Impact responses of a magnetorheological energy absorber

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ABSTRACT

Magnetorheological (MR) fluids are a kind of smart material with a reversible rheological property in milliseconds and large range of controllability. The controllable actuators-energy absorbers (EAs) based on MR fluids have prospect to be applied to the control systems to mitigate the high-speed impact. To verify the feasibility of MREAs for high-speed impact, a MREA utilizing an internal bypass that we proposed earlier is further investigated in this paper. The MREA is a linear configuration with double cylinders. The piston connected with a piston rod divides the inner cylinder into two chambers. Inlets/Outlets set at the upper/lower of inner cylinder are used to connect the inner cylinder chambers and the MR fluid flow channel sandwiched between the inner and outer cylinders into a whole. Based on the flow properties between parallel plates, the mathematical model of mechanical properties of MREA under impact loads is established, and the flow model of MREA is constructed in software ANSYS/Fluent. The damping force characteristics of the MREA prototype are tested under different impact loads based on our test bench in Hefei University of Technology. The research results, including controllable damping force range, constant stroking load velocity range (which is defined by the controllable velocity range that can be adapted by tuning the applied current to the MREA to have the damping force achieve a specific damping force level), and response time, are analysed and compared with the mathematical model.

Figure 1 presents the comparison of constant stroking load velocity ranges of MREA with an internal bypass and conventional MREA. As shown in figure 1, for various damping forces, 1 kN, 2 kN, and 3 kN, the constant stroking load velocity ranges of the MREA with an internal bypass are much wider than those of the conventional MREA. For the conventional MREA case, the smaller the specified damping force level is, the wider the constant stroking load velocity range is.

Figure 2 presents the mechanical response of MREA with an internal bypass under different exciting current levels and different impact excitations.

![Figure 1](image1.png)

Figure 1. Constant stroking load velocity ranges of the MREA with an internal bypass and conventional MREA for specific damping forces.

![Figure 2](image2.png)

Figure 2. Impact response of the MREA with an internal bypass at initial impact velocity of 4 m/s: (a) $I = 0$ A and (b) $I = 4$ A.