

LEAN MANUFACTURING TECHNOLOGY : A WAY TO GREEN BUSINESS PRACTICE AND SUSTAINABLE ENVIRONMENTAL DEVELOPMENT

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"A penny saved is two pence clear. A pin a-day is a groat a-year. Save and have." Benjamin Franklin

Lean manufacturing is often seen as a set of tools that reduce the total cost and improve the quality of manufactured products. The lean management philosophy is one which targets waste reduction in every facet of the manufacturing business. In the Lean manufacturing technology all those methods and tools are identified that help in reducing and steady elimination of waste. As wastes are eliminated it leads to quality efficiency, cost and time efficiency and energy saving and environment sustainability. Scholars from various studies suggest that lean manufacturing is more than a set of lean tools that can optimize manufacturing efficiencies. It is a process and mindset that needs to be integrated into daily manufacturing systems to achieve sustainability. Several recent studies have shown that both lean and green techniques and "zero-waste" policies lead to reductions in overall cost. Not only recognized internationally, it has been widely being adopted in India like in automobiles sector, Apparel manufacturing and Textile Sector. This paper will review the current literature and describe how lean and green can provide a relevant framework for environmentally and economically sustainable Business practices. Examples of lean and green technologies and techniques which can be applied in a global context will be described.

Key Words: *Environmental Sustainability, Green Manufacturing, Lean Tools and Implementation Strategies*

INTRODUCTION

Improving productivity and quality through reducing all types of costs has become an indispensable measure adopted by each organization to sustain in the competitive world. This has led many organizations to implement lean manufacturing system or the Toyota Production System (TPS) (Liker, 2004; Womack, 2003). Lean is the set of "tools" that assist in the identification and steady elimination of waste. As waste is eliminated quality improves while production time and cost are reduced. Thus, it seems to be important to gain an understanding of how Lean manufacturing relates to other methods for improving manufacturing systems including Green Manufacturing and environmental sustainability. In this regard, validation evidence for two premises is sought making it the main objectives of study.

1. To find out whether lean transformation of a production facility likely result in a green transformation and environmental sustainability as well.
2. To analyse various tools makes a lean transformation of an organization possible.

For the purpose various secondary data and extensive literature has been referred and various implications about Lean and green and environmental sustainability has been made.

Paper is divided in to three sections. Section-I deals with national and international literature depicting the techniques of use of lean methods and efficiency achieved in the production system. Section-II deals with case study relating to lean techniques and its impact on organizational

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performance. Section-III deals with implementation techniques, certain recommendations and concluding remarks.

However various scholars in their studies have demonstrated the different methods and tools to apply lean techniques and its effect on the performances of organization. Some of these studies are reproduced here.

Bergmiller and McWright (2009) identified manufacturing firms who had implemented lean manufacturing and received one of lean's most distinguished awards, the Shingo Prize (The Shingo Prize for Operational Excellence, 2009). He found that these firms were significantly greener than a general population of other manufacturers in twenty five of twenty-six measures of green manufacturing. Bergmiller and McWright utilized an online survey tool in order to harvest information from Shingo award-winning manufacturers. The survey was divided into three sections, as follows:

- Status of their plant(s) environmental management system (EMS)
- Fourteen questions regarding the application of environmental waste techniques at the plant(s)
- Ten questions about advantages/ disadvantages of the EMS at the plant(s)
- The survey results identified and validated a strong correlation between the successful development and implementation of lean to the "greenness" of a manufacturer. He stated that "lean seemed to transcend green". Also, he identified that the surveyed companies tended to strategically vertically integrate versus horizontally integrate their plant(s). The vertical integration led to reductions in many of the green wastes as found in following table-1.

Table: 1, Nine Forms of Waste Identified by Green Manufacturing

Concept	Description
Permit Compliance	Compliance with applicable permits.
Toxic Release Inventory (TRI)	Over 300 chemicals subject to release.
33/50 Chemicals	A subset of TRI chemicals identified by the EPA as priority candidates for voluntary reductions by industry.
Clean Air Act Toxics	189 chemicals listed in the Clean Air Act as air toxics.
Risk Weighted Releases	Toxic chemicals weighted by their relative toxicity.
Waste Per Unit of Production	Percentage of production lost as waste, generally measured by weight.
Energy Use	Total energy use by all aspects of corporate operations; also expressed as carbon dioxide.
Solid Waste Generations	Total solid waste going to landfills or other disposal facilities.
Product Life Cycle	The total impact of a product on the environment from raw materials sourcing to ultimate disposal.

Sawhney, Teparakul, Aruna, and Li (2007) show the connection between lean manufacturing and the environmental movement stating that "it is natural that the lean concept, its inherent value-stream view and its focus on the systematic elimination of waste, fits with the overall strategy of protecting the environment", which they call Environmental Lean (En-Lean). A focus group of environmental and lean professionals compared the environmental impact of a cellular manufacturing scenario (common with lean production) versus a batch-style manufacturing scenario. The focus group reported that several green manufacturing metrics were more positive in lean manufacturing than batch-style manufacturing:

- Air pollution was lower in a cellular manufacturing scenario since exhaust and power consumption was less.
- Employee's safety and health were better with an optimized plant layout.
- Exposure to dangerous material was reduced by eliminating unneeded material transfers.

Teresko (2004) made the connection between green manufacturing and the lean movement in his research into Bill McDonough's book "Cradle to Cradle". Teresko recites McDonough's statements that the goal of lean, when applied to a manufacturing facilities layout, is to "shrink-wrap a structure around an optimized process; including the entire external commercial environment in the optimized process, integrating all the manufacturing flows from global to national to submicroscopic levels". Teresko pointed to McDonough's success in the construction of Ford Motor Companies new, revitalized Rouge Center with "its innovations at the brown field site which included a 10-acre roof planted with sedum sod and water-permeable paving" throughout the complex. Much like Bergmiller and McWright's study, Teresko identified that lean seems to transcend green. The above studies shows that lean is Green and no doubt adoption of lean technology may help to attain the objective of sustainable development

Lean Manufacturing

The lean manufacturing movement was first highlighted in contemporary manufacturing by a five-year study done at Harvard University by Womack, Jones, and Roose which was published in a book called "The Machine that Changed the World" in 1990. In this book, the history of the automobile industry was studied and the quality and productivity improvement techniques applied by Toyota were termed "lean production". This production system, termed the Toyota Production System, TPS, is the over-arching frame work and philosophy that can be used to organize manufacturing facilities and processes as well as to restructure suppliers and customers to provide best quality, lowest cost, and shortest lead time through the elimination of the several forms of waste and involving all the employees. Henry Ford is considered by to be the father of lean thinking, and was reportedly a master at finding waste. In 1930 in his book "Moving Forward" Ford said, "It is the little things that are hard to see – the awkward little methods of doing things that have grown up and which no one notices. And since manufacturing is solely a matter of detail, these little things develop, when added together, into very big things".

Table: 2, Diffrent Forms of Production System

Form	Description
Overproduction	Producing more than is needed and / or used
Human resources	Not using people mind and getting them involved
Transportation	Moving tools materials to the point of use
Inventory	Materials or information. Includes WIP and finished Goods.
Motion	Movement of people (walking, riding) as well as smaller movements.
Corrections	This includes rework or correction of work.
Over processing	Additonal work above the requirements and / or needs.
Waiting	Time delays for materials, information or people.

Waste reduction is typically seen as the heart of the "Lean Philosophy." Waste is broadly defined and can be thought of in a variety of ways. In his book on "Ford's Lean Vision", Levinson uses the word friction instead of waste. Friction can be defined as chronic problems and inefficiencies that become accepted aspects of a job and limit productivity. The lean literature typically identifies seven or eight specific types of waste that must be attacked on the journey to lean as given in table 2:

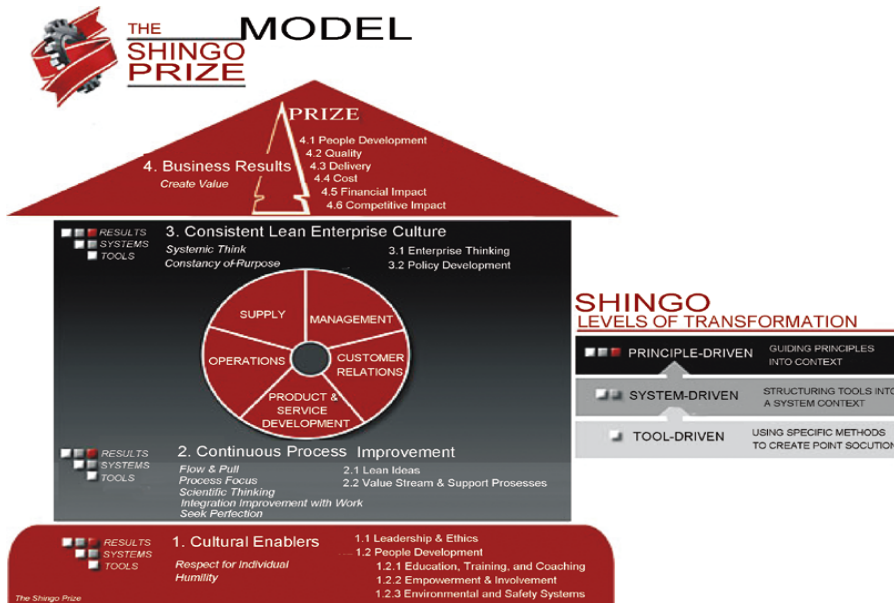
As more and more companies attempted to become lean and struggled with lean implementation, it became apparent that applying lean as only set of tools on the production floor did not work. In his follow up book about lean manufacturing,

Womack tackled the process to become lean and defined five steps to guide its successful implementation . These are:

- (1) Specify value from the standpoint of the end customer by product family.
- (2) Identify all the steps in the value stream for each product family, eliminating whenever possible those steps that do not create value.
- (3) Make the value-creating steps occur in tight sequence so the product will flow smoothly toward the customer.
- (4) As flow is introduced, let customers pull value from the next upstream activity.
- (5) As value is specified, value streams are identified, wasted steps are removed, and flow and pull are introduced, begin the process again and continue it until a state of perfection is reached in which perfect value is created with no waste .

In 1988, the Shingo Prize, named for the industrial engineer Shigeo Shingo, was established. This prestigious prize was developed to honor the lifetime of work Shingo spent studying and developing lean cultures. The Shingo Prize Model (Fig,1) however, is not just a production floor model. It is an overall systems model that incorporates all aspects of business operations and processes.

Fig: 1, Shingo Prize Model



The model was developed to promote lean/world-class business practices that result in ability to compete globally and demonstrates that culture is the foundation of a lean enterprise. The Shingo Prize uses business metrics as a measure of success; thus, only companies whose positive results are driven by the transformation to lean are given recognition.

The Shingo Model recognizes “Cultural Enablers” as the foundation of a lean enterprise. Culture as a central lean implementation requirement is reiterated in the US Environmental Protection Agency (EPA) study of lean manufacturing and agreed upon by many other studies. The EPA study exemplifies the characteristics of a successful lean organization with the following four statements:

- A continual improvement culture focused on identifying and eliminating waste throughout the production process;
- Employee involvement in continual improvement and problem-solving; Operations-based focus of activity and involvement;
- A metrics-driven operational setting that emphasizes rapid performance feedback and leading indicators;
- Supply chain investment to improve enterprise-wide performance; and
- A whole systems view and thinking for optimizing performance.

Lean and its Impact on Environment

Lean philosophy can also be used as a powerful tool to improve environmental sustainability. Lean practitioners save money finding undiscovered opportunities to eliminate the same waste that concern environmental agencies. On the other hand, much expertise in environmental waste-minimizing opportunities already exists. It is readily available by tapping into the many years of knowledge the environmental experts and in-house Environment, Health and Safety (EHS) personnel have in finding and eliminating wastes in ways that can significantly boost the economic bottom line. Lean manufacturing first came to EPA's attention through case studies that demonstrated that very significant reductions in so-called “environmental wastes” (that is, the 8th Deadly Waste) (The 8th Deadly Waste is a term coined by lean manufacturing companies and assistance providers that have partnered with EPA in pursuing the goal of enhancing the environmental benefits inherent in lean manufacturing.) “Environmental waste” is a term used to distinguish between those emissions and solid/hazardous wastes that EPA typically considers waste from the 7 Deadly Wastes associated with lean manufacturing resulted from Lean activities solely focused on increasing production efficiency. In 2003, EPA published this report, a collection of case studies of lean manufacturing activities and the environmental benefits that resulted. One of the case study is mentioned below :

In the above case study, General Motors use of lean techniques not only facilitated reduction in costs, production gains but also led to a reduced or very less emission of hazardous gases in the environment. Lean manufacturing confers very real benefits by reducing the costs of production and more efficiently using capital. If lean manufacturing also incorporates environmental considerations, it can help a company achieve many other long-term goals, such as environmental sustainability and maintaining a good relationship with the public.

Method to Implement Lean and Green Strategies : Tools and Techniques

Some key lean tools and techniques have proven especially effective in improving sustainability. Lean implementation is an integrated system, with several key elements. These include Green Value Stream Mapping, 5S and Safety, Statistical Process Improvement, and Management Operating system.

A Value Stream Map(VSM)

A value stream map(VSM) is a simple diagram of the material flow through the system that shows where waste is occurring. One of the best resources for how to create a value stream map is the book “Learning to See”. A value stream map can be constructed for the entire enterprise or for a single production line. While a powerful tool for lean, a VSM typically focuses on the forward

product material flow and does not typically consider other material flows and waste streams, especially energy. A Green Value Stream Map (GVSM) includes not only the material flow through the system, but also all of the energy and waste flows. The GVSM process can be used to identify sources of emissions, opportunities for improvement in material and energy usage, non-value added activities, and to provide a road map for possible innovative technologies and community partnerships. It can also be good communication tools among the stakeholders for all these activities. The technique has been applied effectively to improve both cost and environmental impact. For example, a bicycle manufacturer in China analyzed the flows of water, energy, and solvent pinch in the painting and drying processes independently which then resulted in one process pre heating the air intake for the others. In addition to looking at just the present flow of material, energy and waste in the system, GVSM can be used to also look at the life cycle of the product.

5S and Safety

5S is an acronym for activities which provide for an ordered workplace in which visual cues can facilitate problem detection and resolution. In English, the 5S's stand for Sort, Straighten, Shine, Standardize, and Sustain. Frequently Safety is included as a sixth 'S' because of its importance to the workers and to the community. Lean manufacturing principles ultimately target the elimination of all forms of waste. The 5S process follows the same philosophy and helps to identify what is waste so that it can be eliminated. A 5S cornerstone is "the right thing in the right place at the right time"; anything else should be disposed of in a safe and environmentally correct manner. When a workplace is implementing 5S, it is very evident to both workers and visitors; providing physical demonstration of the organization's lean philosophy. Maintaining 5S reinforces that management commitment to lean philosophy. 5S is a key element of an overall Management Operating System in that items which need management attention and oversight are blatantly visible to all, fostering the common understanding of what is important. From an environmental sustainability perspective, 5S calls attention to uncontrolled waste and/or emissions because they do not fit the standard. 5S can assist with energy efficiency by calling attention to machines and items which should or should not be running given standard operating procedures.

Statistical Process Improvement

A key tool supporting lean implementation are probabilistic and statistical methods required to improve the quality of products and processes. Six Sigma methodologies incorporate a toolbox of statistical process improvement (SPI) techniques that can effectively drive sustainable process improvement. It is crucial to identify the true root causes of waste and SPI insures that those root causes and the corrective actions will truly impact those wastes significantly. Statistical Process Control (SPC) Charts can be an important part of both a Management Operating System and the 5S process in the foundry to drive improvements in both process control and environmental control. SPI can be used for reducing foundry scrap with resulting cost and sustainability benefits. Designed experiments can be used to make process improvements as well as environmental improvements. SPI techniques can be powerfully used to develop better understanding of material and energy usage, production line productivity, and environmental impacts. SPC charts can be used for controlling electrical usage, or improving emissions.

Management Operating System

While lean is a holistic system for managing any business, the method to manage that system must itself be lean. Thus a lean Management Operating System is crucial to the foundry lean and green implementation framework. Like 5S, and as part of 5S, the Management Operating System

hones the requirements to insure operational success just to the crucial items, and discards the rest. The management system is transparent and visible to all of those working and visiting the facility. The process supports the foundry's lean philosophy by insuring that managers and supervisors can 'walk the talk' with a consistent message and consistent performance measures including sustainability measures. A lean management team will determine the key goals for the organization and the measures of success, usually with a process which insure the input of as many people in the organization as possible. This insures buy-in. It is important that the number of metrics is limited, that they are reviewed regularly, and that key metrics, including environmental metrics, are visible to everyone in the organization. It is also important that these measures are consistent and aligned throughout the organization. Ideally, the process reinforces the lean organization philosophy regularly. It measures improvements in throughput at each level of the organization. It includes environmental impacts, such as energy usage and emissions. It asks on a regular basis whether innovative technologies exist to make improvements, and drives partnerships.

In a developing countries like India, Govt should make efforts to motivate and aware the small firms to implement the lean technologies by providing subsidies and other incentives. There is a scarcity of methods that at best explains how and which tools help to implement lean practices in an organization. For this purpose a systematic design workshop focused how these lean principles and methods are implemented should be conducted with the help of professional workforce.

CONCLUSION

This paper provides a broad perspective on combining lean manufacturing methods with environment sustainability and demonstrates the synergetic and additive effects of manufacturing technologies and lean practices on production cost, quality, lead time and flexibility. Lean manufacturing confers real benefits by making the production process cost effective and making the efficient use of capital. Arrangement of specialized trainings and workshops along with the toolkits can encourage the effective use of lean methods. Thus for purpose of various stakeholders, development practitioners and policy makers lean technology combined with existing resources if applied efficiently, can pave the way for sustainable development of the economy in general and organization in particular. Thus lean methods implemented at all levels from physical to human resources taking in account environmental considerations as well, may facilitate the organization to achieve its long-term goals and save for future generations.

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