CP 4

CONCEPT PAPER

for KIER International Cooperation project

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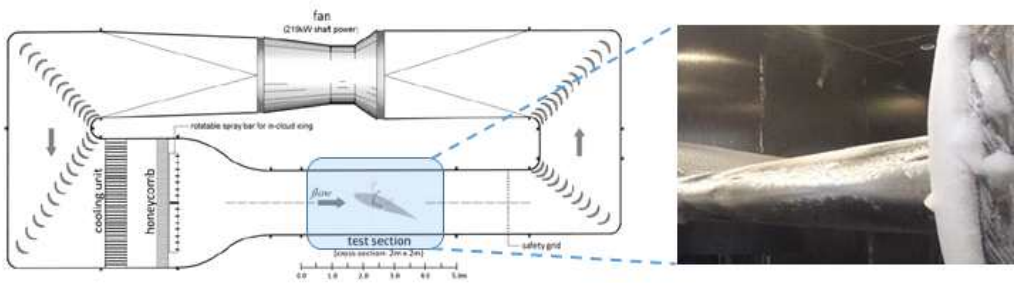
Title	Structure integrated de-icing element using fiber reinforced composite materials			
Barriers to tackle	● Ice build-up poses a number of problems for wind turbine blades and solar panels in cold climate. For wind power generation, up to 20% performance losses can occur due to the changes of blade surface geometry from ice build-up. In addition, imbalanced ice loading increases wear in the structural and mechanical components, which have shown an increase of 10% in total fatigue design loads. ● The primary barrier to overcome is to prevent the de-icing element from becoming a structural load and defect in the target structure and from being an additional factor in the cost of manufacturing composites. In order to meet these requirements, the heating element should be integrated to the target structure to have its own load supporting capability by using high strength light weight materials. In addition, a composites manufacturing process should be developed so that the de-icing element can be integrated simultaneously with the target structure on the resin infusion molding process. ● The secondary barrier to tackle in this project is to develop structure integrated de-icing element to improve the melting time under the thermal resistance of the composite core material, which has been a problem in the existing hot-air based de-icing technology. (a) hot-water spray (b) structure installed hot-air (conventional) (b) structure integrated electro-thermal(proposed)			
Strategy to solve	● Task 1: Structural integration of de-icing surface elements using carbon fiber reinforced composite materials - Design and fabrication of carbon-glass fiber stitched fabrics for surface heating element - Development of composite matrix materials with conductive polymer and nano-fillers to increase electrical conductivity of electrodes - Development of infusion based composites manufacturing process for the simultaneous curing of target structure with heating element			

- Consideration of design load conditions in cold-climate (< - 10°C)
- Target tensile strength of integrated composite materials > 110MPa

- Task 2: Localized heating control of structure integrated de-icing element
  - Development of local heating control techniques for improved heating efficiency
  - Uniform heat generation characteristics under various load conditions
  - Target de-icing time < 10min @ - 10°C cold-climate

- Task 3: Numerical analysis and experimental verification of integrated de-icing structure under cold-climate
  - Modeling and analysis of structure integrated de-icing element for the comparison of weight impact and structural characteristics with conventional reference models
  - Fabrication of test specimen of de-icing structure with composite materials
  - Experimental test in cold-climatic wind tunnel for glaze and rime ice conditions
  - Verification of the design by comparing the numerical and experimental results



(a) Cold-climate wind tunnel (b) test section

Outcomes*

Hard Targets:

- Composite material based structure integrated de-icing element
  - Resin infusion molding based simultaneous curing process
  - 5 % energy loss for heating (current 10% energy loss, hot air based)
- Design of composite materials with carbon-glass fiber stitched fabrics
  - Target tensile strength > 110MPa, tensile stiffness > 10GPa
- Optimized heating control
  - de-icing time < 10min @ - 10°C
- Verification of application effect (concept model for commercialized blade)
  - Less than 10% AEP loss (current 20-25% AEP loss due to icing)

Soft Targets:

- 2 papers and 1 technical patent