Industry Partners

Energy Harvesting Using Magnetostrictive Devices

MEng Group Project

James McAdam, Eilidh Scott Dickins, Jonathan Biggin, Colin Fraser

Department of Electronic and Electrical Engineering, Strathclyde University

Supervisor Dr. Martin Judd

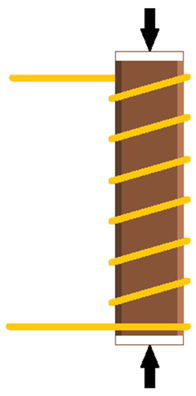
Theory & Simulation

What is Magnetostriction?

This is a property of all ferromagnetic materials, and is their ability to change physical shape under the influence of magnetic fields. When transformers hum, we are hearing the time-varying expansion and contractions of iron under the influence of the magnetic fields associated with the transformer.

How do we get Energy?

Energy Harvesting is possible by exploiting the opposite of this, known as the Villari Effect. Where we stress the material longitudinally and induce a changing magnetic field. This field is then transferred into a time-varying current through a pickup coil as shown.



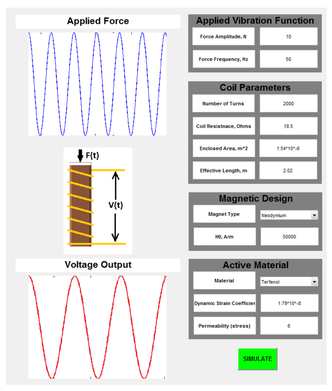
Matlab Simulation

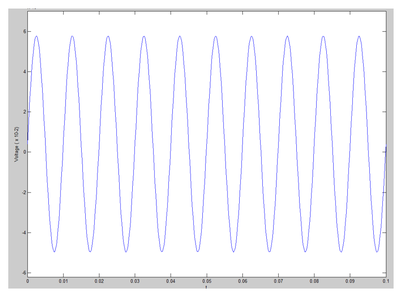
$$B = f(\sigma, H)$$

$$B = M\sigma + \mu H_T$$

$$\sigma = \sigma_0 + \sigma_{Asin}(\omega t)$$

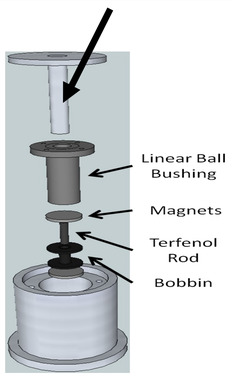
$$V(t) = NA\frac{dB}{dt}$$



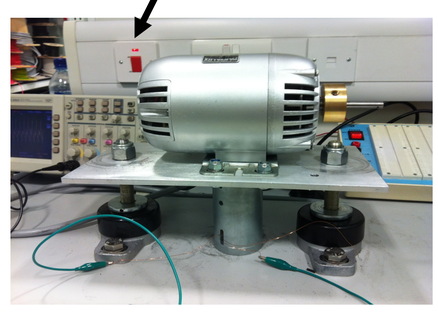


Implementation

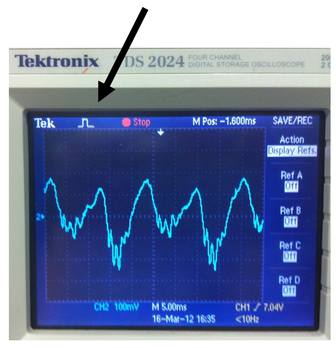
Design Test Block



Build Rig



Output 1.5mW



Initial Testing

ProEngineer was used to model a simple harvesting device that would translate vibrations from a motor into a linear force that acts on a magnetostrictive material. The linear bushing ensures that the 3-Dimensional vibrations act in one direction to protect the low tensile strength Terfenol-D.

Subsequently, a small motor was placed on a plate and the harvester positioned underneath. With the motor screwed down onto the harvester an oscilloscope was attached and around 1.5mW was produced.

Application

2 Distinct areas of future application were conceived: One heading towards miniaturisation and condition monitoring and the other towards large-scale Green mounts for engines.

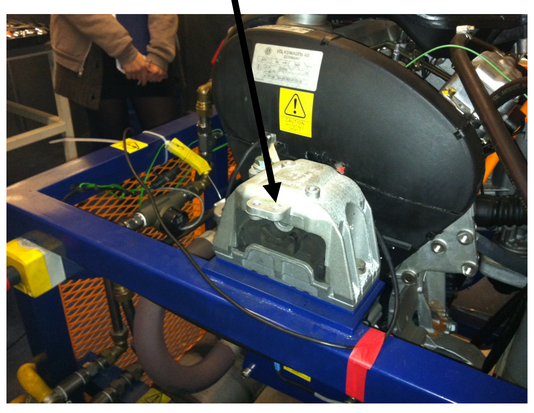
Large Scale

Large diesel engines such as this one, which as a1.9l VW based in the University of Strathclyde, are heavy and mounted with large blocks made of rubber and metal.

There is great potential to combine a large (or multiple) harvesting module within this arrangement. We predict useful energy being created per mount of 10s of Watts.

Work is being carried out to assess the impact of harvesting on the primary function of dampening the vibration.

Large industrial diesel engines produce lots of vibration, generally damped by rubber mounts like this.



Small Scale

As condition monitoring becomes more and more prevalent there has been a drive towards self-powered wireless sensor networks. Magnetostrictive Energy harvesting is suitable for this application as it can operate over a lifetime of cycles with no degradation and does not saturate like Piezoelectric technologies.

This concept design shows a small scale module, combining harvesting, sensing and transmitting capabilities. We envisage that a harvester producing around 1mW could be built using Magnetostrictive Energy Harvesting technology.