TOPIC OF A COMPETITION PROMOTING STUDENT ENGAGEMENT IN SCIENTIFIC ACTIVITIES

Topic: **Investigation of the Vibrations of Piezoelectrically Actuated Exponentially Tapered Beams**

Goal: Investigate the forced vibrations of exponentially tapered beams for vibration isolation

Smart structures incorporating piezoelectric materials have attracted considerable attention in aerospace, mechanical, civil, and precision engineering applications because of their ability to sense and control structural vibrations. Piezoelectric actuators can generate mechanical deformation when subjected to an applied electric voltage, making them suitable for active vibration suppression and control.

At the same time, tapered beam, i.e., beams with non-uniform cross-sections, provide opportunities for reducing structural weight and tailoring stiffness and strength along their length. An exponentially tapered beam is a particularly important non-uniform beam in which the cross-sectional dimensions vary exponentially along its length. Because both the mass and flexural rigidity change continuously along the beam, its vibration characteristics differ significantly from those of uniform beams. Understanding these characteristics is essential for predicting resonance, dynamic stability, and structural performance.

The main aim of this research is to investigate the vibration characteristics and active vibration control of piezoelectrically actuated exponentially tapered beams, to achieve the following:

- Develop the mathematical model governing transverse vibration of an exponentially tapered beam.
- Determine the natural frequencies and corresponding mode shapes for different boundary conditions.
- Develop a mathematical model for the coupled mechanical and electrical behavior of an exponentially tapered beam with piezoelectric actuators.
- Evaluate the effectiveness of piezoelectric actuation for active vibration suppression.

The research is expected to establish the relationship between exponential tapering and the dynamic characteristics of piezoelectrically actuated beams. The study is anticipated to demonstrate that appropriate selection of the taper ratio and piezoelectric actuator configuration can significantly alter the natural frequencies and reduce vibration amplitudes. The results will provide useful information for predicting and controlling vibration in tapered structural components. The findings may contribute to the design of lightweight and vibration-resistant structures used in aerospace, mechanical, civil, and other engineering applications.

Student level: Fourth year or Master student.

Required skills: understanding of vibrations and dynamics, programming skills in Matlab and Python, experience with electronics projects is plus, experience with structural mechanics is a plus.

Supervisor researcher/lecturer: Samer Houri