Research Experiences for Teachers and Young Scholars in Advanced Self-Powered Systems of Integrated Sensors and Technologies (ASSIST)

Efficient Aeroelastic Energy Harvesting from HVAC Ducts

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Overview

Energy harvesting is an important part of the ASSIST project because it is a way to create a self-sustaining energy source to power wearable devices for people with medical needs from body movement. We are developing an Aeroelastic Energy Harvesting Device (AEHD) that harvests energy from air movement, such as that through HVAC ducts. The energy is created when a piezoelectric material, such as PVFT or PZT, is bent or strained. One way to create that strain is to attach the PVFT/PZT to a rigid body and a filter that can be inserted into the HVAC duct. The rigid body resonates from the air flow which creates a useable electrical current. The AEHD could harvest energy for sensors that are housed within the ducts.

Problem

Battery-powered sensors are used to measure parameters of air quality inside HVAC to maintain a healthy atmosphere for the environments that the air is forced into. However, maintenance is costly and inefficient.

Solution

An integrated, self-sustaining energy source would help to alleviate some of these challenges. However, an energy harvesting device made from a piezoelectric material could power these sensors and reduce maintenance issues.

Harvesting Energy from Air Movement

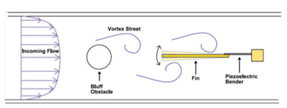
On a larger scale, wind turbines are an example of how energy is gathered from wind. Wind turbines convert kinetic energy into mechanical power which rotates the blades and spins the shaft. A generator is connected to the shaft which converts mechanical energy into electricity. However, wind turbines are complex, expensive to manufacture and require bearings; raising questions about long-term reliability.

When working in a confined environment, a wind turbine is not feasible. Placing a piezoelectric material in the air flow path can also harvest energy from vibration. PZT is used in everyday objects and can also generate energy from bending, straining or vibration.

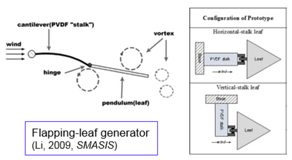
Air Movement = Energy

Through past research and experiment we have found four different methods of generating energy from air-induced vibration. These methods include vortex induced vibration, galloping, flutter and harmonia inspired device. Galloping had best results with minimal change in the existing system.

- Vortex induced vibration

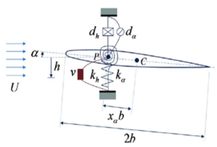


Vortex shedding induced energy harvester (Weinstein, 2012, *Smart Materials and Structures*)

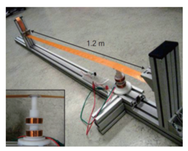


Flapping-leaf generator (Li, 2009, *SMASIS*)

- Flutter

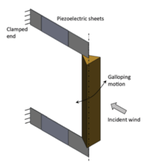


Piezoaeroelastic airfoil (Erturk, 2010, *Applied Physics Letters*)

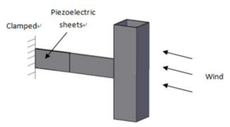


Wind flutter energy harvester with an extendable beam (Fei, 2009, *Proceedings of the 2009 IEEE International Conference on Robotics and Biomimetics*)

- Galloping

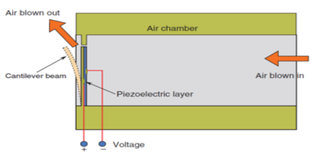


Galloping energy harvester with equilateral triangle cross-section tip body (Sirohi, 2011, *Journal of Intelligent Material Systems and Structures*)



Galloping energy harvester with rectangle cross-section tip body (Zhao, 2012, *SMASIS*)

- Harmonica inspired device

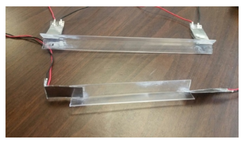


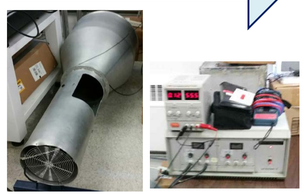
Flow-induced self-excited generator Bibo, 2011, *Journal of Intelligent Material Systems and Structures*)

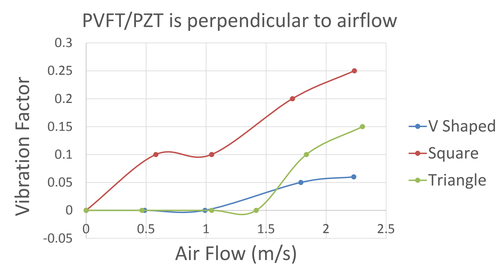
Evaluation of Harvester Designs

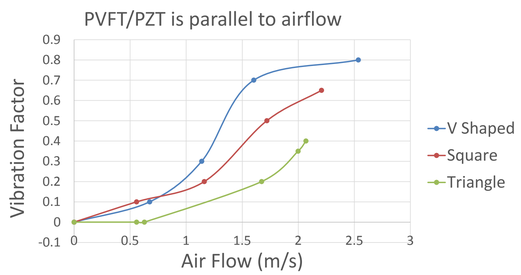
We are developing devices that would power the sensors from the air movement already flowing through the ducts. Testing and designing in MatLab has shown that a galloping 'V'-Shaped design for the AEHD will give the most energy output. The devices are tested in the simulation wind turbine to determine if the movement created will produce energy with a measurable resonation.

'V' Shaped Energy Harvesting Device → Air flow output is controlled for maximum output → V-Shaped Galloping parallel to air flow produced most resonation









Challenges Ahead

There are challenges involved is designing the most effective and efficient AEHD to get the most energy output from air flow in HVAC ducts.

- The air flow moving through the ducts fluctuates at varying speeds and intensity and, at times, does not flow at all.
- The AEHD needs to be most effective without a creating pressure drop.
- The AEHD must have a design that integrates well into the existing system.

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