VII International Conference on Mathematics and its Applications in Science and Engineering (ICMASE 2026)

ICMASE 2026

AN INSIGHT ON FOUNDATION MODELS FOR THE PROCESS INDUSTRY

Joao Luis de Miranda [1,2] *

[1] *ESTGD/VALORIZA, Portalegre Polytechnic University, Portugal*
[2] *CERENA/IST, Lisboa, Portugal*

ABSTRACT

Foundation models (FM) are important for the process industry because they can help connect data, models, and decisions across complex production systems. The process industry includes chemical, pharmaceutical, food, energy, wood-based, agro-industrial, and circular bio-based industries (CBI) and sectors. These sectors typically operate with strict quality requirements, high capital costs, safety constraints, sustainability targets, and uncertain supply and demand. While traditional digital tools often solve isolated tasks, such as short-term scheduling, maintenance planning, or supply chain optimization, FMs can add value because they can be trained on large and diverse data sources and then adapted to several decision-support tasks [1].

In process industry, useful data are often distributed across sensors, maintenance records, production schedules, or supply chain databases, and FMs can support the integration of such distinct and heterogeneous sources. This is especially relevant for batch scheduling (Batch), where production campaigns, cleaning operations and associated times, storage upper-limits, and delivery dates are strongly connected in order to maximize the equipment utilization. Research on batch processes shows that these scheduling problems can be computationally difficult, which supports the use of advanced computational and heuristic methods [3].

FMs can also support long-range planning (Plan), which usually focus the strategic decisions on capacity expansions of continuous processes. In Plan problems, equipment investment, production targets, inventories, suppliers, and sustainability policies define the limits within which daily schedules must operate. If the Plan macro-level considerations are not aligned with the detailed scheduling constraints, production targets may become infeasible. Optimization-based decision making provides a structured basis for analyzing these links between objectives, constraints, and uncertainty treatment [2]. FMs can complement the widely known Robust Optimization approaches by improving access to data, generating scenarios, or even explaining results trajectories.

The FMs importance is also clear in supply chains (SC). Pharmaceutical SC and other process industries face multi-level risks that often drive to medicines shortages; for instance, on demands variation due to virus outbreaks, disruption on the supplies of APIs or ancillary materials, or even quality failures on manufacturing. Decision support systems and SC optimization methods are needed to improve resilience and reduce shortages [4], [5]. FMs can also assist by organizing knowledge from multiple sources, supporting health emergency systems, and helping to assess operational and supply risks.

However, FMs should not be treated as autonomous authorities in safety-critical industrial decisions, either in Pharmaceutical SC or in energy processing sites. Their outputs must be checked against validated models, processes and equipment constraints, as well as regulatory requirements. Their main value is to support decision making by combining industrial data in real time, optimization methods, and advanced decision support, in a way that can improve long range planning, batch scheduling, and sustainability management in the process industry.

* *Corresponding Author's E-mail: jlm.estgp08@gmail.com*

***K*eywords** Foundation Models · Process Industry · Batch Scheduling · Long range planning

References

[1] Bommasani, R., et al., On the Opportunities and Risks of Foundation Models. Stanford CRFM, 2021. https://arxiv.org/abs/2108.07258 .

[2] Miranda, J.L., Introduction to Optimization-based Decision Making. CRC Press, 2021. DOI: https://doi.org/10.1201/9781315200323 .

[3] Miranda, J.L., The Design and Scheduling of Chemical Batch Processes: Computational Complexity Studies. Computers and Chemical Engineering, 121, 2019, 367374. DOI: https://doi.org/10.1016/j.compchemeng.2018.11.011 .

[4] Barbosa-Póvoa, A.P., Corominas, A., and Miranda, J.L., eds. Optimization and Decision Support Systems for Supply Chains. Springer, 2016. DOI: https://doi.org/10.1007/978-3-319-42421-7 .

[5] Barbosa-Póvoa, A.P., Jenzer, H., and Miranda, J.L., eds. Pharmaceutical Supply Chains: Medicines Shortages. Springer, 2019. ISBN: 978-3-030-15398-4. https://link.springer.com/book/10.1007/978-3-030-15398-4 .