THESIS ABSTRACT

Energy harvesting represents a very broad field encompassing technologies [1] for converting ambient energy to electrical energy, both on large scale and small scale [2], being yet a little explored field, but attracting an increasing research interest worldwide. Single source scavenging is intermittent and has limitations due to the interruptions occurring when there is not enough ambient energy available [3]. In order to overcome this issue, multisource energy harvesting [4], [5], [6] is required, using several ambient energy sources simultaneously.

The thesis focuses on developing a small-scale multisource energy harvesting system (piezoelectric and thermoelectric). The aim is to harness the energy from the vibrations and heating effects of industrial equipment (rotary bladed machines such as compressors, gas turbine engines, etc.), in order to assess the electrical output and a future storing of enough electrical energy to power wireless sensors monitoring these machines' operation or providing structural health monitoring (SHM) or fault detection.

The thesis aims to validate on a test bench, in relevant industrial conditions, the functionality of piezoelectric harvesters and thermoelectric generators. Thus, within the present thesis, a technology readiness level between TRL 5 and TRL 6 has been achieved, by demonstrating piezoelectric and thermoelectric subsystems in relevant industrial environment.

Previous researches [7], [8], [9], [10] have shown that the output voltage from one device does not suffice to power a demo energy harvesting circuit for wireless sensor nodes (WSN). The piezoelectric alternating current outputs should be rectified with diodes bridges in order to avoid cancelling each other's electrical response if vibrating in antiphase. The rectified electric output is envisaged to charge a capacitor or a rechargeable battery, and then go through a specialized piezoelectric harvesting circuit with embedded sensors.

Thermoelectric generators, with heat sinks for achieving higher thermal to electrical energy conversion efficiency, are envisaged to harness the thermal gradient due to equipment heating during operation [11], [12].

Within the present doctorate thesis, numerical simulations and experimental tests with physical piezoelectric and thermoelectric devices have been conducted, both in laboratory as well as on a compressors test bench. It is worthwhile to mention that the two types of micro energy harvesting principles are basically regarded as incompatible. On one hand, the piezoelectric materials require vibrations and are recommended to operate near room temperature due to exhibiting a decrease in the electric response both at higher and lower temperatures, which can lead to material depolarization. On the other hand, there are the thermoelectric materials requiring high temperatures at the hot side to produce energy, but do not withstand lateral axial forces. However, on a compressor skid, it was possible to install both piezoelectric and thermoelectric devices in optimal spots, after thorough vibrational and thermal analyses.

The multisource energy harvesting system proposed, original through the author's own approach and combination of harvesters, also brings some novelty elements that have not been addressed in the existent literature, and that can be consulted in the author's submitted and published papers during the doctoral stage (2019-2024).