Multi-axis Magnetorheological Aircraft Seat Suspension

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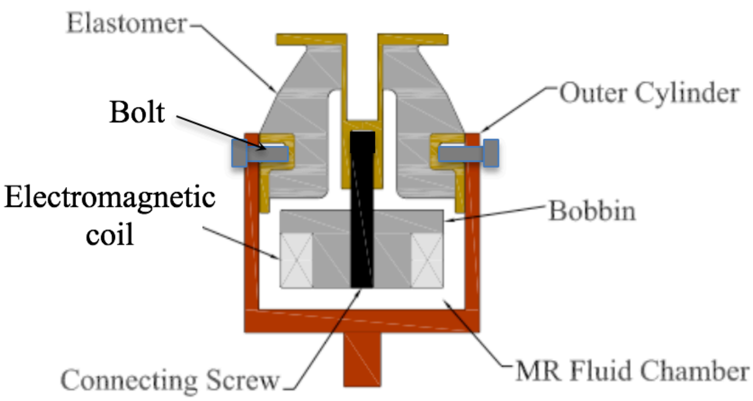
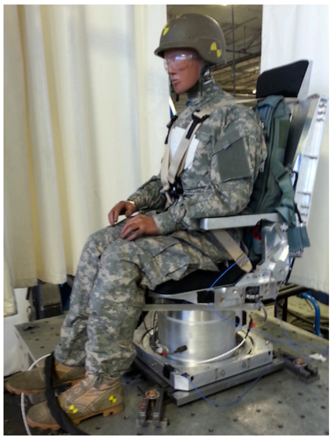
ABSTRACT

The excessive vibration of ground and aerial vehicles affects the human body of crews and passengers. Short-term vibration effects on the occupants are the discomfort, inattention, distraction, and fatigue. Occupants exposed to long-term whole-body vibration may experience back pain, as well as neck and spine injuries. Specially, vibrations up to 80 Hz can strongly effect the human body [1,2]. The resonant frequencies of the neck and lumbar region are between 2.5 and 5.5 Hz, and of the head and shoulder regions are between 20 and 30 Hz [4]. Thus, prolonged vibration can produce chronic musculoskeletal stress on the affected areas and may cause permanent damage [3]. This study presents the three-axis vibration isolation performance of a full-scale magnetorheological (MR) seat suspension multi-axis inputs (vertical and lateral) to mitigate these problems. A semi-active multi-axis MR seat damper was designed and manufactured (Fig. 1a). The damping capability of the three-axis MR seat damper was experimentally, using a servo-hydraulic load frame, evaluated for both axial and lateral excitations in terms of dynamic stiffness and loss factor. Before building the full-scale MR seat suspension, a 1/3rd scale MR seat suspension was developed to ensure that the MR seat damper was capable of achieving the desired seat vibration reductions under practical excitation levels. In addition, to efficiently suppress the seat vibration, a narrow-band frequency shaped semi-active control (NFSSC) algorithm was formulated and implemented. A full-scale MR seat suspension test was set up with a 50th percentile male dummy (Fig. 2). The three-axis vibration isolation performance of the full-scale MR seat suspension was evaluated by using a hydraulic multi-axis simulation table (MAST) for both individual (for this case, sinusoidal excitation input with a constant acceleration level of 0.1 g was swept over wider frequency range up to 200 Hz) and simultaneous three-axis directional inputs (for this case, representative transient inputs for X, Y, Z-axis were applied). The feasibility of the full-scale MR seat suspension effective for the seat vibration reduction was experimentally verified.



(a) Multi-axis MR Isolator



(b) Experimental Set-up

Figure 1: Multi-axis Magnetorheological Seat Suspension

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