OSCILLATING BLADE DESIGN FOR ENERGY HARVESTING IN AUTONOMOUS SELF-POWERED FLOWMETER

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ABSTRACT

This paper presents the development of an energy harvesting mechanism that will power an autonomous flowmeter in the range of miliwatts (mW). More specifically, the power needed to develop a self-powered flowmeter is around 5 mW. The proposed conceptual design consists of a novel blade that has a bluff leading edge and is numerically studied.

INTRODUCTION

Energy harvesting is called the process by which small amount of power that otherwise would be wasted as heat, vibration or kinetic energy is captured and used. The proposed shape of the blade leads to the creation of vortices that force the oscillation of the blade. The motion of the blade is a one degree of freedom (1DOF) rotation. At the blade's axis of rotation an electric generator is going to be coupled. This generator is modeled with the use of a damper. The behavior and the performance of the proposed energy harvester is examined with three dimensional, transient, turbulent simulations in the Reynolds number (using as a characteristic length the pipe's diameter) range of $112248 \leq Re \leq 1571475$. An investigation of the effect of various parameters on the motion and performance of the energy harvester is being made. So, the effect of the blade's span length, the effect of the flow velocity, the effect of the damper, the effect of the pipe's diameter and finally the effect of using winglets are investigated.

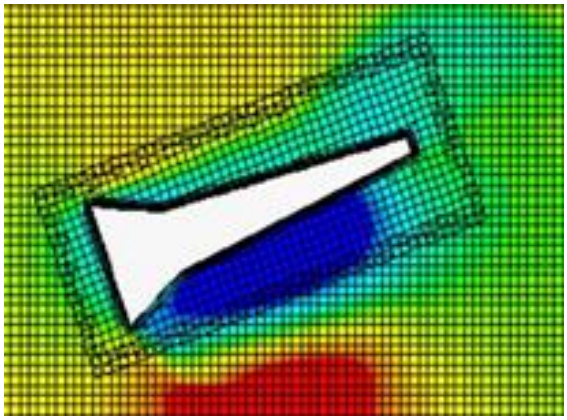

Figure 1. Proposed blade with bluff leading edge

RESULTS AND DISCUSSION

The main findings of the present work can be summarized as follows:

- The effect of the blade's span length is a crucial parameter that can lead to the oscillation or not of the blade.
- Furthermore, the effect of the damper is also of great importance, since it is the parameter that defines the energy that is going to be extracted for given flow velocity and dimensions.
- Finally, for a flow velocity of 2 m/s inside a pipe of DN200, the maximum power that can be extracted is around 50 mW.

REFERENCES

1. O.Goushcha, H.D Akaydin, N. Elvin, Y. Andreopoulos (2015) “Energy harvesting prospects in turbulent boundary layers by using piezoelectric transduction”, Journal of Fluids and Structures, v54, April 2015, pp. 823- 847.
2. Xiaobiao Shan, Rujun Song, Bo Liu, Tao Xie (2015) “Novel energy harvesting: A macro fiber composite piezoelectric energy harvester in the water vortex”, Ceramics International, In press.
3. Lin Ding, Li Zhang, Chunmei Wu, Xinru Mao, Deyi Jiang (2014) “Flow induced motion and energy harvesting of bluff bodies with different cross sections”, Journal of Energy Conversion and Management, v91, 2015, pp. 416 - 426
4. A.Mehmood, A.Abdelkefi, M.R.Hajj, A.H.Nayfeh , I.Akhtar, A.O.Nuhait (2013) “Piezoelectric energy harvesting from vortex – induced vibrations of circular cylinder”, Journal of Sound and Vibration, v332, May 2013, pp. 4656- 4667.
5. D. Hoffmann, A. Willmann, R. Göpfert, P. Becker, B. Folkmer and Y. Manoli (2013) “Energy Harvesting from Fluid Flow in Water Pipelines for Smart Metering Applications”, Journal of Physics, Conference Series 476 (2013).
6. P. Becker, B. Folkmer, R. Göpfert, D. Hoffmann, A. Willmann and Y. Manoli (2013) “Energy Autonomous Wireless Water Meter with Integrated Turbine Driven Energy Harvester”, Journal of Physics, Conference Series 476 (2013).
7. Qiang Zhu (2012) “Energy Harvesting by a Purely Passive Flapping Foil from Shear Flows”, Journal of Fluids and Structures, v34, October 2012, pp. 157- 169.
8. A.S. Bahaj, W.M.J. Batten, G. McCann, (2007) “Experimental verifications of numerical predictions for the hydrodynamic performance of horizontal axis marine current turbines”, Journal of Renewable Energy, v32, October 2007, pp. 2479 – 2490.
9. Quan Wen, Robert Schulze, Detlef Billep, Thomas Otto, Thomas Gessner, (2014) “Modeling and Optimization of a Vortex Induced Vibration Fluid Kinetic Energy Harvester”, Journal of Procedia Engineering, v87, pp. 779 – 782.
10. Miguel Piñeirua, Olivier Doaré, Sébastien Michelin, (2015) “Influence and optimization of the electrodes position in a piezoelectric energy harvesting flag”, Journal of Sound and Vibration, v346, March 2015, pp. 200 – 215.
11. Marco Demori, Marco Ferrari, Vittorio Ferrari, Stefano Farisè, Pietro Poesio, (2014) “Energy Harvesting from Von Karman Vortices in Airflow for Autonomous Sensors”, Journal of Procedia Engineering, v87, pp. 775-778.
12. Hunkee Cho, Qiang Zhu, (2014) “Performance of a flapping foil flow energy harvester in shear flows”, Journal of Fluids and Structures, v51, October 2014, pp. 199 – 210.
13. Firas Siala, James A. Liburdy, (2015) “Energy harvesting of a heaving and forward pitching wing with a passively actuated trailing edge”, Journal of Fluids and Structures, v57 , May 2015, pp. 1 – 14.
14. John Young, Joseph C.S. Lai, Max F. Platzer, (2014) “A review of progress and challenges in flapping foil power generation”, Journal of Progress in Aerospace Sciences, v67, January 2014, pp. 2 – 28.