THE REDUCTION OF WORK IN PROGRESS BETWEEN PROCESS IN STRUT PRODUCTION LINE OF A MANUFACTURING FACTORY

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ABSTRACT

In today's competitive business world, companies require small lead times, low costs and high customer service levels to survive. Because of this, companies have become more customers focused. The result is that companies have been putting in significant effort to reduce their lead times. The purpose of this thesis was to reduce work in progress (WIP) between processes at ST (strut) production line in APM Shock Absorber Sdn Bhd. In order to achieve this, all processes that focus on three processes only which is ABW ABF, CO_2 welding, and LET KHP. Some changes based on the Toyota Production System (TPS) were implemented, The results were then shown in Yamazumi chart and then the implementation were sustained in the standard operating procedure (SOP). APM Shock Absorber Sdn Bhd has more than 32 years' experience of producing absorber for automotive part. Due to globalization and stiff competition, the reduction of WIP for each process is important so that they have a smooth production line flow and could maintain their customer satisfaction. It was found that the most appropriate method for lead time reduction was doing the visualization of current cycle time on Yamazumi chart. Another observation that was derived from the Yamazumi chart is the bottlenecks can be derived and waste at ST line can be eliminated by having Kaizen activity such as reduce waiting time and position the machine comfortably for the operator doing their process. Some other recommended changes based on applying TPS are reduction of work in process inventory (WIP), reduction of waiting time, stop the process to build in quality, collect more information, and implementation of the 5S methodology. By implementing these changes, the future state the of WIP can be reduce in between of the process and smooth production flow can occur.

ABSTRAK

Dalam dunia persaingan tinggi kini, kos yang rendah dan perkhidmatan yang memuaskan untuk pelanggan diperlukan untuk kekal dalam dunia perniagaan. Disebabkan ini, hampir semua kilang fokus kearah kepuasan pelanggan mereka. Tujuan tesis ini dibuat adalah untuk mengurangkan stor WIP diantara proses pada ST (strut) barisan produksi di APM Shock Asorber Sdn Bhd. Demi untuk mencapai pengurangan stor WIP pengiraan kitaran masa akan diambil bermula pada awal proses tersebut bermula sehingga proses terakhir pengeluaran produk. Hasil masa kitaran akan dipamerkan di carta Yamazumi dan operator bekerja secara teratur dan di catatkan di kertas SOP (Standard Operating Procedure). APM Shock Absorber Sdn Bhd telah lebih 32 tahun berpengalaman dalam penghasilan penyerap bahagian automotif. Disebabkan persaingan dunia perniagaan yang makin sengit, stor WIP bagi setiap barisan produksi di dalam APM Shock Absorber Sdn Bhd dikurangkan demi untuk mendapatkan pengeluaran produk dalam produksi tersebut berjalan dengan lancar. Dijumpai bahawa cara yang lebih bersesuaian untuk mengurangkan stor WIP untuk mendapatkan produksi yang lancer adalah dengan mengambil kira kitaran masa dengan mengunakan mengisi data didalam carta Yamazumi. Selain itu, untuk meningkatkan kadar pengeluaran, keseimbangan bagi setiap barisan produksi tidak harus dilupakan. Pemerhatian lain yang dapat dibuat adalah dapat untuk mengesan kelemahan iaitu dimana pengumpulan WIP yg besar terjadi boleh dikesan, dan aktiviti kaizen untuk mengurangkan pembaziran di dalam ST line turut dapat dilaksanakan seprti pengurangan masa menuggu dan menyusun mesin mengikut keseleseaan operator untuk melaksanakan prosesnya. Beberapa pendapat yang digunakan berdasarkan pengunaan TPS (Toyota Production system) turut digunakan seperti, Pengurangan Work In Process (WIP), pengurangan masa menunggu, memberhentikan proses demi menjaga kualiti, mengumpul maklumat, dan mengamalkan cara 5S. Dengan mengamalkan perubahan ini, pengurangan stor WIP dakan dapat mewujudkan barisan produksi yang berjalan dengan lancar, pada masa yang sama kualiti setiap produk terjamin.

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ABF	AB bracket fitting
ABW	AB Bracket welding
AA	Arc argon
CRM	crimping
CT	Cycle time
DFT	Damping force testing
HPC	High pressure cleaning
HC	Hose checking
KHP	Knuckle hole punching
LET	Leak tester
OFI	Oil filling
SIZ	Sizing
SOP	Standard operating procedures
TT	Takt time

CHAPTER 1

INTRODUCTION

1.1 COMPANY BACKGROUND

The APM (Automotive Part Manufacture) Shock Absorbers Sdn Bhd is located at Port Klang and start incorporated since 9 September 1980, with the latest manpower is 232 people. APM Shock Absorbers turnover is RM76Million/annum (USD 22Million). This company produces shock absorber which is part of automotive structure, type of shock absorber in this company produce such as Strut (ST), Telescopic (SA), Suspension Module, Height Adjustable Shock, PERFORMAX Shock Absorber, and Gas Spring. These company main customers are mostly from car manufacture such as PERODUA is 35%, TOYOTA is 25%, and PROTON is 20%.

In this research, the focus is on the reduction of WIP inventory of strut product in between process at the Strut (ST) production line. The strut that was introduced is shown in Figure 1.1.As a vehicle is driven over varying conditions, strut absorber has a tendency to bounce and hop depending on the roughness and bumpiness of a given road surfaces. Struts absorber applies various degrees of tension to the front and rear of a vehicle that limit road bounce and bumpiness.

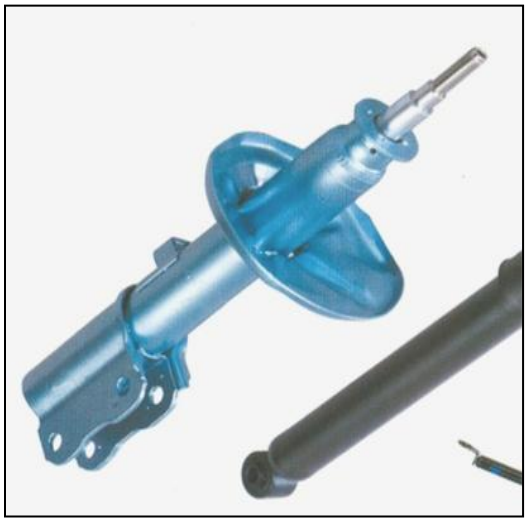


Figure 1.1: Strut absorber (ST)

1.2 RESEARCH BACKGROUND

In the present environment of intense global competition companies spend millions of dollars each year on the achieving smooth production flow with the goal of improving the quality of product by eliminating the waste. A well designed production line results in less inventory for WIP and minimize waste between process, leading to smooth production flow.

The main purpose of the reduction of WIP is to enhance the performance of the overall production process by reducing manufacturing cycle time. In order to improve the performance of production flow, implementation reduction lead time is involves both human and technical factors. These human and technical factors interact over time and go through three somewhat overlapping transitional stages. In the first stage, both human and technical problems exist however, human problems dominate, and require conflict management skill. In the second stage, human problems improve, but technical problems persist, requiring formal problem-solving methods to resolve. Finally, in the third stage, both human and technical problems improve. It is important to recognize these transitional stages because they must be effectively managed in order for the material handling functions to perform at the optimal level. The implications of this research, including directions for future research, are also provided.

1.3 THE MANUFACTURING PROCESS

In ST production line, there are five type of model which is A1001, A2990, BLM, SRM with ABS, and SRM without ABS. Every each model go through a slightly different process in ST line. However, the research conducted were focused on the BLM model.

The general manufacturing process flow for a BLM model of strut product in the ST production line shown in Figure 1.2:

1.4 ASSEMBLY LINE OF MACHINE PROCESS FLOW

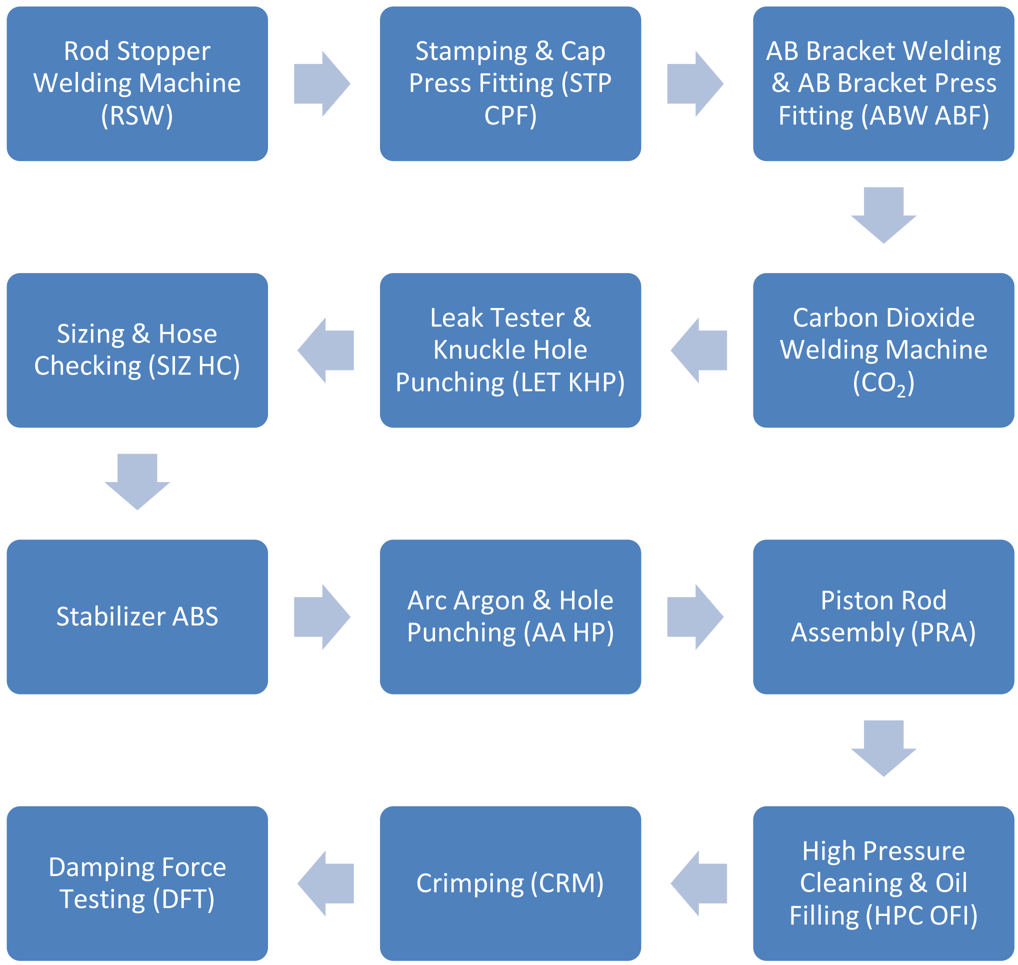


Figure 1.2: General machine process flow in ST line for model BLM

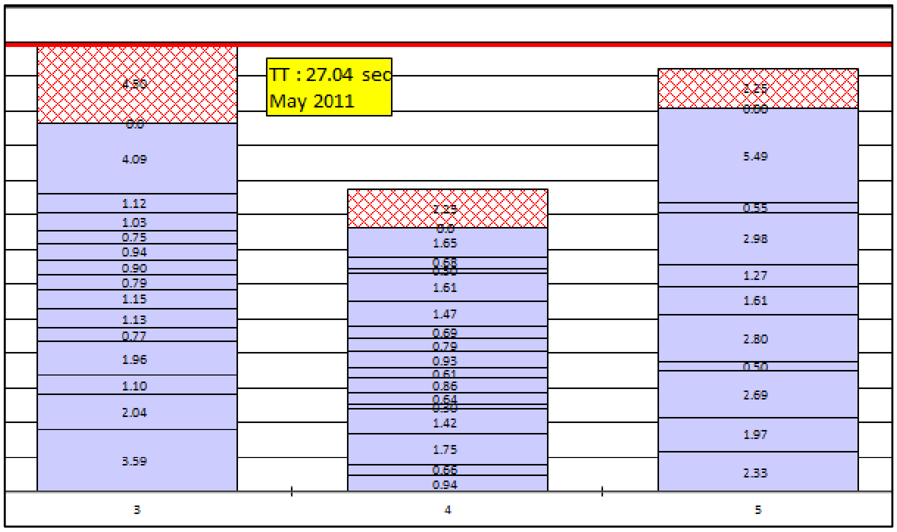
The process in this production line started with Rod Stopper Welding Machine (RSW) process and ended with Damping Force Testing (DFT) process for the quality inspection before sent to storage.

There are 17 machines involved in this line including of Rod Stopper Welding (RSW), AB bracket welding (ABW) and Carbon Dioxide Welding (CO_2). The rest of other processes are Hole Checking (HC) and AB Bracket Fitting (ABF) .This line production has been run by 13 of the operators.

1.5 PROBLEM STATEMENTS

The WIP reduction between processes in the production line is important so that the smooth production flow occurs. In other words, the flow of product through each process will be smooth and not build large WIP in between before and after the process. In this research, the study production line which is ST line were not smooth. By observation from the working area of ST production flow, each cycle time is recorded via video. The most big WIP occur is processed between two machines of CO_2 welding and leak tester together with knuckle hole punching.

Between both processes which is CO_2 welding machine and leak tester, there are high WIP have been built up which can be categorized as waste. This is because the time cycle of CO_2 welding machine is faster compared to the cycle time of leak tester, so the WIP is build up in order to wait there next process to finished.



	Operator 3 Operator 3 (abw abf)			Operator 4 Operator 4 (co2)			Operator 5 Operator 5 (let khp)	
1	Take bracket A & B at supply area	3.59	1	combine workpieces	0.94	1	takeout workpieces from machine	2.33
2	Walk to ABW machine	2.04	2	open slide door	0.66	2	take workpieces from raw mater	1.97
3	Take out workpiece after welding and put at WIP area	1.10	3	take workpieces	1.75	3	insert workpieces	2.69
4	Insert bracket A, press button and insert bracket B	1.96	4	Insert workpiece at OFI machine	1.42	4	press button	0.50
5	Press button again	0.77	5	Press button	0.30	5	walk	2.80
6	Walk and take bracket	1.13	6	closed slide door	0.64	6	takeout workpieces from machine	1.61
7	Take AB Bracket welding at WIP area	1.15	7	combine workpieces	0.86	7	stored workpieces	1.27
8	Insert into jig	0.79	8	walk	0.61	8	insert workpieces	2.98
9	Take base shell	0.90	9	take out workpieces to its place	0.93	9	push button	0.55
10	Insert into jig	0.94	10	walk	0.79	10	walk	5.49
11	Press button	0.75	11	open slide door	0.69	11		
12	Waiting	1.03	12	take out workpieces	1.47	12		
13	Take out base sub and put at WIP area	1.12	13	insert workpieces	1.61	13		
14	Walk back to ABW	4.09	14	press button	0.30	14		
15			15	closed slide door	0.68	15		
16			16	walk	1.65	16		
17			17			17		
18			18			18		
19			19			19		
20	Periodical work	0.0	20	Periodical work	0.0	20	Periodical work	0.00
21	Set-up	4.50	21	Set-up	2.25	21	Set-up	2.25
	Total	25.85		Total	17.51		Total	24.44

Figure 1.3: Yamazumi chart in 3 processes of ABW ABS, CO_2, LET KHP

Figure1.3 shows the half of the part of Yamazumi chart for BLM model with it's Takt Time (TT) at 27.04 second. This chart focuses on three types of processes in ST line which is AB Bracket Welding & AB Bracket Press Fitting (ABW ABF), Carbon Dioxide Welding Machine ($CO_{2)}$, and Leak Tester & Knuckle Hole Punching (LET KHP). Able to see that cycle time of CO_2 are less than other process which is 17.51 second, cycle time of ABW ABF is 25.85 second and LET KHP is 24.44 second. If a process cycle time is lower it is mean that this process is producing a high rate of product in other words it is overproduction.

Although it is good for CO_2 process is producing part faster so that the company can aim for high productivity but, in this case, CO_2 process seems to be the bottleneck of entire ST line. This is because since the cycle time CO_2 process is faster than it's next process which is LET, so, big WIP will occurs between those processes. All of other process has a smaller variance of cycle time from each process except CO_2 process, because the gap of its cycle time is big which is almost 8 second.

Since the CO2 process is a bottleneck, so the work in progress (WIP) before the CO2 process started will become low of WIP. This has happened because the cycle time of the process before the CO2 process which is ABS ABW is slower, so the places of WIP before CO_2 started is always empty and sometime operator need to wait part after ABW ABS process complete.

For the WIP after the CO2 process which is before the LET KHP process started, it WIP is always full until the number of WIP that completion is more than six in other words excessive number of WIP is occurring, and this is can occur the quality problem and first in first out (FIFO) will not be achieved.

1.6 OBJECTIVES

The objectives of the project are as the following:

1. Identify and eliminate waste and bottleneck in the ST production line
2. Reduce manufacturing work in progress (WIP) between process
3. Achieving smooth production flow by focusing on three processes which is ABW ABF, CO_2, and LET KHP.

1.7 SCOPE OF PROJECT

The scope of this project is on the ST production line for BLM model which is the assembly line in APM Shock Absorber Sdn Bhd.

CHAPTER 2

LITERATURE REVIEW

2.1 LITERATURE REVIEW

Lead time plays an important role in today's logistics manage- ment. Defined as the time that elapses between the placement of an order and the receipt of the order into inventory (Silver et al., 1998), lead time may influence customer service and impact inventory costs. As the Japanese example of just in time production has shown, consequently reducing lead times may increase productivity and improve the competitive position of the company (Tersine and Hummingbird, 1995).

One of the first papers dealing with a variable lead time in an inventory mode is due to Liao and Shyu (1991). The authors assume that lead time can be decomposed into several components, each having a different piecewise linear crashing cost function of lead time reduction, and that each component may be reduced to a given minimum duration. Under the assumption that the lot size is predetermined and that demand is normally distributed, they calculate an optimal lead time and show that reducing lead time may result in lower expected total costs.

Ben-Daya and Raouf (1994) revisit Liao and Shyu (1991) and propose a model that treats both lead time and order quantity as decision variables. They develop two models, one that uses the lead time crashing cost-function proposed by Liao and Shyu and one that uses an exponential crashing cost function. Ouyang et al. (1996) introduce another extension and include shortages in the model. They assume that a certain fraction of the demand during the stockout period is backordered and that the remaining fraction results in lost sales. Chandra and Grabis (2008) develop a model with lead time-dependent procurement costs and assume that shortening lead time results in increased procurement costs. The relationship between lead time and procurement costs is established with the help of a linear and a nonlinear procurement cost function.

2.2 PRINCIPLES OF ERGONOMIC

In order to achieve good material handling design, since it mostly run by a human so ergonomic are bringing some important role to this study. There are 10 principles of ergonomic that in to consider from Dan MacLeod, 1990, 2008:

1. Work in Neutral Postures.
2. Reduce Excessive Force.
3. Keep Everything in Easy Reach.
4. Work at Proper Heights.
5. Reduce Excessive Motions.
6. Minimize Fatigue and Static Load.
7. Minimize Pressure Points.
8. Provide Clearance.
9. Move, Exercise, and Stretch.
10. Maintain a Comfortable Environment.

2.3 WHAT IS LEAN?

Lean manufacturing sets of principles that continually identifies and eliminates sources of waste in the entire value chain. The core idea is to maximize customer value while minimizing waste [1]. Lean manufacturing was originated from the Toyota Production System (TPS) and identified as lean only in the 1990s [2]. There are 8 types waste identified in lean manufacturing (can be abbreviated as D-O-W-N-T-I-M-E) which are Defects, overproduction, Waiting, Non-engaging employees, Transportation, Inventory, Motion, and Excessive- processing.

Defects are defined as bad parts are out of specification parts that need to be reworked or need to be scrapped. Overproduction is defined as producing product ahead of demand. Waiting is defined as idling time of parts waiting to be processed, for example, waiting for equipment, operating or raw materials. Non-engaging employees could be defined as poor use of human intellects or work force. Transportation is defined as unnecessary movement of products or materials that is actually is not -required processing. Inventory is defined as raw materials, work-in-progress (WIP) inventory and finished product that are not being processed. Keeping inventory requires space and there are costs associated with it. Motion is defined as unnecessary motion in operations, for examples, equipment or operator movement. Excessive-processing could be defined as doing non-value added process for products.

There are five Lean Principles which are described in the book. ‘Lean Thinking’ as shown below [3].

1. Specify value. Value is described as what the customers are willing to pay for. One example could be processed which transform the product, for example, machining assembly. It is defined only by the customer, however sometimes it could be distorted by pre-existing organizations, especially engineer’s experts. They add complexity of no interest to the customer.

2. Identify the value stream. The value stream is all the actions or processes needed to bring a product or deliver value to the customer. The complete value stream flows through the complete supply chain, from raw materials to finished goods.
3. Flow. The value-creating steps or processes should be made to flow without delay interruption. One should try to eliminate departments that execute a single task process on large batches.
4. Pull. The production should be made to order. The production processes should be activated when the customers want to receive, not when the supplier wants to provide.
5. Pursue perfection. There is no end to the process of reducing time, space, cost and mistakes. One should strive for perfection by continually reducing waste.

Lean principles have several strengths. They provide a structured methodology for diagnosing and executing waste elimination. Lean focuses on workplace organization and preventive techniques. It is also very effective at rapidly reducing operational costs. Typical results that are obtained techniques after Lean implementation in manufacturing system that includes shorter lead times, increased productivity and efficiency, less inventory, lower overall production costs which lead to higher profit and return on assets, cleaner work areas, and waste elimination [4]. Some limitations of Lean principles include that does not bring a process under statistical control [5]. In other words, it is not capable of removing bottlenecks driven by process variability or defects [4]. Lean relies heavily on intuition, or trial-or-error problem solving, hence it could be a weakness when a problem is caused by interactive factors and make problem resolution complex [6].

2.4 LEAN GLOSSARY

The following list provides the definition of terms that will be used extensively throughout the thesis:

- Lead time (L/T): the time required for one piece to move all the way through the process or value stream, from start to finish.
- Manufacturing lead time: the time required for one piece to move all the way through the manufacturing process.
- Supplier lead time: the time required for the supplier to deliver raw stocks of forged components, from the time the orders are placed until it arrives in the company's warehouse.
- Product family: a group of product that pass through similar processing steps and over common equipment in the downstream processes
- Value added time (V/A): the time taken for the process that transform the product in a way for which the customer is willing to pay.
- Takt time: the customer demand rate
- Processing time: the time a product is actually being worked on by an operator or a machine.
- Cycle time: how frequently an item or product is completed by a process. For example, a welding process takes 4 hours to finish a product, if there are 4 welders available in the station, the cycle time of the welding process is 1 hour.
- Bottleneck: a process that cannot meet takt time.
- Queue time: the time a product spends waiting for the next processing step.

2. 5 LEAD TIME DEFINITION

Lead time is a total time required to complete one unit of a product or service. Figure 2.1 shown a simple illustration of lead time. In this research the lead time of ST production line is started from first process which is RSW and ended with inspection of DFT process.

Figure 2.1: Lead time illustration

The challenges of implementing lean manufacturing environment are the difficulties to see the flow because of the variations of time cycle processes and also because sharing of equipment resource. However, some of the basic lean tools as such 5S and visual management could be applied.

5S stands for Sort, Set in order, Shine, Standardize and Sustain [9]. It is a lean tool which focuses on the workplace organization, Sort means only keep necessary tools or equipment which are needed in a workstation. Set in order to arrange these tools or equipment in an orderly manner and labeled in order to promote efficient workflow. Shine means keeping the workplace tidy and organized. Standardize means that the first 3S should be consistent and standardized so that all workers know their responsibilities. Sustain refers to maintaining and reviewing the first 4S, example of visual management in a manufacturing line is production board as well as printed posters.

2.6 THE IMPORTANCE OF SHORTEN LEAD TIME

Based from the journal "Practical Strategies for Lead Time Reduction" by J. Wallace the importance of shortening lead time from sales perspective is:

1. Offer the ability to quota faster delivery to customers.
2. Lessen the impact of cancelled orders
3. Reduce the need to make forecasts about future demand

From the production perspectives, shorter lead times:

1. Improve quality management by reducing the opportunity for work to be damaged and shortening the time between manufacture and detection.
2. Reduce in process inventories.
3. Decrease disruption of the production process due to engineering change orders.
4. Enable shorter frozen in the Master Production Schedule, thereby reducing the dependence on distant forecasts.
5. Allow easier overall management of the facility because there will be fewer jobs to keep track of and fewer special cases (e.g., expedited jobs) to oversee.

There are three key points involved in lead reduction time. First, in the major components of flow times (and hence lead time) are queuing time and waiting time. Practical strategies for reducing lead time must be attacking these components to achieve significant results. Second, WIP and flow time are proportional to each other for a given level of throughput. Consequently, causes of excessive lead time can be determined by identifying locations with large inventories. Finally, lead time is related not only to average of flow time but also to the variance of flow time. Although most strategies that reduce the average flow time reduce its variance, there are situations where this is not true and lead times may actual increases.