



Smart and Sustainable Manufacturing Systems

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Special Issue on Smart Manufacturing in Energy Intense Process Industries

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Editorial Objectives

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Purpose and Scope

This journal fosters transdisciplinary research that crosses the boundaries of information science, systems engineering and engineering design, manufacturing, and product life cycle with a focus on how to make manufacturing systems smarter and sustainable.

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Overview

Special Issue on Smart Manufacturing in Energy Intense Process Industries

Chemical manufacturing is one of the most energy intensive manufacturing sectors in the U.S. Over the past decades, the energy efficiency of this sector has significantly improved. However, new methods, technologies, and tools are sought for further energy efficiency gains with less environmental impact. In recent years, smart manufacturing has become an emerging area of research and practice. It promotes the use of data and information technology, advanced computer-aided design, computer control, sensor networks, and production management software to improve manufacturing sustainability.

This special issue contains eight invited papers that demonstrate state-of-the-art research in the key areas of smart manufacturing in the energy intensive process industries. The paper contributed by Pichardo and Manousiouthakis describes their investigation on natural gas-based hydrogen production systems utilizing hybrid energy sources and introduces an effective process synthesis methodology utilizing the Infinite Dimensional State-space (IDEAS) technique. The methodology has been tested for simultaneously synthesizing a hydrogen production process and its associated heat exchanger network system. The derived intensified system demonstrated a significant reduction of the use of methane as a fuel source, thus enabling the use of concentrated solar power based renewable energy for hydrogen production. An alternative technical approach is through electrolysis using renewable resources. Electrolysis is the process of using electricity to split water into hydrogen and oxygen. Ogumerem and Pistikopoulos introduce an optimal operating strategy for the Proton Exchange Membrane (PEM) water electrolysis process using the Parametric Optimization and Control (PAROC) framework. Their method employs a multi-parametric model predictive control (mp-MPC) technique, which could avoid online optimization at every time step because the optimization was performed once and offline. By their method, the high cost of operation due to its energy intensity can be greatly reduced.

In addition to the paper by Ogumerem and Pistikopoulos, there are also three other papers in this issue that propose different process control approaches. In process plants, sensor placement is critical to real-time information collection. Sen et al. develop a unique stochastic programming based algorithm for optimal determination of the numbers, locations, and types of sensors in a large-scale process with the estimator-based control system. The algorithm has been successfully implemented in an acid gas removal process unit as part of an integrated gasification combined cycle (IGCC) power plant with pre-combustion CO₂ capture. Giuliani and Durand introduce a new economic model predictive control (EMPC) design method, where process data gathered from sensors will be used to develop a physically-meaningful empirical model for a process control. A chemical process example was used to demonstrate the potential of a data-gathering EMPC methodology. In a control hierarchy, production scheduling is a process of arranging, controlling and optimizing work

and workloads in a manufacturing process. The paper by Westberg et al. studies a production scheduling problem with batch manufacturers in a smart grid environment. In their work, the authors analyze how batch process facilities are well suited to respond to power grid changes as they function in a manner that allows for variable production scheduling. Additionally, the utilization of on-site energy storage is discussed for how it could be managed to reduce peak demand at necessary times. They demonstrate that fairly simple automation could drastically lessen an industrial facility's impact on the grid.

Energy efficiency improvement with significant reduction of greenhouse gas (GHG) in manufacturing regions has received increasing attention in the past decade. Mukherjee and El-Halwagi describe a network design approach for hydrocarbon processing involving multiple manufacturing sectors located in proximity. The system, which is called the carbon-hydrogen-oxygen symbiosis network (CHOSyN), was designed using first-principle-based mass and energy balance. This methodology can be applied in the design stage to ensure safety, reliability as well as cost efficiency of the entire network. Aiming at investigating the energy efficiency and CO₂ emission in geographically distributed manufacturing regions, Amini-Rankouhi et al. introduce a general data-driven modeling and analysis methodology. Their paper demonstrates that an integrated use of the openly accessible data from different data sources could generate new information about energy efficiency and environmental impact in different manufacturing regions in the U.S., and a case study provides a detailed model-based analysis of energy consumption, energy loss, and CO₂ emission of 15 energy intensive manufacturing sectors in different states as well as in counties.

In the manufacturing industry, the Internet of Things (IoT) is emerging as a technology promising a powerful foundation for plants to identify ways to monitor, analyze, and adjust production processes effectively and to increase efficiencies, profits, and customer satisfaction. The paper contributed by Nguyen and Dugenske proposes a low-cost architecture based upon the publish-and-subscribe standard for implementation of IoT in manufacturing systems. The architecture is a nonintrusive and flexible system, which is being enhanced for wider applications.

Taken collectively, the papers in this special issue add considerable value to readers in the field of smart manufacturing toward industrial sustainability. Researchers in both academic and industrial organizations will benefit from this collection of papers, which is aimed at enhancing the impact of current research.

Producing this special issue required significant efforts from authors, reviewers, and the publication team, which is gratefully acknowledged. We would especially like to thank Dr. Sudarsan Rachuri, Advanced Manufacturing Office, Office of Energy Efficiency and Renewable Energy of DOE, for his guidance in the development of this issue. We are also thankful for the assistance provided by ASTM staff members, Alyssa Conaway and Sara Welliver. In particular, we acknowledge the financial support from the U.S. National Science Foundation through grants (Award Nos. 1140000, 1642400 and 1629385).

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IN APPRECIATION

The high quality of the papers that appear in this publication is a tribute not only to the obvious efforts of the authors represented but to the unheralded, though essential, efforts of their reviewers. It is to the reviewers dedication to upholding the high standards of their profession that this note pays tribute. On behalf of ASTM International and the authors as well, we acknowledge with appreciation their important contribution to the success of this journal.



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