AN INTRODUCTION TO APPLICABILITY OF LEAN IN SHIPBUILDING

Sandeep Phogat

Abstract: Lean principles in shipbuilding environment is quite restricted due to the novelty and the restriction of the concept. Lean Shipbuilding is a very specialized, limited division of application of Lean and is considered to be “one of the extensions beyond Lean Construction”. Lean Shipbuilding refers to cost reduction through elimination of waste, non-value adding processes and inventories, for the improvement of customer’s satisfaction. It is anticipated that by implementing Lean manufacturing principles in shipbuilding, the productivity could improve by at least 45% and the built time by 85%. Statistics show that for the period from 1965 to 1995 Japanese shipbuilding industry improved its productivity by 150%, which is due to the development of some of the Lean principles at the same time as Toyota Production System.

Keywords:- Lean design & construction, shipbuilding, TPS, NSRP.

I. INTRODUCTION

The term ‘Lean’ goes back to the 1990s when a book called “The Machine That Changed the World: The Story of Lean Production” introduced the term ‘lean production’ (Holweg 2007). The book follows up transfer of manufacturing ideas from craft production to mass production to Lean production (Poppendeick 2002). It origins come from the automotive industry and the Toyota Production System (TPS) in particular but nowadays it has been applied in other lines of businesses such as Lean Design and Lean Construction. The objective of Lean is to eliminate waste, to increase productivity and efficiency, to add value, to reduce costs, as well as to increase the competitive performance. All that aim at bringing customer satisfaction (customers, being the center of Lean).

1. Identify the value – investigate the processes from customers perspective i.e. define the needs of the customers out of the processes. It can be done with tools as value management, function deployment and simulation.
2. Map the value stream – the consequence of processes required to make a product is defined as value stream, and mapping of those processes will help understanding how the value for the customers is build through the processes.
3. Create flow of the processes – the aim is to create a value stream and one-piece flow, as well as to avoid or reduce the batch and queue, if possible.
4. Establish Pull – adjustment of the production to the customers’ needs and requirements, i.e. produce when and what the customers want. The production processes should be supported by JIT and standardization.
5. Seek perfection – once the above-listed actions are performed, they should be supported by continuous improvement, evaluation of the changing processes and waste elimination in a repetitive manner in order to consolidate the changing processes. Furthermore, the following methods are sound supplement of the above-mentioned key Lean principles for Lean production.
6. Implement a plan-do-check-act (PDCA) improvement framework to achieve results fast.
7. Use metrics and performance feedback to improve real-time decision-making and problem solving.
8. Approach improvement activities from the perspective of the whole enterprise or system.

Lean practices help organizations to improve fundamentally their competitiveness, by cost reduction, increased quality and response to customer needs. Rationale behind the implementation of Lean is typically strong business drivers, and successful implementation of Lean requires significant transformation of the organization’s culture and practices. Lean practitioners assert that time of crisis is when changes are most successfully fostered and
followed in (Ross&Associates Environmental Consulting 2004).

With the necessary adaptation, the principles of Lean have expanded its applicability from the production, to service industry, the military, and in construction processes, which speaks about the universality, and efficiency of the concept. Liker (2004) clams that every type of organization business can benefit from Lean not by imitating the tools used by Toyota in a particular manufacturing process but rather, by developing principles that are the right ones for the organization or businesses and by practicing them, to achieve high performance that continues to add value to the customers and society.

**2. LEAN PRODUCTION AND LEAN TECHNIQUES**

The foundation of TPS tools and techniques laid ground of Lean Production. Just as in the original concept of Lean, the principles behind Lean Production aim at minimization of resources, and by this minimization of waste in the context of mass production, i.e. less human effort, less manufacturing space, less inventory, less defects (NSPR 2004). Accordingly, Lean production aims at meeting customers’ expectations by delivering quality products and services at the right time and at the right cost (Ross&Associates Environmental Consulting 2004).

There is a common interchangeable usage between the terms Lean Thinking, Lean Production, Lean Manufacturing and TPS, which is due the a lack of a common agreed-upon definition but defying one is difficult since Lean is considered constantly evolving (Pettersen 2009; Demeter and Matysuz 2008).

While the traditional mass production involves predetermined production of large lots of products referred to as ‘batch and queue’, the production processes in Lean Manufacturing are organized in such a way that processing steps are adjoining each other in a continuous, one-piece flow (Lean Thinking and Methods). Such production processes need to be closely controlled in a well maintained, ordered and clean operational environment, which incorporates JIT production principles. Moreover, shift to Lean production requires system-wide, continual improvement with the participation of all employees.

The extent to which Lean concepts in production systems have been adopted in various manufacturing industries brings in question the universality of the concepts of Lean in manufacturing. The doubt in the universality of Lean Production is supported by the fact that achieving production leveling and consequently the fundamental JIT for Lean manufacturing, dependent upon various factors such as business conditions or buyer-supplier relationship. When these conditions are not met, batch or mass flow may be a better manufacturing practice. However, the adaptation of some of the Lean production practices in batch and mass flows does not imply that they are ‘in transition’ to Lean production.” (Cooney 2002, p.1145).

Lean production exists on both strategic and operational level. The strategic level refers to the customers value and identification of value stream, while the operational level deals with various tools and practices that lead to waste elimination and support continuous improvement (Demeter and Matysuz 2008). Accordingly, different opinions on which tools and practices are associated with Lean Production (see Appendix 1) have been expressed, however, some common concepts are recognized and in order to give insight into Lean Production some of them will be discussed below.

Implementation of Lean in the production or in the various levels of an organization needs to be supported by establishment of Lean environment. This can be done through five processes for achievement of standardization, effective work place organization, and continuous improvement known as the 5S - short-stands from the Japanese words for sort, set in order, shine, standardize, and sustain.

**Sort** - organization and tidiness has to start from elimination of the unnecessary items at the work place. This will remove the excess, broken or obsolete materials, and will clear up floor space. Useful practice for sorting is the red tagging. The redundant items are tagged with a red paper note, and then taken out to a central holding area where they are further evaluated. The items which are considered useful are kept in an organized storage, while the rest of the items are discarded.

**Set in Order** – all the materials has to be well organized, and an efficient and effective storage methods should be established. Strategies for effective storage of the items are painting of the floors, outlining working areas and locations, shadow boards, etc.

**Shine** – after the clutter has been removed and the work environment organized, the working area has to be thoroughly cleaned and keeping it clean has to turn into a regular practice.

**Standardize** – having achieved the previous 3S’s it is required to standardize the best practices in order to further sustain the processes.

**Sustain** – it is hard to change the ossified processed, so sustaining the changes is considered the most difficult “S” to implement and maintain. Resistance typically accompanies the changes, and the personnel easily turn bacback to the status quo, therefore understanding and promoting the changing processes is essential.

Even though not common in the literature, a sixth S has been recognized by some practitioners (DiBarra 2002). It stands for Safety and is positioned between Shine and Standardize. It refers to the safety of the work place and respectively of the employees. It is arguable whether the 6th S can be regarded as supplementary pillar to the 5S tool, or rather as an aspect of each of the 5S pillars, since safety is considered inherent to the concept of 5S. Bicheno (2004), for example, claims that safety procedures and their standardization should be developed, maintained and audited as part of the 5S program (Bicheno 2004).

The idea behind the 5S tool is that well-organized environment contributes to the optimization and productivity by: Creating and maintaining organization and orderliness; Using visual cues to achieve more consistent operational result; Reducing defects and making accidents more less likely; The 5S principles refer to Manufacturing Management but are more popular in Lean Manufacturing Processes. However, this standard approach for housekeeping appeared to be applicable in various activities, such as data
organization, office housekeeping, measurements and management systems within the supply chain and factory (Sheldon 2008).

Though Lean practices appear to be easy to grasp, they can be difficult to execute in consistency. Many companies have reached a superficial implementation of Lean and that is due to the fact that they are concentrated on some of the Lean tools like 5S or JIT, rather than grasp the concept and apply it as a cultural change throughout the whole organization (Liker 2004). Often companies implement only the first 3S but fail to standardize the processes and in this way doom the sustainability of the results of the project to failure, therefore the completeness of the 5S tool is essential.

3. APPLICABILITY OF LEAN IN SHIPBUILDING

The available literature on the implementation of Lean principles in shipbuilding environment is quite restricted due to the novelty and the restriction of the concept. Lean Shipbuilding is a very specialized, limited division of application of Lean and is considered to be ‘one of the extensions beyond Lean Construction’ (Dugnas and Uthaug 2007, p.60). The sources of information and examples for this thesis come from the U.S., the Japanese, and the Norwegian shipyards. The interest in the matter set the foundation of The National Shipbuilding Research Program (NSRP) in U.S., and the Lean Shipbuilding Project under the Norwegian Research Council MAROFF-program and the Norwegian shipyards.

Lean Shipbuilding in Japan

Successful application of lean principles puts Japanese manufacturing companies, including the Japanese shipyards, in the position of ‘role-model’, in terms of productivity, product quality and the utilization of human resources. Thus, the Japanese shipyards are considered best-examples of Lean thinking in shipbuilding (Sanidas 2001; Koenig, Hitoshi, and Baba 2002). Research of some Japanese world-class shipyards shows that the shipyards haven’t applied all of the Lean manufacturing principles due to specifications such as process time (months-long) and product delivery (very low) (Lamb 2001).

It is not possible to say to what extend the application of lean principles helped the shipyards in Japan in achieving the high productivity, since Lean manufacturing blurs with Total Quality Management and other Japanese development. However, they have used some applicable principles, such as one-piece flow, JIT, and Lean to some level. Accordingly, quality is built in at the source, rather than inspected in, processes are highly standardized and timed, raw materials are brought in on a JIT basis, and all the employees are engaged in work initiatives and carry responsibilities to follow up the processes (Liker and Lamb 2000; Lamb 2001). In contrast to the automobile industry and Lean theory, the production in the Japanese shipyards is driven by pull at the top, and fixed schedules at the lower level, i.e. the construction processes cannot start until the customer pulls the order. The production process can start only after the previous ship launches, or moves to the next position. Thus, the pull-style prevents from overproduction. However, ship production from the erection schedule on down is based on schedule development and conformity. Thus, in cases of drops in the downstream stage, upstream schedule is not allowed to slip in. Moreover, in case of production problems that interfere the schedule, the workers does not have the authority to halt the upstream production (Koenig, Hitoshi, and Baba 2002).

Lean Shipbuilding in Norway

Norwegian shipbuilding is a complex production, the performance of which is organized in projects. The industry is characterized by high degree of outfitting, and at the same time low degree of standardization. The ships are built to order and are often highly customized. Different suppliers and work force are involved in the execution of the projects (Aslesen 2007) 31

Due to the nature of the shipbuilding industry, Norwegian shipyards have adopted a completely new production concept of lean shipbuilding, which is blended between Lean manufacturing and Lean construction (Bertelsen 2007). The features that characterize the Norwegian shipbuilding industry are one-of-a-kind product, consistent production facilities, and fixed position layout (Longva 2009; Salem 2006). In search of process improvement and achievement of competitive advantage, Norwegian shipbuilding companies are developing Lean Shipbuilding based on cooperation with Lean construction forums (Longva 2009).

Lack of information on any particular case of implementation of Lean or 5S in any of the Norwegian shipbuilding companies prevents from presentation of such in this research. However, it is known that lean has been implemented in Brunvoll AS (Molde, Norway), which is manufacturer and supplier of thruster systems and is part of the Norwegian Maritime Cluster. The production of the company is tailor-made, highly specialized and with the deployment of Lean practices (which includes 5S) in the production and the warehouse department, the company aims at improvement of the processes through efficient value stream. However, no data on the evaluation and efficiency of the project has been performed so far.

Source: Interview with Dag Brunvoll, Manager of Logistics and Planning at Brunvoll AS

Lean Shipbuilding in U.S.

Driven by the mission to establish international shipbuilding competitiveness, and cost reduction, The National Shipbuilding Research Program (NSRP) has launched a Lean Shipbuilding Initiative, in order to facilitate transformation to Lean practices throughout the U.S. shipbuilding and ship repair industries (NSPR 2004).

Research conducted by Liker and Lamb (2000) for the NSPR shows that despite the improvements of facilities and process in the U.S. shipyards, the results are still marginal compared to those in Japan and Korea. Moreover, at that time the productivity of the U.S. shipyards has been half that of Europe and third of the Japanese shipbuilding. Thus, Liker and Lamb (2000) suggest that significant improvement can be achieved through the adoption of lean manufacturing principles.

As part of NSPR – Advanced Shipbuilding Enterprise, Todd Pacific Shipyard has implemented the Lean program in 12 areas of the shipyard, as well as onboard ships. The practical experience of the implementation of lean shows that it is a powerful tool for cultural change, which is easily
applicable to the realities of the environments. It is of low cost and could have a substantial payback for the investment involved. Benefit of lean is that it involves analytical thinking and by that support successful outcome of the improvement efforts. However, applied in isolation from other Lean practices, it may lose inertia, that is why 5S should be used as a ground tool for further change efforts such as Lean (DiBarra 2002).

4. SPECIFICITY OF THE LEAN SHIPBUILDING INDUSTRY

Taken out of the original context - the automotive industry - but still following the main principles of Lean manufacturing, and sharing the same principles as Lean Construction, Lean Shipbuilding refers to cost reduction through elimination of waste, non-value adding processes and inventories, for the improvement of customers satisfaction. It is anticipated that by implementing Lean manufacturing principles in shipbuilding, the productivity could improve by at least 50% and the built time by 100% (Lamb 2001). Statistics show that for the period from 1965 to 1995 Japanese shipbuilding industry improved its productivity by 150%, which is due to the development of some of the Lean principles at the same time as Toyota, and probably learned from each other (Liker and Lamb 2000).

Delivering products with coordinated cost/value relationship (value commensurate with cost) is a tedious task for mass-production manufacturers, such as car manufacturers. Example of this is the difficulties that the Japanese automakers (including Toyota) experienced in the late 1980s to early 1990s due to excessive product variety, unnecessary options, over-specification, and ‘overquality’. On the contrary, this is rarely a problem for the international commercial shipbuilding industry. One reason is that the owners can determine the value they require based on business criteria. Another reason is that the merchant ships are built-to-order and the shipbuilding company and the owners communicate the requirements of the owners through the order contract (Koenig, Hitoshi, and Baba 2002).

Being suitable for large volume production, this approach has also been adopted by word-class shipyards. Applicable in Japan and some European shipyards, (e.g. Damen shipyard in Gorinchem, The Netherlands), this model is not in accordance with the shipbuilding approach of the Norwegian maritime cluster, as the vessels produced are advanced and highly customized. However, it is applicable in the construction of vessels with standard modular design, low complexity and little customization where building is organized on moving lines (Longva 2009; Liker and Lamb 2000). Common features of the shipbuilding industry is that it is labor-intensive, since the production automation format is limited (Kang). The products of the shipbuilding industry are high in volume and weight and each product contains numerous of different components, which makes the production processes and their command highly sophisticated. The concept of ‘teamwork’ is essential in shipbuilding, since the design, planning and manufacturing process overlap and at the same time the production processes are extremely complicated (Lyu and Gunasekar 1993). However, shipyards across the world have specific mechanism in their production practices and thus their approach to the implementation of Lean varies, examples of which are presented below.

REFERENCES

1. Ackerman, Ken, ed. 2007. Lean Warehousing; Ackerman Publications.