Energy harvesting using soft dielectric elastomers

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With the rapidly increasing number of portable smart devices and sensors a great deal of research focus has been concentrating on power these devices without conventional batteries. Energy harvesting from ambient vibrations, among other well accepted methodologies like wind and solar energy, remains a topic of high interest. Vibrational energy harvesting consists of two major parts: the method of converting mechanical energy to electrical and the physical concept of the device that dictates how the vibrational energy is captured. The former currently consists of four types of methods: piezoelectric (PE), electromagnetic (EM), electrostatic (ES) and triboelectric (TE). The PE and EM methods have been thoroughly investigated in last decade, whereas the (ES) and (TE) have been explored less. However the physical concept also plays an important role and it has been shown that using nonlinear vibrations for energy harvesting is more efficient than using linear ones.

This presentation discusses the idea of nonlinear energy harvesting by implementing a vibro-impact and non-impact interaction of a rigid ball with Dielectric Elastomer (DE) membrane thereby introducing a novel concept for a vibrational energy harvesting device. The proposed generator consists of two dielectric (DE) membranes coated with compliant electrodes, which when cyclically deformed by a ball. Input voltage is supplied to the membranes for converting the ball kinetic energy to electrical using ES principle. This novel design consists of a heavy ball, either moving freely inside the externally excited capsule, or sandwiched between two DE membranes. Highly nonlinear dynamic behaviour of both the generators, including a rich deterministic and stochastic dynamics of the ball plays a key part in the efficiency of the device and is the topic of this talk. Bifurcation and stability of the 1:1 and 2:1 vibro-impact motion will also be discussed in the second half of the presentation along with the grazing phenomenon for various the device's layouts.

Keywords: vibro-impact, nonlinear dynamics, energy harvesting, bifurcation, grazing.

Dr. D. Yurchenko was awarded his PhD in Mechanical Engineering from Worcester Polytechnic Institute, MA, USA in October, 2001. From 2001 to 2005 he was an Assistant Professor in the Mechanical Engineering Department of the University of Miami. From 2005 to 2010 Daniil Yurchenko was employed as an Associate Professor in Department of Mathematical Sciences of Saint-Petersburg State Polytechnic University. In 2007 he received his Doctor of Science Degree. In 2010 he was appointed as a Reader in the Mechanical Engineering Department of Heriot-Watt University. Daniil has published over 90 papers, he is a member of Editorial Boards of International Journal of Dynamics, Control and Journal of Complex Systems, Journal of Complex Systems and Applications, International Journal of Energy Engineering, Journal of Geological Resource and Engineering.