Simulation of an Electrically Heated Carbon Fibre Fabric

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Introduction: Carbon fibre reinforced plastic combines desirable properties as high stability and low weight. To accelerate the curing of the resin, it is common practice to apply heat. The fibretemp® method allows for efficient creation of a heating system within the fabric by using the electric resistance of the carbon fibres to transform electric energy into heat [1].

The aim of this project is to establish and to validate a simulation model for the heat distribution within a carbon fibre fabric when the fibretemp® method is applied.

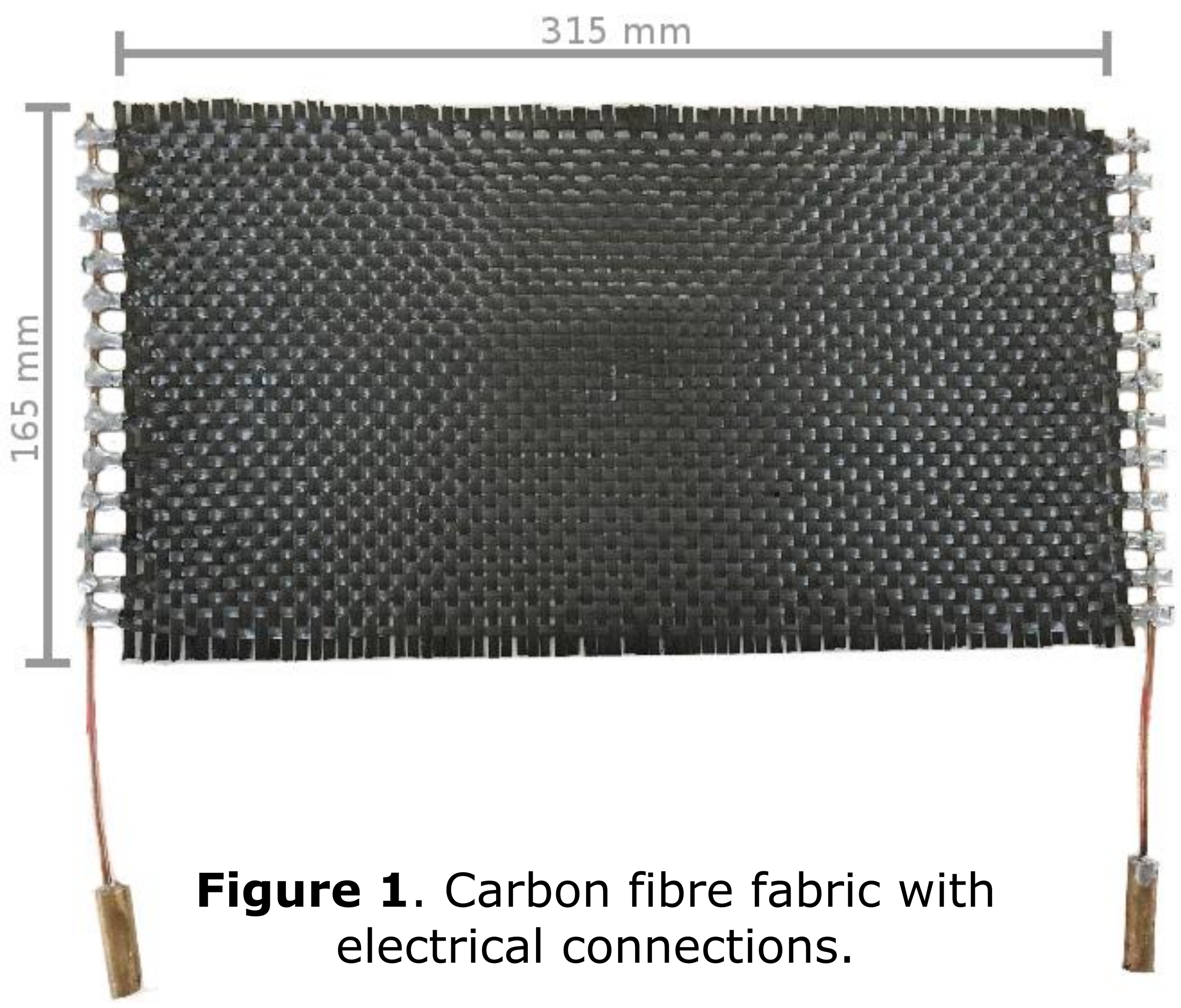

Figure 1. Carbon fibre fabric with electrical connections.

Use of COMSOL Multiphysics®: To model a square single layer fibre fabric (Fig. 1) the Joule Heating interface combined with the Curvilinear Coordinates interface to account for the anisotropic thermal conductivity is used for the simulation.

Since the fabric is located on an EPS board during the experiments the back side is assumed to be thermally insulated. To account for the emitted heat a convective heat flux is defined at the front of the fabric. The heat transfer coefficient of $10.9\ \mathrm{W/(m^2K)}$ is determined by measurements. Moreover, a contact impedance is used to model the additional resistance between the fibers.

The experiments are carried out with a current of $3.5\ \mathrm{A}$, which corresponds to a power of $4.2\ \mathrm{W}$ in this fabric.

Validation and Results: For validation the numerical results are compared with measured data. For this purpose, five temperature probes are installed on the back of the fabric and a thermographic image is taken (see Fig. 2).

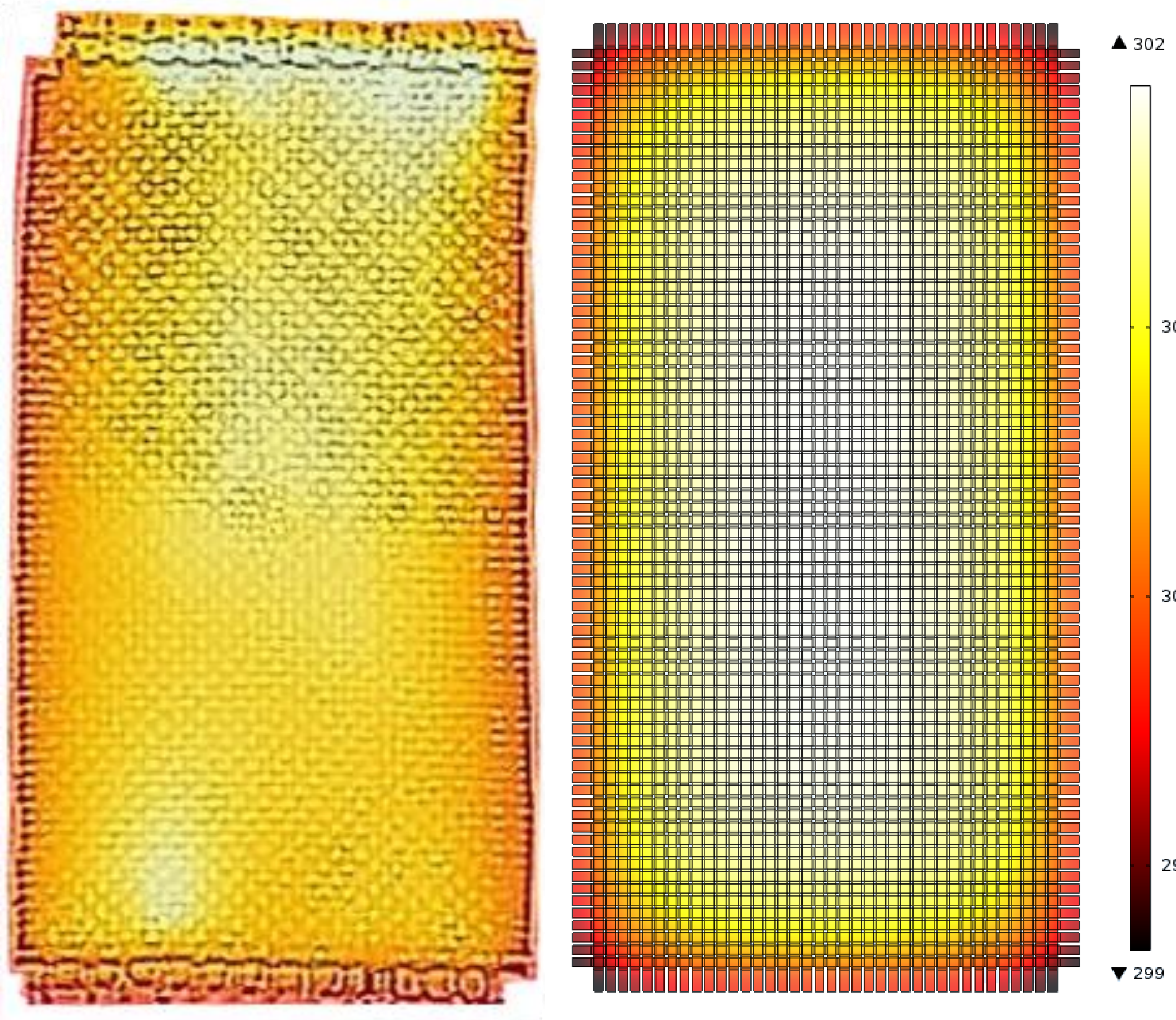

Figure 2. Temperature distribution: thermographic image (left) and simulation results in K (right).

The comparison of the induced temperature changes shows large concurrence of the simulated and the measured values, with a mean deviation of only $0.52\ \mathrm{K}$. As the thermographic imaging shows the deviations are manly caused by nonuniformities within the fabric and the soldered contacts. These lead to scattered hotspots, which cannot be considered in the simulation.

Conclusions: The established model is appropriate to investigate the basic heat distribution within a square fibre fabric. In future projects this simple model can be improved by implementing the anisotropic electric conductivity as well. In addition, more complex geometries of the fabrics can be analyzed.

References:

1. About Fibretemp. (n.d.). From http://www.fibretemp.de/en/about_fibretemp/