



The Role of Lean Manufacturing Practices in Greener Production: A Way to Reach Sustainability

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Abstract: Due to globalization and competitive market, sustainability has increasingly gained importance to the manufacturing industry and Lean approaches are becoming more and more outstanding in order to improve operational and competitive performance. In addition, currently, firms have become more conscious of the fact that it is no longer adequate to take care of economic aspects, being crucial to take care of social and environmental aspects to succeed in the current and future markets. Lean manufacturing provides quality products at minimum cost to satisfy the customer. Aims of Lean manufacturing are to identify and eliminate the production process wastages for quality improvement, cost reduction, on-time delivery, i.e. to make efficient production processes to face the highest competition level, so lean is the latest tool to achieve it. While the aim of the Greener production is an environmental improvement of production processes by adopting best practices and seeking to eliminate waste and waste generation manufacturing processes. This research investigates how the Lean and Green practices and tools are being used for improvements in social, economic and environmental performance that directly affect overall business performance. The findings show that, a strong synergy linking between Lean and Green and that a lot of Lean practices and tools can positively contribute to environmental sustainability which will help for both academicians and practitioners to take the advantage of their synergistic effects for achieving sustainable development in the manufacturing industry.

Keywords: Lean Manufacturing, Greener Production, Sustainability, Practices, Tools

1. Introduction

Currently, there is a need to create an environmentally conscious sustainable society which would help in fulfilling our present needs without affecting the future generation [1]. Organizations are constantly changing as per change in technology and management to meet the requirement of the customers, society, stakeholder and finally government. Thus reduction of impact generated due to manufacturing processes on the environment becomes an additional value to be added by firms. Pil and Maxwell [2], Yang Hong and Modi [3], have opined that the integration of Lean Manufacturing with environmental strategies could be a solution to eliminate wastages that are affecting the environment. The Lean concept creates an efficient operation and pulls together best practices such as Just-in-Time (JIT),

Total Quality Management (TQM), continuous improvement, resource planning, and supply chain management [4]. In literature, the term green manufacturing often used synonymously with the concept of sustainability.

Cleaner Production is a technique used for minimizing waste and environmental pollution [5, 6] while LM makes the manufacturing process more efficient while decreasing waste elimination in every production stage [7, 8]. Sarkis and Bergmiller & Mcright [9, 10] opined that the practices integrated into the organizational system for environmental protection can be determinant for reducing the environmental impact.

In this way, it becomes necessary to incorporate techniques or practices in the organizational system to reduce the environmental impact. Lean practices and tools can help control the use of resources in various stages of production [11, 12, 13]. Understanding the Lean and Greener/Cleaner

relation is essential for organizations implementing these manufacturing systems since they can maximize their operational gains.

2. Literature Survey

The Lean system was originated at Toyota as the Toyota Production System and is known worldwide [14]. According to Womack and Jones [15] lean philosophy is to pursue using less of everything, which means to produce more with fewer

resources while eliminating waste.

According to Yang et al. [3]; Bandehnezhad et al. [16] Lean improves environmental management practices that improve the environmental performance of processes and products [16, 17]. Shingo [19], Womack and Jones [20] opined that TPS is based on continuous improvement in production processes, seeking to eliminate unnecessary associated costs. The important definition of lean operational practices, Liker [14] and Womack and Jones [15] are presented in following table 1.

Table 1. Definition of Lean Manufacturing Operational Practices.

Tools and Practices	Authors	Description
Kaizen	Araujo; Rentes [21]; Imai [22]	It is a continuous improvement practice of a process to add value and eliminate wastages.
5'S	Feld [23]; Lean Enterprise Institute [24]	It is a practice for improving working environment.
Value Stream Mapping	Rother; Shook [25]	It is lean tools which study the current state of process and make improvement in it.
Standardized Work	Lean Enterprise Institute [24].	It is a standard procedure for each employee's work in a production process.
JIT	Shingo [26]; Lean Enterprise Institute [24]	JIT control inventory so that everything is produced in required quantity at right time and right place when needed.
Kanban	Ohno [27]; Feld [23]; Lean Enterprise Institute [24]	Kanbanis a Lean tool that works as a customer demand signal, i.e., authorizing the start of production or removal of items in a working system. It also controls the level of work in process.
SMED	Feld [23]	Aims to reduce the setup time, known as Quick Change die set.
Manufacturing cells	Lean Enterprise Institute [24]; Black [28]	Involves the workstations producing similar products in a sequence and in continuous flow.
TPM	Feld [23]; Lean Enterprise Institute [24]	Aims to ensure the reliability and overall productivity of equipments, involving all employees of the organization.
Heijunka	Hüttmeir et al. [29]	Production capacity is kept constant under many issues..
Ishikawa Diagram	Ishikawa & Loftus [30]	It is a graphical representation that illustrates relationships between a specific result and its causes.
Water spider	Womack & Jones [7]	Rapid and efficient movement to collect and deliver materials.
Poka yoke	Feld [23]; Lean Enterprise Institute [24]	Mistakes proofing tool.
VM	Lean Enterprise Institute [24]	Measurement of system activities and performance indicators so that workers can quickly understand the system status.
Autonomous Inspection	Swanson [31]	Machine Performance improvement through communication which causes elimination of possible failures and problems with the equipment in their inspection.

3. Methodology

A literature review was conducted to analyze the relationship between operational practices of Lean manufacturing and reduction of environmental impact in organizational contexts. The procedure to perform the literature review was based on the use of databases to find peer-reviewed journal articles that contained at least a keyword related to both, Lean and Green/Clean manufacturing. The search results showed that 42 articles from 1986 to 2017 have been published to address the connection between Lean and Green/Clean, with the majority being published in the last 10 years. The information was examined qualitatively considering the technique for content analysis and to find out the relationship between them.

4. Greener Production

In the search for sustainability, different approaches have

come out to deal with industries' environmental impacts. In the year the 1960s and 1970s efforts have been taken for the regulation of industrial activities which objective was reducing impacts of manufacturing on the environment. According to OECD (organization for economic co-operation and development), greener technologies pull out and use natural resources as capably as possibly in all stages that generate harmless products for the society which minimize releases to air, water and soil during production and after its life cycle that product can be recovered or recycled.

Greener production reduces cost while improving process efficiencies, whereas investment in cleaner production is low for replacing existing systems or equipment. "Green" product is the product that must be manufactured as per environmental legislation. Greener Production and Pollution Prevention have the same goal: continuous reduction of pollution and eliminating environmental waste in the process. The main concern of the greener production is to create responsiveness for the prevention of pollution and to find the source of wastes and emissions generation by implementing and documenting Greener production strategy. Greener

production's driver is to reduce the costs associated with environmental waste, besides the reduction of environmental impacts.

5. Lean and Greener Production

While reducing environmental waste and increasing productivity is necessary for all industries which are possible by using Lean with Greener production [32]. Song and Liang [33] opined that while Lean concentrates on improving cost and time performance and can bring immediate economic value, environmental sustainability is considered a different aspect of value, which is related to reducing environmental impacts. They also state the gain of Greener production with Lean through the elimination of waste by providing the concept of "Free Green". Sawhney et al. [34] determined that lean focus on systematic waste elimination with ecological protection. According to Song and Liang [33], the environmentally sustainable outlook, Lean can result in environmental impacts that vary in type and magnitude

reinforcing the perception that the combined implementation of the two concepts can be often argumentative. Lapinski et al. [35] applied an interesting approach to make use of Lean concepts and tools and add to Lean customer values a value related to environmental impacts. Other than the value related to cost, time and quality desired, other factors are included in the customer value, such as environmental occupation, environmental performance, and minimal environmental impact, among others; at the same time that environmental waste is defined as waste.

The concept of "value" in the Lean theory should be associated with sustainability to ensure a win-win association between Lean and GP [33]. Dues et al. [36] analyzed both concepts and provided evidence of the areas where lean and green overlap. Both practices are beneficial having a positive influence on existing Lean business practices. A generalization of their findings is presented in Figure 1, where both concepts overlap on creating value for the customer and improving waste elimination to achieve business success.

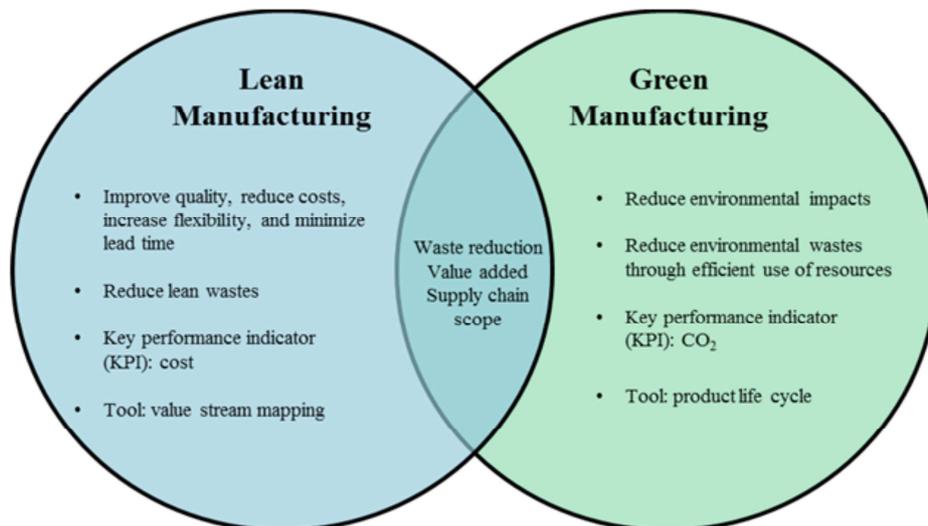


Figure 1. Lean and Green philosophies [36].

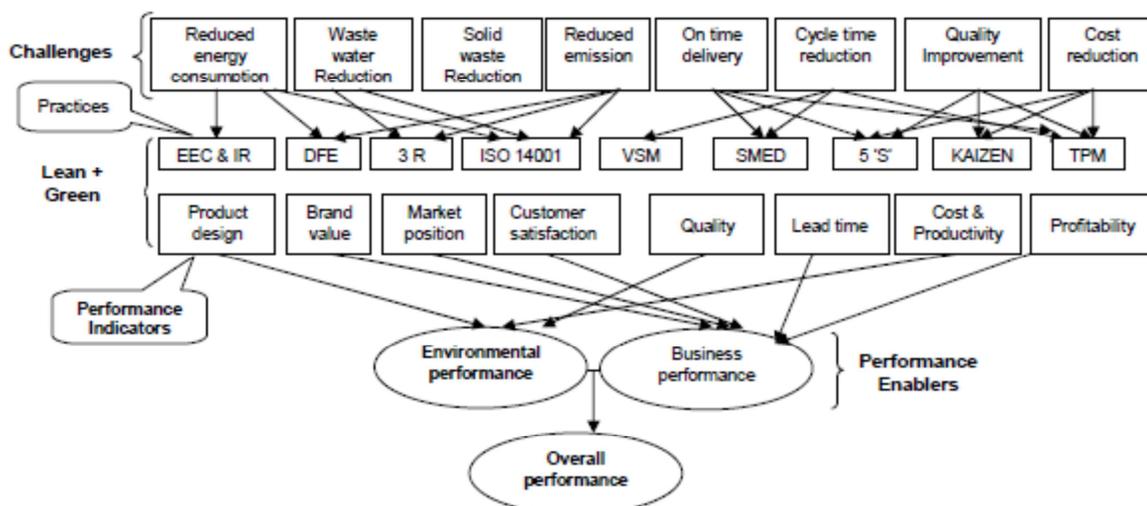


Figure 2. Integrated model for tools, methods and techniques of Lean-Green system [37].

Xiaoyong Zhu et al. [37] presented an integrated model as shown in figure 2 for tools, methods and techniques of lean green system to improve the overall operational performance of the manufacturing industry. The main challenges faced by the organization now a days are cost reduction, quality improvement, customer satisfaction, on time delivery, cycle time reduction, waste reduction, resources conservation etc. which need to implement lean practices such as TPM, VSM, JIT, KANBAN, 5S, KAIZEN, SMED etc. together with some green practices like 3R, EMS 14001, EEC & IR which will enhance the business and environmental performance of the organization.

6. Results

In this section the information extracted from the 42 literatures, selected are going to be described in order to identify which and how Lean Manufacturing tools can be used in Greener Production in order to promote environmental improvements. It was found that there is evidence for the existence of relationship between the practices of Lean manufacturing and their effect on environment. This reduction was observed after implementation of these practices that resulted in the reduction of energy and water consumption and at the same time proper resource utilization. Galeazzo et al. [38] in a research work also opined that there is interdependency between Lean and Green practices which may be implemented either sequentially or simultaneously.

Johansson and Sundin [39] demonstrate that from a Lean perspective, when a waste is minimized; it provides benefits from a sustainability perspective since inefficiencies lead to increased environmental burdens with this support, Upadhye et al. [40] states that Lean manufacturing systems provide a competitive strategy to achieve sustainability.

Soltero and Waldrip [41] found that Lean manufacturing provides the organization with the tools and techniques to attain its pollution prevention goals. Most of the authors have suggested that when an organization achieves sustainable improvements in a Lean production system, they may create a competitive advantage [42].

7. Conclusion

No. of Lean Manufacturing tools can be used for obtaining environmental benefits, such as cleaner - greener production which is environmental conscious type of manufacturing process. The method utilized helped to identify some practices that favour of lean environmental performance. However, it is not possible to generalize the results because of limited reviews of articles were analyzed, among which only the outcomes of the success stories were presented. For a better understanding of the study subject, it is suggested that further studies are conducted, to quantitatively evaluate the environmental benefits achieved through the accomplishment of lean

tools and techniques to promote the cleaner production of a manufacturing industry.

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