Optimising the consolidation of thermoplastic composite laminates

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Fabric reinforced thermoplastic plates are produced by melting plastic sheets at high pressure and high temperature onto a fabric layer. Polyetherimide (PEI) and polyphenylenesulfide (PPS) are commonly used as matrix material. The use of alternative polymers potentially offers an increase in performance combined with a decrease in cost. A thorough understanding of the production process is required to develop an optimal processing route for these new thermoplastic composites.

Thermoplastic resin needs to infiltrate into a dry fabric during the consolidation phase. This is a complex process with various interrelated phenomena, as shown in figure 1. Pressure, applied to force the viscous resin to infiltrate into the fabric, leads to deformation of the compliant fabric, thereby altering the infiltration kinetics. The process temperature significantly affects the resin viscosity. Impregnation will improve at higher temperature, and conversely, heat transfer will improve as impregnation proceeds. Currently, the exact pressure distribution evolution in the variably inhomogeneous composite system is yet unknown while it is essential input to any impregnation model.

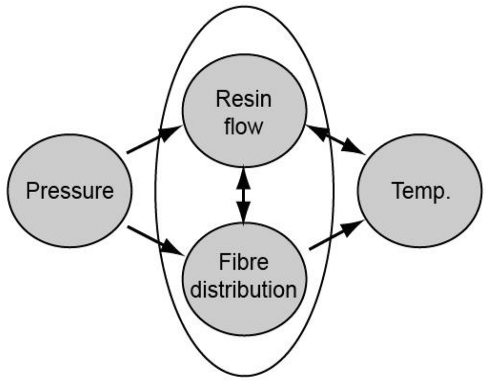

Figure 1: Relation between processing conditions and fibre/resin distribution

Impregnation of the fabric will be considered at both the micro scale, i.e. between the individual fibres, and meso scale, i.e. between the fibre bundles, in order to describe the infiltration process completely. Infiltration on micro scale can be described with Darcy's Law, while the Stokes Flow equations can be used to describe resin flow at meso scale.

The first objective of this research is an improved understanding of the phenomena involved and how they are related to each other. The second objective is the development of a simplified impregnation model. This 'design tool' will shorten the time to market for new thermoplastic composite materials.

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