Optimizing Manufacturing Sequencing in Real-Time based on Petri Nets+Miniterms: A Case Study on Ford's Multimodel Welding Line

Author: Judith Vizcaino Hilario (jvizcai2@ford.com)

Co-Authors:

Nicolás Montés Sánchez (nicolas.montes@uchceu.es), Nuria Rosillo Guerrero (nrosillo@uchceu.es), Lucia Hilario Pérez (lhilario@uchceu.es), Eduardo García Magraner (egarci75@ford.com), Antonio Falco Montesinos (afalco@uchceu.es)

In the manufacturing industry, the optimization of production lines is crucial to increase productivity and reduce costs. A common approach is to use heuristics or mathematical models to determine the optimal manufacturing sequence of products, which can lead to significant improvements in cycle time and production efficiency. However, these methods can be limited in their ability to account for real-time changes in the manufacturing line, such as machine breakdowns, material shortages, or changes in customer demand.

To address these challenges, in this work it is proposed an algorithm based on manufacturing maps, which combines Petri nets and Miniterms, to determine the optimal manufacturing sequence of a multimodel welding line with the real-time state of the manufacturing line. The algorithm minimizes the difference in cycle times between different models to minimize workstations' stoppage or blocking time, thereby reducing total production time, resulting in benefits such as energy savings and increased production.

The proposed algorithm is implemented on the 8XY line at the Ford factory in Almussafes (Valencia) using manufacturing maps. Simulation is conducted using actual production data for three different types of orderings (random, optimal, and unfavorable) to compare production time. Results show a considerable gain in time using the optimal sequence, validating the algorithm's effectiveness.

Moreover, the algorithm's flexibility enables it to adapt to real-time changes in the manufacturing line, allowing it to optimize production sequences on the fly. This feature is particularly useful in scenarios where customer demand fluctuates or when unexpected events occur, such as machine breakdowns. By minimizing the time workstations are stopped or blocked, the algorithm can reduce production time and improve efficiency, leading to significant cost savings and increased profitability.

As future work, it will be planned to explore other applications of manufacturing maps for optimizing production lines, such as determining the optimal sequence for an anomaly or rebalancing production lines in real-time to save energy. By leveraging the power of manufacturing maps and real-time data, we believe that the proposed algorithm can revolutionize the manufacturing industry by enabling manufacturers to optimize their production lines more efficiently and cost-effectively than ever before.

Keywords: Industry 4.0, Manufacturing maps, Petri Nets, Miniterms, Optimal Pathfinding Algorithm, Optimal Manufacturing Sequence.