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Future Composites Manufacturing Research Hub

In-process monitoring and control of the resin flow during the Resin Transfer Moulding Process

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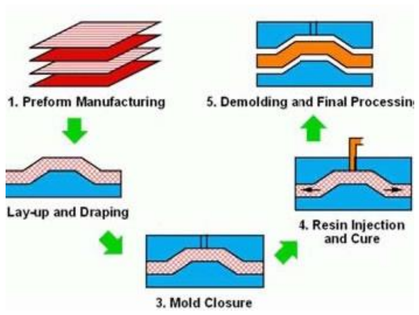
What is the Resin Transfer Moulding (RTM) process?



- Process that can be tracked back to the 1930s
- Composites manufacturing via the injection of a thermoset resin through a dry fibre bed reinforcement in a closed tool

Main fields of application:

- ❑ Aerospace/Defence
- ❑ Automotive industry
- ❑ Sports/Leisure
- ❑ Marine industry
- ❑ Construction

What is an Active Control System (ACS) and why is it needed for RTM?

The impregnation of the dry reinforcement by the resin is critical to the composite part performances (mechanical, aesthetic, etc); this manufacturing step is also where most deviations occur. Thus, better control and more automation of this stage is needed to allow the use of the RTM process in larger industrial scales.

Passive control systems

- ✓ Control method based on data collected prior to process cycle from simulation, preliminary experiments, operators' experience, etc.

Problem: if anything unexpected happens during the impregnation stage; nothing can be done to fix it and the part will be scraped

VS

Active control systems

- ✓ Use simulation to define the ideal filling scenario depending on the manufacturing settings
- ✓ Use of sensors to verify in real-time the progression of the resin
- ✓ Implement corrective actions to steer the flow in the right direction in case the resin flow's behaviour is inadequate

→ Reduced waste and gain in process efficiency

Work methodology employed to design an ACS for RTM

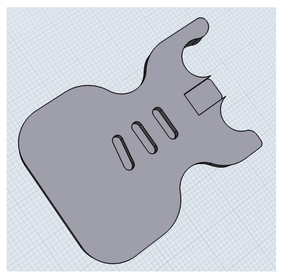
Complex composite parts present higher risks to be defective at the end of the manufacturing cycle, hence the potential defects need to be modelled and then detected thanks to a suitable sensing strategy

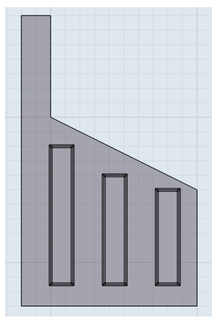
Design of the part under study:

- Complex enough so there is an actual need for active control
- With universal enough elements for the results obtained to be extrapolated to various situations

Two geometries are being considered:

- One inspired by a musical instrument with curves and hollow sections





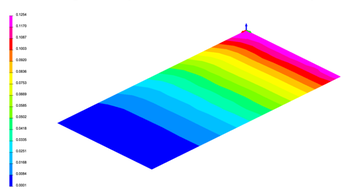
- One inspired by panels that can be found in aeronautics or in the automotive industry, asymmetrical with inserts

Modelling/Simulation:

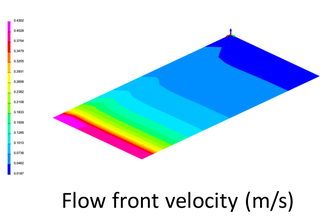
- To verify the manufacturability of the geometry under study
- To help define an optimal sensing architecture
- To model possible defects and help define the pairings filling scenario/corrective actions

Example:

- Rectangular plate with several pressure sensors virtually placed across it

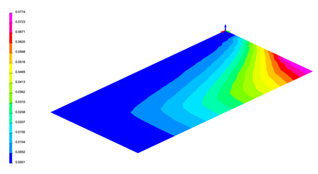


Filling time (s)

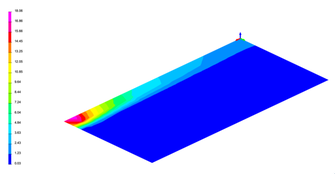


Flow front velocity (m/s)

- Rectangular plate with a low-permeability channel creating a preferential flow path for the resin (a phenomenon called race-tracking), several pressure sensors virtually placed in the channel and in the middle of the preform



Filling time (s)

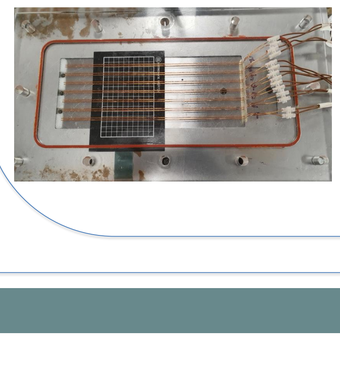


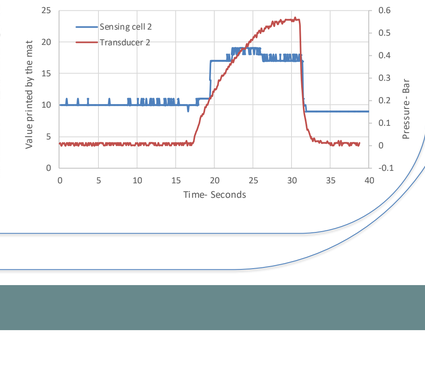
Flow front velocity (m/s)

Experimental work:

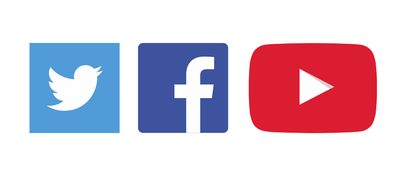
- To test different sensing options and corrective actions
- To validate simulation results

- Pressure transducers





- Force Sensitive Resistor (FSR)



- Multi-point FSR sensor / Pressure mapping sensor

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