17th International Conference on Flow Processes in Composites Materials (FPCM17)
Sheffield, United Kingdom, 30 June to 02 July 2026.

TITLE: Case study on data infrastructure and data processing for process control in vacuum infusion processes

AUTHOR(S): J. Faber[A)], M. Vistein[A)], F. Krebs[A)], N. Kemper[B)], A. Göbel[C)]

AFFILIATION(S):

[A)] German Aerospace Center (DLR), Center for Lightweight Production Technology, Am Technologiezentrum 4, 86159 Augsburg

[B)] University of Augsburg, Institute of Computer Science, Chair of Organic Computing, Universitätsstr. 2, 86159 Augsburg

[C)] University of Augsburg, Institute of Computer Science, Chair of Control Engineering, Universitätsstr. 2, 86159 Augsburg

ABSTRACT:

In composites manufacturing, data acquisition and data-driven process control is key to increasing process robustness and high-volume production. At the DLR Center for Lightweight Production Technology (DLR-ZLP), Augsburg, Germany, and the University of Augsburg, a comprehensive approach on the active manipulation of vacuum infusion processes is investigated. In the context of the Bavarian research association "Intelligent Manufacturing Processes & Closed-Loop Production – FORinFPRO", funded by the "Bayerische Forschungsstiftung", the researchers of DLR-ZLP and University of Augsburg develop a methodology for data acquisition and closed-loop control. Therefore, a concept for the data infrastructure was defined, combining real process data (e.g. sensors and machines) and model-based virtual data. A major element of this approach is the centralized data management system *shepard*, which allows storage and analysis of structured data.

In principle, the methodology addresses industrial use cases for aerospace composite part manufacturing. Technically, all subcomponents used for vacuum infusion of large composite structures are taken into account. Nevertheless, in the context of FORinFPRO, a downsized testbed consisting of a vacuum infusion machine, a stand-alone infusion setup with camera for flow front detection, a vacuum pump and pressure sensors was set-up. A central computer for data-acquisition, connected to all subcomponents, ensures the data processing to *shepard*.

This paper presents the key elements of the process control system. Based on the variety of data types (e.g. time series data and camera images), the data processing requires different strategies. Time series data such as valve positions, temperature and pressure values are structured and semantically annotated using an ontology. This ontology defines the baseline process architecture and describes the interfaces and dependencies of the process parameters. For flow front analysis, camera images are first processed using computer vision algorithms and then stored in *shepard*.

When dividing the whole concept into two implementation phases, phase one focuses on the manual process manipulation based on the fully available raw and processed data. In this context a study is presented dealing with the technical benefits and limitations of the control system. The research question of this comparative study bases on the hypothesis, that parts, manufactured with a controlled VARI[1)] process, have no reduced part quality compared to parts, manufactured with VAP[2)]. The part quality is discussed based on water-coupled ultrasonic testing and microscopic inspection.

For implementation phase two, an outlook will be given sharing the current developments of the authors from University of Augsburg. Regarding model-based process control, an infusion model is presented that can be optimized using derivative-free global optimization methods or reinforcement learning algorithms.

Finally, this paper brings together views and insights of different perspectives. Combining engineering and computer science with a comprehensive understanding of vacuum infusion processes leads to a new methodology for closed-loop control in vacuum infusion processes.

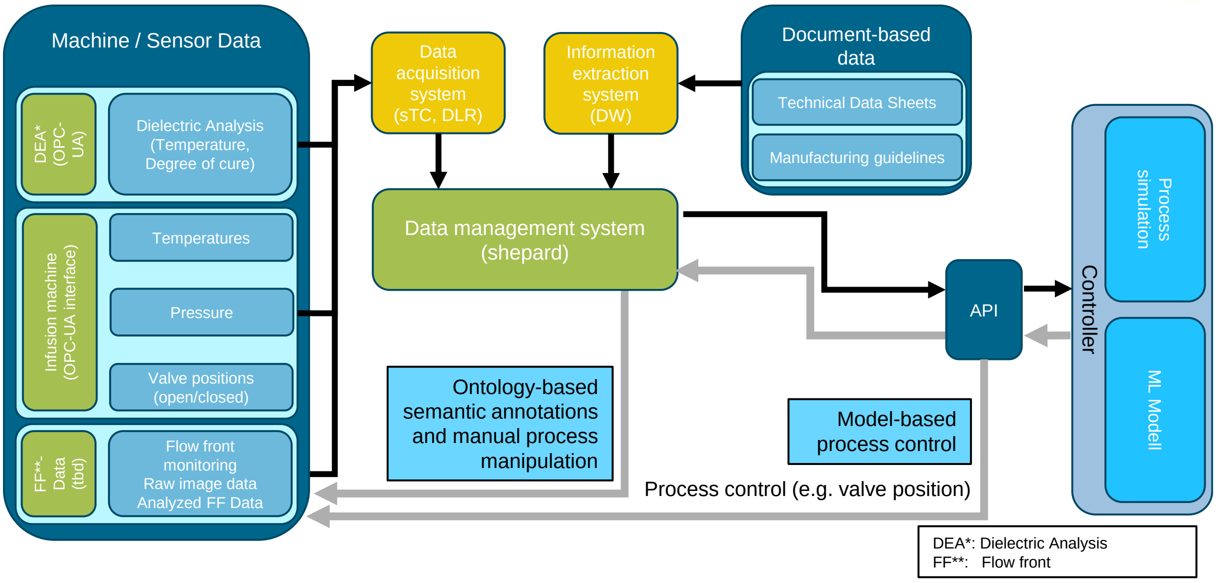

Figure 1: Data infrastructure for vacuum infusions processes at DLR-ZLP

[1)] VARI: Vacuum assisted resin infusion

[2)] VAP: Vacuum assisted process