Tuned Liquid Damper Design Using Liquid Sloshing in a Horizontal Cylinder

THESIS DEFENSE

Presented by: Vedant Manish Patel

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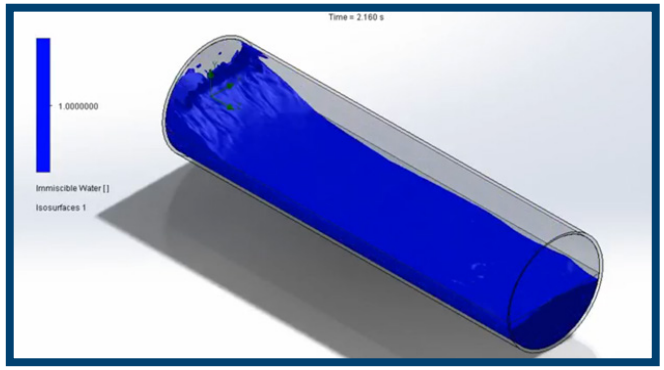

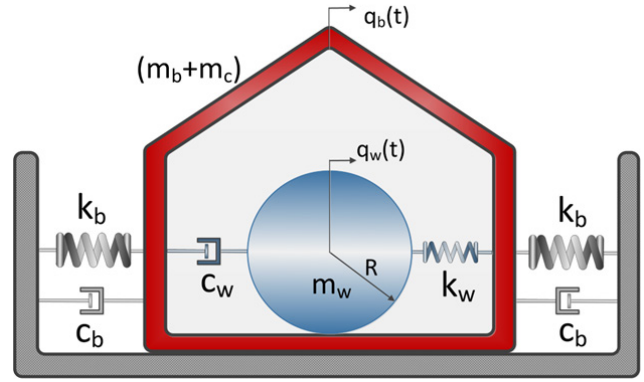

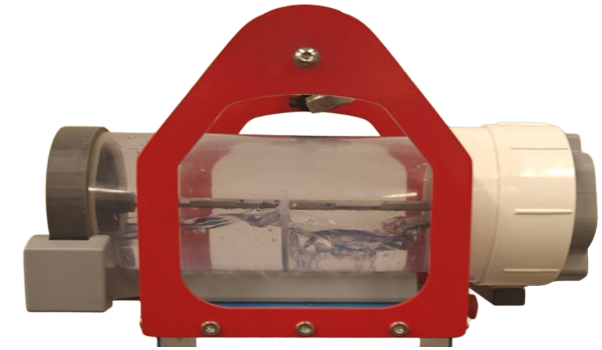

Vibration isolation is an essential design requirement for several real word applications including industrial machinery, automobiles and building structures. Different techniques of vibration isolation are employed in each of these applications. One such vibration isolator used in tall buildings is known as the tuned mass damper, where a mechanical mass (pendulum, bogey, cylinder) is located at the top portion of the building and is connected to the building through a suspension. This mechanical mass – suspension system is designed to oscillate out of phase with the building in order to dissipate the vibration. Several buildings such as, Taipei 101, have such vibration isolators installed. A fluid variant of the tuned mass damper, known as a tuned liquid damper, is also used in several tall buildings (Citicorp center in New York City) to achieve vibration isolation. In this research study, one such design of a tuned liquid damper in the form of a horizontal cylindrical fluid container has been investigated. The concept of liquid sloshing in horizontal cylinders was utilized for the purpose of designing the tuned liquid damper.

The research involved a multiple pronged approach which started with a detailed first principles approach of utilizing concepts from fluid mechanics to obtain a mathematical model of liquid sloshing in two different shaped containers (rectangular vessel and horizontal cylinder). These results were utilized to size the appropriate cylindrical vessel to be used as the tuned liquid damper. This analytical study was then extended to include Rayleigh and Lagrangian dynamics in order to transform the governing expressions obtained in the fluid domain to an equivalent mathematical model in the conventional mechanical domain (mass spring damper model).

A second approach involving the use of Solidworks fluid simulation was utilized to simulate liquid sloshing in a horizontal cylinder and the results were corroborated with both the mathematical models (fluid domain and conventional mass domain).

The results from both these studies were experimentally corroborated by building a research prototype and testing on the existing Tuned Mass Damper equipment in the vibrations lab. The research study culminated in the creation of a student-friendly Tuned Liquid Damper product which could be utilized as laboratory equipment both in the undergraduate and graduate vibrations courses of the Mechanical Engineering curriculum.

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