IN-PROCESS FLOW FRONT DETECTION IN RECLAIMED CARBON FIBRE MATS USING SURFACE MAPPING SENSORS

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Introduction

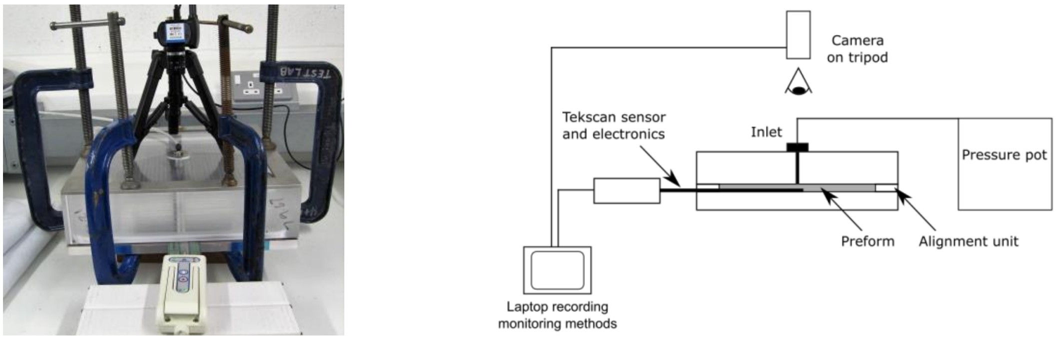
Most composite manufacturing processes happen with little real-time information regarding changes to the composite microstructure. Information regarding the position of the flow front between discrete measurement points could be used to detect defects, such as dry spots in liquid moulding processes created by fibre volume fraction variations that influence the local permeability. Low fibre volume areas can lead to race tracking, whereas high fibre volume fractions could prevent full infiltration of dry fibre regions. Race-tracking is often observed in continuous fibre process were a gap is present in the reinforcement or at the mould wall. Variations in the fibre volume fraction are less common in continuous materials, but reclaimed carbon fibre mat have shown spatial variations in fibre content [1].

Sensing techniques have been used to monitor the mould filling stage during the resin injection process. Common techniques include, inter alia, direct current (DC) analysis, ultrasonic sensors and pressure transducers [2]. Some sensing methods of flow front detection are combined with flow front prediction to influence and thus improve resin flow. Di Fratta et al. [3] reconstructed flow front patterns at any point of the infusion process without using a simulation of the mould cavity filling. This was realised by positioning a small number of pressure transducers inside the mould cavity. The obtained flow-front estimations were in good agreement with experiments if permeability ratios and small disruptions were known.

The aim of this paper is to investigate whether surface mapping sensors, with measurement points on the order of millimetres can detect fine-scale flows in liquid moulding processes. To date, pressure mapping sensors have not been used before for flow front detection but have found use to measure the compaction stress of fibrous reinforcement and fluid pressure [4].

Experimental methods

Experiments using both a surface mapping sensor and a transparent upper mould surface were compared to identify whether flow fronts are detectable by a change in pressure when a fluid saturates an initially dry fibrebed. The experimental set-up is shown in Figure 1. A Tekscan 5101 pressure mapping sensor was placed between the bottom ply and bottom mould surface ash shown in Figure 1(b). This sensor has a 111.8 mm square sensing area with measurement points every 2.5 mm.



(a) (b)

Figure 1: *Experimental set-up (a) and schematic (b) showing the position of the pressure mapping sensor.*

Results

The resin flow position detected with the surface mapping sensor seems to be in good agreement with the images captures by the camera, as observed in Figure 2. The initial pressure distribution includes a hole Figure 2(a, e, i) that was punched in the centre of the preform to create a rectangular flow through the thickness of the fibrous reinforcement. As the test fluid was injected, golden syrup diluted with 15% water, a flow front was observed by the pressure mapping sensor in Figure 2(b, f, j) and by the camera Figure 2(d, h, l). Smoothing the raw pressure map in Figure 2(c, g, k) further clarifies the flow front detected by the pressure mapping sensor. A strong semi-major axis effect was observed in the continuous unidirectional material elliptical flow front due to a higher permeability along the fibres. A more circular, albeit slightly irregular flow front was observed in the reclaimed fibre material, and a non-circular flow front was observed in the condition where race-tracking was encouraged.

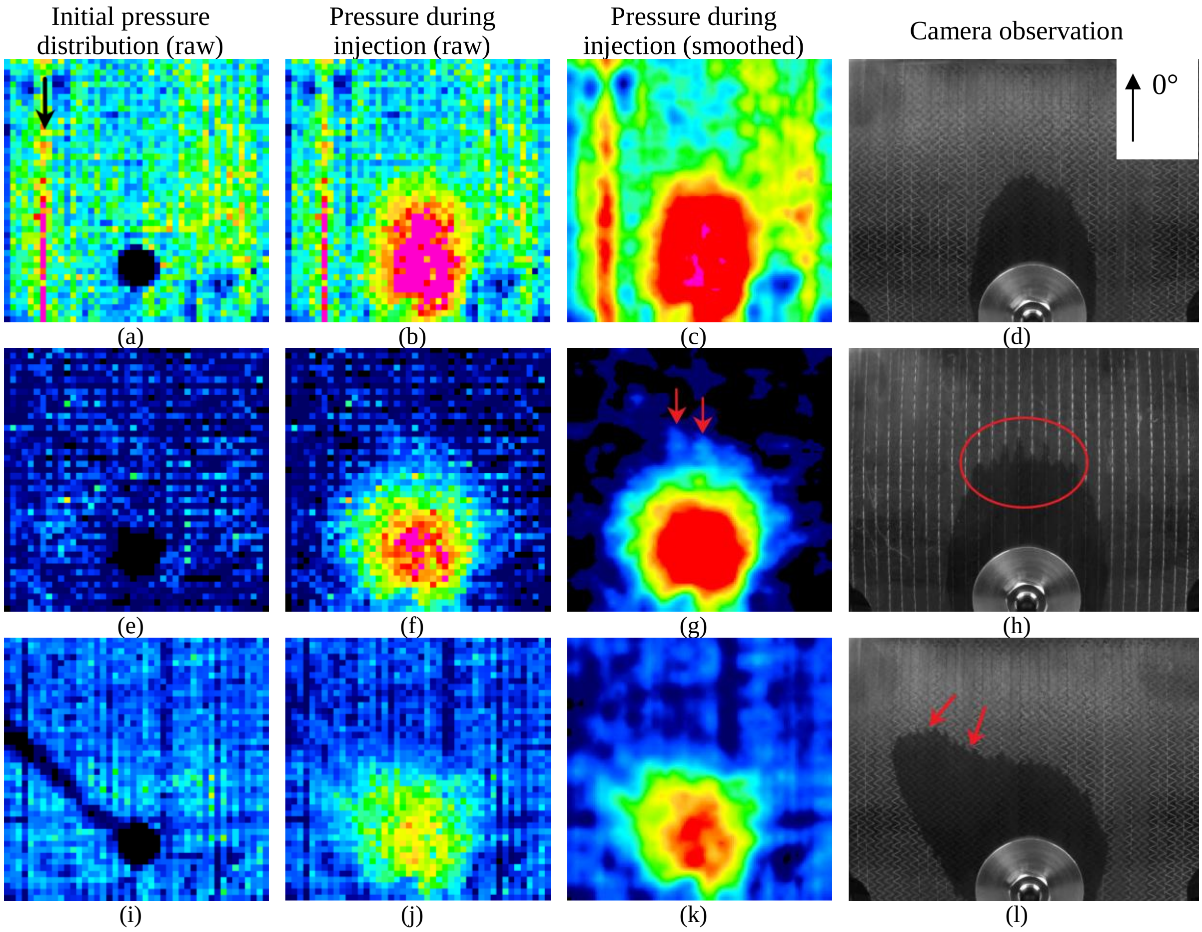


Figure 2: *Flow in continuous unidirectional fibre reinforcement (a–d), reclaimed discontinuous fibre materials (e–h), and continuous fibre materials with a -45° gap in central plies to create a race-tracking effect (i–l).*

Conclusions

The results obtained to date have identify pressure mapping sensors as a promising approach for flow front detection in liquid composite moulding. A more detailed analysis is currently underway to compare and contrast the flow fronts detected by the pressure mapping sensor and optical camera in-order to draw more reliable conclusions about this method.

References

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