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RELEASING FLEXIBILITY: SIMULATION OF A FLEXIBLE MANUFACTURING SYSTEM

Boyang Song
Windo Hutabarat
Ashutosh Tiwari

Department of Automatic Control and Systems Engineering
University of Sheffield
Portobello Street, Amy Johnson Building
Sheffield, S1 3JD, UK

Shane Enticott

Cosworth Ltd
St James Mill Road,
Northampton, NN5 5RA, UK

ABSTRACT

This paper describes how simulation can be an effective tool for investigating the dynamic behavior of complex manufacturing systems. Flexible Manufacturing System (FMS) aims to provide optimal machine flexibility, process flexibility, and product flexibility. However, releasing flexibility in FMS is challenging due to the necessary complexity of coordinating all subsystems while simultaneously scheduling multiple product families. In this paper, an automotive industry case study is outlined, and a Discrete Event Simulation (DES) model has been developed. The model sufficiently represents all primary subsystems to capture their dynamic interactions, providing a bird's eye view of all critical activities within an FMS. A series of manufacturing problems and their corresponding hypothetical solutions have been explored and evaluated in a number of simulation scenarios. The results demonstrate that releasing FMS flexibility can result in significant performance improvements whilst also removing barriers (such as operation sequencing or line balancing) associated with dedicated manufacturing systems.

1 INTRODUCTION

FMS is defined as a group of workstations/machines connected by a Material Handling System (MHS), processing or assembling a number of different product families, under a central control system (O'Keefe and Kasirajan 1992). It was hoped that FMS can combine the flexibility from job shops and the high productivity from transfer lines (Joseph and Sridharan 2008). Various hypothetical models of FMS have been proposed, but due to its inherent complexity the behaviors of FMS have not been fully explored. Conventional manufacturing best-practice methods such as Value Stream Mapping (VSM) and Statistical Process Control (SPC) are not sufficient to capture the complex dynamic interactions across the subsystems and discover the root causes associated with FMS problems. There is a gap in simulation case studies that investigates the complete FMS system and real-world flexibility challenges. We take advantage of an industrial FMS where development and validation of a FMS simulation model was found to be critical.

2 CASE STUDY

A UK-based company specializing in the design and manufacture of niche-volume automotive components aims to achieve higher productivity by implementing a FMS. Their FMS is a multi-machine FMS comprising multiple machine centers, load and unload stations, MHS, tool store, pallets, and Working In Progress (WIP) buffer. This FMS can perform simultaneous production of multiple niche-volume products. It can also deliver more quick adaptation for product design change or process engineering change.

3 SIMULATION MODELING AND EXPERIMENTS

A DES modeling of the FMS was carried out. SimEvent from MATLAB was chosen due to the ease of exploring various modeling architectures. Figure 1 depicts the top layer of the resulting comprehensive FMS model; in total there are three layers containing all key subsystems such as 'load station' and 'pallet store' along with their logic. The hierarchical model is able to represent all main manufacturing problems, their dynamic interactions, and their corresponding hypothetical solutions. These have been explored through a number of simulation scenarios that can incorporate optimization algorithms (Song et al. 2016).

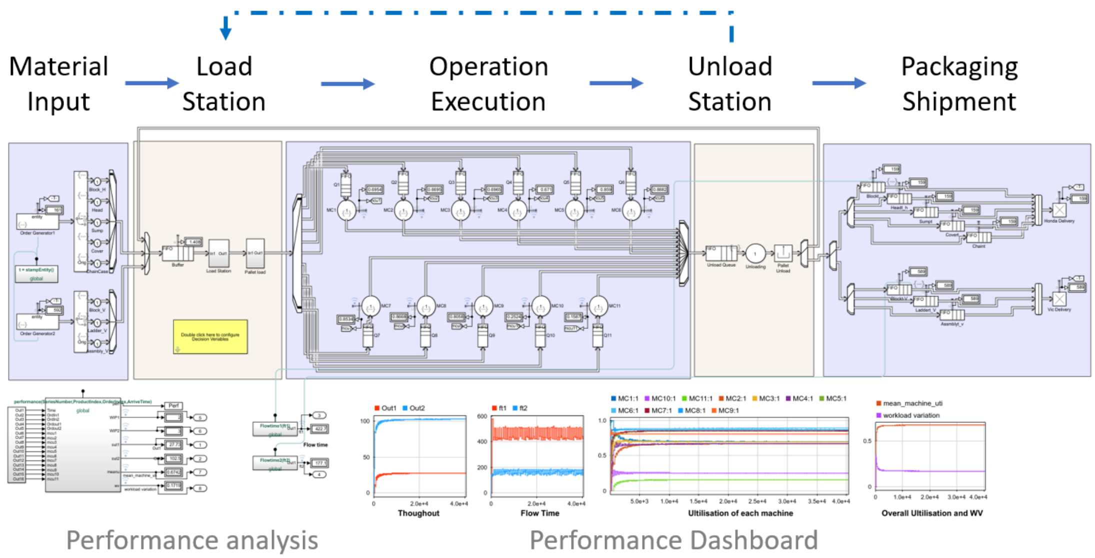

Figure 1: The top layer of the FMS simulation model.

4 DISCUSSION

We performed iterative experiments that combine simulation of future scenarios, hypothetical solutions, and real-world testing. Several behaviors of FMS that are distinct from the behaviors of dedicated manufacturing systems were discovered: e.g. changing FMS operation sequences have no significant impact on its overall performance. We then introduced a scheme to perform Level of Flexibility (LoF) experiments, that has resulted in demonstrable benefits of releasing flexibility in FMS.

5 CONCLUSION

A comprehensive FMS simulation model of a modern FMS implementation has been developed. Using the simulation model, real-world operational problems have been investigated and their potential solutions explored. The simulation findings have been verified with the industrial stakeholders, providing confidence that the model can be used as a test bed for further research.

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