Simulation Modeling for Smart Manufacturing System

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Abstract: Manufacturers are always seeking ways to increase the performance of their production systems. Today, the principal ways include the use of smart technologies for data collection, analysis, prediction and decision-making. These technologies will facilitate the deployment of smart manufacturing systems to enable manufacturers achieve the increased agility needed to respond to a wide range of changes and disruptions. Smart systems can also help to reduce the environmental impacts of their manufacturing activities while simultaneously increasing equipment utilization. Modeling and simulation technologies can provide an answer to this assurance question. Appropriately designed simulation models can analyze the behavior and predict the performance of a smart manufacturing system. Both are integral to the kinds of real-time, dynamic, decision making – including decisions related to machine configuration, work schedules, maintenance, and other operating characteristics – needed for that assurance. The analysis of simulation output for specified output parameters of the performance of a production system enables evaluation and assessment of a manufacturing process’s performance. In this paper, we discuss the challenges and issues associated with designing and executing those simulation models. We also discuss challenges related to data input, output analysis, and decision making. This paper outlines approaches to overcome these challenges and concludes with a presentation of a conceptual model of a new, data-driven, performance-assurance methodology.

Keywords: Smart Manufacturing, Real-Time, Decision Making, Simulation Modeling, Performance Improvement

1. Introduction

Modern manufacturing industry faces relentless global competition and increasing uncertainties in the cost and supply of input materials. In addition, the demand for manufactured products is unpredictable with more customers demanding high-quality, customized products. Orders are received in an unpredictable manner and subject to changes in terms of product design, quantities, priorities, quality, and due dates. The products are often made of materials and parts manufactured in different countries, with an increasing potential for delays and quality problems.

In the new manufacturing environment that is increasingly customer driven, on-time delivery of both components and final products is an important competitive factor. Internal factors such as variations in manufacturing processes, throughput capacity, production lead time, and machine availability can also impact delivery times. Such forms of variability are subjecting manufacturing systems to both short and long-term operational uncertainties to which they often have no capability to respond effectively. These uncertainties often result in lost production time, low machine utilization, and adverse environmental impacts. To minimize the impacts of these uncertainties, modern production systems must be: 1) equipped with advanced manufacturing technologies that are adaptable and reconfigurable and 2) able to use these technologies to respond in real-time to impending problems, and 3) able to use a variety of sensors to collect and analyze shop floor data to identify those problems.

In the 2012 report, “Emerging Global Trends in Advanced Manufacturing”, the Institute for Defense Analyses identified five major trends instrumental in the shift to advanced manufacturing technologies (Shipp et al., 2012). They are: 1) information technology, 2) modeling and simulation of manufacturing processes, 3) global supply chain management, 4) rapid changeability of manufacturing in response to customer needs and external impediments, and 5) sustainable manufacturing. These trends are the embodiments of what is called “smart manufacturing.” Smart manufacturing, through the pervasive application of technologies resulting from these trends, hopes to dynamically integrate and effectively respond to manufacturing needs throughout the entire production system. If this happens, then smart manufacturing will provide real-