EFFECT OF FABRIC DEFORMATION AND FLOW VELOCITY ON GENERATION OF POROSITY IN INFUSION PROCESSES

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Introduction

Resin Transfer Moulding is widely used in the composite industry to produce cost effective parts that have both technical and environmental advantages. Many parameters during the process influence the quality of the final part and, in particular, can result in the generation of voids.

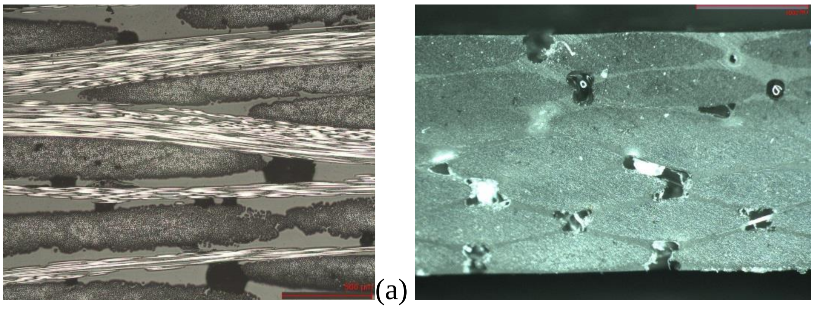
(a) (b)

Figure 1: *Voids presence in a carbon fibre specimen (a) and in a glass fibre specimen (b).*

Porosity generation in composite materials is as a dual scale phenomenon that occurs at the flow front. It has been demonstrated by Ruiz et al. [1], that the generation of voids is a near logarithmic function of the flow front velocity. Therefore, there exists a strong relationship between permeability and the presence of porosity, in particular local changes deriving from defects or process variables such as compaction, shearing and race tracking can strongly influence the generation of voids during infusion.

Simulation model

A dual scale model based on the work of Leclerc and Ruiz [2] for porosity prediction has been investigated for glass quasi-UD and carbon fabrics. For porosity characterisation, the material capillary number has been calculated through experiments on the wetting properties. Simulations have been performed using the commercial software PAM-FORM. Furthermore, the model has been extended to take into consideration local fabric deformations and process variables, such as compaction [3], shearing, and the presence of phenomena such as race tracks and vacuum that effect the final part quality.

Experimental analysis

Testing work has been divided in two phases.

The first phase focused on generating material properties data regarding permeability and wetting properties for fibres and resin, then validating compaction and shearing models. This testing has been conducted using a radial RTM mould with a transparent top for process visualization.

The second phase focused on the porosity study. For this a linear RTM mould and a VARI set up with fixed cavity were used.

Results and conclusions

Data obtained during compaction and shearing tests for permeability have been used to validate the simulation tool and predict local defects during the process.

The first set of experiments for model validation was performed with 6 layers of Glass quasi-UD fabrics, under 1 bar infusion pressure, with variation in the effect of race tracks. Race tracks have been modelled in the simulation taking into account the filling time and the fibre placement during the infusion preparation. A second set of experiments was run with a different lay-up and inserting an extra patch of fibre material for greater local compaction at the end of the plate. Different inlet pressures and vacuum were tested.

It has been found that both race tracks and compaction effect flow rates and are key parameters for porosity generation.

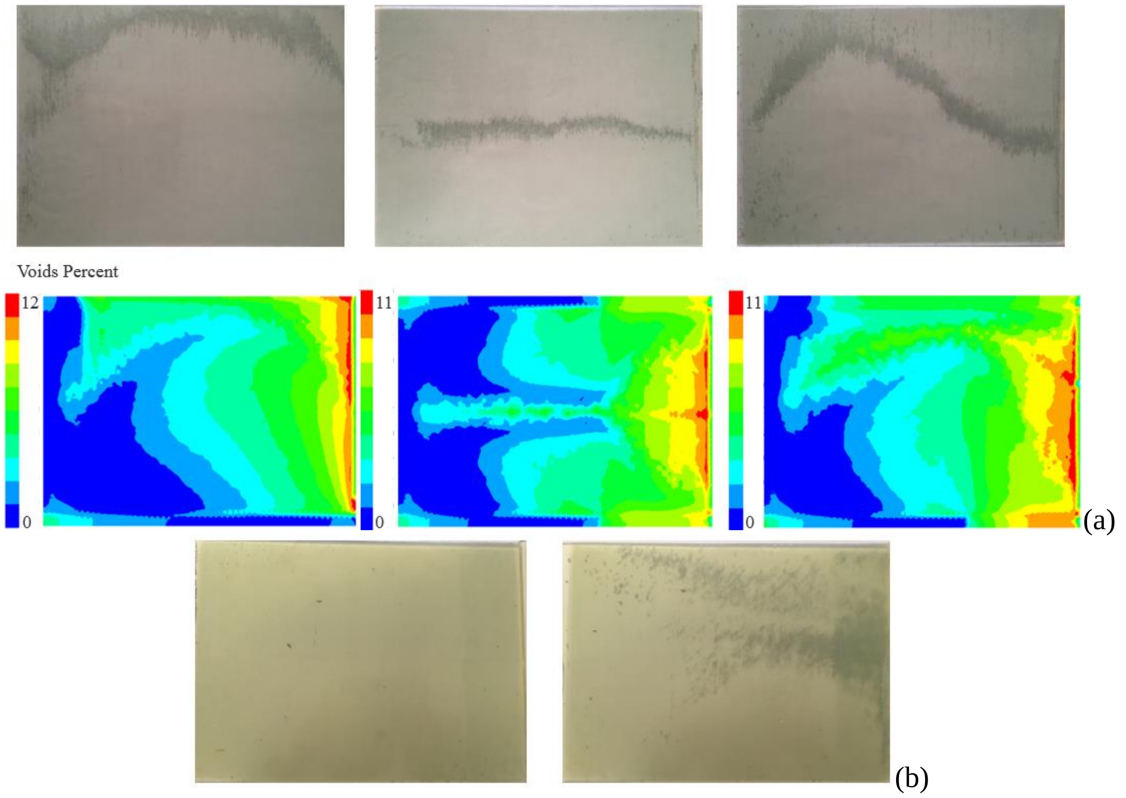

Figure 2: *Simulation and test comparison of three glass plates infused under the same infusion conditions, variating the entity of race tracks along the edges (a). Presence of porosity in a plate with local compaction, infusion with and without vacuum condition*

It has been shown that the model is able to predict the major void patterns present in the infused parts. Although it has been observed that there is an over prediction of the global amount of voids. This is due to the fact that voids are not only generated, but can move following the stream of resin and, once the part is completely infused, will be compacted under the inlet pressure until the resin starts to cure. Another limit of the model, is that it cannot account for the effect of vacuum, which is often used at the outlet in practical infusion manufacture, as cause of void removal. A model for voids compaction and for vacuum representation are currently being investigated.

Acknowledgements

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References

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