KEYNOTE

MULTIFUNCTIONAL COMPOSITE AEROSTRUCTURES UTILISING DIFFERENT CARBON NANOTUBE ASSEMBLIES

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ABSTRACT

Lightweight carbon-fibre aerostructures, which account for approximately 50% of the structural weight of the latest generation of wide-bodied passenger aircraft, have delivered higher operating efficiencies and lower CO_2/ NO_x emissions per revenue passenger kilometre compared to previous generations. Besides being lightweight, they also exhibit superior fatigue and corrosion resistance relative to their metallic equivalent. Nonetheless, even with these higher efficiencies, while today's CO_2 emissions from aviation account for only 2.5% of global sources, and around 12% of all transportation sources, these percentages are likely to increase significantly over the coming decades. This is due to a combination of a projected increase in demand for air travel, where on average, air traffic is doubling every fifteen years, and concerted efforts to reduce greenhouse gas emissions from non-aviation sources. Consequently, the aviation industry continues to seek new technologies to further minimise its environmental footprint. This includes the development of next-generation lightweight structures with multifunctional capability.

The Advanced Composites Research Group, at Queen's University Belfast, is pursuing the development of multifunctional hierarchical composite aerostructures utilising the combined properties of different carbon nanotube (CNT) assemblies. This keynote lecture will initially focus on the use of CNT webs towards the development of an energy-efficient highly tunable electro-thermal device, suitable for anti-icing/de-icing applications. A CNT web's electro-thermal properties may be tuned by controlling the growth of the CNTs and the number of layers, where it is known that the resistance is inversely proportional to the number of layers. What is particularly novel is the further tailoring that can be achieved by laying up CNT webs at different orientations. Since these webs are highly aligned, they exhibit orthotropic conductivity, and for a given CNT web 'laminate' the resulting conductivity may be predicted using the thermal conductivity theory of anisotropic solids.

This is followed by demonstrating the use of a single CNT web, embedded within an adhesively-bonded structural composite joint, which is shown to be a highly effective strain/damage sensor for *in-situ* structural health monitoring under quasi-static and low/high-cycle fatigue. An exploration of different CNT-based strategies for improving the surface electrical conductivity of composite aerostructures, is presented next, in pursuit of imbuing the structure with adequate lightning strike protection, mitigating the standard practice of incorporating a metallic mesh on aerodynamic surfaces. Other aspects of nano-enhanced composites will be briefly reviewed outlining approaches for increasing through-thickness thermal conductivity and fracture toughness.