LEAN PRODUCTION: A WAY TO REDUCE THE INTERNAL INVENTORY AND CYCLE TIME

ILYAS MASUDIN
Jurusan Teknik Industri Univeristas Muhammadiyah Malang
Jalan Raya Tlogomas 246 Malang
Ilyas@umm.ac.id

ABSTRACT

The progressive competition among industries and the increase of customer expectation will lead the progressive efforts in reducing the cost of production and logistic activities in the future. The companies (mass production, job shop and service industries) are forced to tighten their production process effectively by cutting the unnecessary activities in logistic flow, delete dummy and redundant elements, specializing the core business, and eliminate the wastes to simple and make their production process is more competitive. The lean concept could be the alternative way to reduce the main wastes: inventories and production cycle time. Eventhough it is very expensive to implement the lean production in the shop floor production, but the waste elimination and continuous improvement as the main key of the lean thinking has promised a significant improvement and profit for companies which implement the concept. The tools that could be used as methods to make the production process leaner such as just in time with kanban card system, kitting principle, collaborative scheduling and production plan, group technology, cell manufacture design and line balancing are well implemented in the worldwide. The efforts in leaning production will continue due to the lean thinking basically try to make the system better and believe that there is no best system but there is always better system.

***Key words**: lean production, wastes, flow shop, job shop, inventory*

INTRODUCTION

In the early 1990s, the progress of workplace changes is very contradictive between the workers' respect and the overload works in the workplace. In one side, the management wanted to give more attention to the worker's rights and respects but on the other hand there are over workload must be completed by workers. That occurs because there is unproductive and inefficient production process in the production floor in term of limited resources and overload jobs. The lean production is a system which is introduced to optimize the "many things to many people" (Parker *et al*, 2004). The successful implementation of the lean production is proved by General Motor, Toyota and Ford in the business of making efficiency and productivity in their mass production.

Most big companies interested to implement this system because it is able to give a significant impact to the shop-floor of production operation not just for the production system itself but also to the people involved even to whole division or organization (Kollberg *et al*., 2007). The other reason why most modern companies tend to use lean production system is about the cost saving. The companies can reduce the production caused by minimizing the uses of less human efforts uses, less manufacturing space and less tooling (Hunter, 2003).

Some areas in the production line such as scheduling, Job shop flow, flow shop and service industry can take some benefits by implementing lean production (Chase and Aquilano, 2006), for instance reducing material handling cost, work in process or even product waiting time. This research attempt to explore the advantages or benefits gained by firms in the different areas of production line which implementing the lean production. This research will also determine in what cost reductions can be saved by implementing lean production and its impact in the logistic activities. In the last section, this research will conclude if the lean and mean production is the appropriate way to reduce the internal logistic costs, furthermore the research will be ended by recommendation regarding the best on literature review lean implementation.

Lean can be categorized into two levels; they are strategic level and operational level. Lean thinking in the strategic level means that the strategic thinking centered to the customers and not only applicable in manufacturing process (shop floor) but also most company's organization functions. Womack and Jones (1996) defined the lean thinking as 5 principles which have to be achieved such as customer value identification, production flow capability development, developing the pull and push system material in process and reducing the wastes. The operational level of lean thinking is named lean production which provides 5 elements such as lean manufacturing, lean product development, supply chain coordination, customer distribution and lean enterprise management. But most researchers focus on the lean manufacturing because it could impact and change significantly to shop floor (Kollberg *et al*, 2007). Therefore the scope of lean production is wider than lean manufacturing because lean production concept is prepared to scope the shop floor activities to the whole company's organization function.

Lean Production

Lean production is the assembly line manufacturing which was firstly operated for Toyota-the world class automobile company, therefore it is also known as Toyota production system. The aim of lean production is "to get the right thing to the right place at the right time" (Malloy, 2004). The concept of lean in production originally introduced by Taiichi Ohno from Toyota Motor Company with main purpose to reduce the production costs by giving extra attention to the operating costs involved. The cut of operating cost by implementing lean production is the biggest saving due to the four main attributes accompanies lean implementation such as the lowest unit cost, 100% good quality, shortest throughout and flexibility (Hunter 2003). Dell computer and Boeing are the great company examples which currently succeed in implementing lean production philosophy. The success in implementing lean production in reduction cost and increase the quality is trigged by the concept of lean itself where it combines the "best features of craft production" (high quality, individualized and customs made products) and "mass production" (great quantity of production with lower cost o satisfy customers) in their every industrial sectors (Shields, 1999).

The Main Goals of Lean and Mean Production. The lean production system result the progressive improvement of operating cost reduction in term of:

Production Speed

Adjustable production speed is arranged based on the customers demand, not based on the cycle time so that there will be a high effective production because the production quantity depends on the time required by customers.

Pull-System Production

The production floor will just produce the particular quantities when only customer or next customers require them. So there is no more over production and overload capacity. This production system is called pull-system production.

Unit Per Unit Production

The company just produce unit per unit along the year, so that there will no inventory in process anymore. Lean production is the continuous process to improve the customer satisfaction which focused on the speed, flexibility and quality by reducing the wastes and overburden of resources (Neese, 2007). The main aims of Lean and Mean production system are. To improve quality; because of current competitive market, the companies should understand their customers' need and expectation and try to design system which meet their requirements.

To eliminate the wastes; the production activities which consume time, space and resources but do not add the product or customer value must be eliminated (Suzuki, 2004). To reduce time; the cycle time of finishing products is the most effective way to lower the wastes. To reduce total cost; only produce what customer need/demand will minimize the production cost rather than overproduction that increase the inventory carrying cost.

There should be some wastes eliminated when practicing the lean production in the production floor such as: 1) Overproduction (occurs when production should have stopped); 2) Waiting (periods of inactivity); 3) Transport (unnecessary movement of materials); 4) Extra Processing (rework and reprocessing; 5) Inventory (excess

inventory not directly required for current orders; 6) Motion (extra steps taken by employees due to inefficient layout; and 7) Defects (do not conform to specifications or expectations.

Just In Time and Lean Production

The modern theory in production system called Just in Time or Toyota Production System is the way to improve the production process continuously by increasing the speed and flexibility without ignoring the quality (Neese, 2007). Just In Time (JIT) and "Autonomization" are the techniques in implementing the Lean system in term of eliminating the wastes (Suzuki, 2004). The two main foundations in mass production system focus on reducing the work in process (WIP), producing a small lot production rather than a huge lot production and prefer to pull rather than push are the examples Japanese manufactures' lean production system which have resulted outstanding output, effective and efficient process and high standard of quality. Just In Time system attempt to link the finished product and real market demand so that the production system just produce the products needed or process the component in required lot of quantity. Therefore JIT is effective way to reduce the stocks or keep the stocks minimally (Suzuki, 2004).

The effect or result of implementing JIT is the same with the concept of lean thinking; they are shown from the Table 1.

Key Issues

The implementation of lean and production system will automatically reduce the unused wastes through the internal logistic flow. By reducing the wastes in the internal logistic mean there will be cost saving of total logistic cost that result the increased competitiveness to products produced. There are some wastes in the internal logistic activities within production floor areas can be saved by implanting lean and mean production system such as:

Lean and Inventory

The biggest production cost invested by company is in inventory, which is almost more than 1/3 of investment spent to hold, schedule and arrange the inventory. J.R Tony Arnold and

Table 1. The Effect of JIT Implementation (Suzuki, 2004)

	Effect
1. Inventory reduction between manufacturing processes and untrammelled production flow	a. Reduced inventory Efficient use of space in factory premises and construction sites b. Reduced storage (and non-deterioration of purchased parts) c. Reduced number of personnel required in warehouse management, material handlers d. Reduced production progress management e. Productivity gain via broader range of operation pace management f. Reduced cost for inventory investment
2. Greatly reduced set-up times	a. Rise in operating ratio → unit depreciation cost b. Rise in operating ratio → increased labour productivity
3. Greatly reduced production lead-times	a. Rise in observance rate of delivery dates, shorter delivery times b. Product diversification

Stephen N. Chapman in *Introduction to Materials Management* argued that "Financially, inventories are very important to manufacturing companies". Thus, inventory become the most valuable strategy to raise benefit by making a good inventory strategy including controlling, scheduling, determining stock and choosing the optimal strategy of lot sizing as well. Absorption about 25–40 percent of logistic cost is also the reason why inventory seem so challenging to be controlled and managed well (Balau 1987).

The main waste that lean want to cut is inventory because reducing the inventories could increase the asset turnover (Burt *et. al*, 2003). According to them, profit margin and asset turnover are the main component to increase the return of investment (ROI). The relationship between the elements which influence the return of investment can be shown by the Figure 1.

As shown by the figure above we could notice that the 5 percent reduction in the inventories can decrease current assets by $75,000. The lean manufacture is one of the suitable strategies in reducing the inventories.

The materials between the process and cells are called Work-In-Process (WIP). The more WIP in the production activities, the less effective the

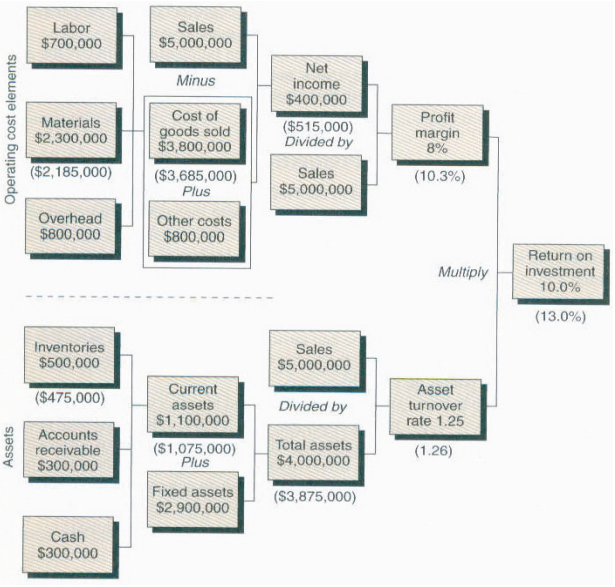

Figure 1. The relationship of basic elements which influence return on investment (Burt, 2003)

process in term of the high inventory on hand. Therefore the modern industries, scientist and economist believe that the ease, quickness and the economy of product manufacture are considered as the main focus on modern manufacturing (Hunter *et al*, 2004). The Lean production system which provides pull system rather than push system in the process flow in the production process, for instance using Kanban card and U-Shape cell for specific design process layout will reduce much material in progress or work in process. This less WIP is occurred because the material or sub-assemblies for assembling products are pulled base on the consumption level not based on the forecast demand or previous sales (Neese, 2007). The obvious example of the success in implementing lean thinking in the business of reducing stocks are Tesco, a British retailer which has cut its stock up to 50% and Pratt & Whitey, an American aerospace company could cut its stocks and work in process by 7% so that the unit cost could be cut by 20% after reorganize their work flow.

Lean and Cycle Time

Lean and mean production allow manufacturing company to design the production flow in term of reducing the distance of process, space and redundancy by designing the manufacture cell that produce products (Hunter, 2003). This design will reduce the cycle time to produce parts. Furthermore, the cells in the production process line are designed to produce parts as the requirement, not less or more. Therefore the parts' waiting time in every process is reduced significantly and eventually that will reduce the work in process or on hand inventory. For instance, Hoffmann Enclosure Inc. could reduce cycle time for about 32 percent and rose the inventory turnover by 14 percent after implementing the lean manufacture for 5 years (Brandt, 2007).

Reducing cycle time is the main goal when practicing lean production because every minute saved in production process will increase the margin sharply if producing mass production. That is why lean and mean production will allow companies to reduce every machines downtime such as setup time

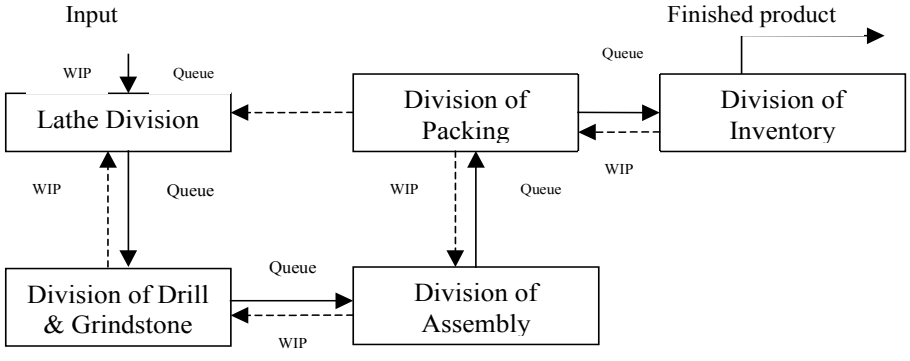

Figure 2. Production line flow and wokstations
Source: Anonymous (adapted and modified from: Kelton and Law(1998)).

and idle time in order to wait operators or waiting time if they can not be operated because wait for other process to get the benefit from reducing cycle time (Haftl, 2007).

Lean manufacture will also reduce the workforce idle time in production activity by eliminating the unbalanced process in each workstation. The balance process means that every workstation does not have higher workload than the others so that the waiting time of product (queuing time of product in progress) and work in progress or bottle neck will be minimized. This important for the product which have a very sensitive constrain in time (short product life) like medicine/chemistry products, vegetable products and fresh food product that have to proceed as soon as possible. Lean will help to balance the line by adjusting the optimum number of workforces in every workstation to make the process balance. Figure 2 is the example process why the process line should be balanced.

From figure 2, the unbalance process occurred when there is so high WIP or queuing time in one or two divisions (workstations) while there is no in others, automatically; the workload and the product waiting time in those divisions are also higher than the others. Lean does not allow this situation and it must be arranged and adjusted in term of reducing those wastes.

Lean Manufacture and Customer Service

Every effort in reducing wastes of lean manufacturing implementation such as shortening the cycle time, waiting time or delivery time and reducing the work in process or inventories is to meet serve the customers optimally. By reducing production time, delivery time and also inventories which save the production cost can improve the competitiveness of the products consumed by customers. Reducing cycle time and delivery time can also improve the responssiveness. Furthermore, responssiveness to customers demand will lead the growth rate of industry (Koenigsaecker, 2006). According to him, the company growth rate will rise 2–3 times if we can consistently reduce the delivery time by 75% with assumption that the increase is because of the responssiveness improvement. Moreover, the competitiveness in the price of products will give advantages to customers to pay less for the good quality products, and it could

Table 2. The Benefits using Lean Manufacturing (Maddy, 2007)

Metric	SePT 2005	Dec. 2005	Dec. 2007 (Target)
Spears on-time delivery	> 15%	90%	95%
Machine on-time delivery	0%	90%	98%
installation time	> 84 days	14 days	7 days
Customer order through acceptance	> 166 days	66 days	45 days
Unit cost reduction	0%	27%	35%
Lean manufacturing floor-space reduction	88,000 ft.^{2}	33,000 ft.^{2}	33,000 ft.^{2}
Supplier quality	< 40%	90%	98%
Inventory accuracy	< 66%	98%	99%
Inventory turns	< 1	8	10

be achieved by making product effectively and efficiently especially in regarding the inventory strategy. Maddy (2007) said that increasing delivery time, reduction work in process inventory, and lead time by implementing lean production will not only increase the cash and capacity but also customer satisfaction, because there is decreasing cost within production process. The figure below shows the implication of lean production implementation in particular company to the logistic entities figure 3.

As shown by the figure above, the benefits using lean manufacturing are obvious, the example of a company which implemented lean manufacturing tell us that there are some improvement in logistic activities especially the customer order through acceptance years by years which means that the customer satisfaction also increase significantly and it impacted to the cash flow which increase more than 50% and profit margin which rose up to 300% (Maddy, 2007).

Industry Implication

Statistic indicates that there are just 10% of industries have implemented lean manufacturing. This is because of the huge capital and continuous improvement required to implement lean manufacturing to the floor production. But, its is obvious that industries especially the flow shop industries which have implemented the lean manufacturing strategy gain much more benefits than the capital invested such as gross margin (10–30% improvement), cash flow improve more

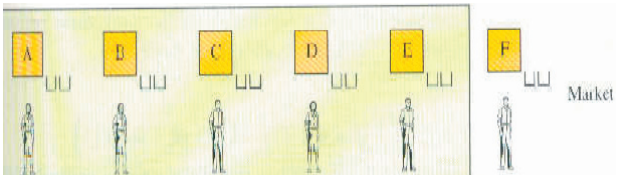

Figure 3. Flow shop production line
Source: Heizer and Reinder, Operation Management.

than 50% and inventory turnover (20–200%) in 12 to 36 months implementation. In the car industry such as Ford company, the benefits is becoming more because the mass production activities. By implementing lean manufacturing in flow shop line, production activities which are operated by workers or machines divided into workstations produce if only required by market. So the forward or pull system start working from the market demand where finished products pulled out from the end of line (F) while the end of line workstation will take replacement from the previous workstations (E) and this way continues up to the starting point (A). The figure below explains the lean in flow line.

The pull system there will be no work in process (WIP) or safety stock inventory along the process because the required materials based on the next process demand, the tool can be used for instance, kanban system, which is able to reduce the work in process inventory by increase the reliability of the process (Hancock and Zayko, 1998). The reliable process also avoids the extra stocks as required when there are machine breakdown or downtime. The pull system in the flow shop process enable the firm to responsd demand or orders more quickly, therefore this system could greatly reduce the

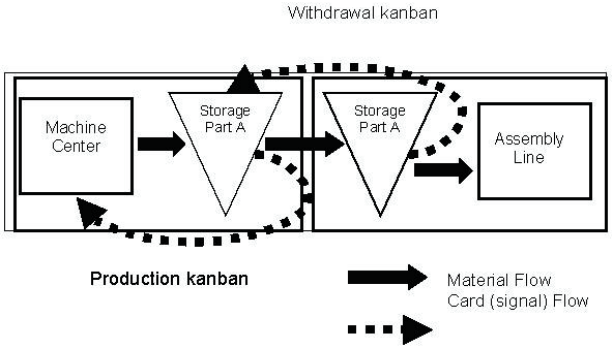

Figure 4. Flow of two Kanban
(Chase *et al.,* 2006)

finished good inventory because the orders can be made as soon as possible. Kanban system also means not bringing materials or sub-assemblies until the process need it so that the number of on hand inventory is low (Policastro, 2006).

Figure 4 shows the Kanban pull system where the inventory (WIP) minimized using pull system concePT The store which is located next to assembly line has withdrawal kanban while the other store located next to machine centre has production kanban. When the assembly line collect the part A from storage, the operator take the withdrawal card and bring the card to the other storage next to machine centre where the operator find the part A from container and removes the production kanban and replaces it with withdrawal card (Chase *et al.*, 2006).

Toyota Company

Toyota Company with its Toyotas Production System (TPS) which is named Just in Time is the other example how lean production is implemented very well in the mass production system. Just In Time is the technique which basically has aim to reduce the setup time, continuous improvement regarding the quality of production processes and lessen the WIP (Suzuki, 2004, 203). Figure 5 explains how important quality in JIT syetem.

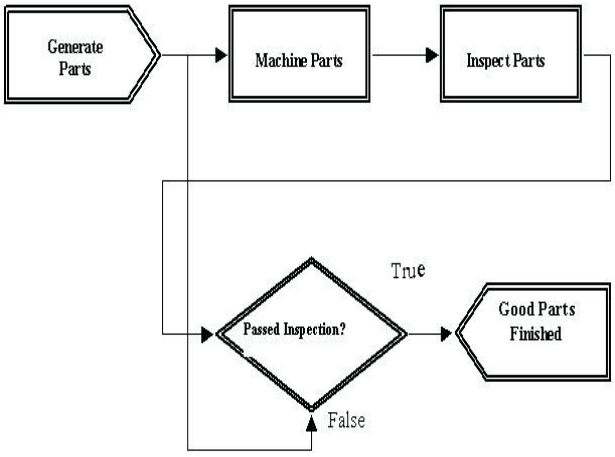

Figure 5. Simple manufacturing system based on the quality
Source: David Kelton and Avrill M Law: Arena Model for manufacturing System

In just in time system, besides every process has to be managed with minimizing stock concept,

it also concern about the process quality. As shown on the figure above, the quality inspection should be done in every process steps, not only in supplier stage (part availability) but in the stage of processes and stage of finished products as well.

Job Shop Industry

In the job shop production, the finished products may not be the same in precision or dimension but the process or machines involved the process should be the same, therefore the most important thing in job shop manufacturing is not about the finished product but the process. Brockhurst (2006) said that the lean manufacturing should be emphasized on the how to reduce 95% wastes of the process rather than 5% of value added that employee or server perform.

Assembling Company

The lean thinking in job shop implementation will lead the job shop process more efficient and productive. For instance, the kitting technique for organizing the required components and tools in the specific and organized way to an assembly area will make the process run quickly (Brockhurst, 2006). This is because the kitting strategy attempt to organize the components and tools based on the human being logical order, therefore the risks (wastes) as missing components or tools or even damage components due to ineffective way to reach can be eliminated. The kitting technique can be shown on the Figure 6.

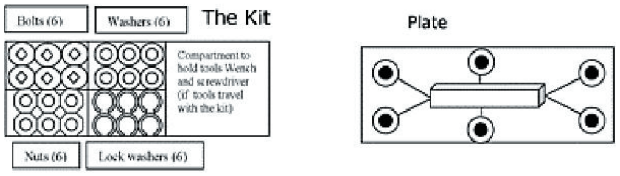

Figure 6. Kitting strategies in job shop operation

Manufacturing Company

The other lean implementation in job shop is group technology which is usually directed to product family. By converting the production system to the design which is grouping the similar components into a set of families, the company can be collected to make parts family. Consequently,

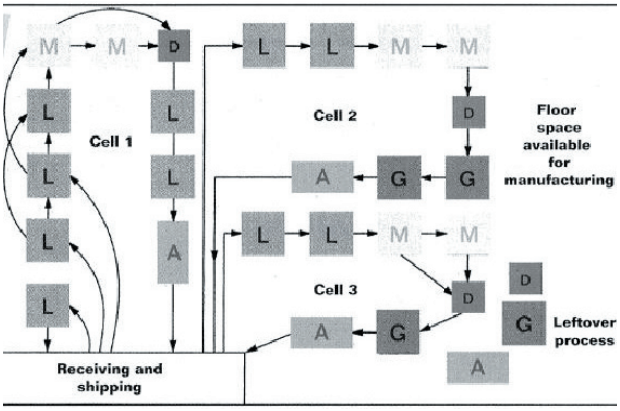

Figure 7. Lean production of three manufacturing cells.
Source: Hunter, FDM, 2003

machines in the cell operate based on the sequences of part of family (Hunter, 2003). Figure 7 how cells are design based on the different process grouped which working together.

Figure 7 explains that the lean production system made of three manufacturing cells which is every cell have different process grouped together and operated by multifunctional workers who work in the cell to do the family of parts (Hunter, 2003).

The benefit from this case are such as providing the shortest distance for every proceses, reducing the idle of worker because of picking materials, while material flow will be reduced. This can lead reducing cycle time of product processes; while the inventory (Work in process) could be reduced due to the distance of material flow is shortened.

In the job shop production process, due to the orders are not continuously received, the process scheduling is becoming important to be concerned. The appropriate schedule of processing products can minimize the total flow time that result the low level of work in progress (Chen, 2005). Lean manufacturing allow the production system especially in the job shop production use some techniques in scheduling process based on time for instance Earliest Due Date (EDD) or Shortest Processing Time (SPT) concePT These methods will reduce the lateness and minimize the makespan. Production scheduling provide detail schedules for making/processing products that specify which operation, which parts, which machines used in what time, what quantity to meet

the due date. In the production schedule sheet, the detail information about work in process or finished product waited to be processed (Jiang and Chen, 2007). Lean production material control on flow shop concept is very relevant with the basic activities in the scheduling process in term of association of materials and work centers, where there is flexible and manipulative of wide range of production variations such as rework, rerouting, partly finished work and jobbing work (Chen and Jiang, 2007).

Southwest Airlines (SWA)

Southwest Airlines (SWA) which won the airline industry's "triple crown" and the only US airline earned a significant profit throughout 1990's is the best example of successful service industry by implementing the lean production line approach to service (Abdi *et al.*, 2006). The crown awards recognize SWA for the fewest late flights, fewest mishandled bags and fewst passenger complaints. SWA operation is driven by lean thingking which eliminate the wastes and cost of services such as eliminating the unnecessary in-flight meal for passenger, Using smaller aircraft (Boeing 737s) to reduce the take off time to only 17 minutes comparing by 45 minutes for the average airline take off (Hallowell, 1996).

SWA concern to increase customer value by empowering the employee from manager line to ticketing personnel by involvement and training true of lean approach and customers are involved in producing the in-flight service such as some games and contests during the flights. In summary, SWA has showed how the lean production line approach can deliver added value to customers especially in low cost and high quality concept by eliminate the wastes such as unnecessary meals in fights (Abdi *et al.*, 2006). The SWA model for using lean approach in service industries can be explained from Figure 8.

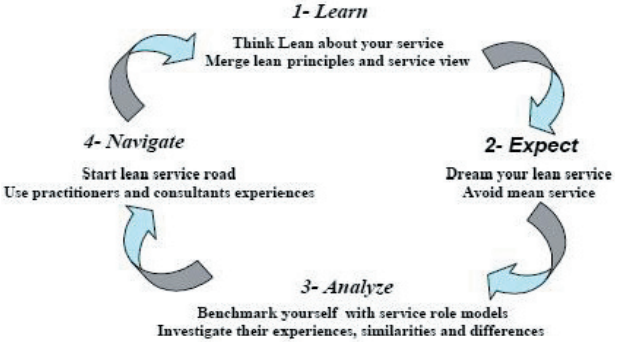

Figure 8. Lean service model (Abdi *et al.,* 2006)

The model consist of our stages such as think lean about the service, dream about your lean service (avoid mean service), benchmark yourself with service role model and start lean service road.

CONCLUSION

The lean production which is assembly-line methodlogy has main aim to reduce the production process wastes. The company which implement the lean production in their production activities more efficient, effective and productive in the business of reducing inventories, reducing the cycle and delivery time and of course improve the customer service (Malloy, 2004). Some implications by implement lean production on industry such as increase cash and information flow and increase the gross margin. The continuous improvements by company which use the principle of lean production will also focuser on the customers' satisfaction and the quality of the product.

The pull system and customer oriented are the main strategy and mission in practicing the lean production which will impact significantly to the cost saving in internal and external logistics activities such as minimizing inventory, reduce the cycle time and shorten the delivery time. The manufacturing technology and information technology such as automation, just in time, kanban system and cell design are the great inventions which are very supportive in implementing the lean production to achieve high customer responssiveness, high competitiveness and customer satisfaction. The progressive competition among industries and the increase of customer expectation will lead the progressive efforts in reducing the cost of production and logistic activities in the future. By cutting the dummy activities in logistic flow, specializing the core business, and eliminate the wastes the positive trend of the lean manufacturing principle implementation will still continue in the next decades, especially in the business of

eliminating the warehouse and distribution centre to reduce the inventory like what DELL computer and Boeing Aircraft have done in their production and supply chain activities (Malloy, 2004).

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