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Investigation of the Performance of Thermoelectric Energy Harvesters Under Real Flight Conditions

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Energy-autonomous wireless sensor nodes (WSNs) in aircraft, acting as health monitoring systems (HMS), have the potential to reduce aircraft maintenance costs. Thermoelectric energy harvesting is a solution for self-powered systems, since it captures enough energy to power up a WSN. The energy harvesting device used in this work consists of a thermoelectric generator (TEG) attached to the inner part of the fuselage and to a thermal storage device, in order to artificially enhance the temperature difference between the bottom and the top surface of the TEG during take-off and landing. In this study, the results of 28 flight tests during a 6-month flight campaign of two identical energy harvesting devices are presented. The results are clustered into two different classes, each having its own characteristics. The two classes comprise typical, similar to standard European short/mid-range flights, as well as atypical flight profiles, where specific flight tests have been performed. In addition, for each class, different parameters such as flight altitudes, flight duration, and temperature profiles are investigated. Moreover, a detailed comparison between a typical and an atypical flight profile is given. In general, for a typical flight profile, the experimental results are in good agreement with simulations predicting the energy output. The average energy output is sufficient to power up a wireless sensor.

Key words: Thermoelectric energy harvesting, thermoelectric generator, wireless sensor nodes, flight test results

INTRODUCTION

Energy-autonomous wireless sensor nodes (WSNs) in an aircraft seem to be an interesting solution for health monitoring systems (HMS). Besides the maintenance costs, which can be as high as 18% of the total costs of a civil aviation company,[1,2] the installation effort is also decreased when choosing this approach. For a self-powered system, energy harvesting is a possible solution, and thermoelectric energy harvesting seems to be the most promising concept.[3] It can capture enough energy for a wireless sensor, and it is a maintenance-free solution. A possible realization is an artificial temperature difference across a thermoelectric generator (TEG), which is created by attaching one side of the TEG to the fuselage and the other side to a container filled with water, which is used as a heat-storage phase-change material (PCM).[4] During take-off or landing, the temperature on the side of the TEG that is attached to the water container changes more slowly, since the thermal capacity as well as its latent heat strongly affect the temperature gradient. A schematic of the idea described above is shown in Fig. 1a, and it is described in more detail in Ref. 5. Two such devices were installed on a real aircraft, and 28 flight tests were performed. This paper presents and evaluates the results and the output characteristics of the device gained during the test flights.

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