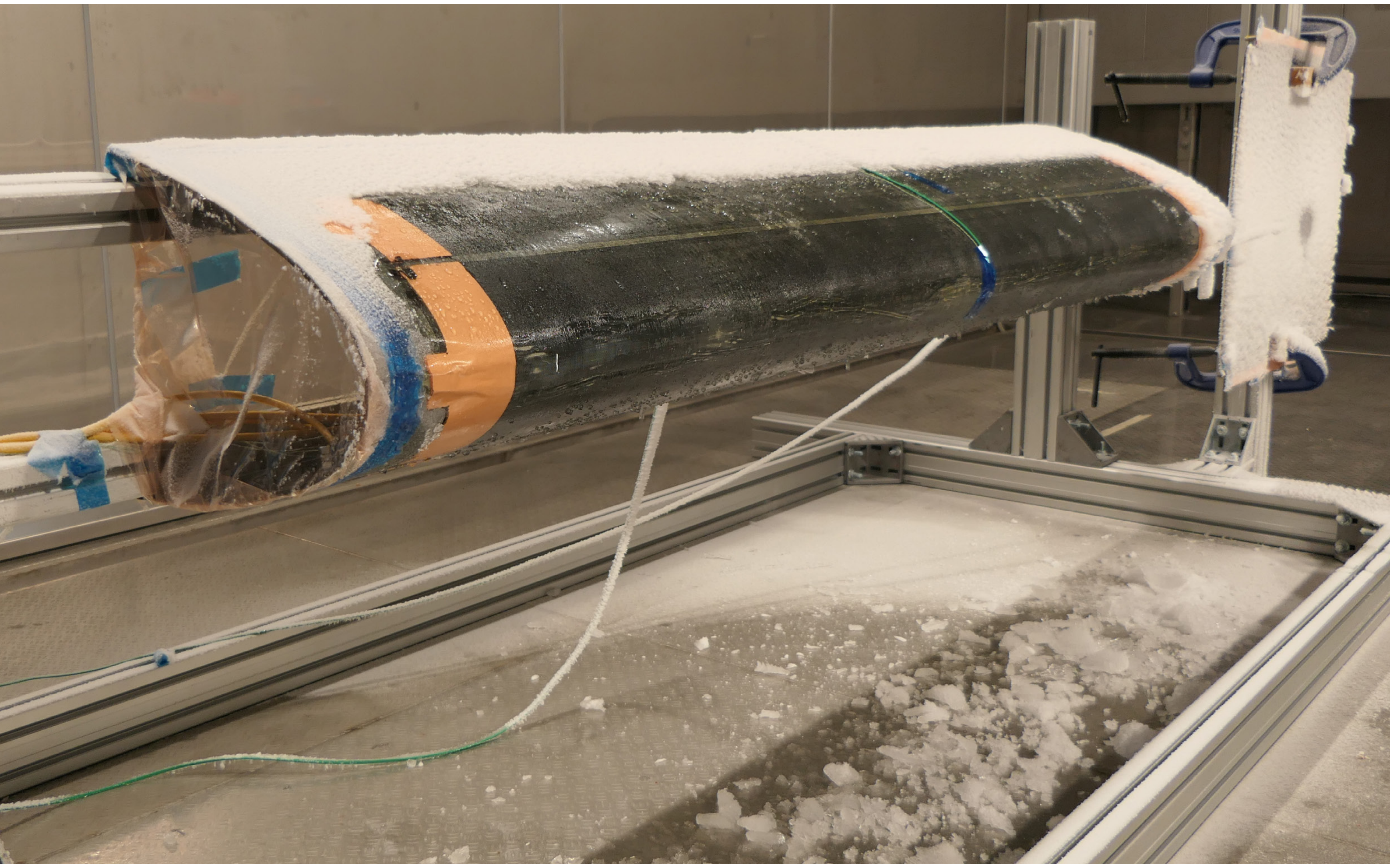
AMRC Composite Centre
Case Study

MASTRO: Developing a thermoelectric anti-icing component for aerospace

Challenge

To develop an electrothermal anti-icing system removing the need of heavier metallic heater elements currently in operation, to stop surface ice build-up in aircraft and automotive applications.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 760940.

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The final demonstrator in a climatic chamber, after being coated in ice at -15 °C, ready for the anti-icing test.

Background

During take-off and landing, an aircraft can experience 'icing conditions' as it passes through clouds at below freezing temperatures. This environment can cause a build up of ice on the surface of an aircraft, which can be a detriment particularly to the aircraft's aerodynamics. If only a few millimetres of ice build up on the surface of the wing, the boundary layer of air can be disturbed and lead to a significant loss of lift, with potentially fatal consequences.

Current anti-icing systems bleed off hot air from the turbine engine and run this hot air through the wing in order to heat it up.

This method works well but makes the engine less efficient. Electrical anti-icing systems based on metallic heater mats are sometimes used to increase efficiency of the engines, however they will soon be a requirement as aircrafts of the future will be electric without the option to use bleed air systems. This work concentrates on development of a thermoelectric anti-icing system, without the weight of metallic heater elements currently used.

Through MASTRO, a three-year Horizon 2020 project, the University of Sheffield Advanced Manufacturing Research Centre (AMRC) has developed multifunctional composites with three different functionalities to move to electrification and reduction in carbon emissions. Working with MASTRO project partner Embraer, these smart functionalities – self-curing, self-sensing and self-anti-icing – have been implemented in an aerospace demonstrator.

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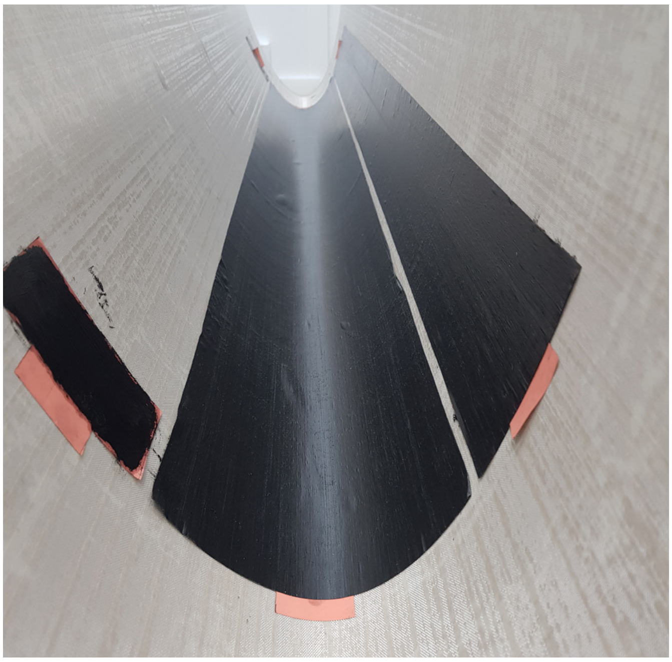
Innovation

The anti-icing system in MASTRO uses the carbon fibres within the component as a conductive heater element, so that additional metallic heater mats are not required to be installed. This solution significantly reduces the weight of the system and means that no additional components have to be added to the manufacture of the component, reducing costs.

This anti-icing system was installed on the MASTRO leading edge demonstrator. Specific unidirectional fibres were laid up near the surface and electrically isolated from the rest of the component. Robust electrodes for powering the system were integrated in the layup. Three zones were laid up to test multiple zone heating, which in an aircraft would be used to ensure that ice melted on the leading edge would not run back and refreeze in another area. The demonstrator was tested in a climatic chamber the University of Sheffield's Lab for Validation and Verification.



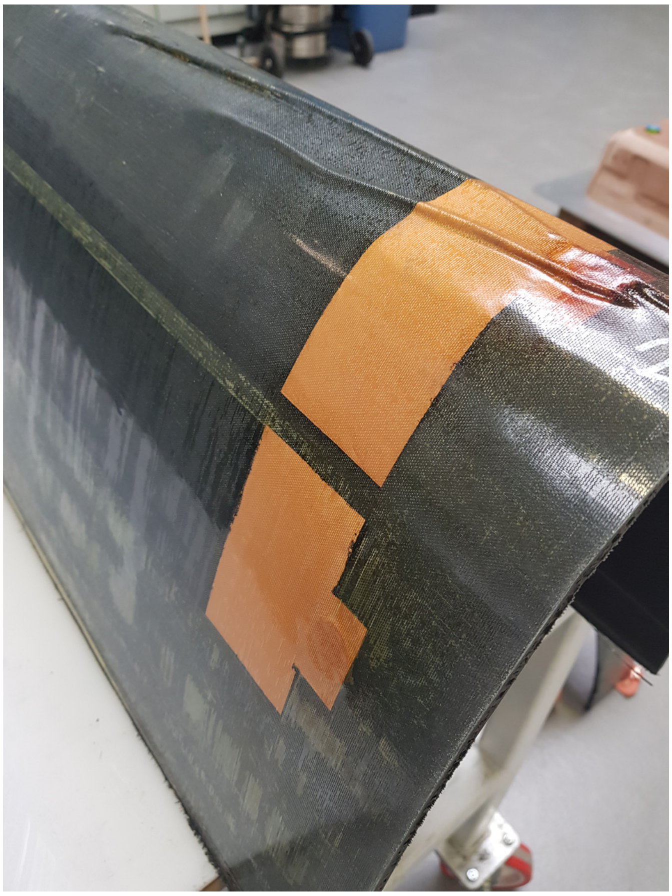
Manufacture of the carbon fibre anti-icing heaters, also showing the copper electrodes with CNT resin applied for low contact resistance.

Results

Manufacture of the component did not interfere with the curing of the component.

To test the anti-icing capability of the heaters, the component was mounted on a frame within the climatic chamber. The temperature was reduced to -15 °C and de-ionised water was sprayed onto the wing section. After a significant amount of ice was built up, spraying was stopped, and the heaters could be turned on. Due to some slight issues in the manufacturing, the heaters could not be run at full power, however even in a low power mode, it was possible to raise the surface temperature of the demonstrator to +6 °C and remove the ice from the surface.

The demonstrator after the anti-icing testing had been completed, showing the difference between where the anti-icing had occurred and where the had been no heaters.



Final component showing the copper electrodes and unidirectional carbon fibre heaters below the glass fibre surface.

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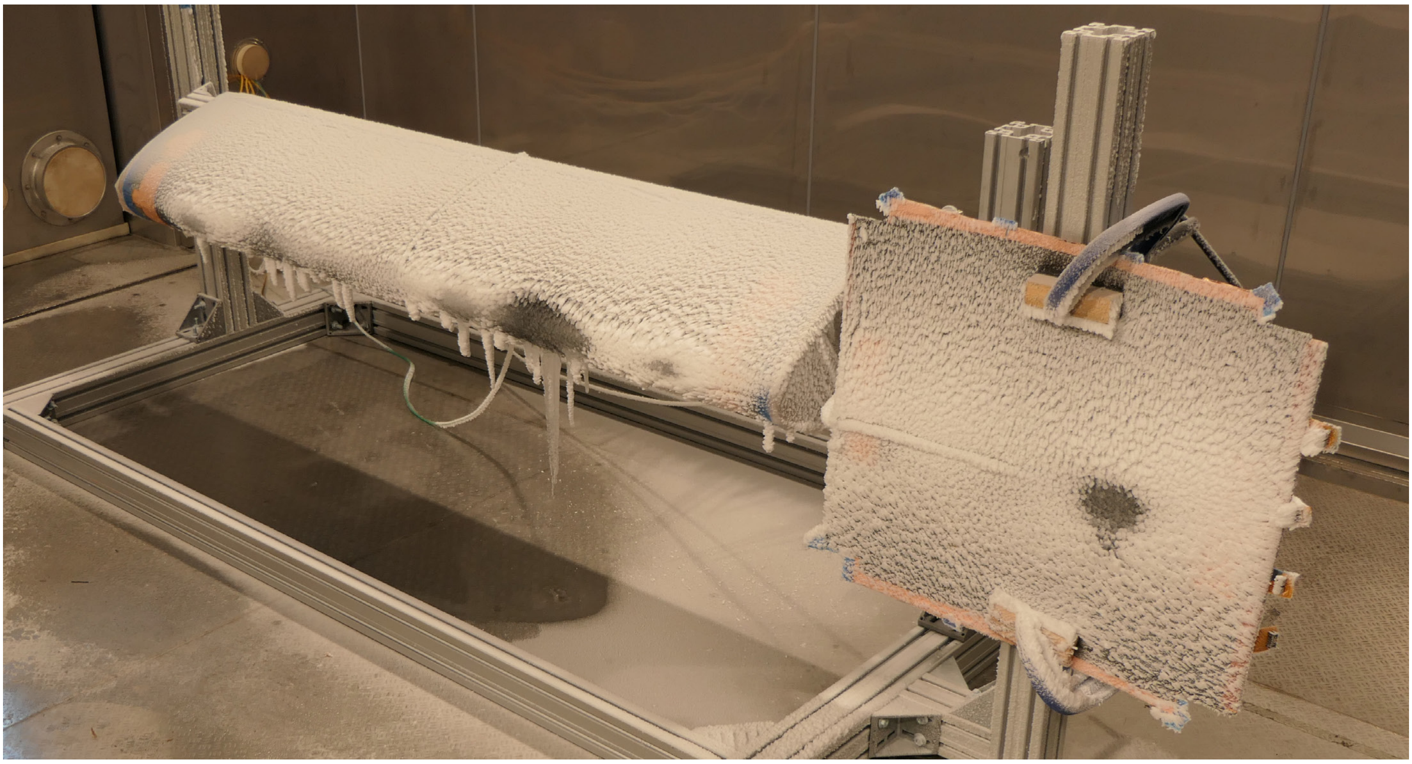

Both the demonstrator and a test panel component covered in ice ready for the anti-icing test.

Impact

This project has shown that it is possible to use structural carbon fibre as a heater element for use in anti-icing scenarios successfully. This allows for lower cost and weight anti-icing systems to be introduced into composite components opposed to traditional metallic based solutions.

Further work is required for tuning the electrical properties of the system to suit aerospace and other sectors that require anti-icing.

This type of low weight anti-icing can also be applied to automotive scenarios, such as clearing ice in aerodynamic sensitive areas for motorsport or heating a cowl cover on a car to ensure window wipers are operational, heating seals to ensure doors do not get frozen and embedding carbon mats in asphalt roads for ensuring roads are safe to drive on.

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For further information please contact Matthew Collinson:

0114 212 6668 | m.collinson@amrc.co.uk | amrc.co.uk

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