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Optimisation of Energy Harvesting for a Composite Aircraft Wing Structure Bonded with Discrete Macro Fibre Composite Sensors

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Abstract : The micro electrical devices of the wireless sensor network are continuously developed and become very small and compact with low electric power requirements using limited period life conventional batteries. The low power requirement for these devices, cost of conventional batteries and its replacement have encouraged researcher to find alternative power supply represented by energy harvesting system to provide an electric power supply with infinite period life. In the last few years, the investigation of energy harvesting for structure health monitoring has increased to powering wireless sensor network by converting waste mechanical vibration into electricity using piezoelectric sensors. Optimisation of energy harvesting is an important research topic to ensure a flowing of efficient electric power from structural vibration. The harvesting power is mainly based on the properties of piezoelectric material, dimensions of piezoelectric sensor, its position on a structure and value of an external electric load connected between sensor electrodes. Larger surface area of sensor is not granted larger power harvesting when the sensor area is covered positive and negative mechanical strain at the same time. Thus lead to reduction or cancellation of piezoelectric output power. Optimisation of energy harvesting is achieved by locating these sensors precisely and efficiently on the structure. Limited published work has investigated the energy harvesting for aircraft wing. However, most of the published studies have simplified the aircraft wing structure by a cantilever flat plate or beam. In these studies, the optimisation of energy harvesting was investigated by determination optimal value of an external electric load connected between sensor electrode terminals or by an external electric circuit or by randomly splitting piezoelectric sensor to two segments. However, the aircraft wing structures are complex than beam or flat plate and mostly constructed from flat and curved skins stiffened by stringers and ribs with more complex mechanical strain induced on the wing surfaces. This aircraft wing structure bonded with discrete macro fibre composite sensors was modelled using multiphysics finite element to optimise the energy harvesting by determination of the optimal number of sensors, location and the output resistance load. The optimal number and location of macro fibre sensors were determined based on the maximization of the open and close loop sensor output voltage using frequency response analysis. It was found different optimal distribution, locations and number of sensors bounded on the top and the bottom surfaces of the aircraft wing.

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