ENERGY HARVESTING FROM WATER FOR LOW-POWER SYSTEMS

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Abstract
An evaluation of an energy harvesting system for scavenging energy from water is presented. The system harvest energy form induced water vortexes using piezoelectric materials and small cylinders. Preliminary results show that some of the configurations can generate a power of up to 0.31 μW.

I. INTRODUCTION

Energy harvesting systems have been in the last two decade a subject of growing interest for engineers and scientists, and currently it is a very active research area. One main motivation is to find alternatives (or complements) to batteries as the main power source for low-power electronics. This is particularly important for systems where the devices are in remote locations of difficult access or with certain risks, or for cases where distributed sensors networks make prohibitive changing the batteries and is important to keep maintenance to a minimum. Additional advantages of energy harvesting systems are the reduction on costs in maintenance and the sustainable source of energy with little impact to the environment.
Currently, most energy harvesters are able to scavenge energy from the environment in the order of micro to milliwatts, which is suitable for some of today sensors and microelectronic systems that can run under very low-power conditions. Most common energy sources for harvesting are light (as solar energy), motion (as structural vibrations), heat (from temperature gradients), or electromagnetic (from Radio Frequency waves).
One of the energies that can be harvested in underwater applications comes from vortex induced vibrations in water currents. There are many different methods for scavenging energy from mechanical vibrations, and we use piezoelectric materials, this are interesting for vibration applications because they have an internal crystalline structure that provides them with the property of generating an electrical charge when subjected to a mechanical stress, and vice versa, to produce a mechanical strain when subjected to an electrical field.

II. SYSTEM DESCRIPTION

The flow downstream of an object placed perpendicularly to uniform current is characterized by the alternated and periodic detachment of vortexes (Kármán vortex street). The vortex shedding generates on the body lateral periodic forces that promote lateral vibrations (in a plane perpendicular to the incidental current), as shown in Figure 1b.

A water channel has been implemented on a hydraulic bench at the Fluid Mechanics Department of the UPC. The bench is powered by an electric pump of 0.37 kW, which can produce a water flow of up to 0.001 [m3/s].
The bench has been modified to accommodate a small open water channel of 45 cm x 7 cm x 18 cm test-section, which allows a maximum fluid velocity of 11 cm/s. To reduce rotational flow and turbulence the channel has a laminar flow head constituted by a large plurality of small area flow paths of 15 cm length which occupy the channel's transverse area.
For the test, a cylinder suspended by a cantilever beam is located in the center of the channel, where the laminar flow is present. The cantilever, that has a piezoelectric film on his sides, is positioned in a way that it can move freely only perpendicularly to the water flow, as shown in Figure 1b. Because the cylinder

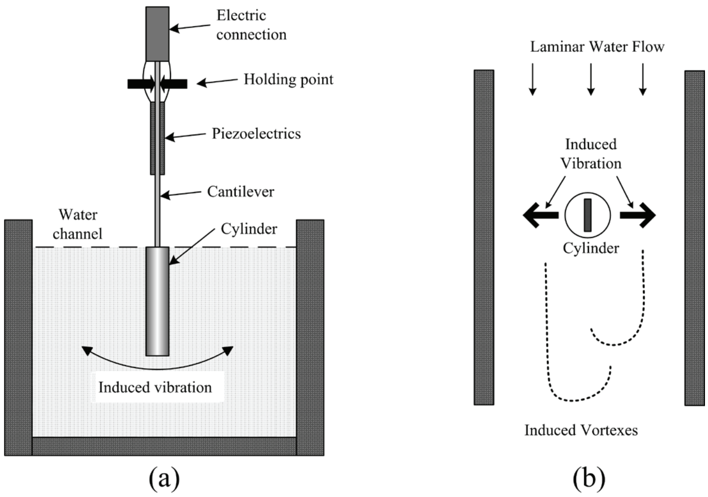


Figure 1 Energy harvesting system. (a) Side view. (b) Top view.

induces vortexes in the water, these in their turn produce lateral forces on the cylinder, which oscillates at the same frequency that vortexes are generated. The energy of these oscillations is harvested with the piezoelectric mounted on the cantilever. The piezoelectric used for harvesting energy is the Volture V22BL device, from MIDE. It is a cantilever of 5.2 x 0.6 cm, with two layers of a piezoelectric material, one on each side.

III. EXPERIMEMTS

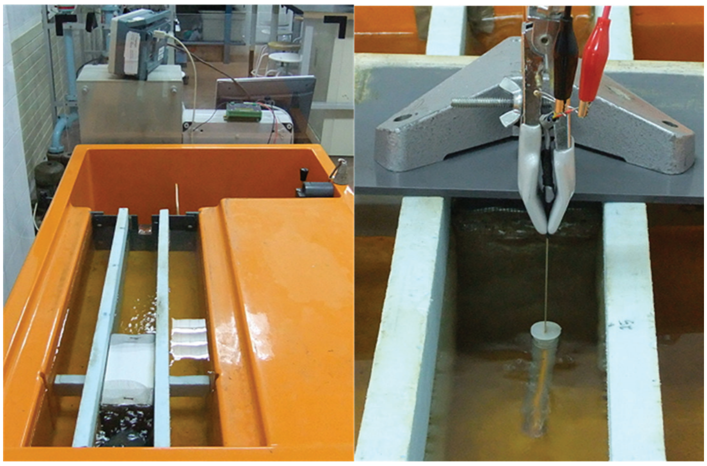
The system used for the experimental is shown on Figure 2. A supporting rod with a clamp is used to hold the harvester system in the middle of the channel. The velocity of the water flow is set to 11 cm/s. Three different parameters are evaluated: the frequency response, the voltage and the power generated.
On Figure 3 the acquisition of the voltage from a cylinder of 0.58 cm in diameter is shown. Here it is possible to appreciate that the amplitude of the signal is not constant. Variations are due to the variability found in the vortexes generation. The frequency response of each cylinder is shows in Figure 4. The power delivered from the energy harvesting system is shown in Figure 5. The maximum voltage from these experiments was 555 mV, and the minimum was 140 mV.

From the obtained voltages and the resistive load, the available power was computed using the well known equation P = V2/R. Because R = 1MΩ, the maximum power was found to be P = 0.31 μW.

IV. CONCLUSIONS

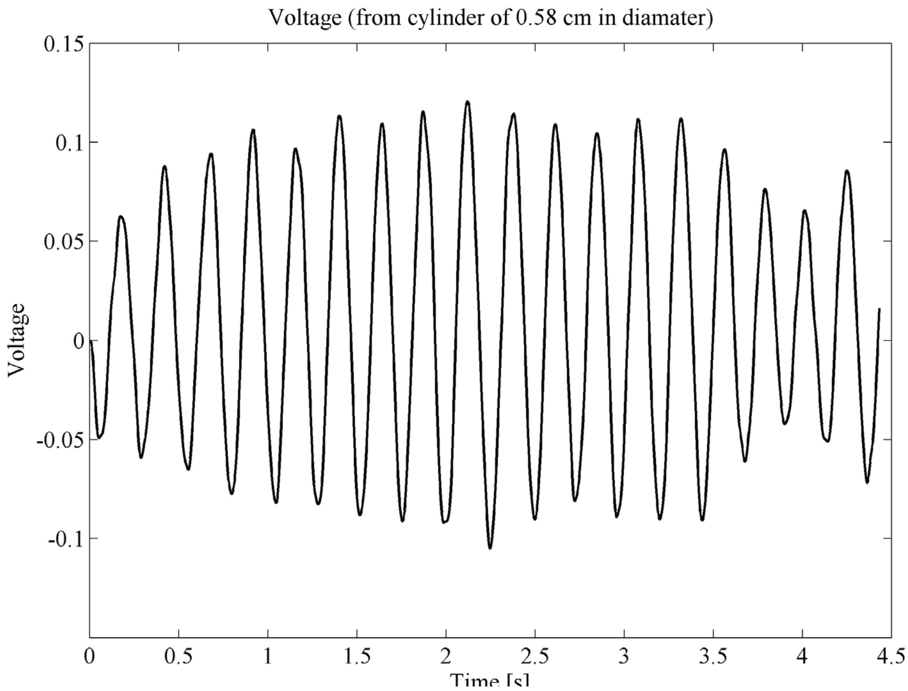
On this paper we have presented an evaluation of an energy harvesting system based on induced vortex in water. The vortexes are induced by a set of cylinders of different size, weight and diameter, in a laminar flow of water, and the harvester is a piezoelectric coupled in a cantilever that holds the cylinders in the flow. The experiments have been carried out in a hydraulic bench in laboratory, and the results show that the proposed sys-

tem is able to scavenge energy from the vibrations generated by vortexes.
This paper is a fragment of a paper presented at the IEEE-I2MTC 2012 congress: “Piezoelectric Energy Harvesting from Induced Vortex in Water Flow”



(left) Figure 2. Pictures of the hydraulic bench, the implemented channel and one of the cylinders under test.

(below) Figure 3. Time history of the voltage acquired, for a water speed of 11 [cm/s]



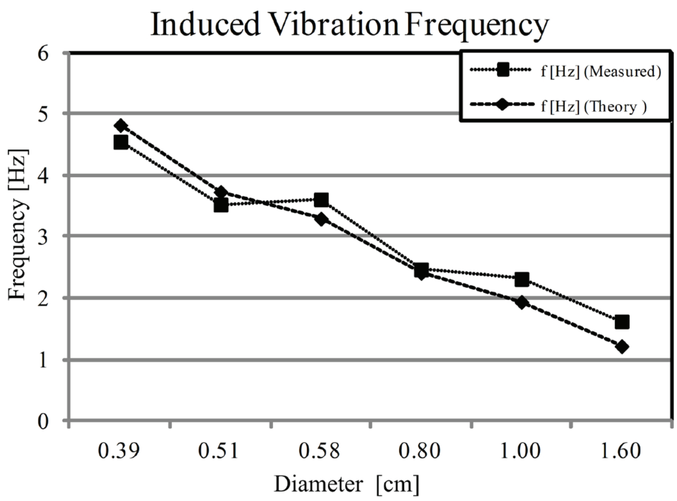


Figure 4. Frequency Vs. Diameter test results with the different cylinders, with a velocity of 11 [cm/s]. Also the theoretical frequency calculated.

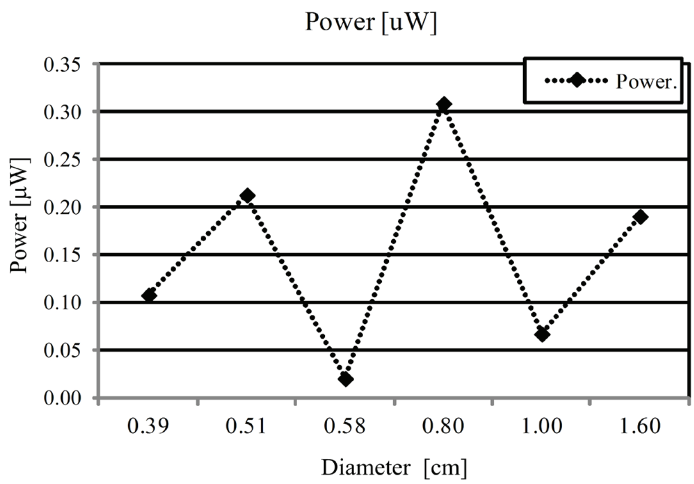


Figure 5 Power in W from tests with the different cylinders, with a velocity of 11 [cm/s].