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ScienceDirect
Int. J. Production Economics 107 (2007) 223–236
international journal of production economics
www.elsevier.com/locate/ijpe

Analyzing the benefits of lean manufacturing and value stream mapping via simulation: A process sector case study

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Received 1 November 2005; accepted 1 September 2006
Available online 28 November 2006

Abstract

The "lean" approach has been applied more frequently in discrete manufacturing than in the continuous/process sector, mainly because of several perceived barriers in the latter environment that have caused managers to be reluctant to make the required commitment. We describe a case where lean principles were adapted for the process sector for application at a large integrated steel mill. Value stream mapping was the main tool used to identify the opportunities for various lean techniques. We also describe a simulation model that was developed to contrast the "before" and "after" scenarios in detail, in order to illustrate to managers potential benefits such as reduced production lead-time and lower work-in-process inventory.

Keywords: Lean manufacturing; Value stream mapping; Simulation; Process industries; Steel

1. Introduction

Lean manufacturing is one of the initiatives that many major businesses in the United States have been trying to adopt in order to remain competitive in an increasingly global market. The focus of the approach is on cost reduction by eliminating non-value added activities. Originating from the Toyota Production System, many of the tools and techniques of lean manufacturing (e.g., just-in-time (JIT), cellular manufacturing, total productive maintenance, single-minute exchange of dies, production smoothing) have been widely used in discrete manufacturing. Applications have spanned many sectors including automotive, electronics, white goods, and consumer products manufacturing.

On the other hand, applications of lean manufacturing in the continuous process sector have been far fewer (Abdullah and Rajgopal, 2003). It has sometimes been argued that in part, this is because such industries are inherently more efficient and have a relatively less urgent need for major improvement activities. Managers have also been hesitant to adopt lean manufacturing tools and techniques to the continuous sector because of other characteristics that are typical in this sector. These include large, inflexible machines, long setup times, and the general difficulty in producing in small batches.

While some lean manufacturing tools might indeed be difficult to adapt to the continuous sector,

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doi:10.1016/j.ijpe.2006.09.009

this does not mean that the approach is completely inapplicable; for example, Ahmad et al. (2005), Melton (2005), Radnor (2000), Cook and Rogowski (1996), and Billesbach (1994). Abdullah et al. (2002) and Abdelmalek et al. (2006) examine aspects of continuous production that are amenable to lean techniques and present a classification scheme to guide lean implementation in this sector. The objective of this paper is to use a case-based approach to demonstrate how lean manufacturing tools when used appropriately, can help the process industry eliminate waste, maintain better inventory control, improve product quality, and obtain better overall financial and operational control. A large integrated steel mill is used to illustrate the approach followed. Since some of the information is confidential, the company is referred to as AB steel (or ABS) throughout this paper. In our approach, value stream mapping (VSM) is first used to map the current operating state for ABS. This map is used to identify sources of waste and to identify lean tools for reducing the waste. A future state map is then developed for the system with lean tools applied to it. Since the implementation of the recommendations is likely to be both expensive and time-consuming, we develop a simulation model for the managers at ABS in order to quantify the benefits gained from using lean tools and techniques.

2. Background

We begin by providing a brief overview of the principles used in this work, followed by some background information on the company where the work was conducted.

2.1. Overview of lean manufacturing and its tools

After World War II Japanese manufacturers were faced with vast shortages of material, financial, and human resources. These conditions resulted in the birth of the "lean" manufacturing concept (Womack et al., 1990). Kiichiro Toyoda, the president of Toyota Motor Company at the time, recognized that American automakers of that era were out-producing their Japanese counterparts by a factor of about ten. Early Japanese industrial leaders such as Toyoda, Shigeo Shingo, and Taiichi Ohno responded by devising a new, disciplined, process-oriented system, which is known today as the "Toyota Production System," or "Lean Manufacturing." The system focused on pinpointing the major sources of waste, and then using tools such as JIT, production smoothing, setup reduction and others to eliminate the waste. A very brief description of the most common lean tools is given below (Monden, 1998; Feld, 2000; Nahmias, 2001); the interested reader is referred to one of the many books on lean manufacturing for more details:

- *Cellular manufacturing*: Organizes the entire process for a particular product or similar products into a group (or "cell"), including all the necessary machines, equipment and operators. Resources within cells are arranged to easily facilitate all operations.
- *Just-in-time* (JIT): A system where a customer initiates demand, and the demand is then transmitted backward from the final assembly all the way to raw material, thus "pulling" all requirements just when they are required.
- *Kanbans*: A signaling system for implementing JIT production.
- *Total preventive maintenance* (TPM): Workers carry out regular equipment maintenance to detect any anomalies. The focus is changed from fixing breakdowns to preventing them. Since operators are the closest to the machines, they are included in maintenance and monitoring activities in order to prevent and provide warning of malfunctions.
- *Setup time reduction*: Continuously try to reduce the setup time on a machine.
- *Total quality management* (TQM): A system of continuous improvement employing participative management that is centered on the needs of customers. Key components are employee involvement and training, problem-solving teams, statistical methods, long-term goals, and recognition that inefficiencies are produced by the system, not people.
- 5*S*: Focuses on effective work place organization and standardized work procedures.

2.2. Overview of VSM

A value stream is a collection of all actions (value-added as well as non-value-added) that are required to bring a product (or a group of products that use the same resources) through the main flows, starting