


Editorial

Editorial for Special Issue “Energy Dissipation and Vibration Control: Materials, Modeling, Algorithm, and Devices”

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Abstract: Many engineering systems, from subsea pipelines to space structures, from moving vehicles to stationary skyscrapers, are subject to unwanted vibration excitations. Often vibration control can be considered as a problem of energy dissipation and vibration damping. The aims of this issue are to accumulate, disseminate, and promote new knowledge about vibration control, especially for topics related to energy dissipation methods for vibration damping. Topics in this issue reflect the start-of-the-arts in the field of vibration control, such as inerter dampers and pounding tuned mass dampers (PTMDs). This special issue also reports other types of new energy dissipation devices, including a multi-unit particle damper, a nonlinear eddy current damper, and layered dampers. Also reported in this issue are structural elements with innovative designs to dissipate energy. In addition, this special issue also reports two research studies on the dynamic responses of a structural foundation and an earth-retaining structure. Though most papers in this special issue are related to passive methods, one paper reports a semi-active vibration control via magnetorheological dampers (MRDs), and another two papers report active vibration controls using piezoelectric transducers and inertial actuators, respectively.

Keywords: vibration control; energy dissipation; passive vibration control; tuned mass damper; pounding tuned mass damper; viscoelastic materials

Many engineering systems, from subsea pipelines [1,2] to space structures [3,4], from moving vehicles [5] to stationary skyscrapers [6], are subject to vibration excitations. Problems related to vibrations are ubiquitous, from the fatigue caused by many low-amplitude vibration excitations [7,8] to the structural failure of buildings caused by excessive seismic events [9,10]. In addition, many civil structures are exposed to the environment and are subjected to many adverse effects such as thermal cycling [11] and corrosion [12], resulting in damages such as cracks [13] and reduced structural stiffness [14]. In these situations, vibration damping becomes even more important. The study of vibrations and the control of vibrations has been a fundamental cornerstone of engineering. The breadth of vibration engineering is matched by the depth of field. Numerous methods, including active [15,16], passive [17,18], semi-active [19,20], and hybrid [21] methods, have been proposed, and a wide range of devices have been developed to control vibrations.

Many vibration control problems can be considered as a problem of energy dissipation and vibration damping [18,19]. The problem encompasses multiple interdependent aspects of research and engineering, including the invention of new energy dissipation materials, the establishment of new

mathematical models [22], the development and implementation of new control algorithms, and the design of novel damping devices [23,24]. Discoveries made in one aspect can lead to breakthroughs in others.

The aims of this issue are to accumulate, disseminate, and promote new knowledge about vibration control, especially for topics related to energy dissipation methods for vibration damping. Topics in this issue reflect the start-of-the-arts in the field of vibration control. In recent years, new dampers employing inerters have received much attention. In this special issue, both modeling and applications related to inerter dampers are addressed. On the modeling side, new equivalent linearization methods for a control system with a clutching inerter damper are developed [25], and on the application side, the inerter dampers are applied to the vibration control of suspended structures [26] and cables [27]. The inerter dampers are effective in reducing structural vibrations.

Recent years have seen the increasing research in pounding tuned mass damper (PTMD) that has advantages of being simple to use, easy to maintain, robust to the target structural frequency, and having a high energy dissipation capacity [28–30]. In this issue, a new type of PTMD that uses a shape memory alloy sponge as the energy dissipating material is reported [31], and the application of the PTMD is extended to the vibration control of suspended piping systems in buildings [32]. Since viscoelastic materials are used in the conventional PTMDs [17,18,24] and the effectiveness of viscoelastic materials are negatively impacted by the water depth (pressure), for its underwater applications, conventional PTMD can only be applied in shallow water where the pressure is low. With the metallic porous shape memory alloy sponge whose damping performance is not impacted by water depth, the application of PTMD can be extended to deep water. In the past, there is no study on the impact of seawater on viscoelastic materials' damping effect. In this special issue, the seawater effect on the impact damping behavior of the viscoelastic material of PTMD is reported for the first time [33]. It is found that the seawater has a minimal effect on the viscoelastic materials for their damping effectiveness.

This special issue also reports other types of new energy dissipation devices, such as a multi-unit particle damper [34], a nonlinear eddy current damper [35], and layered dampers [36,37]. Furthermore, also reported in this issue are structural elements with innovative designs to dissipate energy [38–40]. In addition, this special issue also reports two research studies on the dynamic responses of a structural foundation [41] and an earth-retaining structure [42]. Though most papers in this special issue are related to passive methods, one paper reports a semi-active vibration control via magnetorheological dampers (MRDs) [43], and another two papers report active vibration controls using piezoelectric transducers [44] and inertial actuators [45], respectively. MRDs are essentially passive devices, though their damping forces can be actively adjusted via electromagnets [20]. Please note that, for active vibration control, piezoelectric transducers have quick response and wide bandwidth [46–48], however, their outputs as displacement or force are limited. On the other hand, though most inertial actuators have low bandwidth, they can deliver much larger displacement or force for active vibration control. A special novel liquid transfer active balancing system to reduce oscillations of hollow rotors for high-speed rotating machinery is presented in this issue [49]. Finally, this special issue includes one review paper on the topic of seat suspension technology [50].

In summary, the topics in the special issue include new damping materials development [37], new damper vibration modeling, novel algorithms for active vibration control [44,45], novel passive damping methods and devices [25–30], innovative energy dissipation devices [38–40], and an explorative characterization of materials for energy dissipation [33], among others. For the future trends of research in energy dissipation for vibration control, two avenues should be noted. One avenue points to the integrated vibration control and energy harvesting. Piezoelectric transducers [51,52] and electromagnetic devices [53] can be used to convert vibration energy into electrical energy, reducing structural vibration while harvesting energy. The success of energy harvesting from structural vibration will lead to the second avenue for future work which is the integrated structural vibration control and health monitoring. The harvested energy that dissipates structural vibration can

be used to power sensors that are used in structural health monitoring (SHM) systems. Though many advances have been made in SHM [54,55], the limited power source is currently a major roadblock for the wide application of SHM systems [56]. It is believed that integrated structural vibration control and health monitoring with energy harvesting is an effective way to promote future SHM systems.

Conflicts of Interest: The authors declare no conflict of interest.

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