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ScienceDirect

Procedia Manufacturing 11 (2017) 1288 – 1295

Procedia MANUFACTURING

27th International Conference on Flexible Automation and Intelligent Manufacturing, FAIM2017, 27-30 June 2017, Modena, Italy

Review of socio-technical considerations to ensure successful implementation of Industry 4.0

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Abstract

The paper reviews the Industry 4.0 infrastructure and that beyond the potential cost and efficiency gains from implementation, adoption is argued from the perspective of leveraging internal capabilities to devolve Industry 4.0 as the driver for creating competitive advantage. Industry 4.0 and lean manufacturing methods are presented as mutually supportive, where lean methods are enablers for Industry 4.0 implementation, and conversely, Industry 4.0 realizes the extended lean enterprise. The paper further argues that in addition to appreciating the technical aspects of Industry 4.0, it is necessary to understand the socio-technical requirements to ensure successful implementation.

Peer-review under responsibility of the scientific committee of the 27th International Conference on Flexible Automation and Intelligent Manufacturing

Keywords: Industry 4.0; Cyber-Physical Systems; Internet of Things; Smart Factories; Socio-Technical Systems

1. Introduction

Manufacturing is continually evolving and a common view amongst practitioners, academics and observers is that the current stage of manufacturing is at a revolutionary phase based on digital technologies linked to the

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Peer-review under responsibility of the scientific committee of the 27th International Conference on Flexible Automation and Intelligent Manufacturing
doi:10.1016/j.promfg.2017.07.256

internet. Within manufacturing, business and academia, this revolutionary phase, frequently referred to as 'Industry 4.0', has over recent years been the subject of much comment, debate and research. At the kernel of Industry 4.0 are two enabling technologies, the Cyber-Physical System and the Internet of Things. Through mastering these technologies, advocates of Industry 4.0 visualize an interconnected world that can respond efficiently to the needs of the customer via smart factories, creating a virtual replication of the physical system that enables the real time intelligent analysis of large data sets. Though the Industry 4.0 model has great potential to advance manufacturing capability and meeting the needs of a more customized and tailored customer base, adoption is not necessarily a guarantee for success. Where for example lean/six sigma initiatives have proved successful, it is because the implementation has followed the 'architecture' or rules of the methodology. The methodology becomes part of the culture of the company, where people have received the appropriate training and familiarization as to the relationship of the method to the organizations capabilities and to customers and wider stakeholders. So too will it be with Industry 4.0, to leverage the potential gains from the model, beyond the necessity to ensure adherence to the technical architectures, there will be a necessity to articulate Industry 4.0 as a Socio-Technical System. In doing so, stakeholders engaged within the Industry 4.0 environment will gain the necessary appreciation of the technologies and the relationship of model within their organizations and to the customer base. Succinctly, the rules of Industry 4.0 are still being written, where the focus is primarily concentrated on successful technical deployment. Consequently, it appears that the socio-technical aspects of Industry 4.0 are being overlooked. To overcome this oversight, this paper assesses the socio-technical features applicable to Industry 4.0 to contribute to the evolving and expanding body of knowledge. The paper is organized as follows: Section two presents an appreciation of the technical infrastructure of Industry 4.0; Section 3 examines why Industry 4.0 should be adopted; Section 4 assesses the relationship of Industry 4.0 to lean/six sigma methodologies; Section 5 considers the socio-technical features of Industry 4.0; and Section 6 closes the paper with some concluding remarks.

2. The Industry 4.0 Infrastructure

Industry 4.0 is so named as "the phenomena" is considered to yield a paradigm shift in the use of manufacturing technology to parallel what are considered the first three industrial revolutions that evolved due to mechanization, electricity and automation. The concept originated in Germany in 2011 and subsequently became a strategic initiative of the German Government and included in their "High-Tech Strategy 2020 Action Plan" [1] and promoted as the future of the country's industrial and economic growth [2].

Within the factory environment, Industry 4.0 is visualized as a collection of devices, machines, production centres and products that can autonomously communicate with each other, exchange information, invoke actions and control each other independently within what is defined as a Cyber-Physical System (CPS) [3].

Externally, Industry 4.0 has the potential to place the factory at the heart of a highly distributed but heterogeneous network of customers, retailers, suppliers and a myriad of other interested stakeholders through high speed internet access and the capability to store enormous quantities of data that is available for subsequent analysis.

Through, Industry 4.0, the factory is evolving into what is called a 'Smart Factory' [4]. The Smart Factory has a dual existence. Firstly in the physical sense, in terms of machines and systems that people interact with to manufacture products. Secondly, the factory exists as a 'Digital Twin' in the virtual world or cyberspace where intelligent algorithms can process the data generated by the physical system, yielding information on the performance, condition and health of the physical system in real time. It is in the 'virtual world' where the factory becomes smart – enabling machines to become self aware of their condition, enabling self diagnosis leading to prediction of malfunctioning components or possible failures. Similarly, the manufacturing system is able to schedule the factory to satisfy the specific requirements of a customer through understanding the real-time status of each machine within the factory network.