therefore MR play an important role in semi-active damper as control device [3][4]. However magnetic field applied need to be suitable with the application. Thus a control parameters need to be design for the system in order to control state of MR fluid inside the MR application as previous study [5][6].

2. METHODOLOGY

In this study, a MR damper (RD-8040-1) manufactured by Lord Corporation has been used in the experiment. The experimental work is conducted to study the characteristic of the MR damper on 5 Hz cranked oscillation motion with stroke 0.05 m. The experiment data collected based six current input levels as 0, 0.2, 0.4, 0.6, 0.8 and 1.0 Ampere. There are several characteristic of MR damper in the experiment such as the relation of damper force against velocity of the movement.

The experimental setup in Figure 1 shows the communication of instrument in the experiment. In the experimental setup, the experiment is used in studying the characteristic of MR damper and power by the propulsion system.

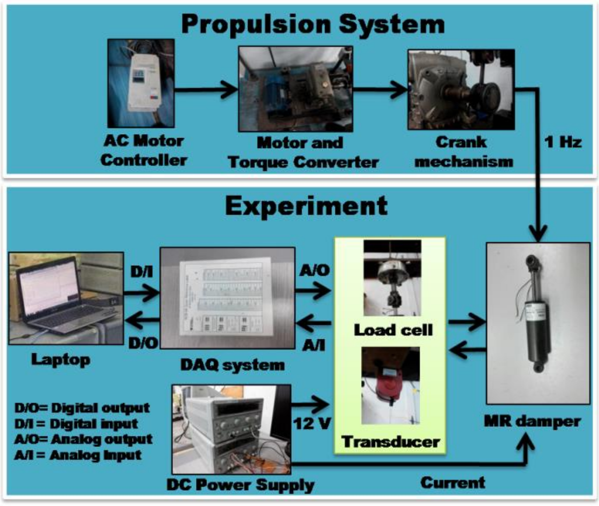

Figure 1 Experimental setup

By using parametric approach, the MR damper model is developed based on Bouc-Wen model [7]. Then, a control strategy is designed by using continuous state feedback controller and the controller parameter is optimized using sensitivity analysis. Lastly, a force tracking control with a different input signal is conducted to evaluate the performance of the controller parameter.

3. RESULTS AND DISCUSSION

From the experimental data, the relation of force and velocity is studied for each current 0, 0.2, 0.4, 0.6, 0.8 and 1.0 Ampere as shown in Figure 2. Figure 2 shows the damper force is increase as the current applied to the magnetic coil damper increase. The maximum and minimum of damper force is 948N and 81N. The MR damper acts as passive damper when there is no magnetic field on the magnetic coil. As the magnetic field increase inside the MR damper, the MR fluids change its state from liquid to semi solid state and make it harder to move the particle of MR fluid inside the MR damper.

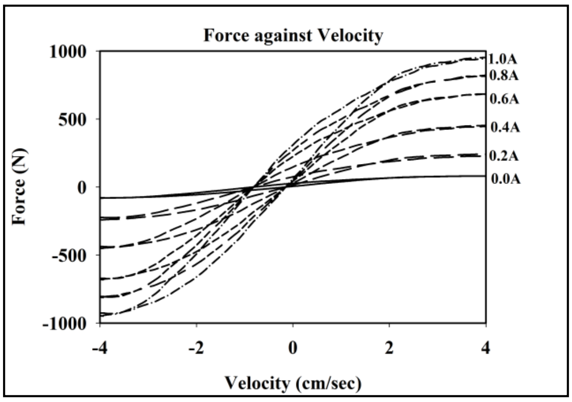

Figure 2 Force against velocity from the experimental data

From the sensitivity analysis in Figure 3 the optimal solution for parameter B and G controller is 0.001026 and 0.027. This is because of the RMS value is the lowest when B and G is 0.001026 and 0.027.

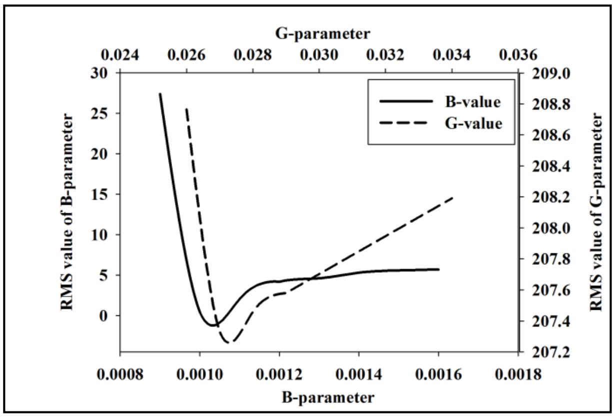

Figure 3 Control parameter of inner loop control system

Figure 4 shows the proposed MR damper model is able to tracking the desired force and produced an actual force by given saw tooth, square and sine input signals.

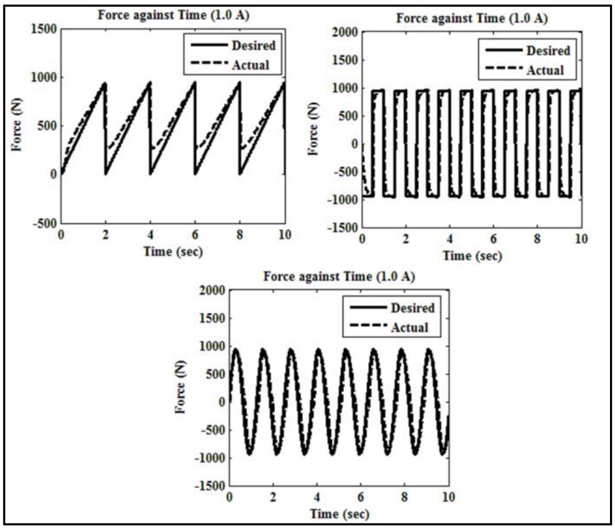

Figure 4 Force tracking control

4. CONCLUSIONS

In conclusion, an experimental work to find the characteristic of MR damper has been conducted in the laboratory. The MR damper model has been developed using a Bouc-Wen model. The tracking ability of the proposed model and control strategy has been investigated in simulation work. The sensitivity analysis method is used to find an optimum value of the MR damper controller. Through this study, it shows the MR damper model is able to track the desired force.

5. ACKNOWLEDGEMENT

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