International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463
Vol. 3 Issue 8, August-2014, pp: (117-136), Impact Factor: 1.252, Available online at: www.erpublications.com

Techniques to deploy lean concept: A Review

Narottam[1], Sachin Kumar[2], Dr. K. Kumar[3], Naveen Kumar[4]

[1,2]Dept. of M.E., Bhiwani Institute of Technology and Sciences, Bhiwani, Haryana, India
[3]Former Director, Maruti Suzuki India Ltd., Lean Consultant.
[4]Counselor MACE, Maruti Suzuki India Ltd.

Abstract

Purpose: Lean manufacturing concept is most important to be used in an automobile industry system for reduction in the waste, which decreases the yield. The techniques used for implementing Lean concept are helpful to find the waste throughout the industry and suggest the techniques to get rid of from that waste. By these techniques without using much cost and labor we can reduce waste producing in the process. In this context, this study is an attempt to remove the roadblocks in implementing Lean concept in Indian automobile industry.

Design/Methodology/Approach: Various tools and techniques have been identified from the literature review. The various roadblocks have been identified through the study and the responses from the experts on the Lean Implementation. . The model consists of six major lean tools, which are Policy Deployment, Visual Management, Continuous Improvement, Standardized Work, Just in Time, and Value Stream Mapping and the other tools and methods which fall within such as 5s, TPM, and A3 thinking.

Findings: Twenty four variables have been identified from the literature review. Out of which six major lean tools are identified for successful lean implementation. . This roadmap consists of four parts: a model for lean implementation, specific barriers to lean implementation along with solutions to those barriers, and best practice checklists for the5s system and Value Stream Mapping.

Research limitations/implications: Summing up it has to be said that the conclusions drawn in this lean survey are more based on indications than on statistically significant results. As shown, the opinions of the respondents could not always be supported by statistics. Even where it was possible, the results should be looked at more closely and considered to be more of a general indication rather than a statistical proof, that certain aspects are critical to successful lean implementation. However, as most of the findings of the literature review were reflected by opinions in the survey, it can still be said that the applicability of the theory to the population could be confirmed.

Keywords: Lean Manufacturing, Quality, Yield, 5S, VSM.

1. Introduction

Lean manufacturing is a conceptual framework recognized in many industrial companies since the early 1990s (Womack, 1990). Lean manufacturing can be best explained as eliminating waste in a production process (Womack and Jones, 1996). Anything (process or product tangible and intangible) that does not add value to the end product is called waste (Henderson and Larco, 2003). Essentially, lean manufacturing seeks to produce a product that is exactly what the customer wants at right time, minimizing all non-value added activities in the production (Womack and Jones, 1994). When the time comes to begin the transformation to lean, management will need to get people together and making them aware what is going to happen, and what is expected (Henderson and Larco, 2003). The lean transition is, an organizational culture transition to manage lean, specifically during the initial phases, is more about managing the change process than managing lean tools and techniques (Csokasy and Parent, 2007). Lean production is a socio-technical system (shah and ward, 2007), which is viewed as a philosophy that takes care of both technical and cultural aspects (Bhasin and Burcher, 2006). Efficiency of manufacturing has been an objective in development of Toyota Production System (TPS) (Holweg, 2007).

1.1 An Overview about Indian Automobile Industry

India was the sixth largest Vehicle/Car manufacturer in the world in 2012. Indian auto manufacturers produced a record 20.4 million motor vehicles in 2011-12 (Apr.-Mar.). 3.124 million Passenger vehicles rolled out from Indian auto plants in 2011-12. India is the largest manufacturer of three wheelers (878,000 in 2011-12) and the eighth largest commercial vehicle (912,000 in 2011-12) while two-wheeler production reached 15.4 million units. India is the largest tractor manufacturing country (around 1/3 of global output) with a total estimated production of 605,000 units in 2011-12. Construction vehicle production was approx. 48,000 in 2011-12. India's automobile exports in 2011-12 (2.9 million units) included 331,539 passenger cars and 1,004,174 two wheelers. India is the second largest motorcycle (6.54 million produced in 2007-08) and the fourth largest commercial vehicle manufacturer in world. Auto exports amounted to almost USD 2.3 billion in the year 2005-06.Over 13 million people work directly or indirectly in the auto industry. Indian car exports have increased at a rapid pace reaching 210,088 units (mostly Maruti-Suzuki and Hyundai models) during the first half (Apr.-Sep.) of 2009-10, well ahead china. The size of the Indian automotive component industry was estimated at USD 40 billion in 2010-11. Auto ancillary exports fetched USD 5.2 billion in 2010-11while the total turnover of India's vehicle tyreindustry amounted to an estimated Rs. 142.5 billion in 2005.05. the total number of registered motor vehicles on Indian road reached 142 million in March 2011.

Established auto Manufacturers and new entrants in the Indian auto market are expanding their production capacities on a large scale. Company undergoing expansion includes Maruti-Suzuki, GM, Tata Motors, VW Group, Toyota, Honda and Hyundai. The Renault – Nissan Alliance's maiden auto plant near Chennai commenced production in 2010. A second plant is planned. New auto makers planning to enter the Indian market include Isuzu, Jeep and Mazda. Source: OICA (The International Organization of Motor Vehicle Manufacturers)

2. Literature review

While many researchers and practitioners have studied and commented on lean manufacturing, it is very difficult to find a concise definition. Lean manufacturing is most frequently associated with the elimination of eight important wastes to enhance the effects of variability in supply, processing time or demand (BMGI). Liker and Wu (2000) defined it as a philosophy of manufacturing that focuses on delivering the highest quality product on time and at the lowest cost. Worley (2004) defined it as the systematic removal of waste by all members of the organization from all areas of the value stream. Briefly, it is called lean as it uses less, or the minimum, of everything required to produce a product or perform a service (Hayes and Pisano, 1994). In a nutshell, lean manufacturing can be best defined as an approach to deliver the upmost value to the customer by eliminating waste through process and human design elements. Lean manufacturing has become an integrated system composed of highly inter-related elements and a wide variety of management practices, including Just-in-Time (JIT),quality systems, work teams, cellular manufacturing etc (Shah and Ward, 2003). The purpose of implementing it is to increase productivity, reduce lead time and cost, and improve quality (Sánchez and Pérez, 2001; Karlsson and Åhlström, 1996).

The main motto of the lean manufacturing system is to reduce the waste or in Japanese language it calls muda. Waste is defined as anything that does not give the positive value to the end of the product from the customer requirement. Lean manufacturing is a pull production instead of push. In the lean and manufacturing system there is a different tool and techniques are used for solving the problem. It is the systematic way to reduction of waste in proportion of the reduction of the inventory. There are some specific quality tools which are much effective in the production of an industry such as 7-qc tool, kaizen, kanban. Growing interest in both Lean manufacturing systems led to natural curiosity about their potential relationship (Maxwell, 2001).

2.1 Definitions of lean manufacturing

Lean manufacturing has become an integrated system composed of highly inter-related elements and a wide variety of management practices, including Just-in-Time (JIT),quality systems, work teams, cellular manufacturing etc (Shah and Ward, 2003). The purpose of implementing it is to increase productivity, reduce lead time and cost, and improve quality (Sánchez and Pérez, 2001; Karlsson and Åhlström, 1996).Lean manufacturing requires that not only should technical questions be fully understood, but existing relationships between manufacturing and the other areas of the firm should also be examined in depth, as should other factors external to the firm (Womack and Jones, 1994).

2.2: Seven types of wastes in manufacturing process

Lean manufacturing is systematic method to eliminate the wastage produces in order to reduction in inventory, over production, waiting and unnecessary motion. The basic idea of the lean manufacturing is to waste reduction, cost reduction and empowering the employee. Lean denotes a system that uses less in order to all inputs given to the process, to create the same output that they created by the traditional mass production system (Panizzolo, 1998). For eliminating the waste lean manufacturing consider the following factors: In particular, Lean manufacturing focuses on the reduction of seven wastes, which are illustrated as:

- **Material -** The usage of all the raw material in the end product and try to reduce the excess of the raw material and the scrap.
- **Inventory:** The continuous flow of material to the customer and do not have extra material.
- **Overproduction:** Production of the final product is as per the customer requirement.
- **Energy:** The utilization of the equipment and people in most productive ways. Avoid unproductive operation and extra power utilization.
- **Quality of manufacturing facilities:** The tools and equipment are to be qualitative as per the modification of the material required.
- **Unnecessary motion:** Avoid the excessive motion of the man, machine and the material.
- **Suggestion scheme:** For increase the idea lean added the task as brainstorming in which ideas are collect.
- **Transportation:** Transportation of material and information cost does not added to the value of the product.

3. Lean Tools and Methods

The objective of lean is to create the most value for the customer while consuming the least amount of resources to design, build, and sustain the product. In their 1996 book, Lean Thinking – Banish Waste and Create Wealth in Your Corporation, Womack and Jones (1996) identified how Toyota's production system is different from the traditional mass production approach, mentioned earlier in Section 2.12. The book explains that companies will gain improvements from lean when they redesign their value streams by applying the following principles:

• Specify value from the standpoint of the customer,
• Identify the value stream for each product or service-line family,
• Make value flow toward the customer,
• Produced based on the pull of the customer, and
• Strive continually to approach perfection.

The objective of these lean principles is to create the best possible system, from concept to consumer using the current financial and resource constraints to provide the most value to the customer. Once the value stream is designed, or redesigned, improvements can be made by implementing lean tools and techniques appropriate to the particular situation (Womack & Jones, 1996).

As mentioned earlier, there are many lean tools. Lean is concerned with eliminating all types of waste, which is much more than eliminating waste by reducing inventory. TaichiOhno identified seven types of waste in his book Toyota Production System (Ohno, 1988). He explained that waste is sometimes hard to see but can be classified by: overproduction, time on hand, transportation, over processing, inventory, movement, and defective products (Ohno, 1988). All the lean tools work toward common goals of eliminating this waste, in order to bring the most value to the customer. An organization striving to be lean will want to have only the required inventory when needed, improve quality to zero defects, reduce lead time through setup time reduction, reduce queue lengths and lot sizes, incrementally revise operations, and accomplish improvements at minimum costs (Womack & Jones, 1996). The various lean tools are discussed briefly in the subsequent sections of this chapter. The tools are presented in the order of relevance from top management to the plant floor of an organization.

2.4.1 HoshinKanri or Policy Deployment

Hoshinkanri or policy deployment is the process of bringing the objectives of top management of the company to the plant floor level (Liker, 2004). Policy deployment is the short-term and long-term process used to identify and address critical business requirements and expand the ability of the workforce. The ultimate purpose of 'policy deployment' is to create a companywide philosophy based on quality being supreme with a customer oriented approach (Akai, 1991). Figure 2.1 shows the basic concept of Hoshin Kanri. Policy Deployment aligns company resources to swiftly recognize and react to changes in the business environment. The goals of the organization as a whole, start at the executive level and at each level below they develop into measurable objectives for the year, which support the overall organizational goals. The hoshin planning system consists of the following: the plan, do, check, and act cycle, nemawashi, catchball, the control department concept, and A3 thinking. For more information about the hoshin planning system consult Hoshin Kanriand Hoshin Kanri: Policy Deployment for Successful TQM by Yoji Akai (Akai, 1988 & Akai, 1991).

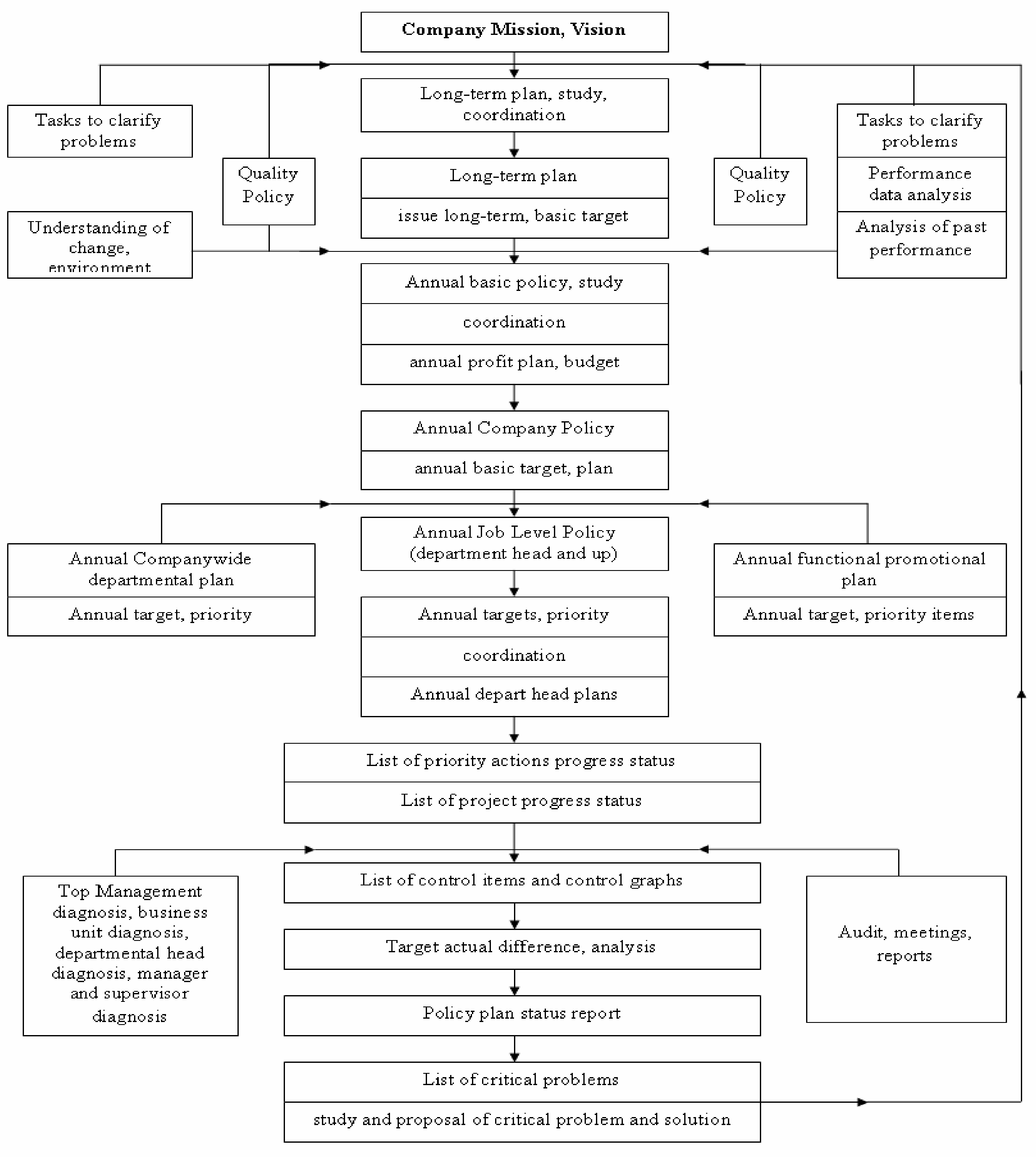


Figure 2.1: HoshinKanri: Basic Concept

Source: Akai, Yoji. (1991). HoshinKanri: Policy Deployment for Successful TQM. Portland, OR: Productivity Press.

2.4.2 Plan, Do, Check & Act (PDCA)

Hoshin planning is made up of PDCA cycles: macro (three to five years) practiced by senior management, annual practiced by operating managers, and micro (weekly, monthly, or biannually) practiced by operating managers and their subordinates. Figure 2.2 shows how the process of 'policy deployment' follows the PDCA cycle as goals pass from top management to the plant floor. PDCA is a continuous cycle which requires cultural change as seen in Figure 2.3.

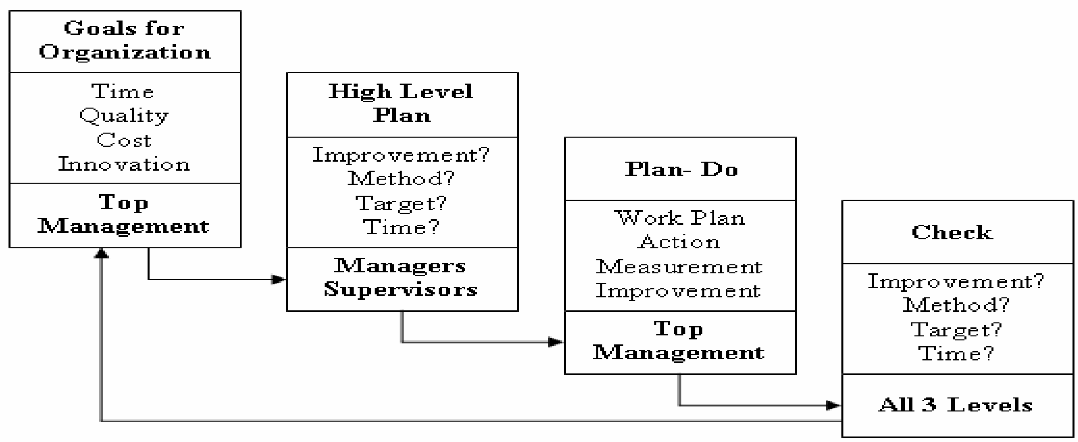


Figure 2.2: Policy Deployment Process (HoshinKanri) Source: Liker, J.K. (2004). The Toyota Way. New York: McGraw-Hill.

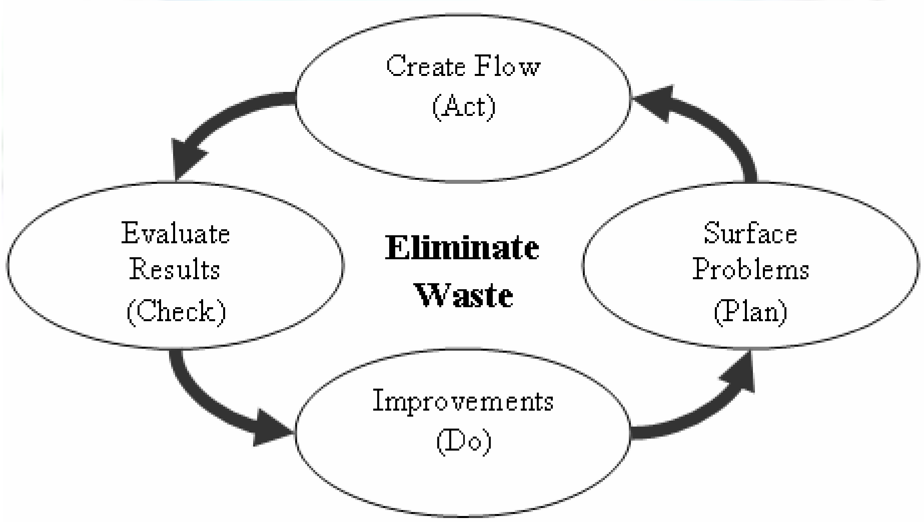


Figure 2.3: Creating Flow and PDCA

Source: Liker, J.K. (2004). The Toyota Way. New York: McGraw-Hill.

PDCA requires supportive management that allows for visible current production status and compel countermeasures or improvements. PDCA also requires solid visual management, because visual systems such as report boards and line-side process reviews create a shared understanding of the production performance data with everyone involved with the production of products (Akai, 1988 & Akai, 1991).

2.4.3 Nemawashi or Change by Consensus

This word translates "to prepare a tree for planting," which means Nemawashi is the process of building for alignment. When using the Nemawashi process, the decisions are made slowly, by consensus, considering all options thoroughly, and then the action to correct is taken rapidly. During this process, many people are giving their input, which generates the consensus, and by the time the proposal has reached top management for final approval, the decision is made and agreed upon (Liker, 2004). Figure 2.4 shows the Nemawashi decision making method as used by Toyota. The Nemawashi process for decision making and policy take longer; however, the implementation process is quicker and more effective as a result (Dennis, 2002 & Liker, 2004).

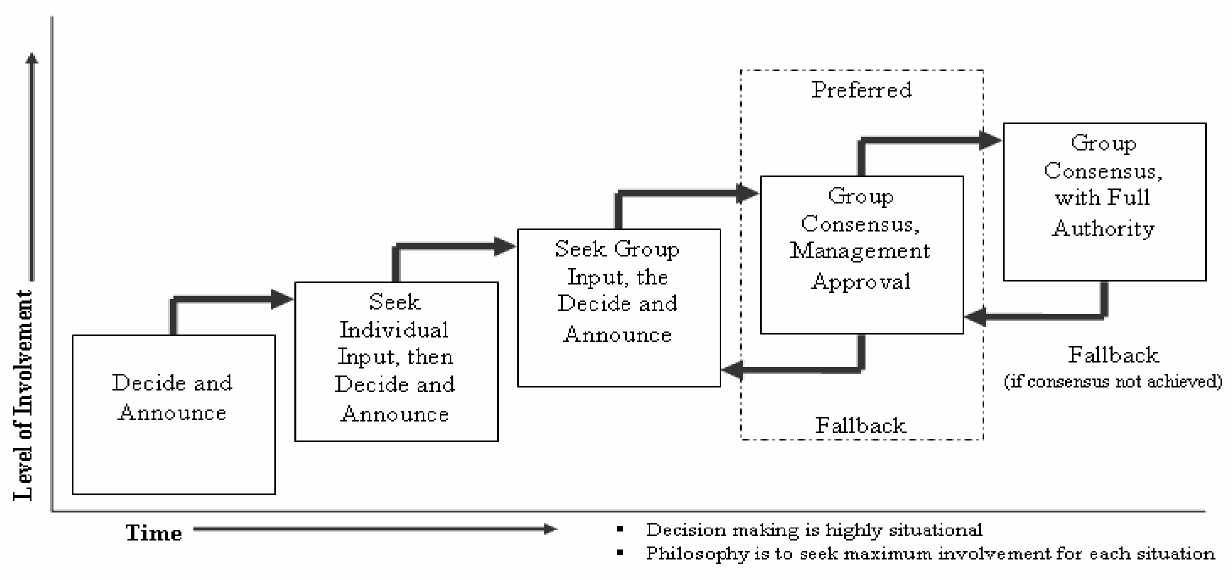


Figure 2.4: Alternative Toyota Decision Making Methods

Source: Liker, J.K. (2004). The Toyota Way.New York: McGraw-Hill.

2.4.4 Catchball

Catchball refers to the compromises required among management levels during the planning process. The objective of 'catchball' is to link the vision of management and the daily activities of the operators or plant floor workers (Akai, 1988 & Akai, 1991). Figure 2.5 depicts the general movement of dialogue or 'catchball," represented by two-way arrows, used among senior management, implementation teams, and middle management to establish and agree upon the goals of the organization. Catchball is the means in which consensusdialogue of nemawashi occurs which helps enable the decision making of Policy Deployment.

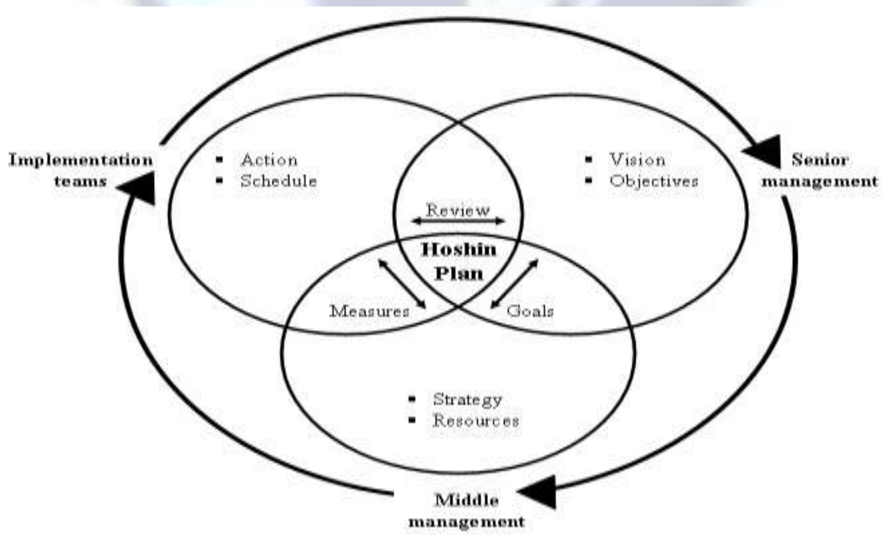


Figure 2.5: Hoshin Model

Source: Akai, Yoji. (1991). HoshinKanri: Policy Deployment for Successful TQM. Portland, OR: Productivity Press.

2.4.5 Control Department or Cross Functional Management

The Control Department or Cross Functional Management concept attempts to combine core company focus areas such as productivity, quality, cost, and safety into cross-functional groups with coordinated efforts towards common goals. Figure 2.6 presents the Departmental Control Concept. The control department develops the Policy Deployment plans for the company, while individual departments develop their own plans for supporting their particular purpose. For example, the quality department would develop a quality plan. To support this plan all the other departments would develop plans to support quality in their department. The control departments are responsible for their own performance (Akai, 1991).

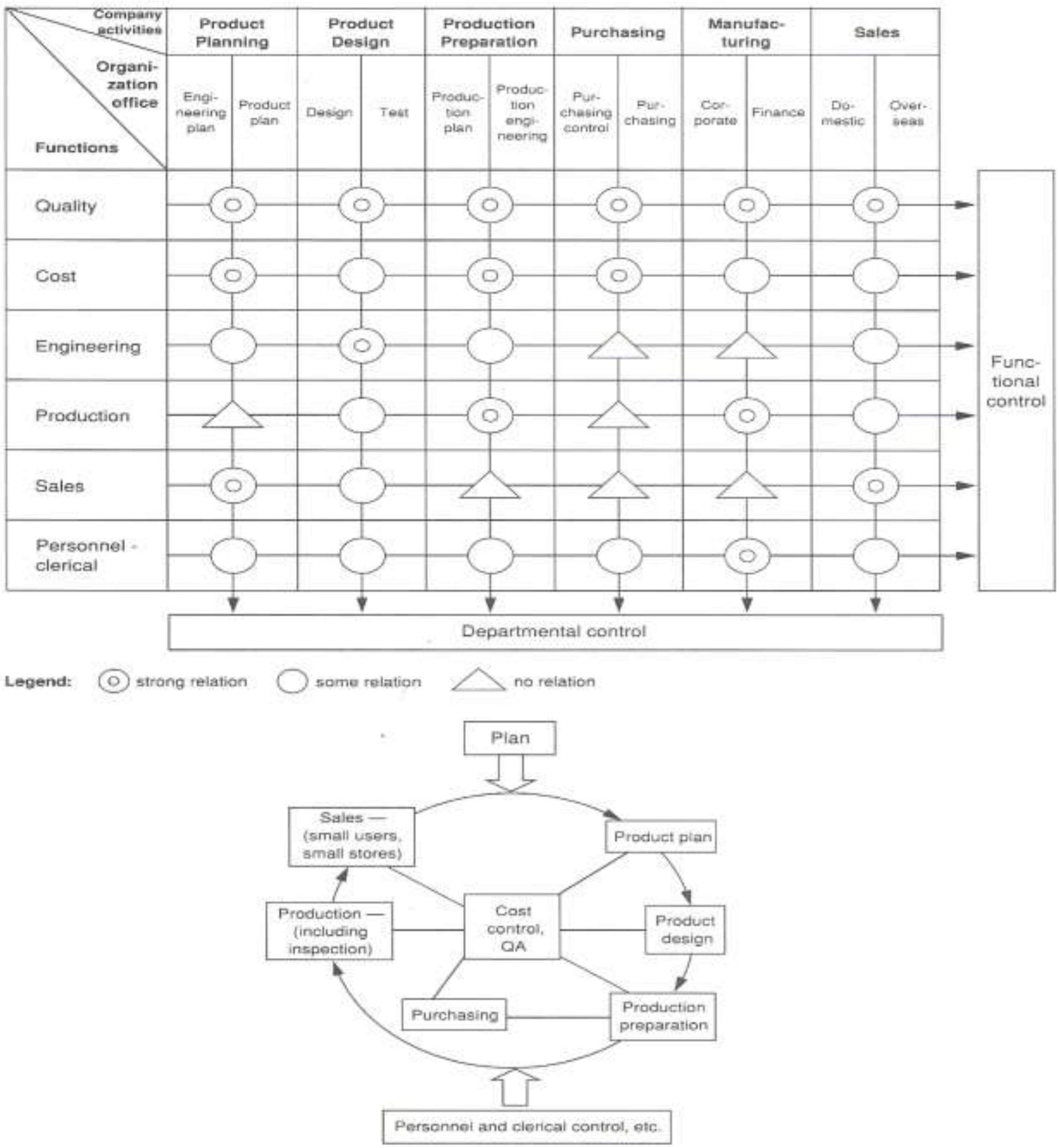


Figure 2.6: Departmental Control Concept

Source: Source: Akai, Yoji. (1991). HoshinKanri: Policy Deployment for Successful TQM. Portland, OR: Productivity Press.

2.4.6 A3 Problem Solving

A3 reports were originally used at Toyota to summarize kaizen activities (see Section 2.2.14). There are four types of A3: 'hoshin planning A3' used to summarize company and departmental plans, 'problem solving A3' used to summarize problems and corrective actions, 'proposal A3' used to present new ideas, and 'current status A3' used to summarize the current condition of a plan, problem, or concern (Liker, 2004). A3 is an important part of PDCA, nemawashi, and catch ball because the reports are a simple means to relay information about the organizational goals and direction to everyone in the company (Liker, 2004 &Sobeck, 2004).

2.4.7 Lean Six Sigma

Six Sigma (6σ) quality is a problem solving methodology which was first used at Motorola to represent its strategy for the lowest possible failed. 6σ represents the mathematical calculation, 99.9996% perfection. The figure equates to 3.4 ppm failed parts per million, which is very close to zero defects. Lean Six Sigma combines Six Sigma methodology with lean manufacturing tools. Lean six sigma is a data driven approach to find the root cause of problems, management strategy to manage lean projects to financial goals, and uses the DMAIC (define, measure, analyze, improve, maintain) process to organize operating processes (Taghizadegan, 2006).

2.4.8 Value Stream Mapping

For almost all companies, value stream redesigns are a critical step to becoming lean; the design of the end-to-end value stream must be considered instead of applying tools randomly, or to address an apparent problem (Womack & Jones, 1996). Value Steam Mapping (VSM) is used extensively in Six Sigma Methodology and has recently been added to the list of tools which can be used to apply the principles of lean (Henderson &Larco, 1999). Value stream maps differ from process flow maps in that value stream maps contain all the value added and non-value added steps/activities, include the information flow along with the material flow to make the product, are a closed circuit from the customer back to the customer, and contain no takt time is taken into account in process flow maps. Figure 2.7 lists and visually represents all the icons used in Value Stream Mappin

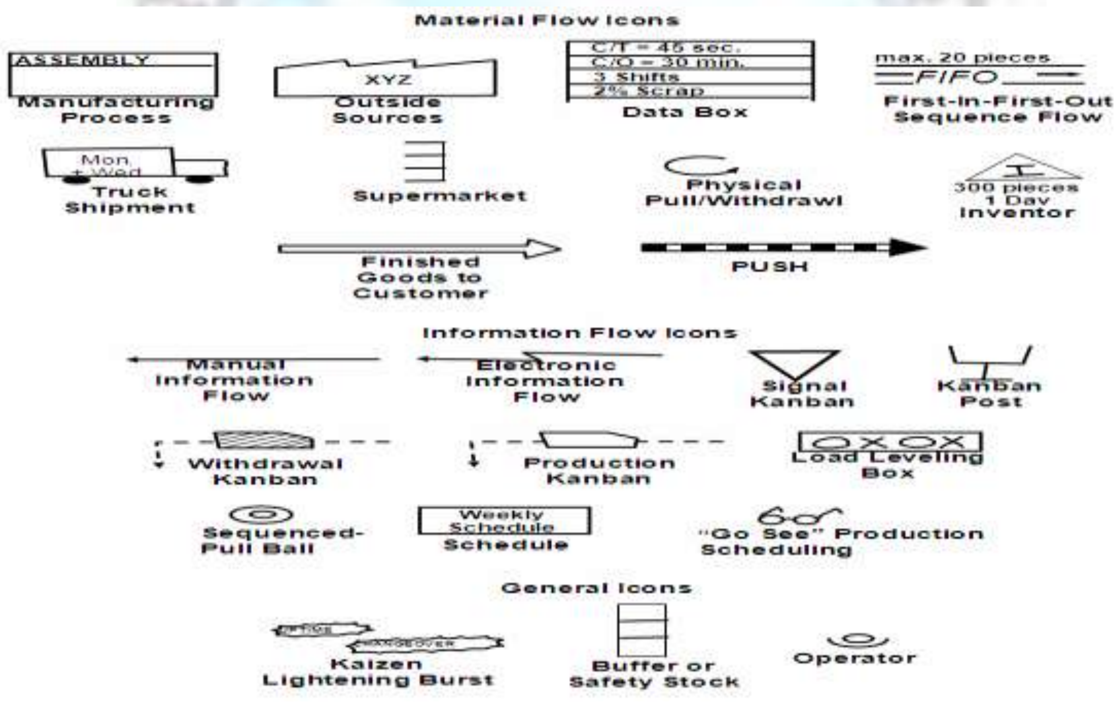


Figure 2.7: Value Stream Mapping Icons

Source: Rother, M. & Shook, S. (2002). Value Stream Mapping Workshop.Brookline, MA: The Lean Enterprise Institute.

Value Stream Maps should be made of the current state of the manufacturing process to make a particular product line or family, all the information should be gathered at one time as the map will represent this particular time and date. Figure 2.8 is an example of a current state map.

International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463
Vol. 3 Issue 8, August-2014, pp: (117-136), Impact Factor: 1.252, Available online at: www.erpublications.com

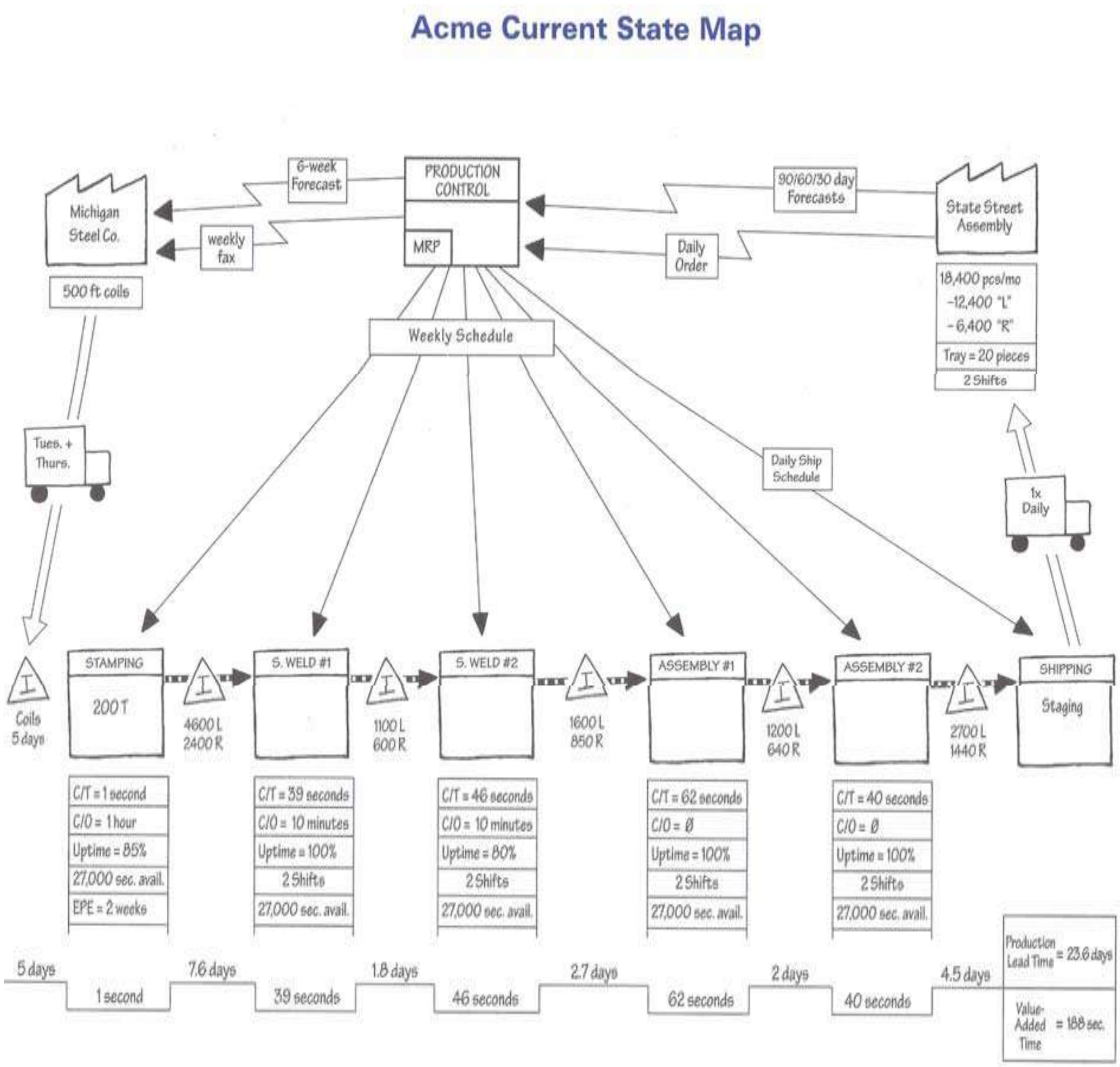


Figure 2.8: Acme Current State Map Source: Rother, M. & Shook, S. (2002). Value Stream Mapping Workshop.Brookline, MA: The Lean Enterprise Institute.

After the current state has been completed, percent value added, the processing time that the customer is willing to pay for, can be calculated as the ratio of the total lead time to value added processing time. From the current state, problems in the process are identified and goals for improvement are identified and placed on the future state map. Figure 2.9 shows an example of a current state map of the same company in Figure 2.8. Value stream maps relay information such as machine utilization and inventory in each process and their effect on the overall lead time of the product, which allows for prioritization of projects which would have the most positive effect on the overall lead time. Value Stream Maps can be used in order to visualize and make improvements on a process; this is done through a future state map of the process, which represents the ideal situation of the process.

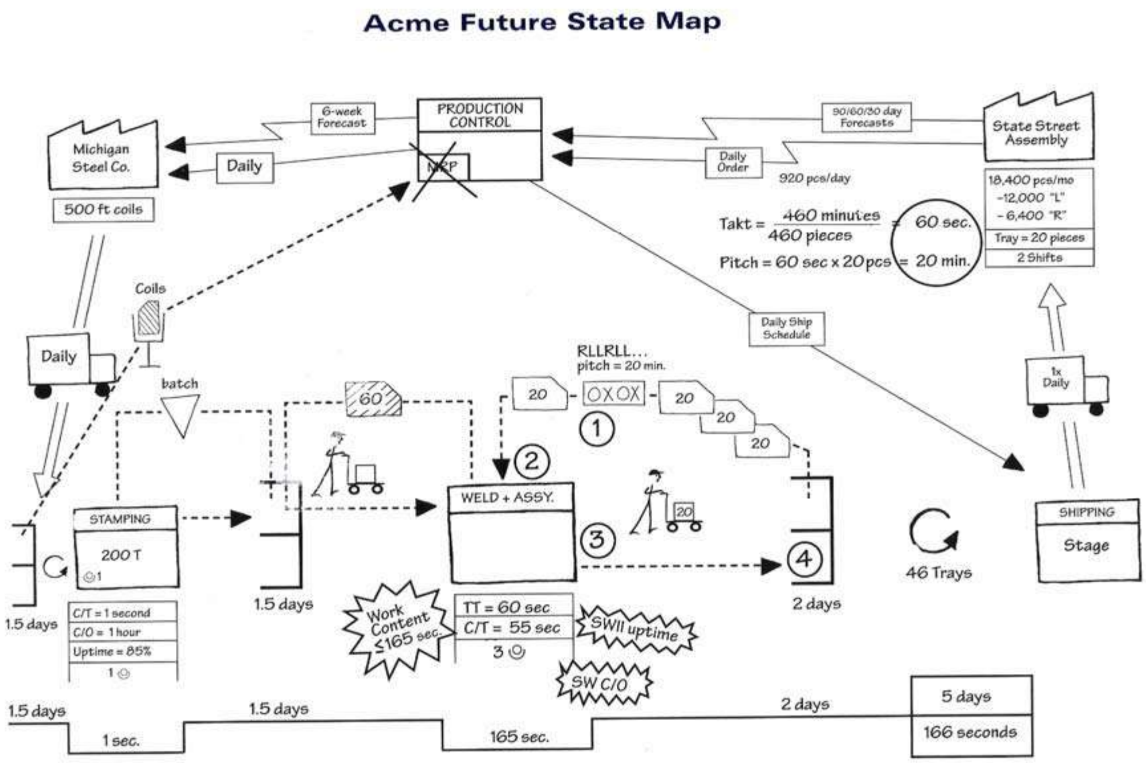


Figure 2.9: Future State Map Source: Rother, M. & Shook, S. (2002). Value Stream Mapping Workshop.Brookline, MA: The Lean Enterprise Institute.

2.4.9 Spaghetti Diagrams

A spaghetti diagram shows the path of a specific product as it moves from one process to another. In a mass production system the product's path typically looks like a plate of spaghetti (Womack & Jones, 1996). Spaghetti diagrams are a simple way to analyze the product flow, but do not contain the level of information found in Value Stream Mapping.

2.4.10 Visual Management

The goal of visual management is to create a work environment that is self-explaining, self- ordering, and self-improving (Grief, 1995). In his book "The Visual Factory," Grief illustrates this idea in a visual management triangle seen in Figure 2.10. In this type of workplace, employees can immediately notice out of standard situations and easily take corrective actions. A vital component of visual management is the 5s organization system, which will be discussed in detail in the next subsection.

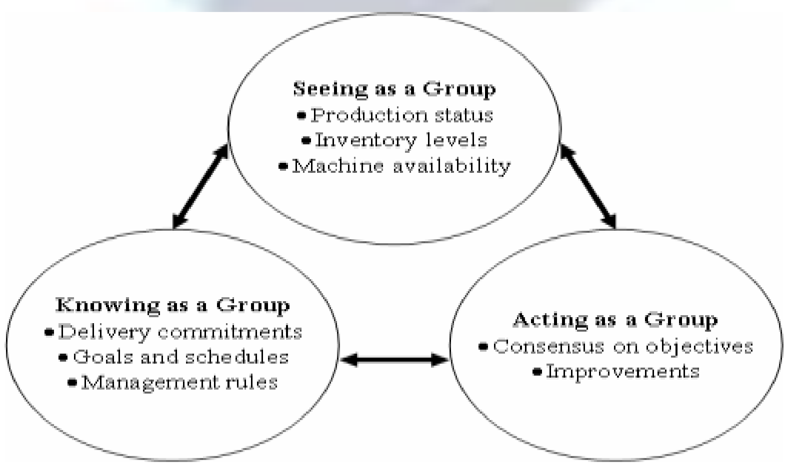


Figure 2.10: The Visual Management Triangle Source: Grief, M. (1995). The Visual Factory: Hiroyuki Hirano. Portland OR: Productivity Press.

2.4.11 The 5s System

The 5s tool is a structural system to organize any type of business or operation, and 5 srepresents five steps including: sort, set in order or place, shine or scrub, standardize and sustain (Hirano, 1996). All these steps must be followed to have success with a 5s event or for an operation to say that they are 5s. However, the second and third step, set in order and shine, may be switched in order depending on the needs of the organization using 5s.

2.4.11.1 Sort

The first step, 'sort' means to simply separate what is needed and necessary in the workplace or station from what is not Sorting reduces problems and annoyances in the workflow, improves communication between workers, increases product quality, and enhances productivity (Hirano, 1996). Anything that is not used or needed in the workplace gets in the way of the actual work being done there.

2.4.11.2 Set in Place

The second step, 'set in place,' is a storage principle in which everything in the work area has a place and is always stored there when not in use. This makes the tools easy to find and anyone should be able to find them and then replace them after use (Hirano, 1996). Using or creating tools with multiple functions can eliminate a variety of tools. Properly setting things in order can eliminate a variety of waste in the workplace including: motion, searching, human energy, excess inventory, unsafe working conditions, and using the wrong tools (Hirano, 1996).

There are several different strategies used to set in place or order, which can be used apart or together. The signboard is a strategy, which identifies what, where and how many items should be stored.

2.4.11.3 Shine

The third step is 'shine' or scrub to keep the work place clean by eliminating all forms of dirt, dust, grease and grime. This builds a sense of pride in the employees, improves the work environment, provides for a safer workplace, and helps maintain equipment value (Hirano, 1996). Cleaning can also be used as a form of inspection. While in the process of cleaning a piece of equipment, a problem can be noticed that would not have been seen in passing.

2.4.11.4 Standardize

The fourth step, 'standardize,' is where working conditions are implemented to maintain sort, set in place, and shine. Standardization creates a consistent way that tasks and procedures are carried out so that absolutely anyone can understand the work (Hirano, 1996).

2.4.11.5 Sustain

The last and fifth step is 'sustain,' making a habit of properly following the correct procedures and continuously repeating all the steps of the 5s process. By sustaining all of the 5s steps, many problems in the work place can be avoided including:

- Un-needed items piling up as soon as the sorting process is completed,
- Tools being put in the wrong place after use,
- No one ever cleaning equipment or picking up after themselves,
- Items being left in walkways,
- Dark, dirty work environments which lower morale of employees, and
- Dirty machines which start to malfunction and/or produce defects (Hirano, 1996).

2.4.12 Total Productive Maintenance

Total Productive Maintenance (TPM) is another component of visual management, which works especially well with the 5s organizational system. As discussed earlier, one pillar of 5s is shine in which cleaning is used as a form of inspection. The goal of this is to eventually train the operators to look after the equipment in their workstation (Nakajimi, 1988). Total productive maintenance assigns basic maintenance work such as: inspection, cleaning, lubricating, tightening, etc., to the operator. This frees up the technicians or maintenance team for productive maintenance, which includes higher value-added activities such as: equipment improvement and overhauls, training, etc. Just as in safety the target is zero incidences, in TPM the target is zero breakdowns (Nakajimi, 1988).

The key measure of TPM is machine effectiveness, which is availability, performance efficiency, and overall equipment effectiveness (OEE).

- Availability =(loading time– down time)/ loading time
- Performance efficiency = (net operating time – lost time) / net operating time
- OEE = availability * performance efficiency * quality rate

Accurate data is essential. It is not time wasted to measure and record machine performance. Accurate equipment records are essential in order to identify potential problems (Hartmann, 1992).

2.4.13 Andons

Another type of visual control or management is the andon. At Toyota each assembly and machining line is equipped with call lights and an andon board (Monden, 1993 & Dennis, 2002). The call light is used to call for a supervisor, maintenance, or general worker. Usually, there are several different colors of lights, which designate different types of assistance. The andon is the indicator board, which shows that the line has been stopped. The andon board and call lights are usually suspended from the ceiling so that they are easily seen and located.

2.4.14 Kaizen

The term kaizen is often mentioned in the application of lean manufacturing. It simply means, "change for the good of all", in Japanese and is used as an improvement tool. Kaizen is the starting point for all lean initiatives. Kaizen is a team approach to quickly tear down and rebuild a process layout to function more efficiently (Ortiz, 2006). Quality in Toyota's just in time manufacturing system was based on the kaizen continuous improvement concept.

This approach is used to create trial and error experiences in eliminating waste and simplifying processes, and this approach is repeated over and over again to continuously look for problems and solutions (Russell & Taylor, 2002). A Kaizen Blitz is a term used to describe when a process is quickly changed to eliminate activities that have no value (Russell & Taylor, 2002).

2.4.15 Kaikaku or Radical, Rapid Improvement

Kaikaku is Japanese for radical or rapid improvement. Like Kaizen a Kaikaku has the goal of eliminating waste, but unlike 'continuous improvement' which is incremental, 'rapid improvement' is a one-time event to make improvements on a particular problem or issue. Kaikaku and its application are discussed further in Womack's Lean Thinking (Womack & Jones, 1996).

2.4.16 Jidoka or Autonomation

Jidoka is a Japanese word comprised of three Chinese characters, ji-do-ka. The first, "ji" is the worker. If there is something wrong or a defect, the worker must stop the line. "Do" refers to the motion to stop the line and the "ka" means action. Taken all together jidoka is defined by Toyota "automation with a human mind." This implies that workers and machines have the intelligence to identify errors and take quick countermeasures forcorrection (Shingo, 1985 a). The ultimate goal of jidoka is to prevent defects. Shigeo Shingo developed and extended the jidoka concept, which is in contrast to W. Edwards Deming statistical process control (SPC). The difference is that SPC shows how many defects will be produced, but jidoka's goal is to prevent defects through 100 percent inspections (Shingo, 1985 a). To achieve this goal, Shingo developed the concept of poka-yoke.

2.4.17 Poka-yoke or Mistake Proofing Devices

Shingo observed that humans are the most unreliable components of complex systems. Standardized work, visual management, and 5s are lean tools discussed previously, which can be used to improve human reliability. Poka-yoke is another tool for this purpose. Pokameans inadvertent error and yoke means prevention. Poka-yoke is implementing simple low cost mistake proofing devices that detect abnormal situations before they occur or once they occur stop production to prevent defects (Shingo, 1985 a). Poka-yoke reduce the physical and mental burden of constantly checking for common errors that lead to defects such as: missing process steps, process errors, miss set work pieces, missing or wrong parts, improper equipment set ups and so forth. A good poka-yoke must be simple and low maintenance, very reliable, low cost, and designed for the specific workplace condition.

2.4.18 SMED or Quick Machine Changeover

Single Minute Exchange of Dies (SMED) is a series of techniques developed by ShigeoShingo for reduction in production changeover time to less than ten minutes. 'One-touch setup'applies to a changeover taking less than a minute and 'zero set-up' are changeovers that happen instantaneous. Shingo has compiled this methodology into his book entitled ARevolution in Manufacturing: the SMED System (Shingo, 1985 b).

2.4.19 Standardized Work

Standardized work is the safest, easiest, and most effective way of doing the job that we currently know, but the purpose of standardized work is to provide a basis for improvement on that job. At Toyota, the supervisor determines the components of standardized work, but at most other companies, this determination is usually made by the Industrial Engineering staff.

Toyota has set it up this way because of their belief that the supervisor has a better knowledge of the performance of workers. Toyota's model for elements of standard operations is depicted in Figure 2.11.

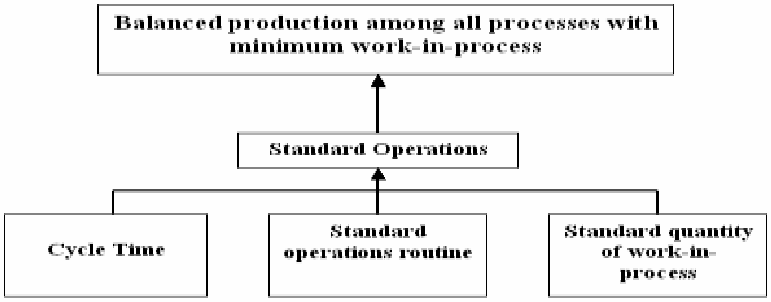


Figure 2.11: Elements of Standard Operations Source: Monden, Y. (1993). Toyota Production System: An Integrated Approach to Just In Time. Norcoss, GA: Engineering & Management Press.

In order to use standardized work, a process must be stable without continuous line stoppages and slowdowns. Lean activities support stability. For example, 5s and TPM discussed in earlier sections support machine stability and safety. Standardized work involves three elements, which are the baseline against which any given process can be accessed: takt time, work sequence, and in-process stock. Standardized work is relayed to the operators through standard operations sheets and charts that define standard work.

2.4.20 Talk Time and Cycle Time

Takt time or cycle time is the time needed to manufacture one unit of a product to customer demand, measured as the elapsed time between the completion of one unit and the completion of the next (Monden, 1993). The word is German describes a stroke in beating time. The takt time reveals the demand frequency, or how frequently a product needs to be produced, tact time is calculated as follows:

$$\text{Takt Time} = \frac{\text{Daily Operating Time}}{\text{Daily Amount of the Product Required by Customer}}$$

This calculation enables understanding of production at a glance. For example, if takt time is 1 minute, we should see a product moving past every minute. This understanding allows for quick countermeasures to get the line moving properly again (Monden, 1993).

2.4.21 Work Sequence

The work sequence is the standard operations routine or the order in which the work is done in a given process and represents the current best way known to accomplish the task. At Toyota, pictures and drawings depicted how to do the job right with such information as proper posture, how the hands and feet should move, how to hold tools, and critical quality and safety issues (Monden, 1993).

2.4.22 In-Process Stock

In-process stock or standard quantity of work in process is the minimum number of unfinished work pieces required for an operator to complete the process. Work cannot progress without this certain number of pieces on hand (Monden, 1993 & Dennis, 2002). The standard quantity held should be kept as small as possible because this will reduce holding costs as well provide a visual control for checking product quality because defects are more evident (Monden, 1993).

2.4.23 Standard Operations Sheet

The standard operations sheet is used to standardize work at Toyota. This sheet contains the following items: cycle or takt time, operations routine or work sequence, in-process stock levels, net operating time, positions to check product quality, and positions to pay attention to safety (Monden, 1993).

2.4.24 Charts Used to Define Standardized Work

There are three common charts used to develop standardized work which are the production capacity chart, standardized work combination table, and standardized work analysis chart (Japanese Management Association, 1989 & Dennis, 2002).

International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463
Vol. 3 Issue 8, August-2014, pp: (117-136), Impact Factor: 1.252, Available online at: www.erpublications.com

Production Capacity Chart

This chart determines the capacity of machines in a process. Production capacity for a given machine is calculated by the following formula:

$$\text{Capacity} = \frac{\text{Operational Time Per Shift}}{\text{Process Time} + (\text{Setup Time} / \text{Parts Produced Between Groups})}$$

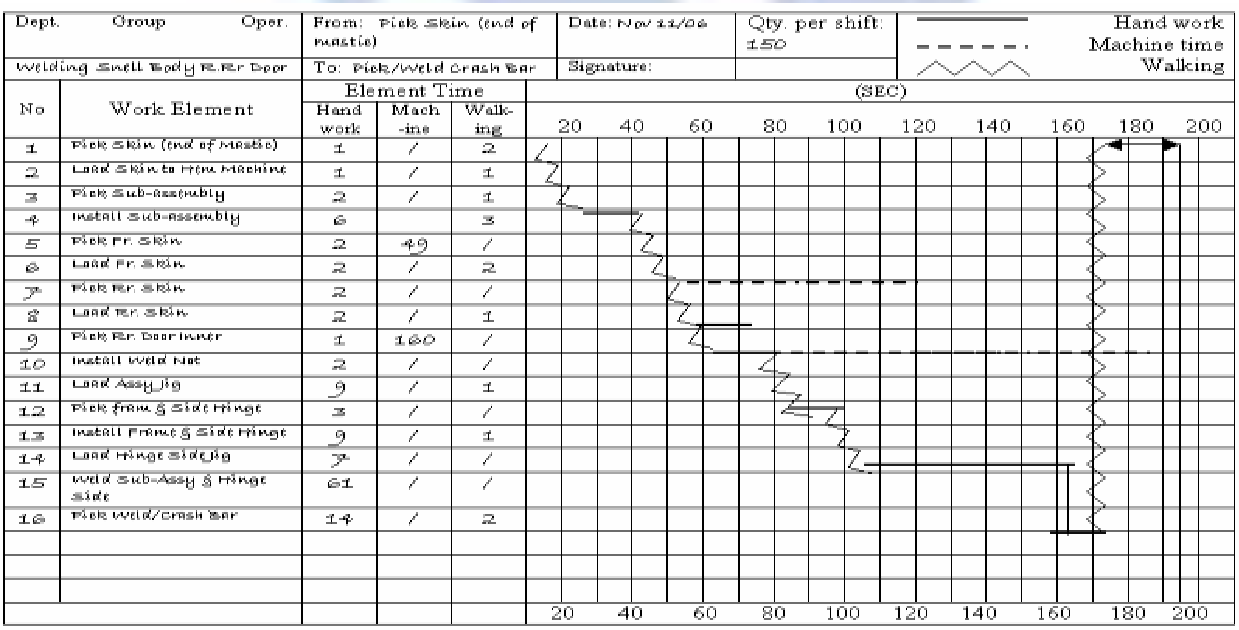
Setup time represents the time required to change from machine setting to another. Figure 2.12 shows a production capacity chart for an automotive punch press.

Manager	Foreman	Standardized Production Capacity Sheet	Part No. 12375-79543 / Part Name: Intake Manifold		UnitType: 22L / No. of Units	Section: 533 543	Name: Suziki Sato	
Process No.	Process Name	M/C No.	Basic Operation Time			Tool Changes		Capacity	Comment
			Manual Time	Auto Time	Time to Complete	Interval between changes	Time Taken		
			Min Sec	Min Sec	Min Sec				
1	Machining of Attaching Face	MIL 1754	3	25	28	100	1'00''	965	
2	Drilling Bolt Hole	DR 2524	3	21	24	1000	30''	1148	
3	Tapping of Threads	TP 1102	3	11	14	1000	30''	967	
4	Quality Check		5		5			5520	
		Total	14						

-Operation time=460 minutes per shift (27,600 seconds)

Figure 2.12: Production Capacity Chart Source: Dennis, P. (2002). Lean Production Simplified. Portland, OR: Productivity Press. Standardized Work Combination Table

This chart shows: work elements in sequence, time per work element, operator and machine time, and interactions between operator and machine and other operators. An example, shown in Figure 2.13 breaks down the movements of the operators and relates them to machine time. It helps with kaizen that is discussed in Section 2.2.14 (Dennis, 2002).



Dept. Group Oper. — Welding Shell Body R.Rr Door
From: Pick Skin (end of mastic)
To: Pick/Weld Crash Bar
Date: Nov 11/06
Signature:
Qty. per shift: 150

No	Work Element	Hand work	Machine	Walking
1	Pick Skin (end of Mastic)	1	/	2
2	Load Skin to Hem Machine	1	/	1
3	Pick Sub-assembly	2	/	1
4	Install Sub-assembly	6		3
5	Pick Fr. Skin	2	49	/
6	Load Fr. Skin	2	/	2
7	Pick Rr. Skin	2	/	/
8	Load Rr. Skin	2	/	1
9	Pick Rr. Door inner	1	160	/
10	Install Weld Nut	2	/	/
11	Load Assy Jig	9	/	1
12	Pick Frame & Side Hinge	3	/	/
13	Install Frame & Side Hinge	9	/	1
14	Load Hinge Side Jig	7	/	/
15	Weld Sub-Assy & Hinge Side	61	/	/
16	Pick Weld/Crash Bar	14	/	2

Figure 2.13: Standardized Work Combination Table

Source: Pascal, D. (2002). Lean Production Simplified. Portland, OR: Productivity Press.

Standardized Work Analysis Chart

Standardized Work Analysis Charts contain information that can be used to help rationalize the process and layout. These charts should also be used to train workers because they contain the work layout, process steps, and the expected amount of time required, critical quality and safety issues, and standardized work in process stock. Figure 2.14 depicts the typical format for a standardized work analysis chart.

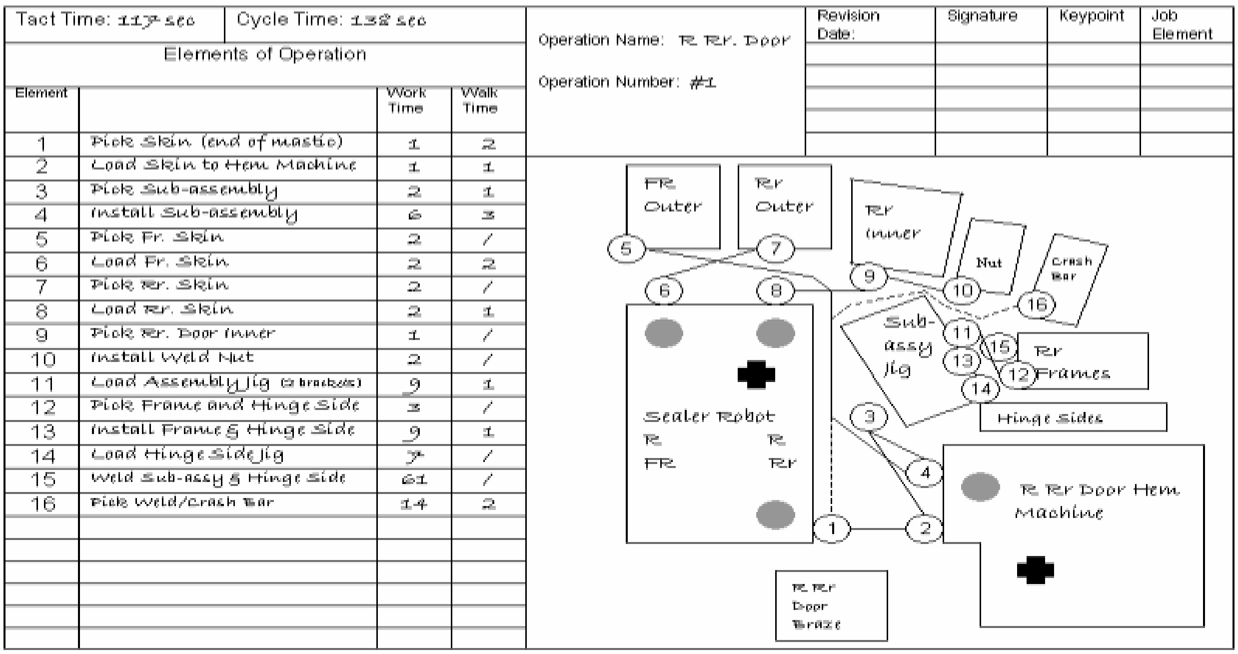


Figure 2.14: Standardized Work Analysis Chart Source: Dennis, P. (2002). Lean Production Simplified. Portland, OR: Productivity Press.

2.4.25 Standard Operational Procedure or Job Element Sheets

Another essential element of standardized work is a standard operation or job element sheet, which contains all the job elements. A job element is the minimum number of actions required to advance in a process. Job element sheets are quick one page snap shots that define: actions making up the job element, rationale, pictures and photos highlighting key points, and a revision record (Dennis, 2002). This sheet is the final step in standardizing an operation at Toyota where the standard operating sheet must also contain: cycle time, operations routine, standard quantity work in progress, net operating time, positions to check quality, and safety issues (Monden, 1993). Figure 2.15 provides an example of this sheet given by Monden in his Toyota Production System second edition.

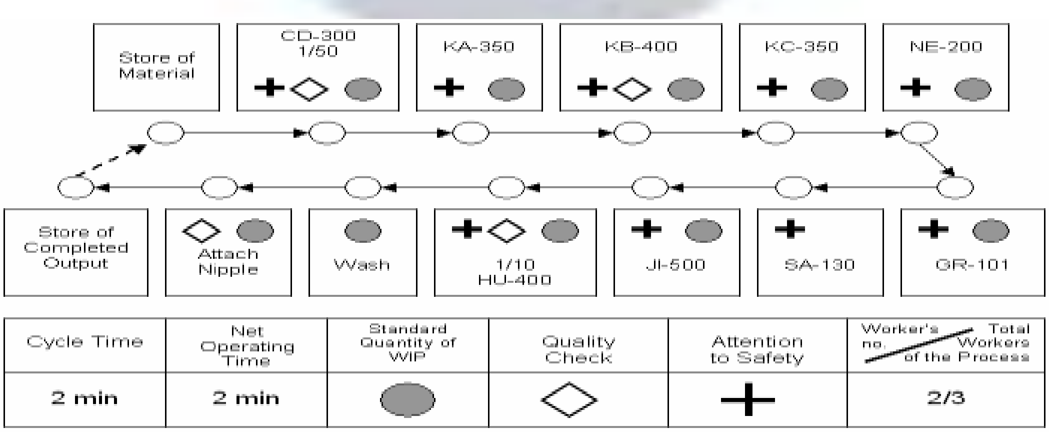


Figure 2.15: Standard Operations Sheet

Source: Monden, Y. (1993). Toyota Production System: An Integrated Approach to Just In Time. Norcoss, GA: Engineering & Management Press.

Standard operation sheets should be displayed in plain view of each worker in order to be used as a visual control for management. The sheets serve as guidelines for each operator to keep his work routine, for the foreman or supervisor to check to be sure each operator is following standard procedures, and to allow management to evaluate the supervisor's ability (Monden, 1993). The goal of standardized work is kaizen. Therefore, standard work needs to continually change in order to improve upon the current process. If the standard procedure remains the same for a long time, management could infer that the supervisor is not attempting to improve the process (Monden, 1993).

2.4.26 Just-in-Time Production

Just in Time (JIT) production means producing the right item, at the right time, and in the right quantity. Anything else is muda or waste, which was discussed at the beginning of Chapter. JIT consists of many other lean tools such as: kanban (card or signal), heijunka (production leveling), SMED or quick machine changeovers, visual management as discussed in section 2.1, and having a stable process which is a benefit of many different lean tools such as 5s, TPM, and standardized work (Monden, 1993).

2.4.27 Kanban

Kanban is the Japanese word for card or communication. Kanban applied to lean manufacturing is a stocking technique using containers, cards and electronic signals to make production systems respond to real needs and not predictions and forecasts. A kanban is a major component of JIT production. Three types of kanbans are mainly used: withdrawal kanban, production ordering kanban, and supplier kanban. A withdrawal kanban specifies the kind and quantity of a product in which the subsequent process should withdraw from the preceding process. A production ordering kanban, sometimes called in-process or production kanban, specifies the kind and quantity of a product in which the preceding process must produce. A supplier kanban or subcontractor kanban is used for making withdrawals from a vendor like a part or materials supplier. The supplier kanban includes instructions, which request the delivery of the supplier is product (Monden, 1993). Figure 2.16 provides a visual depiction of the kanban pull system (Vatalaro& Taylor, 2003).

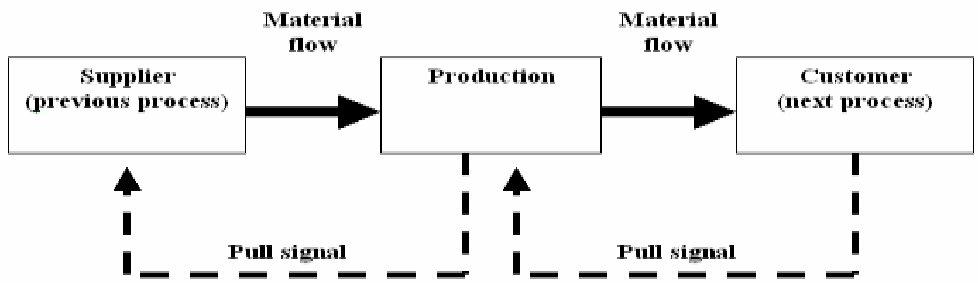


Figure 2.16: Kanban Pull System

Source: Vatalaro J. & Taylor, R. (2003). Implementing a Mixed Model Kanban System: The Lean Replenishment Technique for Pull Production. Portland, OR: Productivity Press

In order to achieve JIT production, Toyota specifies that certain rules in regards to the use of kanbans must be followed (Monden, 1993).

Rule 1: The subsequent process should withdraw the necessary products from the preceding process in the necessary quantity at the necessary point in time.

• Any withdrawal without a kanban is prohibited
• Any withdrawal greater than the number of kanbans is prohibited
• A kanban should always be attached to a product

Rule 2: The process should produce its products in the quantities withdrawn by the subsequent process
Rule 3: Defective products should never be convened to the subsequent process
Rule 4: The number of kanbans should be minimized.
Rule 5: Kanbans should be used to adapt to small fluctuations in demand

In order to determine the number of kanbans needed for any given process, first, a demand analysis and a capacity analysis must be conducted (Vatalaro& Taylor, 2003). Demand analysis determines the current daily demand for each process, which can be done using historical order patterns but ideally with current booked orders. Capacity analysis determines the actual capacity for the particular product. This information is used for the calculation of the actual number of kanbans required by the system.

$$\text{Number of Kanbans} = \frac{\text{Daily Demand}(\text{Order Frequency} + \text{Lead Time} + \text{Safety Time})}{\text{Container Quantity}}$$

Daily Demand is the current quantity level of daily demand for a component. This number must be recalculated often as demand varies over time. Order frequency represents the frequency at which the consuming process will place orders to the supplying process for a component. This number is expressed in days. Lead time is an estimate of how long the consuming process will need to wait for a product once replenishment has been authorized.

After the number of kanbans and the run line for each item has been determined, the maximum and average amount of inventory can be calculated as well as the production lot size for each item.

Maximum Inventory = Number of kanbans * Container Quantity

Average Inventory = Daily Demand (1/2 Order Frequency + Safety Time)

Lot Size = Run Line Value * Container quantity

2.4.28 Supermarkets

A 'supermarket' is a kanban stock point. Like an actual supermarket, a small inventory is available for one or more downstream customers inside a process who come to the supermarket to pick out what they need. The upstream work center then replenishes stocks as required. Supermarkets are used when a one piece or continuous flow is impractical, and the upstream process must operate in batch mode. The 'supermarket' reduces overproduction and limits total inventory (Vatalaro& Taylor, 2003).

2.4.29 Production Leveling, Smoothing or Heijunka

Heijunka or Production Smoothing is Toyota's means for adapting production to variable demand by distributing the production volume and mix evenly over time. Production leveling also determines the schedule of personnel, equipment, and materials (Dennis, 2002). The goal is to have as little quantity variance in the production line as possible. At Toyota, there are two Phases of the leveling process: smoothing the total production quantity and the smoothing of every model's production quantity (Monden, 1993). The goal is to produce the same amount of products every period. Figure 2.17 shows the analysis of the two Phases of Toyota's production smoothing (Monden, 1993). The first phase is the adaptation to monthly demand changes during a year, and the second is the adaptation to daily demand changes during a month. Monthly planning does the first phase and daily job dispatching does the second phase. The daily scheduling is where kanbans are used to activate the pulling system (Monden, 1993).

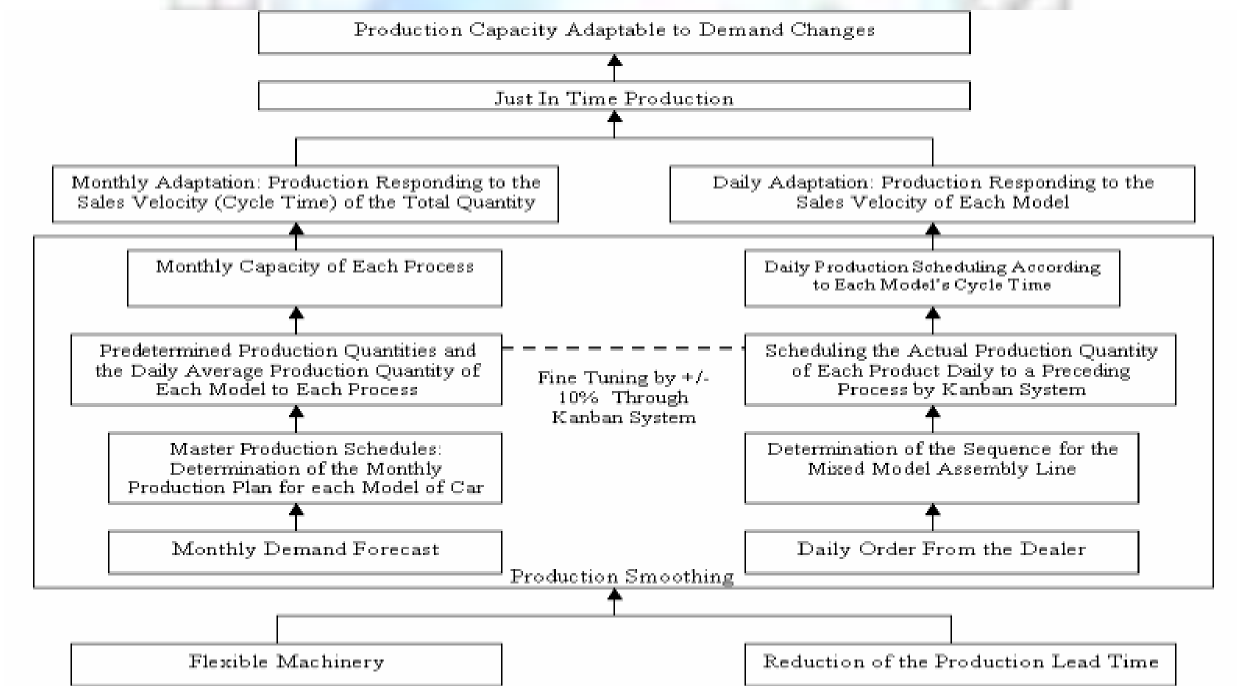


Figure 2.17: Framework of Toyota's Production Smoothing

Source: Monden, Y. (1993). Toyota Production System: An Integrated Approach to Just In Time. Norcoss, GA: Engineering & Management Press.

2.4.30 Cellular Manufacturing

Cellular Manufacturing, or cellular layouts, group machinery and processes into work center, or work cells, which produce similar products or styles or products with similar requirements. Unlike traditional functional layout, dissimilar machines are grouped together. These work cells are arranged in relation to each other so that material flow is optimized or a one piece flow is created. Figure 2.18 depicts a work cell using one piece flow.

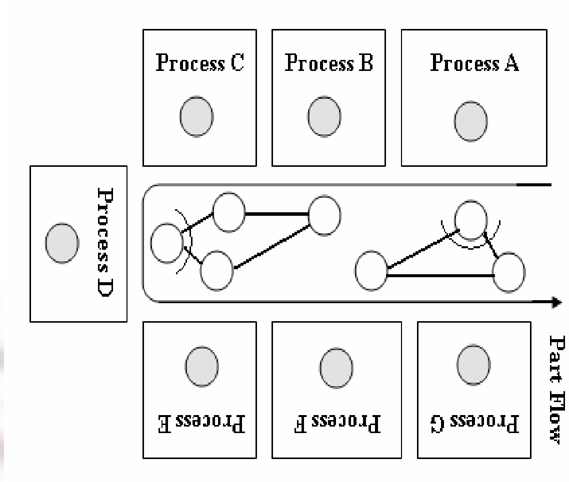


Figure 2.18: U-shaped One Piece Flow Cell

Source: Liker, J.K. (2004). The Toyota Way.New York: McGraw-Hill.

This technique combines the flexibility of a process layout with the efficiency of a product layout. The benefits of 'one piece flow' are better quality, more flexibility, higher productivity, better utilization of space, improved safety, improved morale, and reduction of in process inventory (Liker, 2004).

4. Result and Discussion

4.1 Roadmap for Lean Implementation

The final outcome of this research is a recommendation roadmap for automobile companies to use when implementing lean manufacturing principles. This roadmap consists of four parts: a model for lean implementation, specific barriers to lean implementation along with solutions to those barriers, and best practice checklists for the5s system and Value Stream Mapping.

4.1.1 Model for Lean Implementation

The model for lean implementation in the automobile industry developed through this research consists of recommendations based on the generalization of themes found in conceptualmodels of lean from various sources found in the literature as well as through benchmarking the experiences of industry. The model consists of six major lean tools, which are Policy Deployment, Visual Management, Continuous Improvement, Standardized Work, Just in Time, and Value Stream Mapping and the other tools and methods which fall within such as 5s, TPM, and A3 thinking. Figure 4.1 depicts the recommendation model for lean implementation in the textile industry developed in this study. This model uses the plain English version of some of the Japanese word lean tools, which were identified in Chapter 2. This was done in an attempt to make the tools easier to understand.

At the base of this triangular model is Policy Deployment which addresses the 'philosophy of lean' or the cultural change which must take place in order to base management decisions on what is best for the company in the long term instead of short term financial goals. This process has made the managers at Toyota become successful setting challenging goals jointly with their subordinates who become passionate about measurement and feedback of progress toward those goals (Liker, 2004). The methods of Policy Deployment are meant to get the workforce involved and constantly striving for improvement.

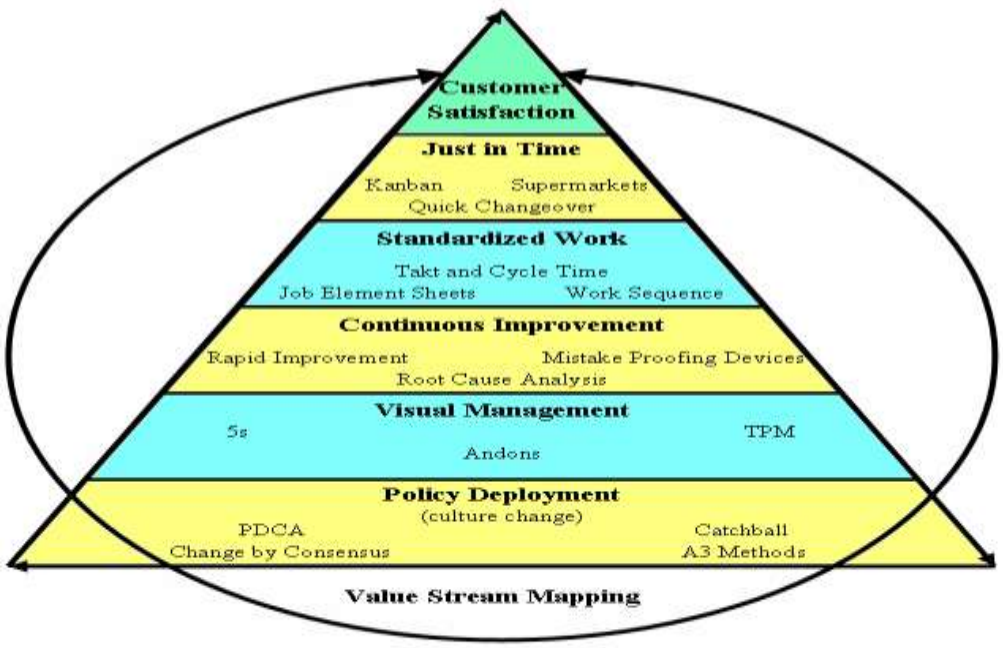


Figure 4.1: Lean Implementation Model

However, some high level individuals within companies may have to have the effectiveness of lean proven before they will be attracted to the philosophy of lean. In such a situation, it may be appropriate to start with Value Stream Mapping, or 5s both of which can bring noticeable improvements. Visual Management tools such as 5s and TPM build a foundation of stability in the process, which enable standardization of the work. Kaizen and other improvement methods might not take into full effect until after employees have had enough experience using lean through tools such as 5s, TPM, and Value Stream Mapping that they understand how the system works. At the center of Standardized Work is the takt and cycle time required for performing the operation to the customer's specification, and if the machine is not capable of performing at this level, the operator cannot either.

Just in Time tools are used to improve product flow and reduce inventories and lead times so the product can get to the customer when they want it and in the quantity they ordered. For this reason Just in Time is the block closes to the customer in the pyramid. The ultimate goal of Just in Time is to make product as it is ordered and to have material move through the plant in a one piece flow. Supermarkets can be used to hold small inventory for downstream customers inside a process to come to the supermarket to pick out what they need. It is recommended to use Value Stream Mapping to help determine the location and size for supermarkets based on takt as determined by the customer. Value Stream Mapping was placed outside the triangle in Figure 4.1, as there is no prerequisite for using the tool, and companies may want to use the tool as a means to prioritize and schedule their improvement projects. Value Stream Mapping is recommended as an important tool for any company wanting to analyze the value their production or service process provides to the customer.

The arrows on each side of the triangle represent the continuous application of these tools. No matter how an organization decides to use lean or its tools, the key to remember is that its purpose is customer satisfaction and growth of the organization.

5. Conclusions

Inspired by the excellent performance of Toyota, many companies would be interested inlooking for more knowledge about Lean and the conditions required for implementation of the system in their own organizations. Most firms are actively working on improving their operational processes and develop their capabilities. The main purpose for everybody in the business world is to respond quickly to the demands of their customers. To stay competitive on the market managers today need to choose the best one of a great number of innovative tools and techniques. The model consists of six major lean tools, which are Policy Deployment, Visual Management, Continuous Improvement, Standardized Work, Just in Time, and Value Stream Mapping and the other tools and methods which fall within such as 5s, TPM, and A3 thinking.

Very often Lean is being associated with a manufacturing approach – a set of tools applied on the shop floor, without considering the customer-centered strategic thinking. So it's being suggested that lean production should be used on the shop floor according to the Toyota's example, but regarding lean thinking – it should be referred to the strategic value chain. Lean exists on two levels – strategic and operational.

The distinction between Lean thinking at the strategic level and lean production at the operational level plays a crucial role in understanding Lean as a whole, in order to apply the right tools and strategies for achieving the customer value. Unfortunately much of the discussions about lean thinking in academic literature are still centered around applying the model on the shop floor. The focus over value creating activities towards the final customer is still missing in most of the companies implementing lean. Lean value system is evolving throughout the implementation process and involves series of value adding network of operations between the companies taking part in the value chain. The application of this approach would require a contingent application which will be unique to the particular value system and industrial sector. The research develops a theoretical framework of the Lean evolution that argue that connection of Lean with only the shop floor tools that Toyota applies to achieve its success is actually not enough to cover all the different faces of Lean.

Advanced lean transformation across the enterprise gives many positive results in regards to developing employees as problem solvers and increasing levels of work satisfaction, changing the management culture from command and control to fact-based and flexible, extending the transformation from the shop floor to finance, engineering, marketing and other support areas improving their activities. What is more the implementation of lean principles at key suppliers and at their key suppliers and transitioning from a tools-based implementation path to a course that applies lean management as a complete business system, change the way organization thinks and conducts business on a daily basis. The Implementation of Lean tools will start from the top management and go to the shop floor. The top management should keen in implementing throughout the plant in an automobile manufacturing Industry.

References

[1]. Bhasin S, Burcher p (2006). Lean viewed as a philosophy. J. Manuf. Technol. Manag., 17(1), pp: 57-72.
[2]. Csokasy, D.L. and Parent, P.D. (2007). Managing lean Manufacturing. Society of Manufacturing Engineers: Dearborn, MI TP07PUB2.
[3]. Doolen.T.L., J.M. Worley, (2006) "The role of communication and management support in a lean manufacturing implementation", Management Decision, Vol. 44 Iss: 2, pp.228 – 245.
[4]. Dennis, P. (2002). Lean Production Simpl~fied: A plain language guide to the world's most powerful production system. New York: Productivity Press.
[5]. Dennis, P. (2007). Getting the Right Things Done. The Lean Enterprise Institute, Brookline, MA.
[6]. R.H. Hayes, G.P. Pisano, Beyond world class: The new manufacturing Strategy. Harvard Business Review, January}February (1994) 77}86.
[7]. Holweg, M., 2007. The genealogy of lean production. Journal of operation management 25 (2), 420-437.
[8]. Henderson, B.A., and Larco, 1L. 2003. Lean Transformation: How to change your business into a lean enterprise. Virginia: Oaklea Press.
[9]. Karlsson C, Ahlstrom p(1996). Assessing changes towards lean production. Int. J. Operation Production Management, 16(2):24-41.
[10]. Liker, J.K. 2004. The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer, McGraw-Hill, New York.
[11]. Liker JK, Morgan JM (2006). The Toyota way in services: The case of lean product development. Academic Managing Perspective., 20(2): 5-20.
[12]. Liker, J.K. and Wu, Y.C., 2000. "Japanese automakers, US suppliers and supply-chain
[13]. superiority", Sloan Management Review 42, pp. 81-93.
[14]. Maxwell.J, Sandra Rothenberg, Fritz Pil, in Production and Operations Management (2001), Volume: 10, Issue: 3, Publisher: POMS, Pages: 228-243.
[15]. Monden, Y. (Ed.) (1986), Applying Just In Time: The American/Japanese Experience, Industrial Engineering and Management Press, Norcross, GA.
[16]. Nakajiimi, S. (1988). Total Productive Maintenance. Portland, OR: Productivity Press.
[17]. Nishiguchi, T. (1994), Strategic Industrial Sourcing, Oxford University Press, New York, NY.
[18]. Ohno, T. (1988), Toyota Production System-Beyond Large Scale Production. Cambridge, MA: Productivity Press.
[19]. Panizzolo, R. (1998). Applying the lessons learned from 27 lean manufacturers.
[20]. Russell, R. S. & Taylor, B. W. (2002). Operations Management. Upper Saddle River, NewJersey: Prentice Hall.
[21]. Rother, M. & Shook, S. (2002). Value Stream Mapping Workshop. Brookline, MA: The LeanEnterprise Institute
[22]. Shingo, S. (1985 a). Zero Quality Control: Source Inspection and the Poka-yoke System.Cambridge, MA: Productivity Press.
[23]. Shingo, S. (1985 b). A revolution in Manufacturing: the SMED System. Stanford, CT:Productivity Press.
[24]. Shingo, S. (1981). Study of "Toyota" production system from industrialTompkins, J.A., White, J.A., Bozer, Y.A., Frazelle, E.H., Tanchoco, J.M.A. and Trevino, J., 1996. Facilities Planning, 2nd ed., Wiley, New York.
[25]. Womack, J. and Jones, D.T., 1994. "From lean production to the lean enterprise", Harvard Business Review 72, pp. 93-104.
[26]. Womack, J.P., Jones, D.T. and Roos, D, 1990. The Machine That Changed the World, Harper Perennial, New York.
[27]. Womack, J.P. and Jones, D.T. (1996). Lean Thinking: Banish waste and create wealth in your co/poration. New York: Simon and Schuster.