Lean Implementation to Improve Scheduling

For a Multi-Cell Manufacturing Facility

by

Kyle Skelley

A Research Paper
Submitted in Partial Fulfillment of the
Requirements for the
Master of Science Degree
in

Technology Management

Approved: Three Semester Credits

Thomas Lacksonen, Ph.D.

The Graduate School

University of Wisconsin-Stout

August, 2009

The Graduate School
University of Wisconsin-Stout
Menomonie, WI

Author: **Skelley, Kyle B.**

Title: ***Lean Implementation to Improve Scheduling for a Multi-Cell Manufacturing Facility.***

Graduate Degree/ Major: MS Technology Management

Research Adviser: Thomas Lacksonen, Ph.D.

Month/Year: August, 2009

Number of Pages: 32

Style Manual Used: American Psychological Association, 5th edition

ABSTRACT

This Parker Hannifin plant in Chanhassen, MN has difficulties meeting customer due dates even though orders have been released to the floor with appropriate lead time. The plant has a goal of on-time shipping of at least 93% of orders, but is consistently coming in short of that goal.

The purpose of this study is to identify root causes for missing customer due dates, and to make recommendations to improve customer delivery. This study will:

1. Evaluate the current state of production scheduling in the plant and identify issues related to on-time delivery.
2. Review the lean techniques currently being used in the plant.

3. Recommend and implement new lean manufacturing concepts for the assembly department to help improve the throughput of the department and increase on time delivery.

The literature review provides background on the lean techniques that were applied to the processes at Parker. The study looks at the implementation of the lean processes in the Chanhassen plant. The results of the lean implementation and the effect of lean in relation to on time customer delivery will be reported. Finally, recommendations will be made on continuing the plants lean transformation beyond the Chanhassen assembly value stream.

The Graduate School

University of Wisconsin Stout

Menomonie, WI

Acknowledgments

Thank you to everyone that has encouraged me to complete this project, especially Erika Henk. I am grateful for your encouragement and support.

TABLE OF CONTENTS

List of Figures

Chapter I: Introduction

Parker Hannifin Corporation (Parker) is the global leader in motion and control technologies. The company's 2008 annual report shows that Parker exceeds $12 billion in annual sales and is divided into nine operating groups, which are located around the world. Those operating groups are further divided into 135 divisions (Parker Hannifin Corporation, 2008). This project examines the implementation of lean processes to improve the planning and scheduling of assembly jobs in the Hydraulic Cartridges Systems division located in Chanhassen, Minnesota.

All parts made in the Chanhassen plant are highly engineered and designed for a specific application exclusive to each customer. Because modifications to part designs are common, Chanhassen is a custom job shop with no finished goods. Many common components are kept in stock and components exclusive to specific assemblies are purchased as needed when customer orders are placed against the plant.

The Chanhassen facility has two value streams, machining and assembly. The machining value stream takes raw aluminum or steel bar stock and manufactures a hydraulic manifold "body". The assembly value stream consumes the manifold body and installs plugs, valves, orifices, accumulators, and various other components to create a finished hydraulic manifold assembly which will be sold to a customer for installation on industrial equipment such as cranes, trucks or tractors. This paper will focus on the scheduling and movement of materials through the assembly value stream.

The assembly department consists of six manufacturing cells. All six cells have the same layout, but each cell has specific features that accommodate certain types of assemblies (e.g. overhead crane, high pressure capability, job specific tooling, etc.).

Assemblies requiring cell-specific features are routed to the appropriate cell. Assemblies with no cell-specific requirements are routed to the primary cell for the product unless redirected by a production planner.

During 2003, Parker made a corporate directive to implement lean manufacturing throughout every division in the company, and a push to make it part of the company's culture. The Hydraulic Cartridges Systems division began a lean transformation in 2005, and has implemented several lean manufacturing principles to help optimize the facility. Lean tools such as value stream maps, team improvement boards and customer service tracking centers have been implemented throughout the plant to evaluate the way materials move through the plant, and to improve on the processes currently in place. If large issues occur, lean tools such as A3's are used to evaluate root causes and contributing factors, and then identify corrective actions to resolve those problems.

Several lean teams have formed at Parker and meet regularly to evaluate different areas of the plant that could use improvements. Once the teams decide on a specific area to evaluate, they conduct a kaizen for the area and focus on lean improvements that can improve the effectiveness of the area. A course of action is then determined, high and low level task lists are formed and the correct people are brought into the process to help resolve any issues.

Statement of the Problem

This Chanhassen plant has difficulties meeting customer due dates even though orders have been released to the floor with appropriate lead time. The plant has a goal of on-time shipping of at least 93% of orders, but is consistently coming in short of that goal. A major reason for this is that once a planner releases a job to assembly, the planner loses visibility of the job and assembly may not work on the jobs in the order they are needed. Under the current system, jobs with future demand are often being produced ahead of jobs with current demand. This results in a lower percentage of on-time delivery to customers and higher inventories of finished goods.

Customer demand varies from day to day with great differences in demand during different times of the month or even different days of the week. It is the challenge of the planners to build product ahead of schedule on the slow days to balance out the days with large demand. If planners cannot balance the work load properly, the plant may be sitting on a large amount of finished goods waiting to ship or may not meet the customer's required ship date.

Other factors such as quality issues and supplier on-time delivery play a large roll in the difficulty of scheduling materials though assembly. If component parts are unavailable when needed or unable to be used due to quality issues, the entire assembly process is disrupted and jobs are placed on hold until the component shortage is resolved.

Purpose of the Study

The purpose of this study is to identify root causes for missing customer due dates, and to make recommendations to improve customer delivery. This study will:

1. Evaluate the current state of production scheduling in the plant and identify issues related to on-time delivery.
2. Review the lean techniques currently being used in the plant.
3. Recommend and implement new lean manufacturing concepts for the assembly department to help improve the throughput of the department and increase on time delivery.

Limitations of Study

This study will focus only on issues related to scheduling jobs through the assembly value steam. Other factors that may delay orders such as engineering changes, customer credit issues, down machinery, or anything else beyond the control of standard production procedures will not be examined.

Methodology

In order to improve on-time delivery, we must first understand the factors that inhibit the on-time delivery of product in this business environment. In this research, several methods including a review of relevant literature, evaluating past-due customer orders, use of the 5S process and more were used to help better understand how materials moved through the manufacturing facility and why customer orders were not always being shipped on time.

Chapter II: Literature Review

Lean Manufacturing

Lean Manufacturing is a philosophy of production that emphasizes the minimization of the amount of all the resources (including time) used in the various activities of the enterprise. It involves identifying and eliminating non-value-adding activities in design, production, supply chain management, and dealing with the customers. Lean producers employ teams of multi-skilled workers at all levels of the organization and use highly flexible, increasingly automated machines to produce volumes of products in potentially enormous variety. It contains a set of principles and practices to reduce cost through the relentless removal of waste and through the simplification of all manufacturing support processes (Blackstone & Cox, 2002).

Lean brings action and intuition to the table. Based on the principals of the Toyota Production System and kaizen (continual improvement) breakthrough methodology, lean focuses on creating one-piece flow with just-in-time management of inventory and materials. Using five-day kaizen events, cross functional groups improve lead time and reduce inventory on the spot, attacking the kind of quality and flow issues identified as "low hanging fruit" (Smith, 2003).

The Toyota production system has been the model for many manufactures across the world. Toyota has established a culture of continuous improvement and change in the company, specifically in the manufacturing facilities. Processes and activities at Toyota are constantly being challenged and pushed to a higher level of performance. By empowering its people, creating teams that interact to meet objectives, and designing its production to optimize performance, Toyota is able to refine its processes and create products that are superior to its competitors. These fundamental principles that have guided Toyota have also made them an example to other companies beyond the automotive industry (Spear & Bowen, 1999).

"Waste elimination is one of the most effective ways to increase the efficiency of a production system. Waste is always the first and cheapest area to change because it usually doesn't require capital expenditures" (Shinn, 2002, 71). Wastes such as overproduction, waiting, transporting, inappropriate processing, unnecessary inventory, excess motion, and creation of defects are reducing the efficiency of a work station (McBride, 2003). The elimination or reduction of any of these wastes can have a direct effect on the productivity of an entire operation.

Evaluating the processes undertaken in a manufacturing process and identifying waste can also shorten the overall production time and profitability of a work area. Identifying non-value added processes in production and eliminating them can reduce the amount if time it takes to process an order and reduce the amount of labor or material required to complete a job (Ray, Ripley & Neal, 2006).

Creating excess motion also slows down the production process. Designing work centers allows employees to complete their jobs with as little repositioning as possible makes production much more efficient. Acts such as reducing the amount the distance an employee has to walk to get supplies by placing common supplies in the work cells can reduce the time it takes to complete a job. Other work cell improvements such as the implantation of shadow boards to help make locating tools or equipment easier can reduce and create consistency in the amount of time it takes to complete work (Ray, Ripley & Neal, 2006).

Visibility of a production system makes it possible for management and other key personnel to make decisions on the status of a work area and manufacturing processes. Key personnel must be able to identify if a work center is functioning properly and producing product as planned. Without visibility it is difficult to identify problems, waste, or root causes within a manufacturing system. Properly functioning work areas allow managers to compare the expected output of the work area against the current output to determine the performance of a work area. If the proper systems are not in place to allow this visibility it is difficult to prioritize resources to achieve desired objectives (Lane, 2007).

Metrics

Metrics are measurements used to determine whether a process is improving. Often, metrics are based on quality, productivity, cost, delivery, profitability, and safety. Good metrics are aligned through the organization in the form of strategic planning, starting from the corporation's goals, which are then linked to the plant's goals and then further linked to each department's goals (Lane, 2007).

"Takt time Sets the pace of production to match the rate of customer demand and becomes the heartbeat of any lean production system. It is computed as the available production time divided by the rate of customer demand" (Blackstone and Cox, 2002, 117). Determining the takt time of a value stream helps establish the amount of time is should take production cell to produce a finished good.

Associating time with all work helps the plant establish the amount of time a given job should take. By determining the amount of time it will take to complete a job, the production planners have a better opportunity to create a schedule that can fully utilize the production assets. Establishing production times also allows production and management to determine if a work unit is on track to meet the production objectives for the day. If the work unit falls behind, schedule management will know there are problems in the production system and can identify the problems to determine why the work area has fallen short of its goals and correct any problems that may exist (Lane, 2007).

In a job shop the scheduling of work orders is important because it reflects the operating plan of the entire work system. With several jobs being scheduled in a given day production planners need to know if capacity exists to complete the work due on a specific day. After determining the amount of time it will take production to complete the work due on a given day the production planners can then take action to react to capacity constraints. A good knowledge of the time it will take to complete work will allow planners to then optimize other metrics the effect the business such as work in process (WIP), inventory costs, and the speed of processing a customer's order (Sule, 1997).

Visibility

Andon signals are an excellent way to visualize the status of a production area. The andon signals can be a number of different visual signals that easily let mangers and supervisors know if a problem exists in one of the production cells. At Toyota the tracking of andon signals is a key metric tracked to help management identify problems that are slowing production. Once the data Toyota collects on the andon signals is collected mangers will Pareto out the data to identify the common causes of production interruptions. The most common problems are then addressed by management to improve the entire system (Liker, 2004).

A3

One common problem with analyzing problems in business has been the over abundance of information and complication of combining information to create actions and drive results. Toyota's solution to this problem was to simplify the process into what they called an A3. The name A3 stands for the 11" x 17" sheet of paper that the important information regarding a problem is compiled on. In the A3 process mangers compile all the necessary information, graphs, and statistics to identify the problem, the current state, determining the root cause, suggested alternative solutions, suggested recommended solutions, and have a cost benefit analysis (Liker, 2004).

Value Stream Mapping

Value stream mapping, although it is not a complete flow analysis, is a graphical tool that uses symbols to show the flow of material and information within your business (Lane, 2007). Value stream mapping is an important process for any business seeking to improve their processes. According to Jared Lovelle, value stream mapping visually outlines the current and future state of a production system, allowing users to understand where they are and what wasteful acts need to be eliminated. The user then applies lean manufacturing principals to transition into the future state (Lovelle, 2001).

Once a value stream is mapped, it is easy to identify inefficiencies such as long setup times, poor uptime, disconnected operations, and long throughput times with large inventories between every step in the process (Smalley, 2004). Value steam mapping reduces cost by reducing lead time. The measurement for lead time is referred to as total product cycle time, which measures the longest path from the receipt of raw material until it is shipped as a finished good. It is clear that reducing the total product cycle time has several benefits such as reduced inventory, shorter lead time, and better customer satisfaction (Lane, 2007).

Once the current state has been mapped, waste throughout the value stream must be identified and eliminated to shorten lead-time and improve the value added percentage – in other words, to transform the production system from a batch and push into a one-piece flow and pull system (Lovelle, 2001). All of the 7 wastes of over-production can be identified by evaluating the current state map (if the wastes exist). Once the wastes are identified they must be addressed by countermeasure that can reduce or eliminate each waste (Lovelle, 2001).

After the current state is mapped and all wastes have been identified, the next step in the value stream mapping process is to create a future state map. Future state maps should include the improvements you believe are reasonable to target in the near future, for example, in the next three months (Lane, 2007). After the future-state map has been developed, an action plan and extended value stream plan must follow. An action plan is created to make the transition from the current state to the future state (Lovelle, 2001).

5S

A lean tool that promotes continuous problem solving and improvement, 5S (sort, stabilize, shine, standardize and sustain) is a series of activities for eliminating wastes that contribute to errors, defects, and injuries. In this improvement method, the fifth S, sustain, is arguably the hardest. It's the one that keeps the first four S's going by emphasizing the necessary education, training, and rewards needed to encourage workers to properly maintain and continuously improve operation procedures and the workplace environment. This effort requires a combination of committed management, proper training, and a culture that makes sustaining improvement a habitual behavior from the shop floor to management (Liker, 2004).

One important part of creating consistency in a production environment is developing an environment that can produce consistent results. 5S programs have been implemented at Toyota and other manufacturers to maintain an environment free of waste and disorganization. A functioning 5S program looks at the following key characteristics of a manufacturing facility that when improved can create a more productive work environment.

1. Sort – Look through a work area and keep only the items that are needed and eliminate any unnecessary items.
2. Straighten – the motto is "a place for everything and everything in its place". Basically this means that everything in a work area has a designated location that it should be kept in unless it is being used.
3. Shine – Keeping a clean work environment can improve the quality of products being produced by reducing contamination and identify anything that may be out of place in the work area.
4. Standardize – Develop systems to maintain and monitor the first three S's.
5. Sustain – Create management audits of the 5S system. Try to create consistency throughout the production area (Liker, 2004, 150).

Summary

As part of the lean implementation at Parker's HCS Plant in Chanhassen, MN the following lean topics will be put into practice.

- Metrics / Planning processes

- Value Stream Mapping
- A3
- 5S

Chapter III: Methodology

Meeting customer expectations is important to building long-term relationships with customers. On-time delivery of products and services is a key factor in retaining customers and creating relationships that will sustain a business or allow it to expand. If customers experience shortages or are unable to meet their production requirements due to shortages from a specific vendor, the reputation of that vendor in the eye of customer decreases and so does the potential of the customer to grant that vendor future business.

Data Collection Procedures

In order to improve on-time delivery, we must first understand the factors that inhibit the on-time delivery of product in this business environment. In this research, the following methods were used to help better understand how materials moved through the manufacturing facility and why customer orders were not always being shipped on time.

- Review of literature pertaining to:
    - Lean concepts
    - Production scheduling
    - Value stream mapping
    - Industry best practices
- Daily tracking of past due customer orders.

Data Analysis

Information gathered during the research was compared against current conditions of the production environment. The comparison of best practices against current operating procedures was then used to make recommendations on potential improvements to the value stream.

Chapter IV: Results

Through data collection and analysis, this research was able to identify the root causes for jobs that were not shipped on time. Several lean processes were implemented to better understand the value stream and to improve the movement of material through the production process.

First, the materials planning team conducted a short meeting each day to review the jobs that are past-due, the jobs that need to be built that day and the jobs that are coming due in the next three days. The team then identified any material shortages that needed to be addressed and other issues that needed to be resolved. If cells were over-capacity, the materials planning team would be able to identify capacity constraints and take action to counteract the capacity shortage.

Second, the cause of the past-due orders was tracked and at the end of each month, the root cause for each past due order was graphed on a Pareto chart (Figure 1). Top causes for past due orders were analyzed monthly and corrective actions were implemented.

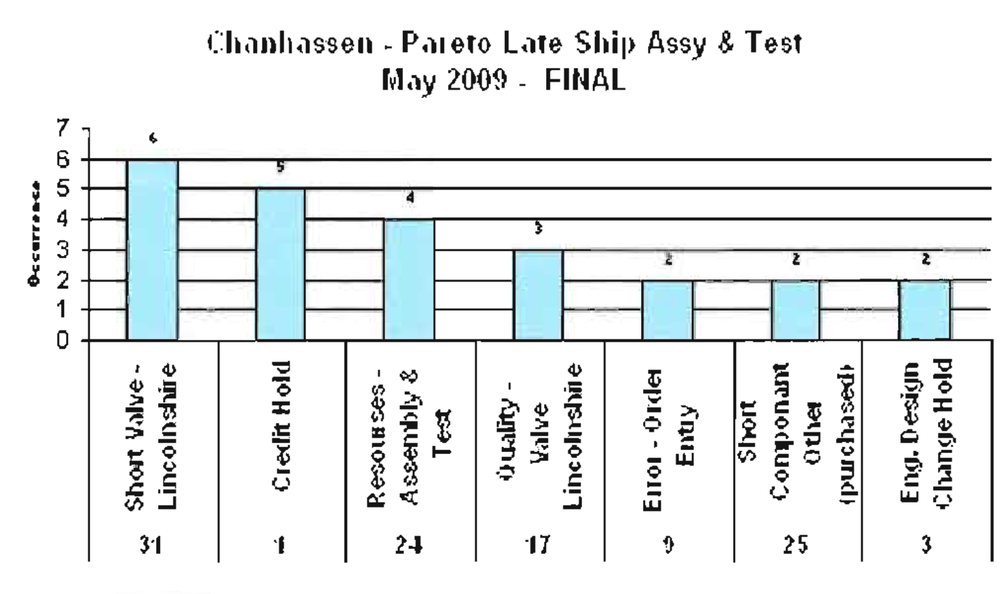

Figure 1. Pareto Late Shipments Assembly and Test, May 2009

Third, Parker's IT department created a Rough Cut Capacity Planning macro that analyzed the work load for each work cell based upon the standard time per job, in order to assist in the production planning process. The demand information was then compared against cell capacity and availability. Planners could then take the information provided by the macro and adjust the work load appropriately meet customer delivery requirements. Management was also able to use the macro to make decisions on staffing and overtime. An example of the Rough Cut Capacity Planning macro is show in Figure 2.

Cell Loading by Week

Cell Capacity based on Cell Rates

Printed: 6/10/2009 11:10

Key: Under 60% / 60%-85% / 85%-115% / Over 115% / Editable Field

Week Ending -->

Cell	People / Shift	Shifts / Day	OT Hours	Total People / Cell	Total OT / Cell	Weekly Capacity	Total Capacity	LATE	06/12/09	06/19/09	06/26/09	07/03/09	07/10/09	07/17/09	07/24/09	07/31/09
O6	0.5	1	0	0.5	0	185	185	0	0	0	12	64	0	4	4	64
O7	0.5	2	0	1	0	350	350	223	12	0	38	13	0	13	13	22
O8	0.5	1	0	0.5	0	75	75	[illegible]	80	[illegible]	0	[illegible]	0	40	28	41
OA	0.5	2	0	1	0	230	230	[illegible]	0	[illegible]	1	28	100	0	100	44
OB	0.5	1	0	0.5	0	100	100	0	12	[illegible]	0	0	[illegible]	0	0	0
OC	0.5	2	0	1	0	140	140	43	25	18	82	21	25	54	55	34
OE	0.5	2	0	1	0	240	240	0	0	31	98	0	110	0	40	70
OF	0.5	2	0	1	0	280	280	202	17	152	3	76	30	100	0	0
OG	0.5	2	0	1	0	370	370	179	122	12	32	0	21	2	40	2
OH	0.5	2	0	1	0	280	280	203	3	7	45	0	76	46	25	[illegible]
OJ	0.5	2	0	1	0	440	440	292	80	[illegible]	98	24	86	8	16	0
OK	0.5	1	0	0.5	0	540	540	12	0	0	0	0	0	0	2	0
EU	0.3	1	0	0.3	0	500	500	84	68	347	491	71	15	272	63	100
EV	0.3	1	0	0.3	0	500	500	54	33	120	157	60	5	86	54	107
EW	0.3	1	0	0.3	0	500	550	[illegible]	0	0	0	0	0	0	28	1

Figure 2. Example of Rough Cut Capacity Macro Output

Fourth, a Value Stream Mapping session was conducted to evaluate the plant's processes. Value steams were mapped to look at the entire manufacturing process and the way material flows through the plant. As material moves through the production processes, value added time and non-value added times was tracked at the bottom of the map to determine the overall lead time of the end product being evaluated.

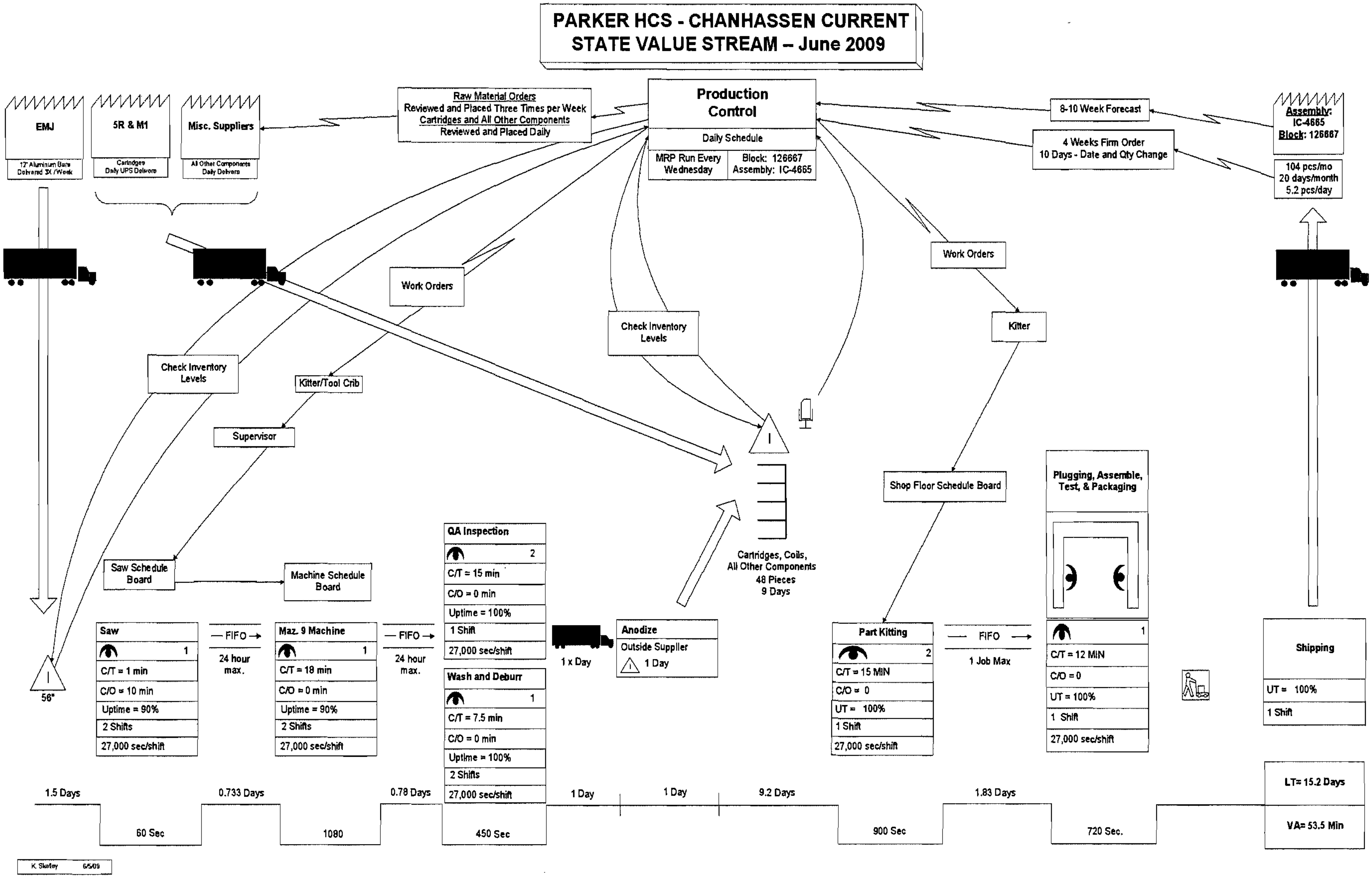

Figure3. Current State Value Stream – June 2009

The team looking at the value stream looked at every process individually and charted the process times for a specific part as it went through the plant. At each process, points of possible improvement were noted. As the current state value stream map was being drawn (Figure 9, Appendix), process times were added into the process stamps. Once the current state was completely mapped, starbursts were added to the map. Key members from each department in the plant then voted on the top causes that should be focused on to reduce the lead time of production parts being manufactured in the facility. After the starbursts were voted on by members of each department, the future state was drawn to reflect the improvement that would result once the top vote receiving starbursts were implemented. High and low level tasks were then created to implement the improvements that would move the plant towards the future state, and a champion was assigned to each task to drive the implementation. The value stream team then met on a weekly basis to evaluate the progress of tasks and provide support for the task champions and their teams. The tasks resulted in shorter lead times and increased throughput for each work cell, resulting in higher on-time delivery (Figure 3).

After value steam mapping the processes within the plant, it was clear that inventory and procurement were major factors in the plant's long lead time. The fifth lean process that was implemented was an A3, to help address the on time customer delivery issues the plant was facing. The A3 received input from planning, purchasing, customer service, and operations on inventory issues that were keeping the plant from meeting its inventory and delivery objectives. The goal of the customer service A3 was to eliminate shortages that were causing increased inventory and backlog, resulting in late delivery to the customer. The on time customer service A3 is shown in Figure 4.

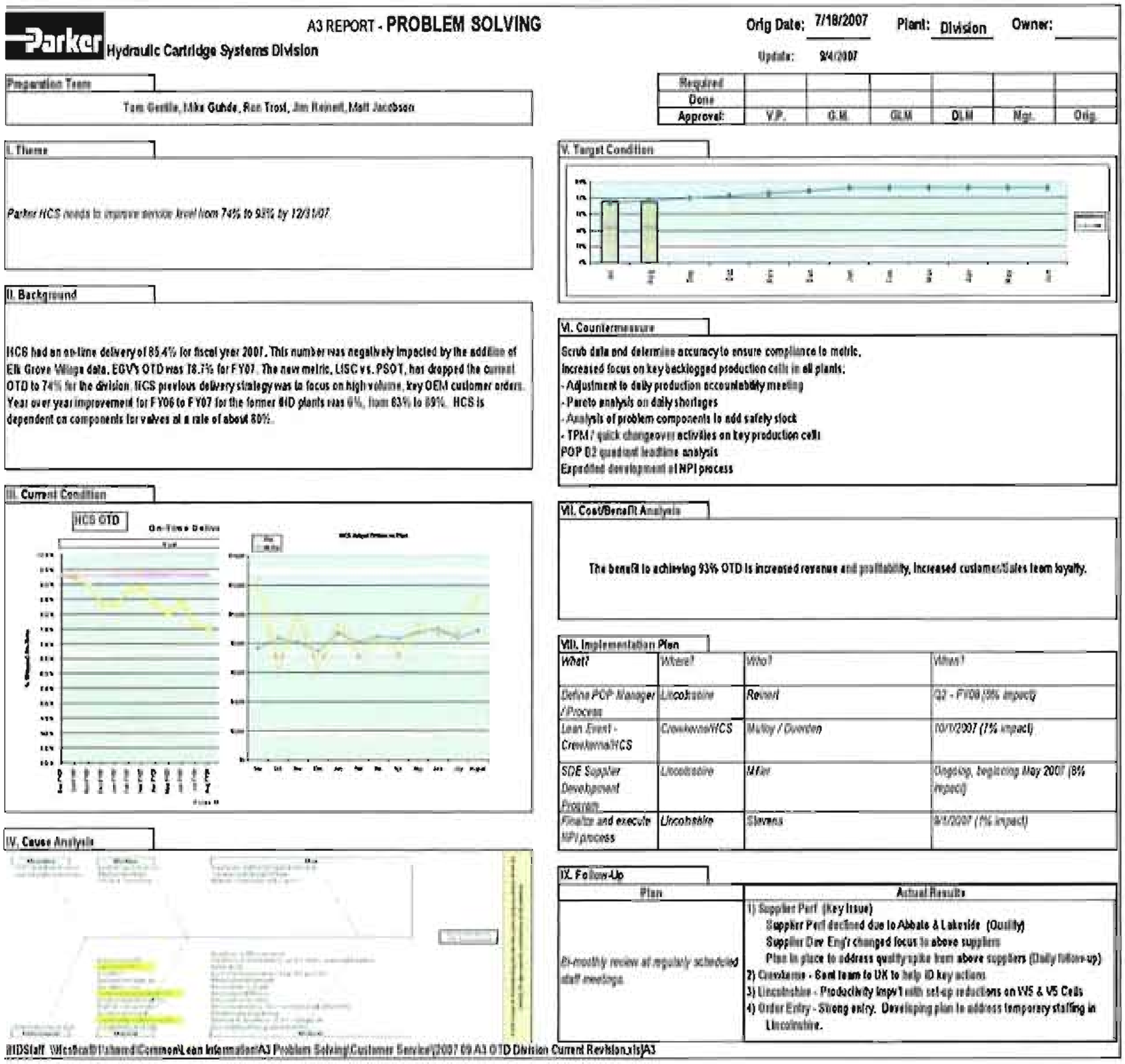

Figure 4. Customer Service A3

The final component of the company's lean transformation was implementing a 6S program (5S + Safety program) in the plant. The 6S program considers different work areas/cells within the plant and evaluates them against the plant's 6S criteria (Figure 10, Appendix), using a 6S scorecard (Figure 11, Appendix) to track the work area's progress. It was the responsibility of the department managers to lead projects that would help improve the work area and improve the 6S scores.

Each day, workers in a cell were responsible for completing the 6S chart for the work area. On a weekly basis, management audited the work area and rated the cell's 6S against the 6S criteria.

The first area of 6S that was addressed was the sort category. To help improve the operation of each cell, the tooling of the cells was evaluated. The department manager took all the tools out of tool boxes and categorized them based on usage. Tools that were used every day were kept at the work cell. Tools that were used weekly were kept at the cell, but off to the side. Tools that were used less than 1-2 times per month were removed from the work cells and placed in a common tooling holding area outside of the work cells. As a result of this sort, the work cells saw a 30% reduction in tooling. The workers would now have a much easier time locating tools because they would have fewer tools to sort through in the cell.

The next step in the 6S process was to straighten each cell. Once the tooling had been sorted, the assembly department created shadow boards with outlines of each commonly used tool (Figure 5). Tools were placed on the shadow boards within an arm's reach of the workers. Shadow boards made it easy to locate commonly used tooling, as well as replace tooling that was in use or identify if a tool was missing or placed in the wrong location. With the use of shadow boards, the assembly department was able to remove tool boxes (which made it difficult to locate parts) from the work cells. The implementation of the shadow boards helped reduce the overall lead time of products because workers were no longer wasting time searching for tooling within the work cells.

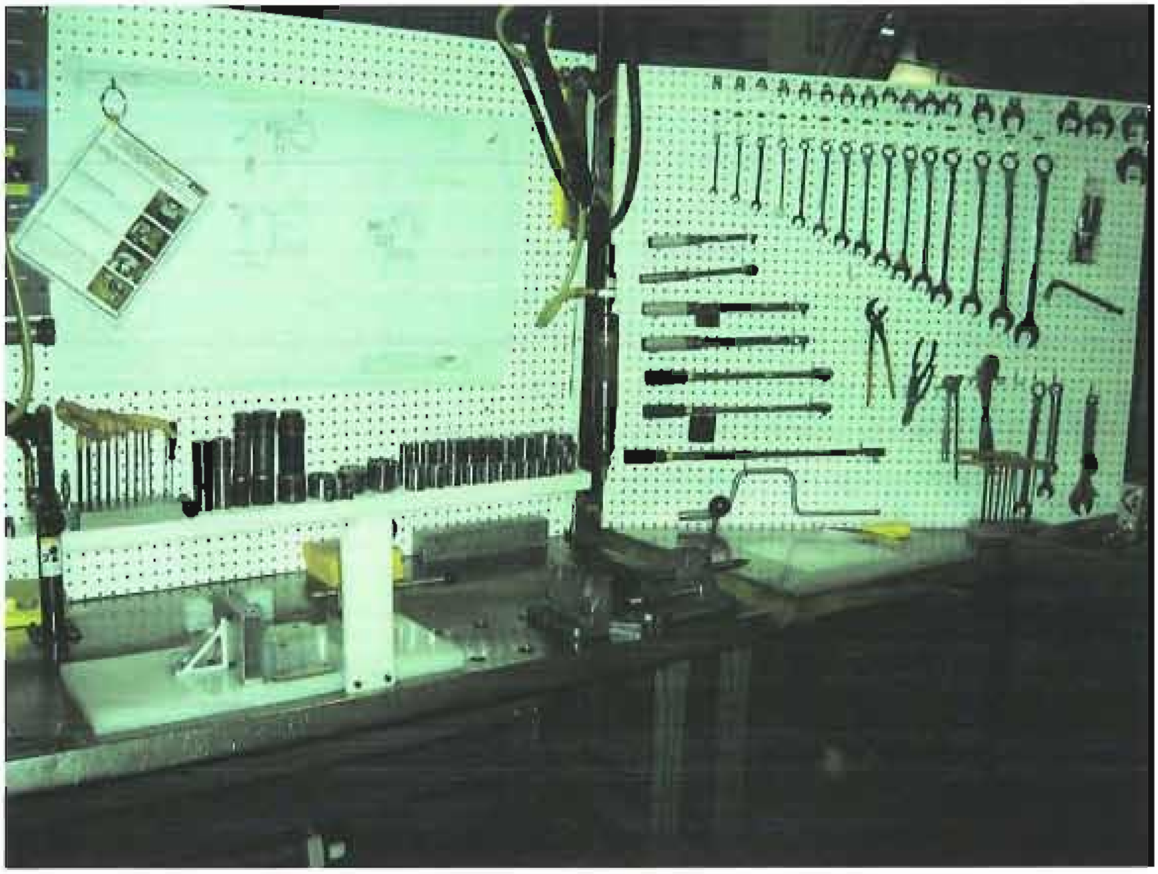

Figure 5. Example of an Assembly Shadow Board

The 6S shine category addressed the cleanliness of the plant. With tooling more organized and work areas free of clutter, it was easy to see out-of-place objects such as soda bottles, rags or scrap because they did not have a designated home. Removing these items made the work areas safer, easier to navigate, and are more enjoyable to work in due to increased cleanliness and organization.

Part of the 6S processes in the plant involved standardizing procedures throughout the cells so that assembly workers follow the same procedures from job to job. Standard work charts were created and posted throughout the department to help streamline processes in the plant. Procedures were published in the plant to identify how to man work cells, kit jobs, test products, read prints, and other process that were performed on a daily basis. The goal of the standard work chart is to have everyone follow the same procedure while completing a task to ensure quality and consistency. An example of the Standard Work that was created is shown in Figure 6.

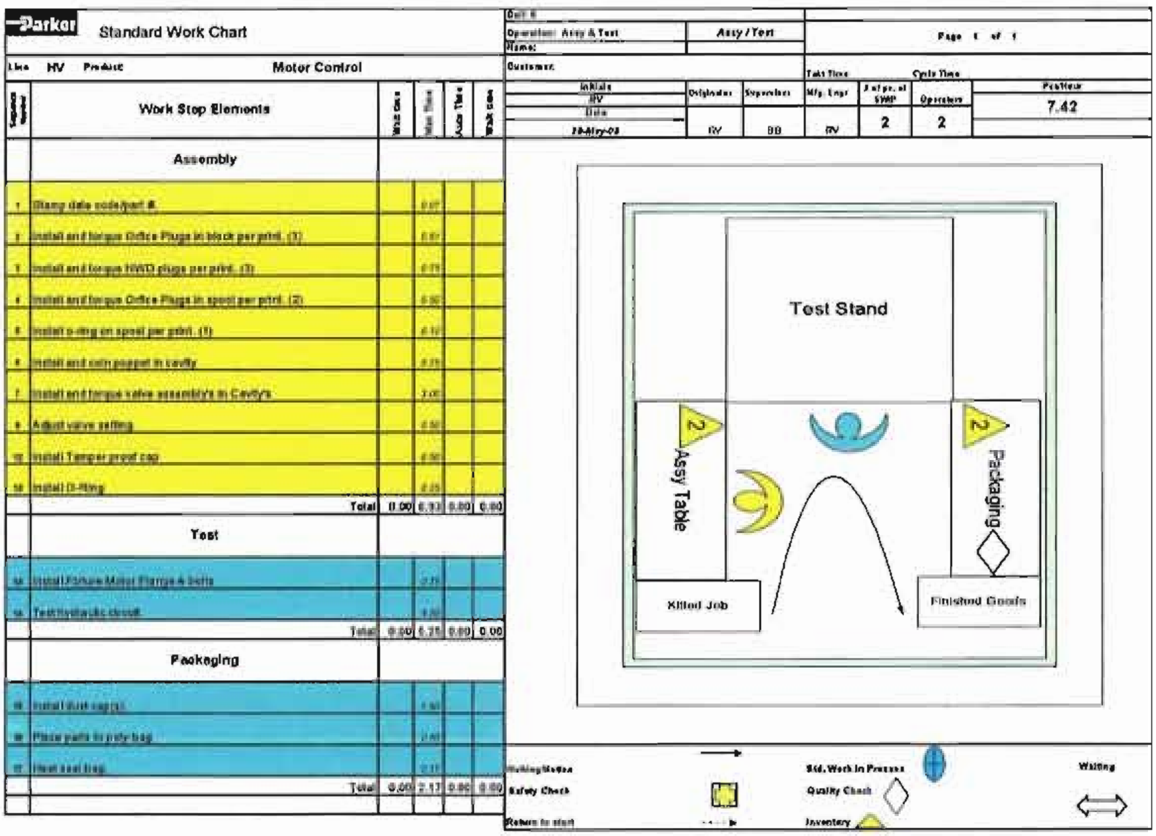

Figure 6. Example of Standard Work for an Assembly Cell

The ability to sustain the implemented 6S processes is also a key to its success. On a weekly basis, the department was audited by a member of management to rate the area's 6S against the 6S criteria score card. Maintaining consistency from week to week was part of the score card, and was important to management as it indicated the dedication of each work area to the 6S process.

The final part of the 6S process evaluates safety in the work center. Assembly personnel were responsible for performing a series of daily checks to ensure safety practices were being followed. Each week, the 6S auditor walked through the department and evaluated the safety of each work area. Safety supplies and the use of personal protective equipment in the work area were evaluated at this time. If any safety issues arose, the auditor was to address them immediately with the appropriate manager or supervisor to ensure the issues were resolved. Safety affects both the people working in each cell and the overall performance of the plant. If someone was injured, many hours were spent addressing the injury. In addition to the personal impact on the injured employee, the injury often results in a financial impact on the business. It is in the best interest of the business and its employees to make sure the work environment is safe and injury-free.

Chapter V: Discussion

The purpose of this study was to identify root causes for missing customer due dates, and to make recommendations to improve customer delivery. During the period of this research, many new procedures were implemented to help improve the on-time delivery of customer orders. The lean processes that were implemented increased on-time delivery, reduced inventory, reduced lead time and improved the overall productivity of the plant.

Limitations

This study only focused on issues related to scheduling of production work orders through the assembly value steam. Other factors that may delay orders such as engineering changes, customer credit issues, down machinery, or anything else beyond the control of standard production procedures was not examined.

Conclusions

The objective of this research was to increase the level of customer service by implementing improvements in the production process. Activities such as increasing the visibility of customer orders, value stream mapping, 6S of work cells, creating standard work, and improving the work environment all had a positive effect on the level of customer service. The combined effect of all these activities helped the plant achieve it highest level of customer service over the past year.

During fiscal year 2009 customer service averaged 93%. This is a 5% increase from FY08, a 4% increase from FY07 and a 9% increase from FY06 (Figure 7). This allowed the plant to seek new business opportunities that were previously unavailable due to the lower level of customer service provided by the facility. In addition, the overall flow of material through the plant was improved and there were fewer emergency or rush orders due to backlog in production.

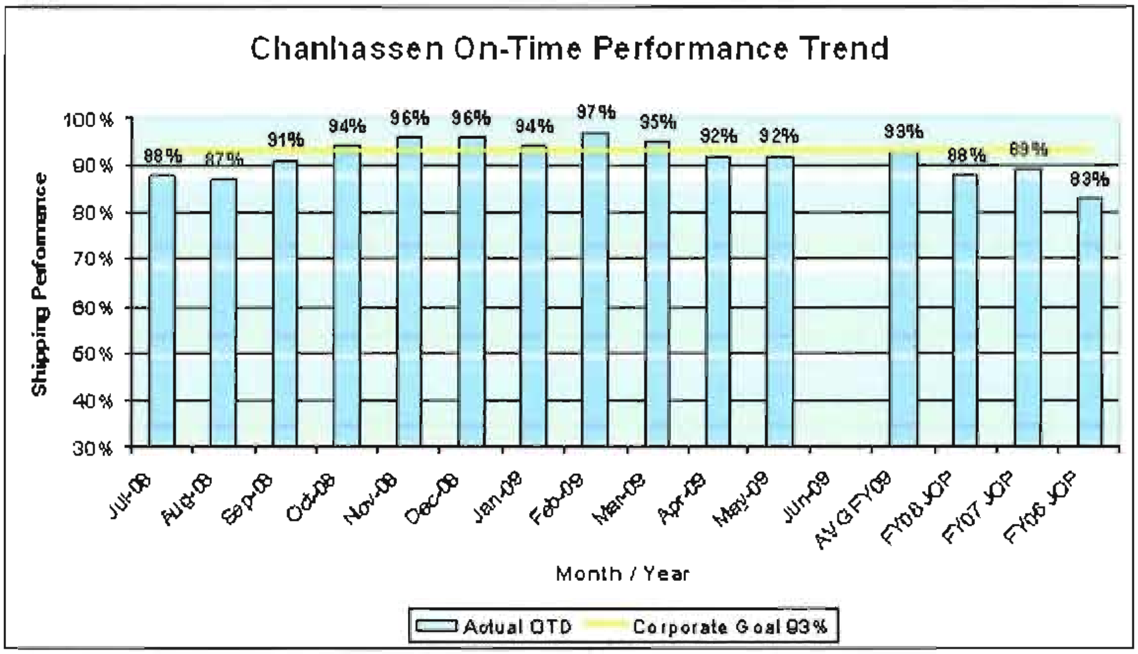

Figure 7. On-Time Delivery Performance

An additional benefit of the improved flow of materials was decreased inventory (Figure 8). As the plants back log decreased, the need to keep extra finished goods inventory and buffer stocks has decreased. As a result, the materials and purchasing teams have been able to take out unnecessary inventory and reduce the company's investment in stock inventory.

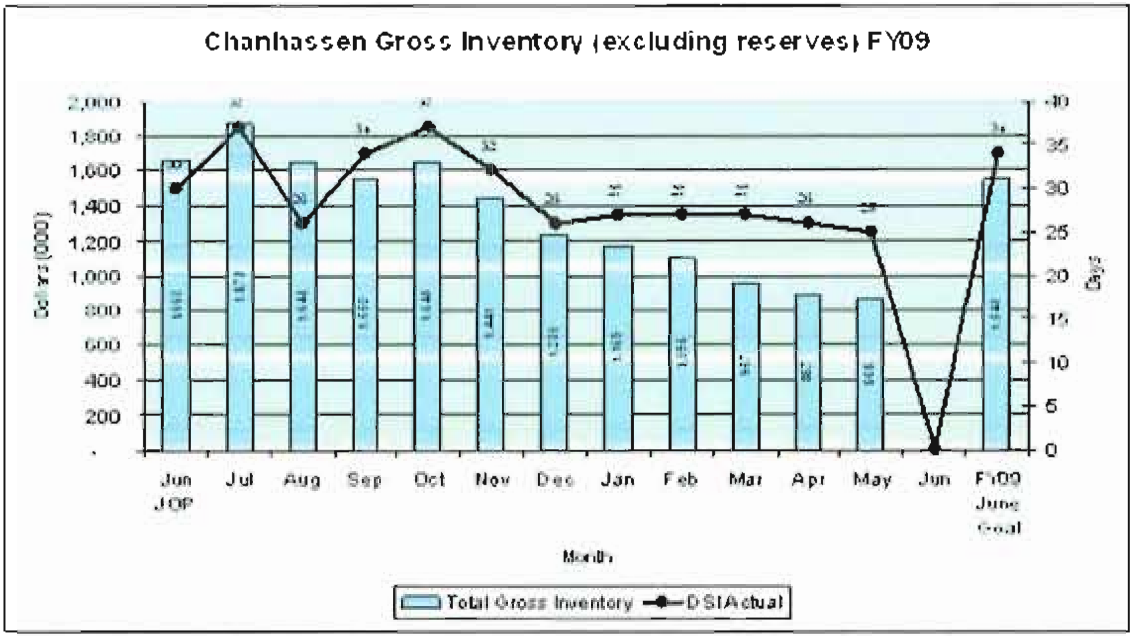

Figure 8. Chanhassen Gross Inventory FY09

Through value steam mapping, the plant has been able to show significant lead time reductions compared to its position 2 years ago. In June 2007, the lead time of a part that moved through this value stream was 27.44 days. Evaluating the same part in June of 2009 showed that the lead time has dropped to 15.2 days. This improvement was a result of large reductions of inventory due to the increased throughput of material through the value stream.

The plant also saw improvements in quality and safety during the lean implementations. 6S processes such as standardization and shine (cleanliness and organization) have increased the consistency of products being produced in each cell. Cleaner and more organized cells increased the efficiency of each cell and reduced the number of workplace accidents. As a result, employees are spending more time adding value to the products instead of wasting time with searching through clutter or lost time due to injuries.

Key Recommendations and Implementations

As part of the lean implementation at Parker's HCS Plant in Chanhassen, MN the following lean topics have been put into practice.

- Metrics / planning processes – tools such as daily planning meeting, the tracking of past due orders, and implementation of a rough cut capacity tool have helped planners better manage the daily work load.
- Value Stream Maps have been created and improvements have been made to reduce product lead time.
- A3 problems solving has been used to address issues such as on time customer delivery and inventory reduction.
- A 6S program has been implemented in the plant. Tools such as standard work, shadow boards, cell audits, and safety audits now occur on a scheduled regiment.

The on time delivery for the Chanhassen facility has improved and consistently remained above the corporate goals for on-time delivery. Although the plant has seen significant improvements in on-time delivery, the management team should continue to stay focused on their lean implementation and continue to improve processes throughout the facility. The next step to improve customer service throughout the division would be to share the gains from these lean implementations with other values streams in the Chanhassen plant and with sister production facilities.

References

Blackstone, J. & Cox, J. (2002). *APICS Dictionary*, 10th Ed., Alexandria, VA: APICS.

Lane, G. (2007). *Made – To – Order Lean: Excelling in a High-Mix, Low-Volume Environment*. New York, NY: Productivity Press.

Liker, J. K. (2004). *The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer*. New York, NY: McGraw-Hill.

Lovelle, J. (2001). Mapping the Value Stream. *IIE Solutions*, 33 (2), 26-33.

McBride, D. (2003). The 7 Manufacturing Wastes retrieved on June 5, 2009 from http://www.emsstrategies.com/dm090203article2.html

Parker Hannifin Corporation. (2008). Parker Hannifin Corporation 2008 Annual Report. Cleveland, OH: Author.

Ray, B., Ripley, P., Neal, D. (2006). Lean Manufacturing: A Systematic Approach to Improving Productivity in the Pre-cast Concrete Industry. *PCI Journal*, 51, 62-71.

Shinn, G. S. (2002). 15 Waste Scenarios "An effective change model must be followed in its entirety to ensure efficiency". *Quality Progress*, 35 (12), 67-73.

Smalley, A. (2004). *Creating Level Pull: A lean production-system improvement guide for production-control, operations, and engineering professionals*. Brookline, MA: Lean Enterprise Institute.

Smith, B. (2003). Lean and Six Sigma- A One-Two Punch. *Quality Progress*, 36(4), 37-41.

Spear, S., Bowen, H.K. (1999). Decoding the DNA of the Toyota Production system. *Harvard Business Review*, 77(5), 96-106.

Sule, D.R. (1997). *Job Shop Scheduling: Industrial Scheduling*. Boston, MA:

International Thompson Publishing Inc.

Appendix A:

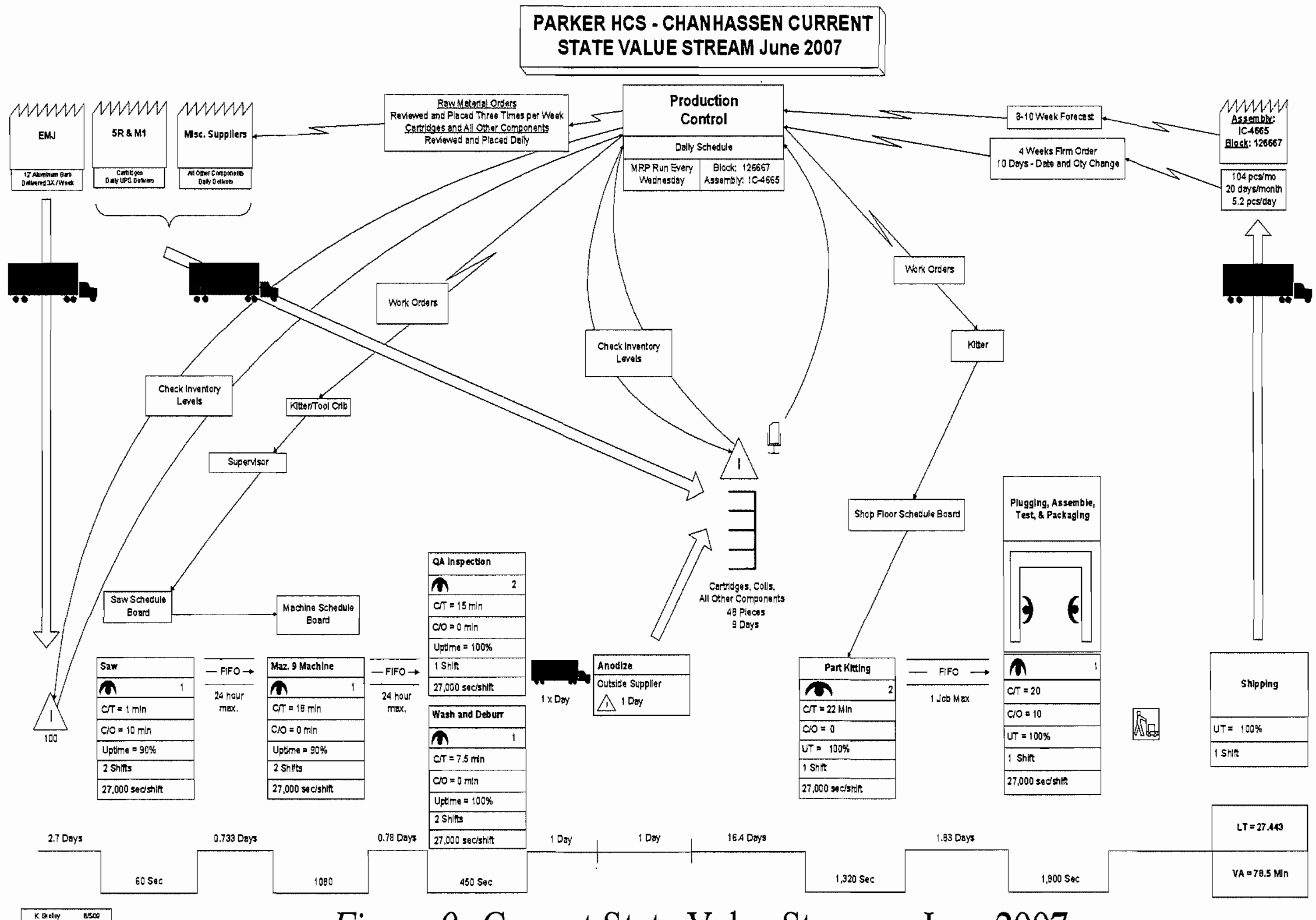

Figure 9. Current State Value Stream – June 2007

6S Audit Criteria

We want to be Level 5.

	Level 1	Level 2	Level 3	Level 4	Level 5
Sort	Necessary and unnecessary items are mixed together in the work area.	Necessary and unnecessary items separated - includes excess inventory.	All unnecessary items have been removed from work area.	A dependable documented method has been established to maintain work area free of unnecessary items.	Employees continually seeking improvement opportunities.
Straighten	Tools, books, supplies, and materials randomly located.	Designated location established for all items.	Designated locations are marked to make organization more visible. Example: Shadow boards, color coding, outlining, or labeling.	A dependable documented method has been established to recognize, with visual sweep, if items are out of place or exceed quantity limits.	A dependable documented method has been developed to provide continual evaluation and process in place to implement improvements.
Shine	Shop / office areas are dirty and disorganized.	Shop / office areas are cleaned on a regularly scheduled basis.	6S schedules are developed and utilized.	6S schedules are understood and practiced continually.	Area employees have devised a dependable documented method of preventive cleaning and maintenance.
Standardize	No attempt is being made to document or improve current processes.	Methods are being improved, but changes haven't been documented.	Changes are being incorporated and documented.	Information on process improvements and reliable methods is shared with employees.	Employees are continually seeking the elimination of waste, with all changes documented and information shared with all.
Self-Discipline	Minimal attention spent on housekeeping and safety.	A recognizable effort has been made to improve the condition of the work environment.	6S agreements and safety policies have been developed and are utilized.	Follow-through of 5S agreements and safety policies is evident.	General appearance of, a confident understanding of, and adherence to the 5S program.
Safety	Oily floors; Trip hazards; PPE not being used; Daily safety cross not filled out; Eyewash station, aisles, fire extinguishers, control panels blocked; Machine guarding not secured; Spills not cleaned up; Poor lighting; Lock-out Tag-out not followed;	No oily floors; No trip hazards; PPE being used; Daily safety cross filled out; Eyewash station, aisles, fire extinguishers, control panels not blocked; Machine guarding secured; Spills cleaned up; Lighting sufficient; Lock-out tag-out followed;	Plant Safety Board is updated.	All employees trained on ergonomics.	Ergonomic audits in place.

Figure 10. 6S Audit Criteria

6S EVALUATION SCORECARD

MONTH: November 08 Assembly

DAILY 6S MAINTENANCE

6S TASK		DATE																														PASS: FAIL:
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
SORT	1st																															
	2nd																															
STRAIGHTEN	1st																															
	2nd																															
SHINE	1st																															
	2nd																															
STANDARDIZE	1st																															
	2nd																															
SUSTAIN	1st																															
	2nd																															

WEEKLY 6S AUDIT

		SORT	STRAIGHTEN	SHINE	STANDARDIZE	SUSTAIN	SAFETY	TOTAL SCORE
Date: Initials:								
Week 1 Comments:								
Date: Initials:								
Week 2 Comments:								
Date: Initials:								
Week 3 Comments:								
Date: Initials:								
Week 4 Comments:								
Date: Initials:								
Week 5 Comments:								

WEEKLY SAFETY AUDIT

SAFETY PASS: FAIL:	Eyewash Station	WEEK 1	2	3	4	5	Machine Guarding	WEEK 1	2	3	4	5	Slippery Floor	WEEK 1	2	3	4	5	PPE	WEEK 1	2	3	4	5
Date: Initials:	Comments:																							
Date: Initials:	Comments:																							
Date: Initials:	Comments:																							
Date: Initials:	Comments:																							
Date: Initials:	Comments:																							

Figure 11. 6S Evaluation Scorecard