Bristol Composites Institute

Model-Driven Design of an Induction Coil for Local Composite Curing Applications

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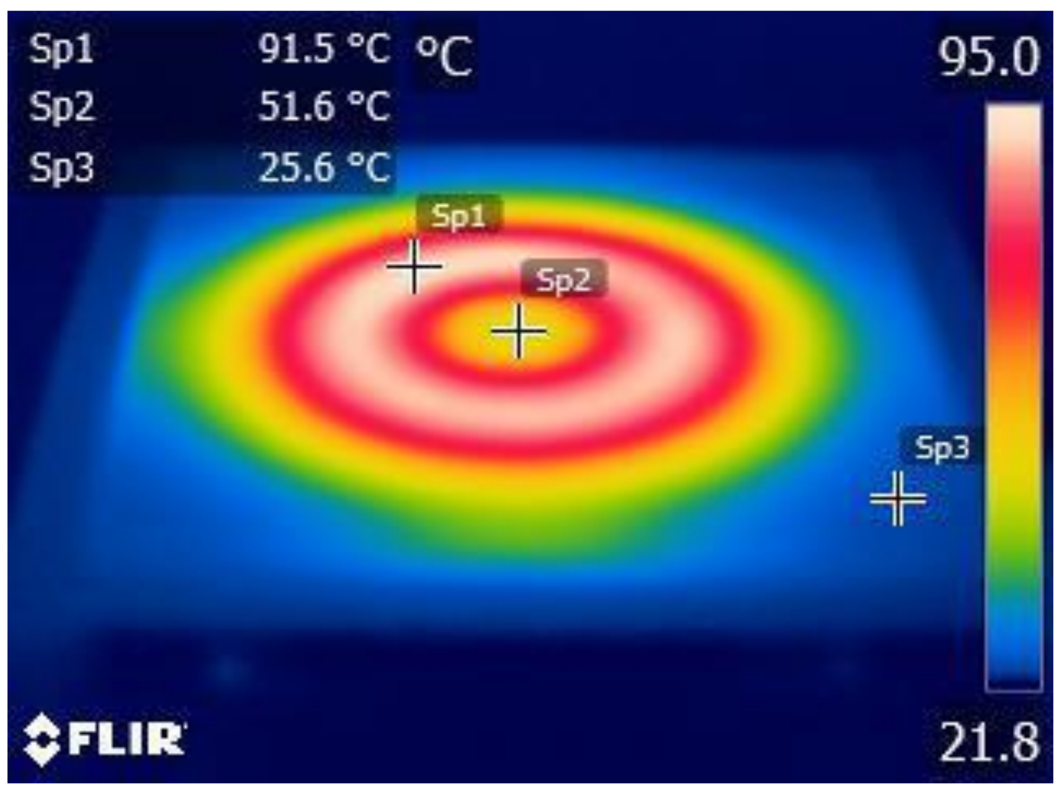
Electromagnetic (EM) induction has great potential in energy efficient manufacturing as it provides rapid, volumetric and localised heating. Heat is induced directly within electrically conductive carbon fibres reducing thermal losses to tooling and producing high heating rates.

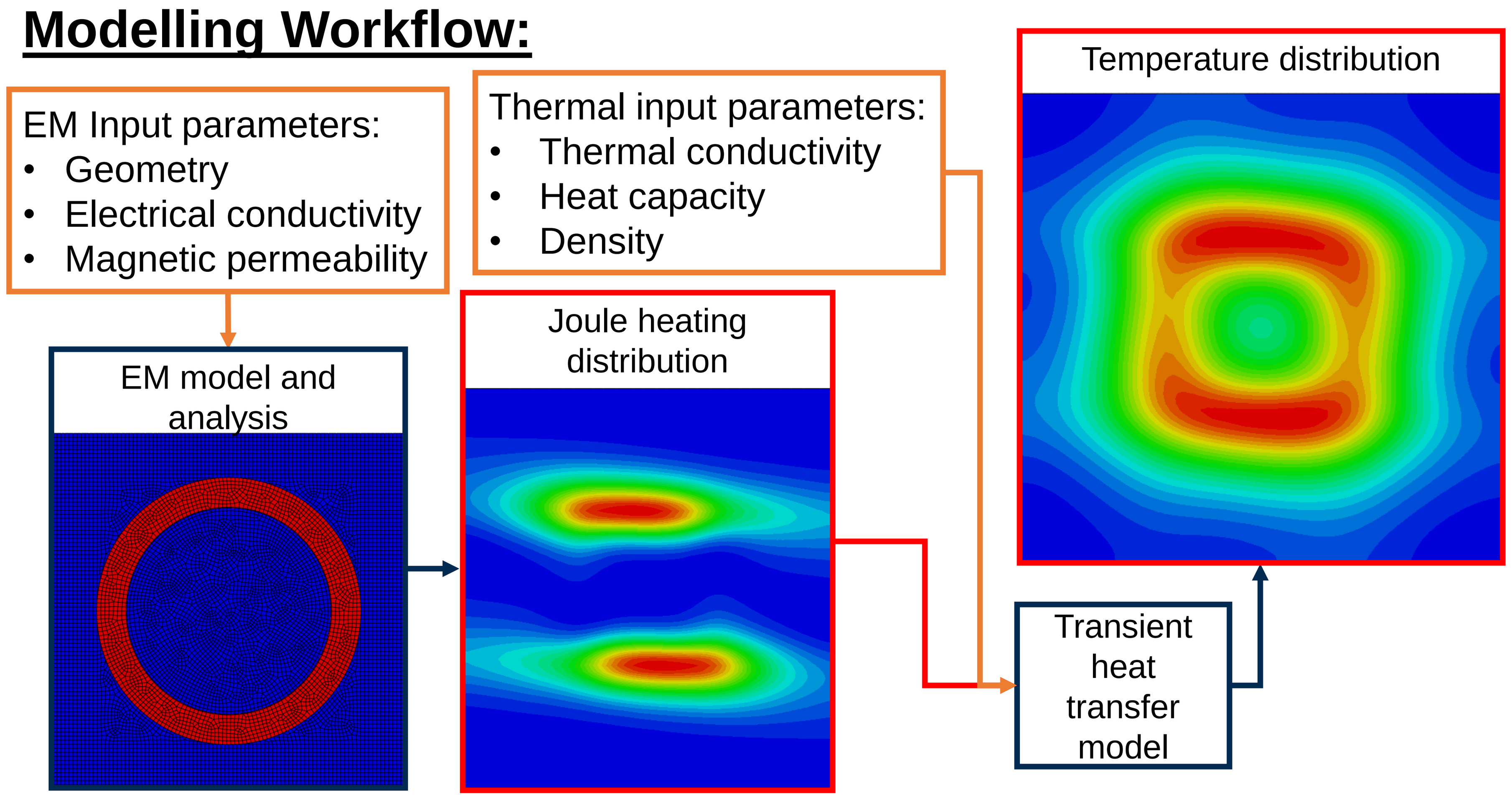
Application of induction to composites is challenging due to (a) non-uniform magnetic field of conventional coil, (b) low electrical and thermal conductivity of CFRP. Sequentially coupled magnetic and transient thermal modelling has been used to optimise the heating process through (i) parametric design of induction coil, (ii) engineering material architecture.

Challenge:



Above: (Left) Photograph showing standard pancake coil design used for metallic processing. (Right) Thermal image showing the ring shaped heating pattern produced using the pancake coil.

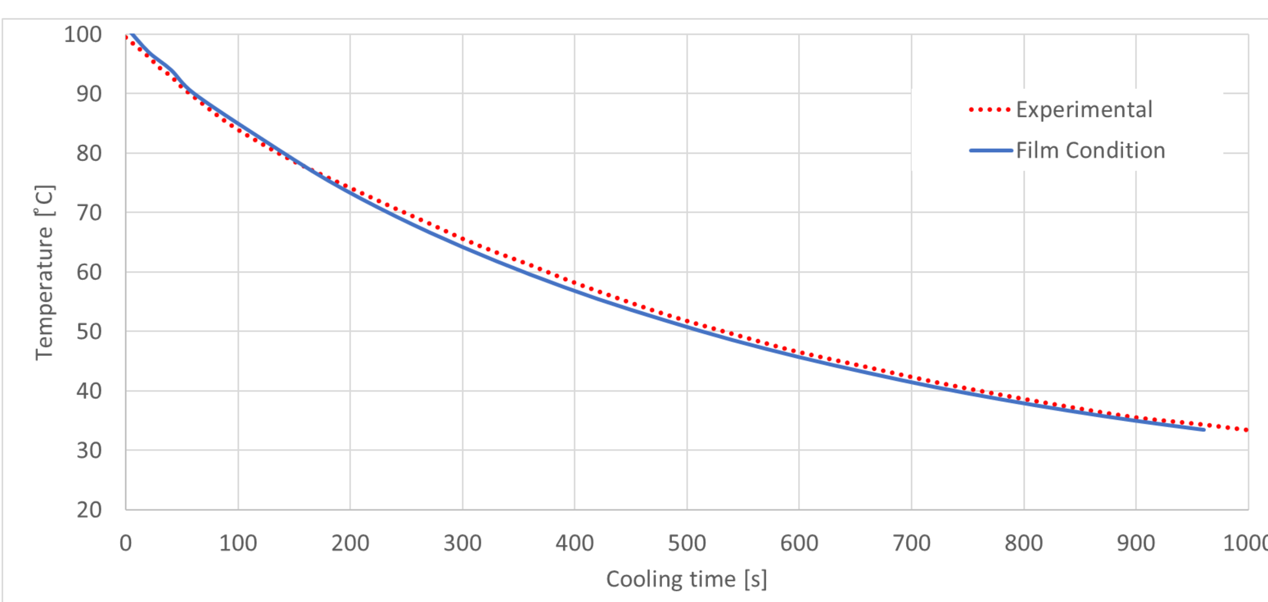
Modelling Workflow:



Model calibration:

Comparison of temperature in carbon fibre laminate between experimental pancake coil and model.

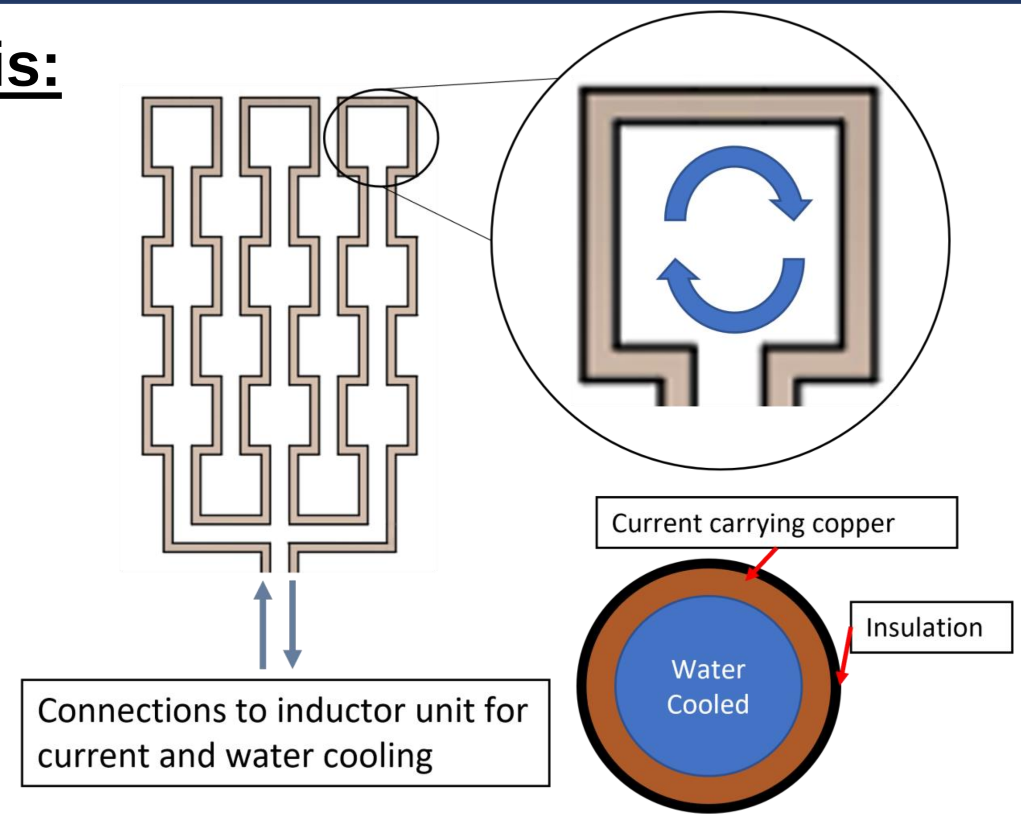
Right: Comparison of cooling rate in lab verses using the applied surface convective film conduction in the model.



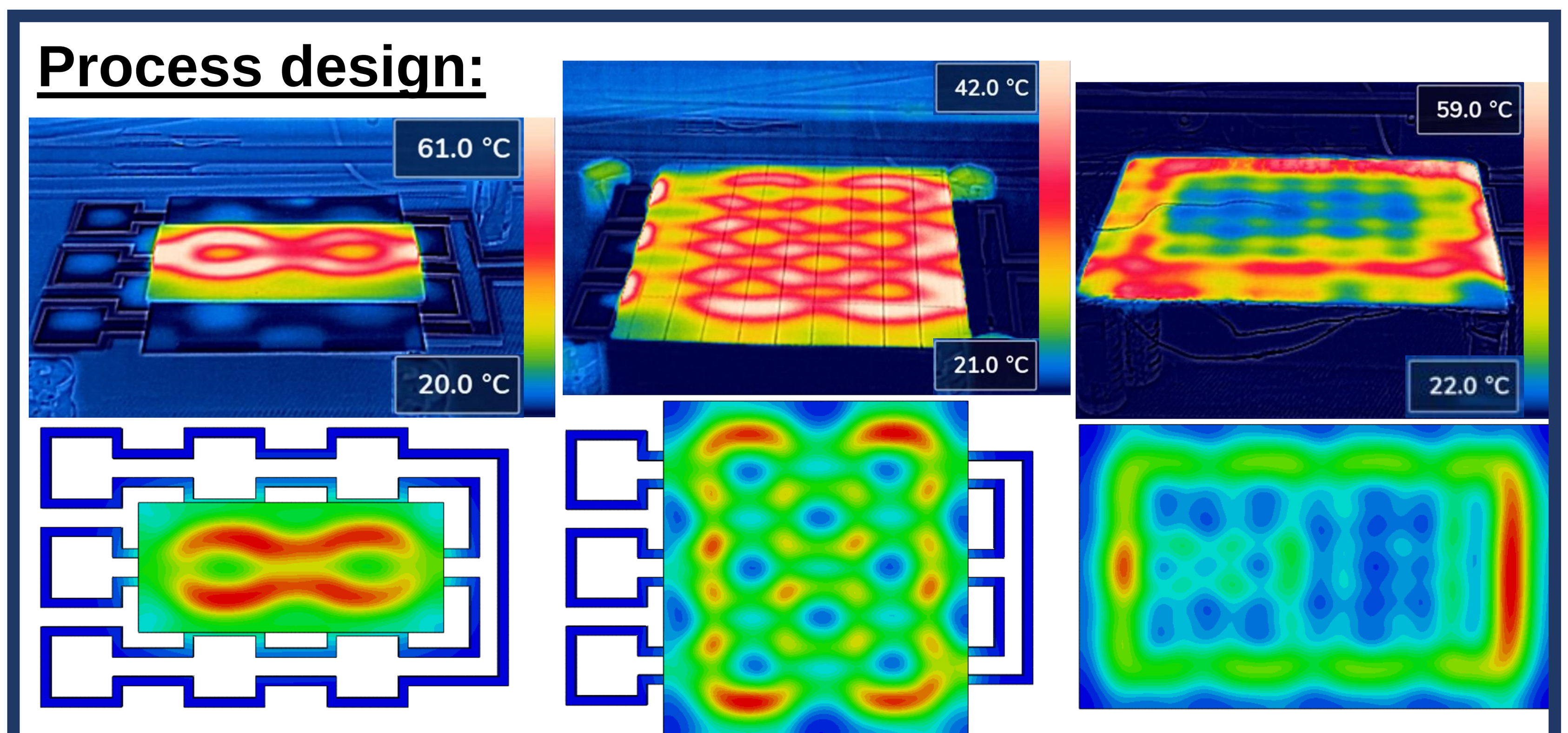
Research Hypothesis:

To reduce characteristic heat propagation length, a cellular coil structure has been trialled. Each cell forms isolated EM vortices if the process parameters are properly tuned. Each EM vortices imprints a pattern of Eddy currents and Joule heating.

Coil manufactured approx. A4 size (350mm x 200mm).

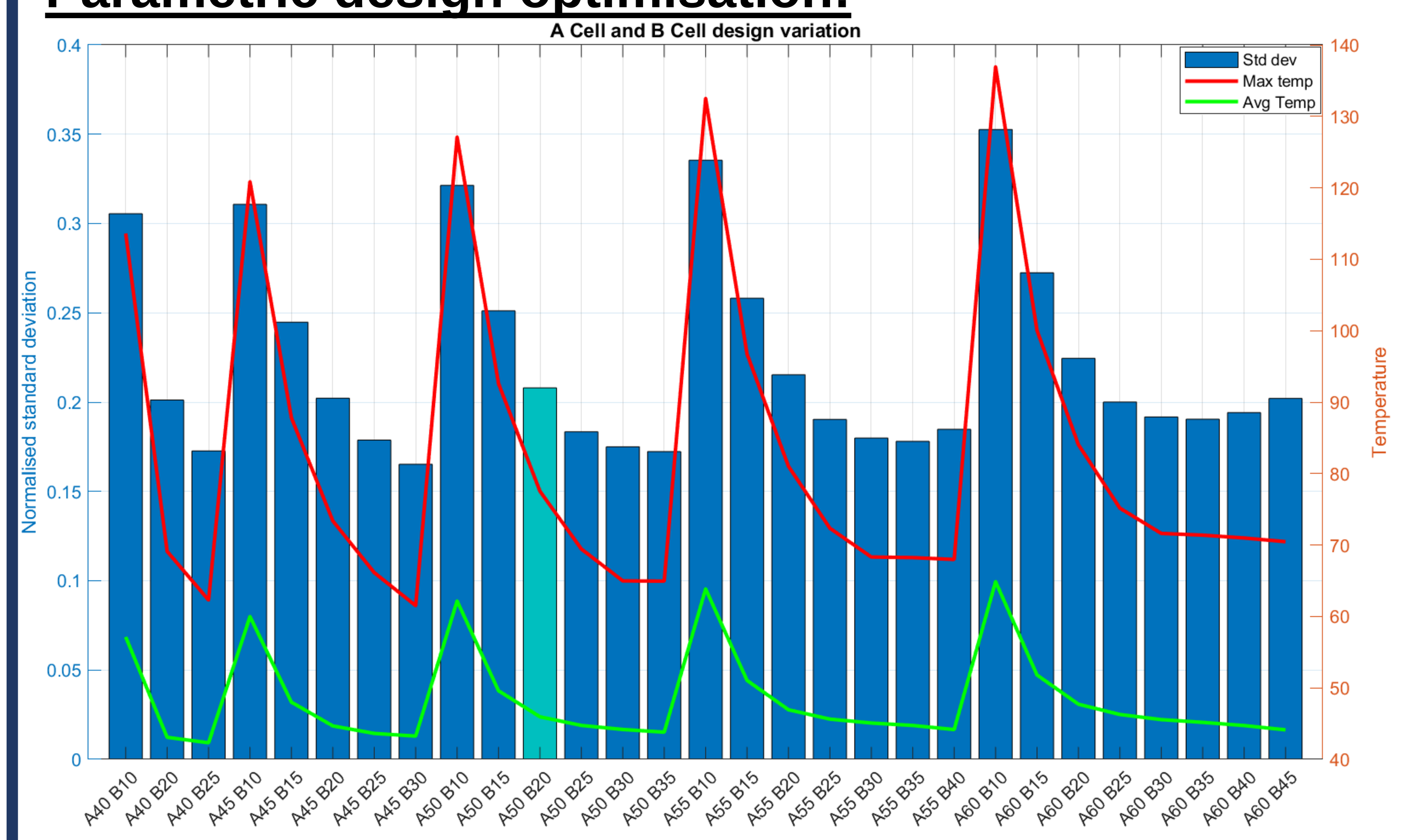


Process design:



Above: (Top) Experimental temperature variation with different QI carbon fibre panel sizes. (Bottom) Modelling results for same sized panels.

Parametric design optimisation:



Above: Graph showing parametric design varying size and spacing of each cell. Focusing on reducing standard deviation to improve inplane temperature uniformity and maximising average temperature for heating efficiency. Light blue bar indicates current experimentally tested geometry.

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