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## MANUFACTURING control

# Fast development and intelligent process control for RTM

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**In high-quality composites manufacturing, there is an urgent need for online quality control tools to optimize and accelerate development and production control. This paper presents an integrated and intelligent quality monitoring system combining resin arrival, temperature and cure sensors from Synthesites and advanced pressure sensors from Kistler, which is used by Airborne to manufacture thick CFRP parts using RTM.**

This work was performed in the framework of the Ecomise R&D project, an EC-funded collaborative European project led by DLR that involved Bombardier Aerospace, Samtech, Fibre Institut Bremen, Polyworx, Hutchinson, Synthesites, Loop Technology, NLR, Airborne and Dassault Systemes. This technology was used successfully in the project's industrial demonstrators, a CFRP wing skin, a CFRP tidal blade and a GFRP suspension blade.

### Advanced process monitoring

Within the Ecomise project, Synthesites developed the OptiCure system, a comprehensive solution for speeding up composites production and ensuring in-mould product quality. OptiCure includes several sensors connected to the OptiMold and OptiFlow process monitoring systems focused on the

industrial production of composite materials. The DC-based monitoring systems measure the material's resistivity and temperature using durable and/or disposable sensors and can monitor the full transformation of a thermoset resin in-situ. Since the resin's viscosity is directly related to its electrical resistance besides resin arrival, the monitoring system can be used to verify the onset of cure, measure the full cure, the quality of the resin matrix or other processing parameters. Comparisons between DC sensing and dielectric systems measuring resin impedance showed the superiority of DC-based cure monitoring, particularly after gelation, while it is user friendly, cheaper and more robust, with a wide range of sensors for industrial applications. These sensors can be installed in several locations in the mould: in the die and at the inlets and/or vents to achieve global process monitoring. Additionally, the real-time transformation of these resistivity and temperature measurements into useful

material properties such as the degree of cure and/or T<sub>g</sub> was developed in the Ecomise project, making the system quite unique and very useful in process development and manufacturing in a range of closed mould applications.

### A new generation of pressure sensors

Kistler provided a new generation of pressure sensors designed specifically for composite manufacturing processes in the aerospace industry, such as the RTM process. With these sensors, it is possible to analyse and monitor the pressure conditions inside the form throughout the process. Due to the flow resistance inside the feeding tubes, the pressure values displayed in the mixing unit can differ significantly from the real pressures inside the cavity. Inside the form, pressures can differ due to the flow resistance of the preform. Important process information such as flow resistance during impregnation of the preform, stable pressure during holding and