BATTWIN T5.6: Post-doc proposal, 12 months

Production control of a reconfigurable and green smart manufacturing system through the modeling and optimization of a digital twin

The production of batteries is more and more investigated and many questions are still opened (Ayerbe, Berecibar, Clark, Franco, & Ruhland, 2022). The associated manufacturing system should be reconfigurable for many reasons. The market demand is supposed to be exponential and the product, the battery, is recent and in constant evolution. The process could evolve suddenly so its manufacturing system might be able to evolve too. Moreover, this system should consider the production of batteries and their recycling.

A Digital Twin (DT) is by definition the coupling of a virtual system (via a simulation model and an information system) and a real system (Cardin, Derigent, & Trentesaux, 2022). Through the virtual system, the objective will be to design and size the manufacturing system considering the future demand. To do so, a modeling of the future system is needed (Beauville dit Eynaud, Klement, Roucoules, Gibaru, & Durville, 2022). A formalization as a multi-agent system could be done, as many different entities could compose the system: resources (human or material: collaborative and/or mobile), products (final product, raw material, components) (Mazar, Sahnoun, Bettayeb, Klement, & Louis, 2022). To do so, collective intelligence might be investigated to model the interaction between the agents.

Optimization, simulation and sim-optimization (including energetics model) will be used to manage industrial engineering problems: line balancing (Abdeljaouad & Klement, 2021) or scheduling (Klement, Abdeljaouad, Porto, & Silva, 2021) problems for instance. We seek also to tackle integrated dynamic scheduling: problems of production, quality control, inspection and maintenance activities, in accordance with Industry 5.0 challenges, namely human centricity, sustainability and resilience (Destouet, Tlahig, Bettayeb, & Mazari, 2023). Artificial Intelligence could be used to deal with hazards and predict some perturbations (Amzil, Yahia, Klement, & Roucoules, 2022).

This tool might be able to consider evolutions of process (in case of the evolution of the product or the volume), and new processes, such as reworking, remanufacturing and/or recycling the products.

Deliverables:

1. Modelling of the reconfigurable manufacturing system through multi-agent system, considering production, energy consumption and reworking, remanufacturing and/or recycling of battery.
2. Sizing of the system, and design of a Decision Support System (DSS) to deal with different optimization problems: line balancing, scheduling. The DSS will be integrated to the DT.
3. Integration of the DT and determination of the connectivity with the real future system. Any decision from the DSS should be transmitted directly to the shoopfloor, any hazards on the shopfloor should be automatically exploited by the DSS.

This tool could be exploited on the existing evolutive learning factory on the Arts et Métiers Lille campus, as a demonstrator.

This subject is part of a European project, named BATTWIN (https://battwin.net/). This task has already been started by our team, using a mathematical formulation as a hybrid flow-shop; solved by a solver

and some metaheuristics. A perspective is to now use Artificial Intelligence to improve the model. Some knowledge in multi-objective optimization would be appreciated.

The position is available for a duration of 12 months at Lille (Arts et Métiers LISPEN and CESI LINEACT).

Applicant should send a resume and a motivation letter to both nathalie.klement@ensam.eu and bettayeb@cesi.fr before 01/05/2025

Références

Abdeljaouad, M. A., & Klement, N. (2021). Tabu search algorithm for single and multi-model line Balancing problems. (C. Springer, Éd.) *IFIP International Conference on Advances in Production Management Systems*, 409-415. doi:https://doi.org/10.1007/978-3-030-85874-2_43

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Klement, N., Abdeljaouad, M. A., Porto, L., & Silva, C. (2021). Lot-sizing and scheduling for the plastic injection molding industry—A hybrid optimization approach. *Applied Sciences, 11*(3), 1202.

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