UNIVERSITI PUTRA MALAYSIA

**REDUCING PRODUCTION LEAD TIME THROUGH
VALUE STREAM MAPPING**

ALIREZA ESFANDYARI

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REDUCING PRODUCTION LEAD TIME THROUGH
VALUE STREAM MAPPING

By

ALIREZA ESFANDYARI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

February 2008

DEDICATION

Dedicated to my mother for her love, support and encouragement.

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment
of the requirement for the degree of Master of Science

REDUCING PRODUCTION LEAD TIME THROUGH
VALUE STREAM MAPPING

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February 2008

Chairman   : Ir. Mohd Rasid Osman

Faculty   : Engineering

This research addresses the application of lean manufacturing concepts to the

discrete production sector of a metal fabrication company in Malaysia. The goal of

this research was to investigate the application of lean manufacturing tools to reduce

production lead time for a dedicated product family. This study is applied to a small

metal-based manufacturing company (referred to as ABC).

Root-cause analysis based on behavioral and informational factors was developed for

seven waste indicators to identify the waste in managerial-level stage. Value Stream

Mapping (VSM) is prescribed as part of the lean production portfolio of tools and

has been applied in a variety of industries to identify lean tools to try to eliminate the

waste. VSM was used to first map the current state in order to realize the current

production lead time and to identify sources of wastes at the worker-level stage.

Then a future state map was developed using lean tools and techniques and

answering the eight questions stated by Rother and Shook (1999). The future state

map identifies the reduced production lead time based on lean concept. Two detailed simulation models using system modeling corporation's Arena 7 package was developed. The current state simulation verifies the current production lead time from current state map and the future state simulation which was developed based on the future state map quantifies reduction of production lead time.

It is concluded that using Value Stream Mapping (VSM), the production lead time of 200 units of 'back plate indoor' reduced from less than 15 days in current state map to less than 9 days in future state map. Also, the simulation shows that production lead time reduction to eight days could be accomplished at ABC if lean tools are utilized. Comparing the production lead time of eight days in simulated model and less than nine days in Value Stream Mapping (VSM) showed that VSM is a reliable tool for production schedule and estimating production lead time in lean production system.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

MENGGUNAKAN PENDEKATAN 'VALUE STREAM MAPPING' UNTUK MENGURANGKAN MASA MENDULU

Oleh

ALIREZA ESFANDYARI

February 2008

Pengerusi   : Ir. Mohd Rasid Osman

Fakulti   : Kejuruteraan

Kajian ini bertujuan untuk menerangkan aplikasi konsep pengilangan berpada terhadap sektor pengeluaran diskret bagi sebuah syarikat fabrikasi logam di Malaysia. Matlamat kajian ini adalah untuk menyelidik aplikasi peralatan pengilangan bagi menilai pengurangan masa mendulu terhadap produk induk yang berdedikasi.Kajian ini diaplikasikan kepada syarikat perusahaan kecil yang berasaskan logam (dengan ini merujuk sebagai ABC).

Analisis berasaskan sebab akibat yang berdasarkan faktor-faktor tingkah laku dan bermaklumat telah dibentuk bagi tujuh (7) indikator pembaziran bagi mengenal pasti pembaziran pada peringkat pengurusan. "Value Stream Mapping" (VSM) telah digunakan sebagai sebahagian portfolio peralatan pengeluaran dan diaplikasikan pada pelbagai industri untuk mengenal pasti peralatan yang digunakan untuk menghapus pembaziran. VSM telah digunakan pada awalnya untuk menentukan keadaan semasa bagi mengenalpasti masa mendulu semasa dan untuk mengenal pasti sumber pembaziran pada peringkat pekerja. Akhirnya, pemetaan   keadaan masa

hadapan dibina menggunakan peralatan berpada dan teknik serta jawapan lapan (8) soalan yang dikemukakan oleh Rother dan Shook (1999). Pemetaan keadaan semasa hadapan mengenalpasti masa mendulu yang dikurangkan berdasarkan konsep lean. Dua buah model simulasi pakej 'Modelling Corporation's Arena 7' telah dibentuk. Keadaan simulasi semasa meverifikasikan masa mendulu semasa dan keadaan simulasi hadapan yang telah dibina berdasarkan pemetaan keadaan hadapan mempamerkan penurunan kuantiti masa mendulu. Model simulasi dibentuk berdasarkan pemetaan keadaan masa hadapan ABC yang digunakan untuk mengira pengurangan masa mendulu.

Kajian ini menyimpulkan bahawa dengan menggunakan VSM, masa mendulu bagi 200 ' back plate indoor' dapat dikurangkan daripada 15 hari dalam keadaan semasa kepada kurang dari sembilan (9) hari pada masa hadapan. Juga, simulasi menunjukkan pengurangan masa kepada lapan (8) hari dapat dicapai pada ABC sekiranya peralatan berpada digunakan sepenuhnya .Perbandingan masa mendulu selama lapan(8) hari bagi model simulasi dan kurang daripada sembilan (9) hari dengan VSM menunjukkan bahawa VSM ialah peralatan yang boleh dipercayai bagi jadual pengeluaran dan mendapatkan anggaran masa mendulu terhadap sistem pengeluaran berpada.

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In the name of Allah, the Most Compassionate, the Most Merciful. All praise is due be to Allah, Lord of the Worlds, The Most Compassionate, the Most Merciful. Sovereign of the Day of Judgment. You alone we worship, and to you alone we turn for help. Guide us to the straightway; the way of those whom You have favored, not of those who have incurred Your wrath, nor of those who have gone astray (Al-Fatiha, the Opening chapter of the Holy Quran).

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Last but not least, I would like to express my heartiest gratitude and appreciation to my mother and all my friends who helped me throughout my research.

I certify that an Examination Committee has met on 19th of February to conduct the final examination of Alireza Esfandyari on his Master of Science thesis entitled "Reducing Production Lead Time through Value Stream Mapping (VSM) Approach" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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Date: 12 June 2008

DECLARATION

I declare that the thesis is my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at UPM or at any other institution.

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ALIREZA ESFANDYARI

Date: 20 May 2008

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LIST OF ABBREVIATIONS / GLOSSARY OF TERMS

5 whys	A simple but effective method of analyzing and solving problems by asking 'why?' five times (or as many times as needed to find the root cause).
5S	A set of workplace organization rules designed to increase efficiency and help enable lean manufacturing.
Autonomation	Machines are given 'human intelligence' and are able to detecting and preventing defects. Machines stop autonomously when defects are made, asking for help. Autonomation was pioneered by Sakichi Toyoda with the invention of automatic looms that stopped when a thread broke, allowing an operator to manage many looms without risk of producing large amounts of defective cloth. Autonomation is a pillar of the Toyota Production System. Also Jidoka.
Batch-and-queue	The production of multiple parts at a given operation as a batch that is finished and moved to the input queue of the succeeding operation.
Bottleneck	A resource that constrains the flow of production, inventory movement or data in a system. In a free-flowing system, the first place to restrict throughput when demand is raised.
Bullwhip effect	The variability in demand is magnified as we move from the customer to the producer in the supply chain.
CM	Cellular Manufacturing: An alignment of processes and equipment in correct process sequence, where operators work within the cell and materials are presented to them from the outside of the cell.
Changeover (C/O)	The time from when the last good piece comes off of a machine or process until the first good piece of the next product is made. Changeover time includes set up, warm up, trial run, adjustment, first piece inspection, etc.
Continuous improvement	The never-ending pursuit of waste elimination by creating a better workplace, better products, and greater value to society.
Cycle time (C/T)	Cycle time is the time it takes to do one repetition of any particular task. Cycle time can be categorized into 1) manual cycle time, 2) machine cycle time, and 3) auto cycle time.
EPEx	Every part every x (time): Measured in terms of time (hours, days, weeks, months, etc.) "Every Product Every X" indicates the level of flexibility to produce whatever the customer needs.

For instance, Every Product Every day would indicate that changeovers for all products required can be performed each day and the products can be supplied to the customer.

Greenfield	A new production facility where lean principles are designed into manufacturing and management systems from the beginning.
Heijunka	An element of the Toyota Production System that averages volume and sequence of scheduled items to provide level production and help enable JIT.
Jidoka	Stopping a line automatically when a defective part is detected. [See Autonomation]
JIT	Just In Time
Kaizen	Taken from the Japanese words kai and zen, where kai means change and zen means good. The popular meaning is continual improvement of all areas of a company not just quality.
kanban	A Just-in-Time technique developed in Japan at the Toyota Corporation in which a work center or department uses a visible card, token or other signal (kanban) to pull material from a feeder work center or supply location.
Lead time	The total amount of time between the recognition of a required task, operation or process and its completion. Elements of lead time can include order entry, material accumulation, machine setup, queue, processing, move and other activities, which can be classified by systems that seek to eliminate waste as valued-added and non value-added.
Load leveling	The process of rearranging demand (in terms of orders or a schedule) so that it is evenly distributed for a given time period.
LM	Lean Manufacturing
Milk run	The combination of shipments from multiple vendors in close geographic proximity into one shipment received by the customer, normally done for a defined route on a recurring basis.
Muda	The Japanese term for waste.
One piece flow	One piece flow production is when parts are made one at a time and passed on to the next process. Among the benefits of one-piece flow are 1) the quick detection of defects to prevent a large batch of defects, 2) short lead-times of production, 3)

reduced material and inventory costs, and 4) design of equipment and workstations of minimal size.

Pacemaker	A device or technique use to set the pace of production and maintain takt time.
Pitch	The pace and flow of a product.
Pokayoke (also poka yoke)	Japanese for 'mistake-proofing'. Mistake-proofing and fool-proofing devices made by designing parts, processes, or procedures so that mistakes physically or procedurally cannot happen.
Product family	A set of items considered as a related group in forecasting, capacity planning or other functions.
Production smoothing	Smoothing Keeping total manufacturing volume as constant as possible. [Same as Heijunka, leveling]
Setup time	The total time required to change settings and tooling from one production run to another.
SMED	Single Minute Exchange of Dies: The reduction in die set-up time. Set-up in a single minute is not required, but used as a reference.
Supermarket	The supermarket is a tool of the pull system that helps signal demand for the product. In a supermarket, a fixed amount of raw material, work in process, or finished material is kept as a buffer to schedule variability or an incapable process.
Takt time	Based on the German word that indicates pace, the rate or pace of production as matched to the pace of customer sales.
TPS	Toyota Production System
TPM	Total Productive Maintenance: A work philosophy that maximizes equipment effectiveness and uptime throughout the entire life of the equipment.
Tsurube system	A way to keep product flow continuous even when there are interruptions such as outside processing or batch operations. The tsurube system is often used when product leaves the flow line for processing through equipment that can not be placed into the cell (vendor operations, heat treat, plating, anodizing, etc.). Also called the "Well Wheel System" because of the similarity to how water is drawn out of a well using two buckets and a pulley wheel.

VSM   Value Stream Mapping

Visual   When the normal state and abnormal state can be clearly and
management   visually defined, visual management is possible. In visual
                      management, simple visual tools are used to identify the target
                      state, and any deviance is met with corrective action.

WIP   Work In Process: Material that has been partially processed but
                      not yet transformed into its final state and not normally usable
                      as is. The status of WIP material is usually described by its
                      current routing operation location.

CHAPTER 1

INTRODUCTION

1.1 Background of Research

In an increasingly competitive world, many manufacturing firms are looking for a winning card over their competition. In order to survive in today's fiercely competitive market, manufacturers have come to realize that the traditional mass production concept has to be adapted to the new ideas of lean manufacturing (Abdulmalek et al., 2006). Lean manufacturing concept is a difficult process to implement that requires effort and high understanding of lean philosophy. However, even though the transition is very difficult, the rewards earned by the transition make the effort worthy to change. The basic ideas behind the lean manufacturing system, which have been practiced for many years in Japan, is often associated with benefits such as reduced inventory, reduced manufacturing times, reduction of production lead time, and increased customer satisfaction (Ahls, 2001; Alavi, 2003; Emiliani, 2001; Ross and Francis, 2003;Womack and Jones, 1994, 2003; Hines and Taylor, 2000).

Given the dramatic customer satisfaction increases and what the companies were able to do because of the increases, it is not hard to understand why so many companies even non-production environment are trying to convert their current operations to lean operations.

In recent years, Value Stream Mapping (VSM) has appeared as the preferred way to implement lean, both inside factories and at the supply chain level linking those factories (Hines and Rich, 1997). VSM allows the user to manage the flow of value through a system and gives a static picture of what is going on within a system and where exactly value is being added to the product. Furthermore all advantages of VSM are not extremely reliable due to some serious limitations. These limitations made some researchers enhance VSM using simulation to consider the dynamic behaviors. Computer simulation is a powerful analysis tool that helps companies makes effective changes because the companies can accurately predict the results of the changes prior to making them.

1.2 Problem Statement

Reducing the lead time of value streams through the implementation of lean methodologies can be seen as an imperative for manufacturers to meet their competitive and customer requirements for the long term (Keogh, 2006). Although lean manufacturing principles have been implemented in many companies with discrete production system and there is reported benefits for lean implementation but there is still complexities for lean transition in industries with high discrete points and job shop production flow.

Also, ABC Company in this study is a small manufacturing industry with job shop operation. It means that the parts move on to different jobs when each job is completed in a discrete flow. Moving in discrete stream for parts at ABC causes complexity in

quantifying inventory when the parts are produced in mass. There is a typical problem mainly in controlling inventory which causes elongation of production lead time. So, decreasing production lead time is important for ABC. On the other hand, how much the ABC Company is able to decrease the production lead time, the market share would be increased and instantly the company turnover will be increased.

One of the lean tools which can be used for analysis and improvement of manufacturing system with disconnected flow lines is Value Stream Mapping (VSM) (Rother and Shook, 1998). Some lean tools may be more focused on the entire Organization as the unit of analysis, while others, such as value stream mapping (VSM), may be more focused on a product value stream (McDonald et al., 2002). By using VSM tool the material and information flow line are analyzed and the production lead time at both current and future state map will be realized. But Value Stream Map (VSM) just gives a static picture of what is going on within the system and it is unable to detail the dynamic behavior of production process.

A static model is a representative of a system at a particular time, or one that may be used to representation of a system at a particular time, or one that may be used to represent a system in which time simply plays no role. On the other hand, dynamic models represent a system as it evolves over time. VSM is the static picture of a system, it does not depict how different operations affect one another and this makes it difficult accurately determine the impact of transformations (Sullivan et al., 2002; Profozich, 1998). For example, by use of VSM at ABC, predicting the levels of inventory through the production process is not possible with only a future state map because with a static

model one cannot observe how the level of inventory will be changed through the time. So, the impact of dynamic behavior of inventory level on production lead time will be questioned.

To solve the problem with VSM deficiency, simulation was created in order to understand how behavior within a manufacturing facility affects the production flow. The time values indicated within a VSM are all necessary bits of information that a simulation requires. By using simulation the changes can be predicted before time and money consumption. Simulation avoids the expensive, time-consuming, and disruptive nature of traditional trial-and-error techniques (Harrell et al., 2004).

1.3 Objective of Research

The final objective of this research is to reduce production lead time for a dedicated production line at ABC Company. Based on this main goal, the objectives of this research are:

1) To model the material and information flow of ABC using Value Stream Mapping (VSM) approach.

   The current state map should be created for ABC value stream in order to realize the actual production lead time. Then future state map will be created consider to lean conception in order to specify the improved production lead time.

2) To model the future state of VSM tool using Arena simulation software.

   Simulation will be used to reduce uncertainty of VSM and create consensus by visualizing dynamic behavior of the process for the given future state map.

1.4 Scope of Research

This research concentrates on production lead time for a dedicated production line at a small metal fabrication industry. According to this aim, lean manufacturing conceptions used at ABC Company, a small metal manufacturer in Malaysia. Further more, this study includes investigating ABC for production lead time reduction if lean tools and techniques are applied and does not carry out how these tools can be implemented.

The study initiate with mapping the current state map of a product family in the dedicated production line. The data were collected for order delivery in current state map includes the 104 days working days. The main goal of mapping the current state is to identify the actual production lead time. After an overview on realizing the wastes at the current state the future state will be created. The future state map is created concerning the approach introduced by Rother and Shock (1999). The result for production lead time from future state map shows the impact of lean conception used for ABC value stream improvement. In order to verify the accuracy and deficiencies from current state map and future state map the simulation was developed. The developed model and simulation for future state of ABC value stream using Arena software reveals the reliability of VSM to decrease the production lead time.

1.5 Importance of Research

The companies with discrete production systems are faced to more complexity due to variations in production stages. So, they require quantifying inventory and standardize

the production time for material between stations. VSM is a valuable tool for investigating production lead time. VSM extensively was investigated in discrete sector manufacturing in purpose of production lead time reduction (Seth and Guptaj, 2005; Brunt, 2000; Abbett and Payne, 1999; McDonald et al., 2002). In current competitive market, manufacturer strives to expand their market share with the less cost for capital investment. This is expected to be impacted through the application of an improvement approach focused on eliminating non-value-adding work and waste.

Also, at ABC which is a plant with high discrete production flow. It means that production flow comes into discrete points early and this points causes complexities related to quantity of parts which should be produced. At ABC, the uncontrolled amount of inventory and unplanned production order released to the shop floor cause the deficiencies with controlling the production stream and excess production lead time. In this way, due to the uncertainty for identifying production lead time for each product at ABC, customer satisfaction is incredibly difficult and turnover ratio for stakeholders is not desired.

It is the importance of this study to reduce the production lead time for the discrete production system while the unscheduled orders makes harder controlling of the production lead time. The improvement targeted for production lead time has been considered that there would be no investment for capital equipment.

Toyota's original flow mapping methodology (Value Stream Mapping (VSM)) has provided us for thinking about flow and designing value streams with shorter lead times.

1.6