Proceedings of the 2023 Winter Simulation Conference
C. G. Corlu, S. R. Hunter, H. Lam, B. S. Onggo, J. Shortle, and B. Biller, eds.

FROM SIMULATION TO REAL-TIME DIGITAL TWIN AND AI – IMPLEMENTATION IN FOOD MANUFACTURING PLANT

Hosni Adra

CreateASoft, Inc
3909 75th St.
Suite 103-105
Aurora, IL 60504, USA

ABSTRACT

Data-Driven simulation models are valuable tools to improve the accuracy of the models and enable them to transition to real-time predictive analytics tools. Adding AI (Artificial Intelligence) and ML (Machine Learning) enables those model to provide feedback and real-time optimization in un-attended environment. This paper details the steps and benefits that were used to implement such system in a large filling and packaging manufacturing setting, from initial randomized models to full real-time digital twin systems. Final models were used to optimize (real-time and offline) changeover, CIP (Clean in Place), production, filling lines, and material handling.

1 INTRODUCTION

The manufacturing facility being modeled produced food products and is subject to specific CIP requirement for product changeover and run duration. The facility produces 123 different products that vary in content and size. The manufacturing process requires a combination of pre-processing, mixing, and in-line additive during the final fill process. Filling lines are constrained based on product viscosity, type, and filling format. Pipes are connected to specific lines based on historical and plant design. Since this is a food manufacturing facility, it is required to perform a CIP process based on time and product produced, and the duration of each CIP varies based on the production sequence.

The initial goal of the model was to assist in scheduling production based on demand while reducing the impact of the CIP process. Another goal of the model was to identify potential improvement to the manufacturing process in order to reduce the scheduling complexity and identify automation feasibility throughout the plant.

The implementation of the model included a data-driven model of the facility and a 3D/VR representation of the flow. The model was later connected to SCADA and ERP systems in order to provide real-time optimization and scheduling.

The data-driven model was built in Simcad Process Simulator and included a full, to scale layout of the facility. The model covered the complete operation from receiving of raw materials via tanker trucks or solids, all the way to refrigerated warehousing and shipping. Since the model was planned to be transitioned to real-time, all piping and valves were also included in the model, as they connected to SCADA systems in the real-time system. Therefore, the model itself represented the physical limitation of the production line.

The model data included all of the variable constraints of the system including production formulas, formula to silo limitations and capacities, filling line limitation by product, production cycle times, CIP requirement per silo and formula, resources and shifts, pipe flow variation due to viscosity, material handling equipment. The dataset was imported into the simulation model and enabled scenarios to be quickly ran to identify potential bottlenecks and issue in the production and storage environment.

The data-driven model was completed in 6 weeks, with model accuracy of 99.97% when compared to actuals, and model analysis followed for 3 weeks afterwards. The final model was used to generate specific scheduling rules to be followed, and CIP process allocation based on resource that maximizes the efficiency of the operation. In addition, allocation of the filling lines was modified to produce an average 13.5% efficiency improvement in the filling process. The only constraint was that the manufacturing process had a lot of variations that are tied to downtime and varied consumer demand. Optimization and validation would have to run daily in order to mitigate any change in the production environment.

The next iteration of the implementation transitioned the model to be a real-time digital twin, and connect AI/ML to improve its predictive analytic and optimization. Using the Digital Twin Studio built-in Neural Network, 2 years of production and operations data were run on the model in an off-line setting. The system auto-created the required network and, by enabling the learning system, the model was more in tune with the way the operation runs. Another run of the network was completed for the same period on the optimized system and a correlation is then created.

The model is then connected in real-time to SCADA and SAP for production and operational data, personnel data set, and customer orders, which was then analyzed by the digital twin in15 minutes interval and predictive analytics were produced and displayed on system dashboards. The visual component of the digital-twin generated the live view of the plant with complete analysis, and the Digital Twin Studio alert system was configured to enable complete awareness of any potential issues. The final implementation provided a complete S&OP operational optimization in 12 weeks.

The transition to real-time enabled the plant to sustain a 10.2% overall efficiency improvement saving on average $1.1M/year. Due to its connectivity to actual systems the digital twin model can adapt to new formulas, variation on the line, and personnel availability without human intervention. The next iteration of the model will include the warehousing optimization from slotting, material handling, put-away and storage density optimization.

AUTHOR BIOGRAPHY

HOSNI ADRA is the Director of Simulation and Digital Twin Technologies at CreateASoft, Inc. His email address is hosni.adra@createasoft.com.