Pioneer

Open Innovation Platform for Optimising Production Systems by Combining Product Development, Virtual Engineering Workflows and Production Data.

PIONEER Project Introduces Cognitive Process Control for Composite Manufacturing

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The European research initiative PIONEER has taken an important step in the digital transformation of composite manufacturing. Marelli, a leading global automotive supplier, has developed, manufactured, and validated an upper suspension control arm using Sheet Moulding Compound (SMC). In parallel, the project has developed a Cognitive Process Control system designed to enhance efficiency, quality, and operator support during production, which is now ready for validation in the pilot line.

A STEP FORWARD IN COMPOSITE MANUFACTURING

SMC, a compression moulding process, is widely used to produce complex yet structurally robust composite parts. Despite its advantages, the process presents challenges such as temperature regulation, defect minimisation, and variability in part extraction. Traditionally, these issues have required extensive operator expertise and costly trial-and-error iterations.
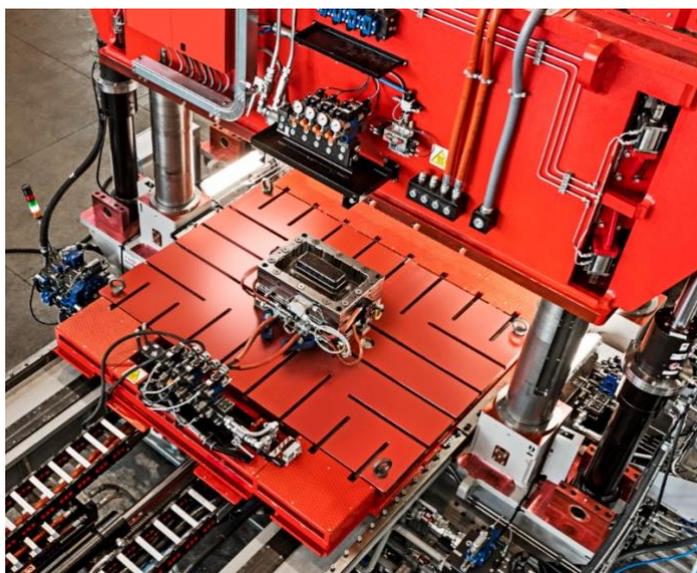
Figure 1. SMC press machine at MARELLI

The Cognitive Process Control system developed in PIONEER addresses these challenges head-on. By combining advanced simulation tools, real-time monitoring, and machine learning models, it creates an adaptive manufacturing environment where quality and efficiency are continuously optimised.

THE PROCESS CONTROL MANAGER: SUPPORTING OPERATORS WITH INTELLIGENCE

At the heart of the innovation lies the Process Control Manager, a digital platform designed to support operators on the shop floor.

- It allows operators to define processing parameters for each part reference.

- It collects and analyses real-time process data directly from the SMC press using interoperable communication standards like OPC UA.

- Through intuitive graphical interfaces, it highlights critical steps and provides immediate visibility of process status, enabling informed and timely decision-making.
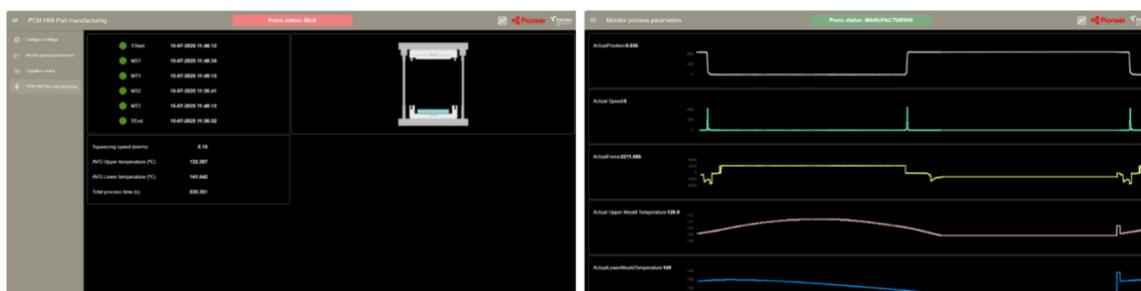

Figure 2. Process Control Manager graphical interfaces (critical steps and process monitoring)

By enhancing operator awareness, the system not only reduces human error but also builds trust in automated decision support, paving the way for human–machine collaboration in manufacturing.

COGNITIVE MODELS FOR QUALITY AND DEFECT PREVENTION

The novelty of the system lies in its **cognitive layer**, which integrates two complementary models to assess and improve process quality:

- **Reduced Order Model (ROM):** Based on physics-based simulations, it predicts the expected process behaviour and ensures consistency with design requirements.

- **Data-Driven Model (DDM):** Built on real-world production data and inspection results, it predicts whether a part will be good or defective, evaluates the difficulty of part extraction from the mould, and estimates void-related indicators such as count, volume, and diameter.

This dual-model approach creates a robust predictive framework that supports real-time decision-making. While the ROM provides a reliable baseline derived from engineering knowledge, the DDM enriches it with data patterns and adaptive learning, making the process both explainable and self-improving.
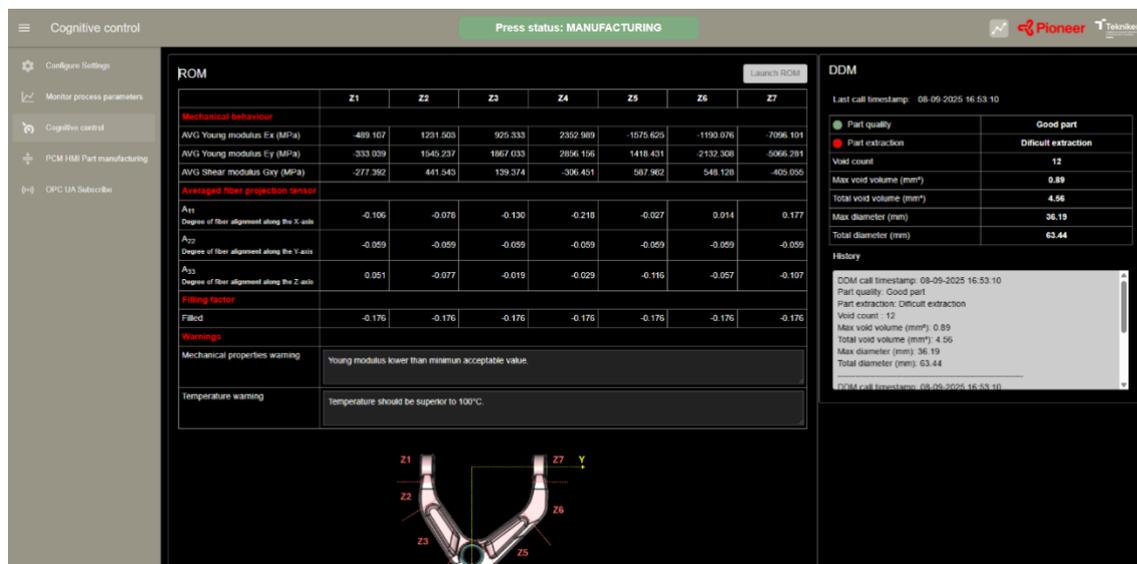

Figure 3. ROM and DDM predictions feedback

BENEFITS FOR INDUSTRY AND SOCIETY

The Cognitive Process Control system offers significant benefits:

- Higher quality and consistency in composite parts.

- Reduced scrap rates and production costs through defect prevention.

- Faster time-to-market thanks to predictive design and process validation.

- Empowered operators, equipped with real-time insights and decision support.

By demonstrating these advantages in the context of an automotive suspension component, PIONEER showcases the scalability of the solution to other composite-based applications in aerospace, energy, and industrial equipment.

TOWARDS THE FUTURE OF DIGITAL MANUFACTURING

PIONEER demonstrates how combining simulation, data-driven models, and interoperable platforms leads to smarter, more sustainable manufacturing. This achievement is aligned with the broader European ambition to promote digitalisation, energy efficiency, and circularity in industry.

The Cognitive Process Control is not only a technological breakthrough but also a concrete example of how AI, modelling, and human expertise can come together to deliver competitive and sustainable manufacturing solutions.

ABOUT THE PROJECT

This Horizon Europe project took off in January 2023. PIONEER develops and implements an interoperable Materials-Modelling-Manufacturing Ecosystem, enabling multidirectional dataflow throughout the material value chain by connecting the production's various stages. Combining a design-by-simulation approach with manufacturing and quality data, PIONEER optimises product development strategies in high-mix/low-volume production schemes.

Project Title: Open Innovation Platform for Optimising Production Systems by Combining Product Development, Virtual Engineering Workflows and Production Data.

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Project Partners:

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