Computers and Chemical Engineering 47 (2012) 145–156

Contents lists available at SciVerse ScienceDirect

Computers and Chemical Engineering

journal homepage: www.elsevier.com/locate/compchemeng

Smart manufacturing, manufacturing intelligence and demand-dynamic performance

Jim Davis[a,*], Thomas Edgar[b], James Porter[c], John Bernaden[d], Michael Sarli[e]

[a] UCLA, Los Angeles, CA, United States
[b] University of Texas – Austin, Austin, TX, United States
[c] DuPont (retired), Sustainable Operations Solutions, Philadelphia, PA, United States
[d] Rockwell Automation, Milwaukee, WI, United States
[e] ExxonMobil Research and Engineering (retired), University of Massachusetts, Amherst, MA, United States

ARTICLE INFO

Article history:
Received 12 April 2012
Accepted 27 June 2012
Available online 6 July 2012

Keywords:
Smart Manufacturing
Advanced manufacturing
Performance-based enterprises
Supply chain performance
Demand-dynamics
Energy productivity
Sustainability

ABSTRACT

Smart Manufacturing is the dramatically intensified and pervasive application of networked information-based technologies throughout the manufacturing and supply chain enterprise. The defining technical threads are time, synchronization, integrated performance metrics and cyber-physical–workforce requirements. Smart Manufacturing responds and leads to a dramatic and fundamental business transformation to demand-dynamic economics keyed on customers, partners and the public; enterprise performance and variability management; real-time integrated computational materials engineering and rapid qualification, demand-driven supply chain services; and broad-based workforce involvement. IT-enabled *Smart* factories and supply networks can better respond to national interests and strategic imperatives and can revitalize the industrial sector by facilitating global competitiveness and exports, providing sustainable jobs, radically improving performance, and facilitating manufacturing innovation.

© 2012 Elsevier Ltd. All rights reserved.

1. Smart Manufacturing

Greater manufacturing complexity, dynamics-based economics and radically different performance objectives will require the pervasive application of networked, real-time information-based technologies that transform a facilities focus to knowledge-embedded facilities, a reactive operational approach to one that is predictive, incident response to incident prevention, compliance to performance, and vertical decision-making to distributed intelligence and local decision-making with global impact. Existing assets will need to become globally competitive while the installed base of equipment runs its investment life cycle. Capital and operating costs will need to be lowered. Performance will need to be responsive to multi-faceted objectives. Advanced manufacturing and advanced networked information and computation technology will become synonymous (SMLC, 2009, 2011; Warren, 2011).

Additionally, the manufacturing workforce with substantially more advanced training and skills will not only be fundamental but will also be the key competitive advantage as dynamic management and operation of demand-driven product profiles increase and as innovation and faster time-to-market for new products becomes a key economic driver. Small, medium and large manufacturers will depend on college level training and skills and the manufacturing workforce will re-distribute throughout the supply chain, advanced technology suppliers, and the innovation and start-up companies (Devol, Wong, Bedroussian, Flor Hynek, & Rice, 2010; Kaushal, Mayor, & Riedl, 2011; Nosbusch & Bernaden, 2012; Nosbusch & Wince-Smith, 2010). Talent and workforce training will no longer be about vertical factory operations but about dynamic interaction, innovation, rapid product changes, and new products to market all with safe and sustainable operations spread across a widely distributed base of small medium and large companies. Not only will talent and workforce training need to address a dramatically distributed manufacturing approach but also the technologies that support it.

In response, a coalition of companies, universities, manufacturing consortia and consultants called the Smart Manufacturing Leadership Coalition (SMLC) has been on a five year 'journey' to define, plan and implement the game changing roles for networked data and information within and across the manufacturing process. Through a set of consensus-driven processes, Smart Manufacturing has been defined as the dramatically intensified application of '*manufacturing intelligence*' throughout the manufacturing and supply chain enterprise. Smart Manufacturing both leads and respond to a dramatic and fundamental business

* Corresponding author.
E-mail address: jdavis@oit.ucla.edu (J. Davis).

0098-1354/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.compchemeng.2012.06.037

transformation toward *demand-dynamic* economics, *performance-based* enterprises, *demand-driven* supply chain services and broad-based *workforce involvement and innovation*. This intensification of 'manufacturing intelligence' comprises the real-time understanding, reasoning, planning and management of all aspects of the enterprise manufacturing process and is facilitated by the pervasive use of advanced sensor-based data analytics, modeling, and simulation (Caminiti, 2011; Chand & Davis, 2010a, 2010b).

Smart Manufacturing envisions the enterprise that integrates the intelligence of the customer, its partners and the public. It responds as a coordinated, performance-oriented enterprise, minimizing energy and material usage while maximizing environmental sustainability, health and safety and economic competitiveness. Business, operations, management, workforce and manufacturing process transformations are in response to new ways of reasoning about the manufacturing process. These same transformations are facilitated by the application of manufacturing intelligence in a "generate-plan-apply" cycle that is sufficiently accelerated to produce a new demand-dynamic performance orientation.

1.1. The Smart Manufacturing Leadership Coalition (SMLC)

The SMLC is comprised of 25 large global companies, 8 manufacturing consortia, 6 universities, 1 government lab and 4 high performance computing centers. It has built on earlier NSF funded work by 20 companies and 20 universities to develop a roadmap for Smart Manufacturing (SMLC, 2009). The SMLC is committed to a comprehensive vision in which technology and the business, operating and workforce models are transformed in concert to achieve a steep change in manufacturing productivity with respect to value add product economics. There is no doubt that the deployment of Smart Manufacturing involves complex on-the-ground detail, difficult applications of technical and operational approaches, difficult business models, the management of significant risk, and the need for research and development in new technologies, business models and organization engineering. The coalition comes together around a set of goals that no one company (even large and global) can accomplish alone (SMLC, 2011):

- Integrate the intelligence of the customer, partner and public throughout the manufacturing supply chain.
- Develop the collective capacity to respond as coordinated factory and supply chain enterprises.
- Perform against new cross factory and supply chain key performance indicators (KPIs) that are radically different from traditional output/input metrics.
- Increase the base of workforce innovation.
- Radically increase productivity and quality by lowering the cost of IT infrastructure, sensing and the pervasive deployment of modeling and simulation.
- Build equivalent capability across small, medium and large enterprises together.
- Build a workforce that is trained in performance oriented decision making.
- Define the technology research and development that is needed to achieve the full vision.

In June 2011 the SMLC released its latest report entitled, "Implementing 21st Century Smart Manufacturing." The report captures the SMLC's consideration of the most *meaningful impacts* in intensifying stage wise application of manufacturing intelligence over a ten-year time horizon:

- *Resources and optimized networks* – 25% reduction safety incidents, 25% improvement energy efficiency, 10% improvement overall operating efficiency, 40% reduction cycle times.
- *Product* – Product tracking and traceability throughout the supply chain; pinpoint product recalls that are dynamically managed; product trustworthiness, e.g. defense products.
- *Transition economics* – 10× improvement in time to market in target industries.
- *U.S. industrial innovation base* – 25% revenue in new products and services; 2× current small and medium enterprises (SMEs) addressing total market; more highly skilled sustainable jobs created.

1.2. Game changing IT

The SMLC has strongly underscored the premise that manufacturing continues to be data rich and knowledge poor, and as a result, operates with constricted decision processes, even in operations using sophisticated modeling and control technologies. New information technologies have been applied to optimize individual unit processes, but Smart Manufacturing (SM) systems that integrate manufacturing intelligence in real-time across an entire production operation remain rare in large companies, and virtually non-existent in small and medium size organizations. Real time management of energy consumption is a perfect example of the contradiction between the potential benefits and barriers to the implementation of SM technology. In many industries, energy is frequently the second largest operating cost; but many companies lack cost effective measurement systems and modeling tools and/or performance and management tools to optimize energy use in individual production operations, much less in real-time across multiple operations, facilities, or an entire supply chain. As a result, business plans and day-to-day management decisions are being implemented with incomplete knowledge of the relationship between product output, energy use and environmental impact, while approximately 30% of the energy delivered to U.S. manufacturing sites is lost as waste heat. Generally speaking, a cost effective infrastructure to integrate real-time manufacturing intelligence and active management above and across the control systems of an entire production operation does not exist today.

Clearly, there is a recognized interest and a base of literature on flexible and adaptive enterprise wide optimization and decision making (e.g. Christofides et al., 2007; Engell, 2007; Grossmann, 2005; Stephanopoulos & Reklaitis, 2011; Wassick, 2009; Ydstie, 2004). To help distinguish Smart Manufacturing, as a 21st century advanced manufacturing model, from the prior 40 years of implementing information, modeling, control and optimization technologies, advanced robotics and automation systems, and financial and business systems, etc., we can draw some important parallels with the recent health care IT initiative especially as it relates to the increasingly broad and pervasive access to health care information and its *meaningful use*. Referring to the December 2010 Report from the President's Council of Advisors on Science and Technology (PCAST, 2010) to the President and Congress entitled, "Designing a Digital Future: Federally Funded Research and Development in Networking and Information Technology", there are meaningful use scenarios for information technology that fundamentally change the existing health care model. We use two of these to draw some analogies for manufacturing:

An 'enterprise' health care record for each patient – There is considerable healthcare related data about each of us that exists across caregivers, treatments, facilities, pharmacists, etc. and across time. Sensors and other observational tools add to a data record of health and state and there is additional important data that we could

Download English Version:

https://daneshyari.com/en/article/172704

Download Persian Version:

https://daneshyari.com/article/172704

Daneshyari.com