DIGITALISATION OF RESIN TRANSFER MOULDING (RTM) IN COMPOSITE MANUFACTURING

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Introduction

- Resin Transfer Moulding (RTM) is one of the commonly techniques used to manufacture composite parts.

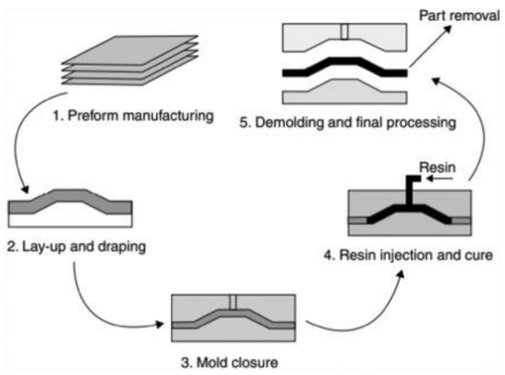


Figure 1. Resin transfer moulding process [1]

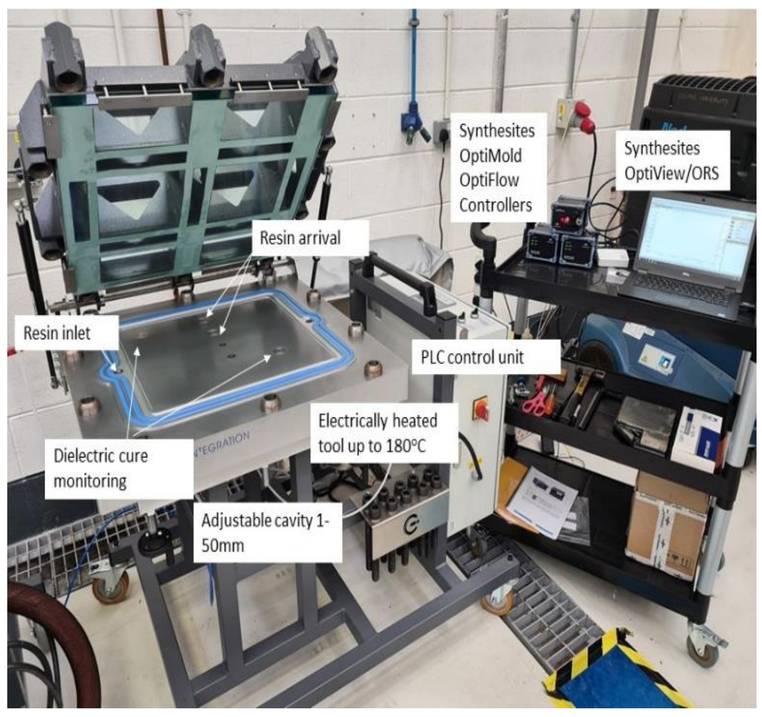
- RTM is preferred over other infusion techniques as more complex geometrical parts can be manufactured with excellent dimensional accuracy and high surface finish [2],[3].
- During infusion, the impregnation of the fabric here mainly depends on resin viscosity, permeability of the fabric, infusion time, and placement of the inlet and outlet ports.
- Since it is a closed process, it is difficult to monitor the infusion process.

Objectives

- In this work, di-electric cure monitoring sensors have been incorporated in the RTM tool.
- To monitor and study, infusion parameters such as resin arrival, temperature, viscosity, gelation, real time degree of cure, and the glass transition evolution point (Tg) of the resin inside the closed mould.
- To optimize the infusion process aiming to develop RTM digital twin.

Methods

- In this study, The Pt100 temperature sensors (Figure 2 (b)) were used to measure the accurate temperature of the mould based on the change in the resistance in the resin.
- Monitoring units such as Optimold and Optiflow (Figure 2 (c)) were incorporated. Optimold was coupled with the RTD sensors, while Optifow was coupled with flow front sensors.
- For this study, 3D woven (carbon fibre) with layer to layer (LTL) architectures with a warp density of 12warps/cm and weft density of 10 wefts/cm were selected along with Gurit Prime 37 epoxy resin system.
- The resin was prepared as a two-part epoxy resin systems with a resin and hardener ratio of 100:29 (Prime 37).
- For Prime 37 the curing temperature is maintained at 50℃ for 16 hours.



(a)

(b)

(c)

Figure 2. (a) Overall view of the digitalized RTM tool, (b) Pt100 sensor. The Resistance Temperature Detector (RTD) element is highlighted in the sensor, (c) Optimold and Optimflow – process monitoring systems.

Results

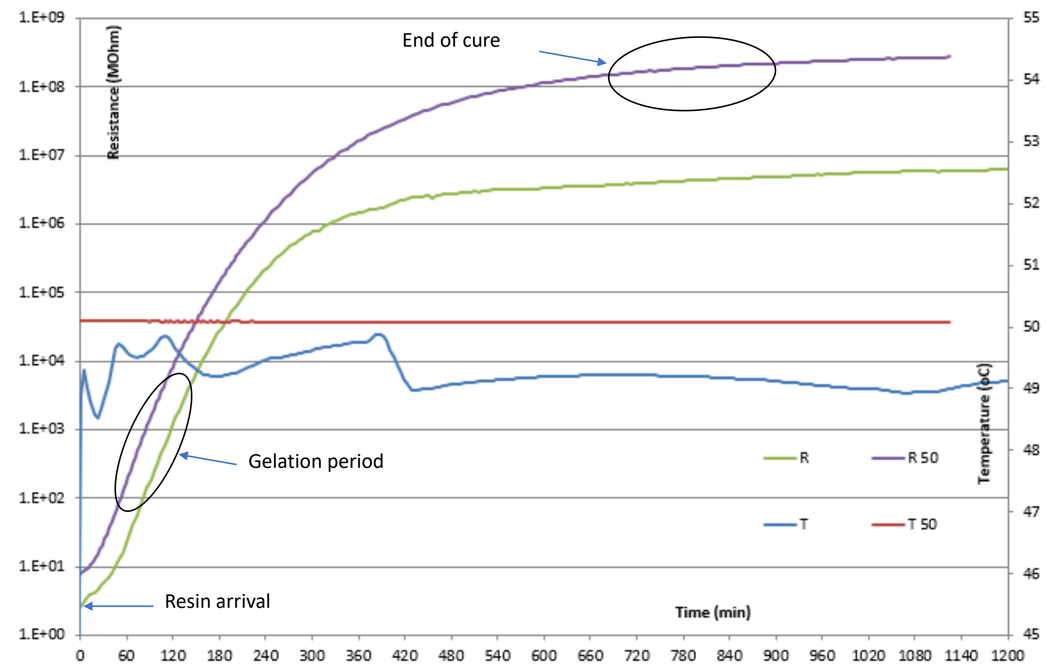


Figure 3. Cure data of Prime 37 resin measured through Optimold and Optiflow system.

- Sensors R and R 50 are placed in the middle of the mould (closer to the outlet port) which measure the degree of cure of the resin as represented in Figure 3.
- Sensors T and T 50 sensors are placed closer to the inlet port measuring the temperature as shown in Figure 3.
- Glass fabric was placed between the carbon fibre and the tool, in order to avoid carbon fibre interfering with resistance measurements.
- The data obtained from the sensors illustrate the resin arrival, gelation period, cure cycle and the end of cure cycle.
- The glass transition (T_g) measured by the sensors through Optimold system was validated with T_g from DSC.
- Furthermore, the cure kinetic value of the resin (Prime 37) calculated through DSC, were used to calibrate the Optimold system.

Conclusion

- These sensors can be used to detect and avoid dry zones and voids in the composite parts.
- Reduce scrap rate and quality control of manufactured parts.
- The obtained data from can be used to perform simulation study facilitating the “right first time” approach that can save time, cost while also improving the quality of the manufactured part.

Future Work

- To monitor and collect the real time data acquired over IoT.
- To remote access, manage and control the digitalised RTM tool.

Acknowledgement

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