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TITLE: Immersive Monitoring of Resin Infusion for Data Driven Manufacturing

AUTHOR(S): Hamed Yazdani Nezhad, Masoud Bodaghi, Arjen Koorevaar, Saif Abdulhamid, Cristian Lira

AFFILIATION(S): Leeds University, Luxembourg Institute of Science and Technology (LIST), Polyworx BV, NCC

ABSTRACT:

Liquid Composite Moulding (LCM) process remains highly sensitive to variations in reinforcement architecture, boundary condition, and curing process, making process robustness and repeatability challenging, particularly for large and complex components. While several previous studies have explored the use of Augmented Reality (AR) to support composite manufacturing, most efforts have limited to visualization or operator assistance, with limited integration into data-driven process analysis and prediction. This work proposes an immersive framework for resin infusion, aimed at enhancing composite manufacturing through Augmented Reality (AR); flow front recognition and predictive modelling. The workflow is demonstrated on a simple flat shape geometry using a transparent mould, which serves as a reference frame for projecting relevant information directly onto the mould surface. In particular, deviations between the observed resin flow front and expected development under ideal/nominal conditions are visualized in real time. Experimentally observed flow front data are transformed into a digital dataset representing the spatio-temporal flow front evolution of resin impregnation, which is then combined with 3D geometry, in-mould sensors, and RTM-Worx/SALT simulations. Non-linear optimization is applied to match sensor data and simulation predictions, enabling precise permeability determination of the reinforcement. Robust real-time flow front recognition is combined with predictive capabilities, enabling comparison between experimental observations and synthetic datasets generated during the infusion process. These synthetic datasets originate from multiple sources, including numerical flow simulations running concurrently with the experiment, machine-learning models trained on offline simulations, and process data such as resin viscosity, inlet pressure, allowing prediction of flow front evolution with and without corrective actions.

The proposed immersive monitoring of resin infusion for data driven manufacturing exemplar benefits from the use of a transparent mould allowing to validate the proposed approach. However, the approach is easily extended to resin transfer moulding (RTM) processes where both mould halves are metal and/or composite materials, allowing to extract relevant information regarding the resin flow front inside the mould. By enabling direct access to process-relevant information at the mould surface and coupling experimental data with physics-based and data-driven models, this work provides a path toward intelligent, adaptive, and quantifiable composite manufacturing systems, where permeability, flow front dynamics, and process deviations are continuously monitored and controlled.

Core theme:

- Liquid Composite Moulding

Additional Themes

- Numerical Simulation
- Novel mould tooling concepts and applications