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# PIEZOELECTRIC ENERGY GENERATORS IN INCOMESS PROJECT

Piezoelectric (PE) materials represent a class of smart materials that can generate an electric potential when mechanically stressed or deformed. This phenomenon, known as the Piezoelectric direct effect, was discovered by the Curie brothers in 1880.

Various applications use PE materials (transducer devices, electrical generators, fuel lighters, gas stoves, etc.), however their widespread implementation in energy harvesting applications remains a challenge. There are several kinds of PE material, like natural (quartz) or polymeric (PVDF) materials, but ceramic materials, such as lead zirconate titanate (PZT), and macro fiber composites (introduced by NASA in 1999) are the most used ones in such applications. Indeed, they are high-energy density materials. However, ceramic-based PE materials are not lightweight and are inherently brittleness. In addition, the toxicity, the lack of recyclability of several elements (like Pb, Bi, Te, Sb) currently employed in lead-based PE materials, such as PZT, and the risk for supplying rare-earth elements remain a major concern for their utilization at manufacturing companies, due to the spread adoption of sustainability policies. All these drawbacks reduce the range of commercial applications, including powering of IoT-based wireless sensors devices. These reasons encourage the research and development of innovative composite polymer-based PE materials to be implemented in more efficient and reliable Piezoelectric Energy Generators (PEGs).

PEGs exploit the direct piezoelectric effect to convert into electrical energy the waste mechanical energy available in the environment, like for instance the energy related to the mechanical vibrations of a structure or self-excited vibrations due to fluid flows. The InComEss project will demonstrate the applicability of innovative PEGs, equipped with novel PE materials, in Structural Health Monitoring (SHM) applications in the aerospace field. The goal is to use a novel thermo-piezo-electric energy generator (TPEG) to supply electricity to a network of sensors, that measure temperature and strain variations for SHM of the leading-edge flap (slat) of an aircraft wing. The TPEG exploits both the vibration and the thermal gradients available on the slat.

Two approaches are available to convert the mechanical vibration of the slat into electrical energy using a piezoelectric energy generator:

1) resonant harvesters;

2) strain harvesters.

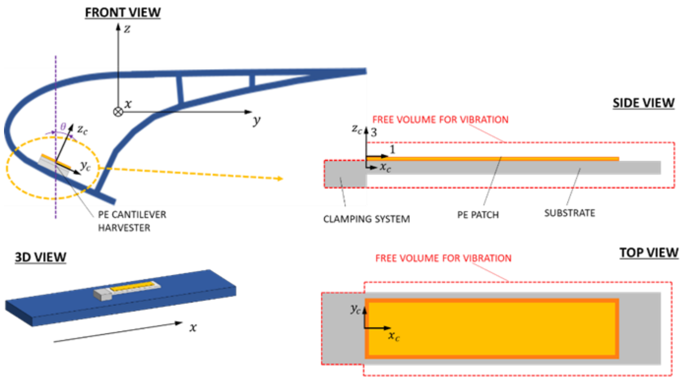

**Figure 1: Scheme of piezo-cantilever harvester**

The first type exploits the phenomenon of resonance. Typically, resonant harvesters assume the form of a cantilever beam, in which the piezoelectric layer is bonded to a structural layer. The cantilever is attached to the vibrating structure and has to be tuned to the frequency of vibration of the structure to optimize the performance.

The second type is represented by a patch of PE material that is directly bonded to the vibrating structure. In this case, no tuning is needed, since the PE patch exploits the mechanical strain which is available. However, in this case, the optimization consists in determining the position on the structure where the strain is the largest.

Figure 1 represents the scheme of a piezo-cantilever harvester installed in the slat of the aircraft while represents a piezo-patch bonded to the skin of the slat. Both types of PEGs were modeled and analyzed in MATLAB and COMSOL, in order to evaluate the performance of the two configurations. The simulations carried out highlighted that a cantilever harvester is much more effective than a strain harvester in terms of generated power, however, the implementation in the aeronautical environment of this device is not easy, due to the volume and mass requested by this PEG. Actually, mass, room, and safety requirements are very stringent in aerospace applications. On the contrary, the strain harvesters can be easily implemented in the existing structure, since the strain harvester is more compact.

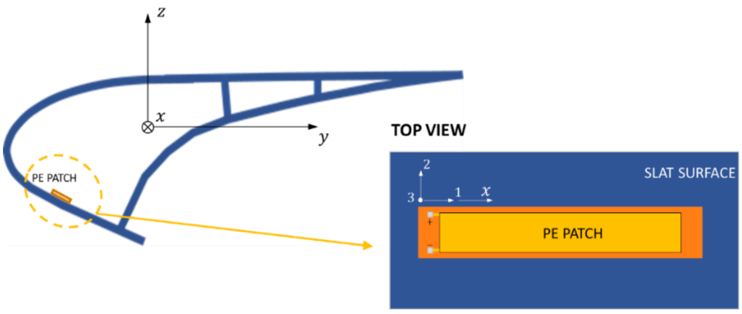

Figure 2: Scheme of a PE patch attached to the slat skin

## Details

**Project title**: INnovative polymer based COmposite systeMs for high efficient Energy Scavenging and Storage

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**Project Consortium:**

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