

Practice Bundles for Integrated Green-Lean Manufacturing Systems

¹J. R. Jadhav *

Research Scholar

Mechanical Engineering

Department, Sardar Patel College
of Engineering, Mumbai - 400058,
India.

²S. S. Mantha, Ph.D.

Chairman

All India Council of Technical

Education (AICTE), 7th Floor,
Chanderlok Building, Janpath, New
Delhi-110001. India.

³S. B. Rane, Ph.D.

Associate Professor

Mechanical Engineering

Department, Sardar Patel College
of Engineering, Mumbai - 400058,
India.

* Corresponding Author

ABSTRACT

Green manufacturing encompasses eco-friendly, energy-efficient manufacturing processes and resource preservation practices to make green products and services. Focus of lean systems is on creating efficient manufacturing through wastage reduction. It consists of many best practices for efficient and effective utilization of resources. Lean practices include quality circle, kaizen, Total Quality Management (TQM) etc. For sustainable environment, fusion of lean and green manufacturing is essential. Organizations can ease environment burdens effectively by following the integrated green lean practices and strategy. Sustainable green lean system demands an integrated structure of supporting practices. Many green as well as lean practices exist and being practiced in various industries. In this research the critical lean practices focused on environment are only considered. The set of lean practices act as enablers for sustainable implementation of green lean system. The purpose of this paper is to categorize and describe integrated Green-Lean (GL) practices in particular bundles.

General Terms

System Modelling

Keywords

Green; Lean; Practices; Practice bundles

1. INTRODUCTION

The inception of 21 century sees the emergence of another imperative modern manufacturing strategy namely *Green Manufacturing*, which integrates all issues related to manufacturing with ultimate goal to reduce and minimize environmental impact and resource consumption during a product life cycle inclusive of designing, synthesis, processing, packaging, transportation and the use of products in continuous or discrete manufacturing industries (*Tan and Zailani, 2009; Tan et al. 2002*). Green manufacturing is an ongoing process of continually improving manufacturing techniques with an ultimate goal of sustainability and it is a process with sustainability as the ultimate albeit distant goal (*Guerry and Boots, 2012*).

Lean systems take a total system approach to creating an efficient operation and pull together best practices concepts. This includes concepts such as Just-in-Time (JIT), Total

Quality Management (TQM), continuous improvement, resource planning and supply chain management (*Oduzoa, 2008*). As Lean evolves and new manufacturing paradigms that go beyond Lean emerge, there will inevitably be an environmental sustainability element (*Found, 2009*). In literature, the term green manufacturing often used synonymously with the concept of sustainability.

Firms are under pressure to prove their environmental credentials. Now a win-win way of weaving 'green' considerations into business decisions is emerging (*Simons and Mason, 2003*). Recent academic research and surveys find the most compelling reason for organizations adopting lean is the economic and environmental benefits of going green (*Ravet, 2011*).

According to *Simons and Mason (2003)* lean and green thinking have a great deal in common, both challenging the way resources are currently used and promoting initiatives designed to "do more with less". Lean and green strategies are often seen as compatible initiatives because of their joint focus on waste reduction (*Mollenkopf et al., 2010; Ravet, 2011*). Lean and green manufacturing can have a more significant, positive impact on multiple measures of operational performance when implemented concurrently rather than separately (*Miller et al. 2010*). Lean strategies coincidentally benefit the environment, without the need for special "environmental" toolkits or a separate focus on environmental considerations (*Kidwell, 2006*).

US Environment Protection Agency (EPA) suggested that environmental agencies have a window of opportunity, while companies are embarking on Lean initiatives and investments, to collaborate with Lean promoters to further improve the environmental benefits associated with Lean (*Found, 2009*). "Environmental" wastes, such as excess energy or water use, hazardous waste, or solid waste, present largely untapped opportunities to the lean practitioner (*Kidwell, 2006*)

To motivate the industry towards green lean implementation, significant GL practice bundles need to be identified, analyzed and discussed. This can be a guide for taking appropriate action for successful implementation of green lean system. The effective and sustainable implementation of green lean assumes great significance in this context.

This paper is further organized as follows. Research methodology is described in second section. Section three contains Green-Lean Practices are introduced briefly in Section three. Section four contains the discussion. Finally, section five contains general conclusions with research findings, implications, limitations and suggestions for future research.

2. RESEARCH METHODOLOGY

The main objectives of this paper is to identify and discuss the GL practices bundles In this research, study factors are the GL practices bundles for sustainable implementation. Authors have identified six significant GL practices bundles from literature review and opinion of the experts.

This work can be characterized as theoretical concept, specifically for review of literature on practices in green and lean systems implementation. The approach of the research is exploratory in nature, which constitutes a secondary source. First the relevant literature is reviewed. The authors focused on literature from 2002 to 2013. Literature Review includes Green and Lean systems implementation in various companies. The literature survey was augmented by use of online computerized data base like Taylor and Francis Science Direct, Google Scholar, Bing etc. using primary keywords such as Just-in-Time (JIT), Lean, green and lean supply chain, green manufacturing etc. and secondary key words like practices, benchmarking, modelling, framework etc.

The research is based on secondary data, which includes compilation of research articles and survey reports etc. after scanning the reference sections of the initially selected papers. The ultimate list of articles reviewed for this paper covers articles published in reputed referred scholarly journals on green and lean manufacturing.

Based on this search, articles that met the criteria of practices in Green-Lean implementation and presented a model or framework were selected. A survey of literature was carried out on the basis of editorial scope and contents of the journals and a list of journals was compiled. Journals stating in their editorial scope issues such as green, environment, sustainable, lean, JIT, TPS, ISM etc. were selected. A comprehensive review of the table of content of the journals, abstracts, and where ever necessary review of the complete paper was carried out. Literature Review primarily focus on Green-Lean implementation in manufacturing sector like automotive, machine tools, heavy industries, aerospace etc. and secondarily on other sectors like supply chain management, transportation, relationship management, service etc.

3. GREEN-LEAN PRACTICE BUNDLES

Green-Lean can be implemented through some well-known practices such as value stream mapping, waste elimination, kaizen etc. Lean and its associated practices are generally considered best practices in the operations management field (Longoni, 2013).

Many researchers grouped these practices in different bundles. The term “bundle” is used to capture categories of inter-related and internally consistent lean practices. Following GL practices bundles are used in this paper based on the literature reviewed and opinion of experts:

- 3.1 Waste elimination practice bundle
- 3.2 Green quality practice bundle
- 3.3 Low cost practice bundle

- 3.4 Green human resource management practice bundle
- 3.5 Health and safety practice bundle and
- 3.6 Creativity and innovation practice bundle

The core content of integrated Green-Lean strategy includes practices for HRM, cost minimization, quality enhancement, waste elimination, health and safety, creativity and innovation etc.

3.1 Wastage Elimination Practices

Lean sees waste as non-value added to the customer; green sees waste as extraction and consequential disposal of resources at rates or in forms beyond that which nature can absorb (Gustashaw and Hall, 2008). Waste may be in the form of material, energy, utilities like water, gas etc. during manufacturing. Usually wastes are hidden and escalate the product cost. Obviously customers are not ready to pay for waste. So it is very important to identify the sources of waste and eliminate them. According to Rose et al. (2010) the organization no matter the sizes, large or small is crucial to eliminate waste, in order to increase the profit or return on investment (ROI). Approach of lean towards waste elimination has tremendous impact on business survival as well as environment sustainability. In fact, there are intrinsic linkages between lean and green – not least due to the relentless focus of lean on waste elimination (Pampanelli et al., 2011).

The identification of opportunities for seven types waste is exposed through value stream mapping. According to Kidwell (2006) the toolkit includes a Value Stream Mapping (VSM) tool, which is basically the same as the traditional VSM, but adding a “starburst” to identify environmentally sensitive processes.

3.2 Green quality practice bundle

In recent year, business ethics, social responsibility, sustainable development, and environmental issues have become important strategic concerns among companies (Chang and Fong, 2010). Growth of environmentalism, stringent international green (environmental) standards and environmental regulations, high degree of green awareness of modern customers, willingness of customer to purchase green products etc. forced the manufacturers for green product manufacturing. Manufacturers have to develop and design green quality products as well as packaging to satisfy the green customers, to retain the loyalty of green customers and create the green corporate image. Simultaneously, customers of the greatest international markets were asking the companies to produce high quality products which were compatible with social and environmental standards if they wanted to be competitive in global markets (Asgharian et al., 2012).

The organizations which have robust green quality foundation and culture only will be able to endure in severe global competition. Green-Lean approach emphasizes on fusion of environmental criteria directly into cost reduction and quality control methodologies. Asian Productivity Organization (APO) promotes green productivity practices at the enterprise level through the applications of productivity and management tools (such as TQM, 5S, TPM etc.). These practices may be merged together with practices for energy conservation, pollution control, waste reduction and emission prevention and Environmental Management Systems.

Total Quality Management (TQM) philosophy is focused on continual improvement to achieve customers' satisfaction through participative management programs. Total quality control aims to improve internal quality whereas vendor development focuses on improving external quality. General Motors (GM) Lean Implementation Program mentors suppliers on environmental and other GM's Supplier Environmental Advisory Team provides feedback from key suppliers to help shape GM's environmental initiatives (Lee, 2008).

These practices improve the green quality in all activities and functions in the organization and in the entire supply network. Thus we can conclude that the green quality practice bundle includes TQM, TQC, SQC and green Supplier Management/green vendor Development.

3.3 Low cost practice bundle

The market forces dictate the price of the product. Profit can be increased by reducing cost price of product (Singh and Khanduja, 2010). Market share of the company is greatly enhanced with selling cost effective and qualitative green products. A company with environment-conscious quality culture, minimal waste, innovative green products and green processes and quick response to customers demand or flexibility will be able to trim the product costs. Application of GL practices (specifically waste elimination) in manufacturing leads to cost reduction attributed to raw material and labor.

The best practices for cost reduction are inventory reduction, and green purchasing. Green purchasing mean purchasing ecofriendly items required for green products or services. It includes direct and indirect material, packaging material, transportation, semi-finished and finish products and other equipment and resources

3.4 Green Human Resource Management (GHRM) Practices Bundle

Human resource practices Management (HRM) act as the adhesive that connects various GL practices as a synchronous unit. GL HRM practices offer tremendous mutual benefits to the organization and workers.

Active employee may play significant role in developing and deploying environment management strategies. Employees may feel empowered to adopt specific environment management principles as a resulted of promoted human resource policies which present better opportunities for improvements related to reduction of waste and promotion of lean manufacturing (Cherian & Jacob, 2012). The ultimate end result of GL HRM practices is customer satisfaction through green products. This paper focused specific attention on HRM practices having impact on cost, quality, environment and resources.

The practices in HRM bundle includes Quality Circle, communication of Green-Lean goals, effective employee development programs, creating a culture of green-lean improvement, rewards and recognition and effective labor management relationship.

3.5 Health and Safety Practices Bundle

Human interaction with machines, working environment and other resources is an integral part of any manufacturing activity. Organization should provide the resources and facilities required to satisfy occupational health and safety

needs. Lean approach emphasis of reduction of Muda (wastage), Muri (strain) and Mura (Errors) during production. Naturally it reduces the risk of health and safety hazards. Another fairly common example is a "6S Checklist" where "Safety" is the sixth "S." This checklist includes items for tagging potentially hazardous materials, and organizing them to minimize the risk of spills or unsafe exposure (Kidwell, 2006). The practices in health and safety bundle consist of five S, Six S, Poka Yoke (error proofing), Visual Management, Standardised Work, Ergonomic Work Station or Cell Design and Total Productive Maintenance (TPM).

3.6 Green Creativity and innovation Practices Bundle

The Green-Lean practitioners need to be creative and innovative in developing newer techniques to make manufacturing more green, qualitative and cost effective. Without adaptation, many lean techniques can also specifically address environmental concerns. They can be used in a kaizen event focused on a specific environmental problem, or in kaizen dealing with process waste in general (Kidwell, 2006). Results from studies carried out by de Haan et al. (2012) indicated that challenging and enabling workers to creatively use their talents and skills in daily work will most likely lead to positive results. Green Creativity and innovation Practices Bundle includes Kaizen (Continuous Improvement), applications of advance technologies.

4. DISCUSSION

Green manufacturing involves use of eco-friendly, energy-efficient manufacturing processes and resource preservation practices to make green products. Lean system takes holistic approach for manufacturing excellence.

Stiff competition, demand for cost competitive green products or services, demand for qualitative on time-in full delivery at right place as well as issues related to - marketing, packaging, environmental, regulatory and economic etc. enforced many organizations to embrace Green-Lean (GL) concepts in the last few years.

Many green and lean practices exist and being practiced in various industries. In this research the critical lean practices focused on environment are only considered. Lean practices include quality circle, kaizen, Total Quality Management (TQM), Total Productive Maintenance (TPM) etc. The set of lean practices act as enablers for sustainable implementation of green lean system.

Green-Lean (GL) practitioners must have the understanding of the major Green-Lean domains and issues to implement it effectively. The major domains of GL system may be categorized as human centric, organization centric, systems centric and technology centric.

The issues of lean system in each domain are as follows:

1. Human centric:
Change management is one the burning issues GL system implementation. It includes employees, suppliers, customers and human related virtues (attitude and behavior) like leadership, teamwork, cooperation, habits etc. Knowledge management is another important area to be focused on extracting, compiling, preserving and sharing the knowledge acquired through experience.
2. Organization centric:
It includes top management, culture, finance, resources etc.

3. Systems centric:
It includes forecasting, infrastructure facilities, logistic support etc.
4. Technology centric:
It includes communication technology, information support, process management etc.

Sustainable competitive gains cannot be achieved overnight. The understanding of people and human motivation, the ability to nurture leadership, team building and GL culture are important enablers for integrated Green-Lean system.

5. CONCLUSIONS

5.1 Research findings and implications

The major implementation issues are related to the human, cultural, facilities and resources factors. For fruitful GL implementation, an organization must accept GL as a philosophy, change or modify - processes, production system and organizational culture. Organizations have to cultivate mutually beneficial relationship with suppliers and customers. Organizations that implement and maintain integrated GL systems will reap viable rewards in terms of improved financial performance.

This paper makes two broad conceptual contributions. First, it explores GL practice bundles for successful implementation and second, it provides concise description of six GL practice bundles that will be helpful for further studies. Another contribution is the transmission of compiled information from researcher to their peers to assist in designing the structurally robust GL implementation strategies. The overall effort put in the present research has ensued in identification of significant GL practice bundles for sustainable implementation in manufacturing organizations. The success of global ecofriendly manufacturing strategies such as GL will not be completely based on application of apt tools and techniques alone but also on the relationship between top management and employees. Top management may play significant role in how the integrated GL strategy is understood, implemented, and deployed effectively throughout the organization.

5.2 Limitations and Suggestions for future research

In terms of limitations associated with the present study is primarily focused on green-lean implementation in manufacturing sector. The GL issues in other sectors may slightly differ from manufacturing sector. The issues may vary based on country, geographic location within the country and work culture of the organization.

Once the GL practice bundles are identified, a number of research propositions may be proposed that would be appropriate for further study and research concerning the modelling the GL practice bundles using various modelling techniques like AHP, ANP etc. Implementation strategy can be developed for successful and sustainable implementation of GL practices using tools like Quality Function Deployment (QFD), Failure Mode and Effect Analysis (FMEA), Balance Score Card and Hoshin Kanari policy deployment etc. Research work in this area may act as a roadmap for successful implementation of integrated green-lean systems. It would be a light house to Green-lean practitioners and researchers.

ACKNOWLEDGMENTS

The authors wish to thank the anonymous referees for their valuable feedback and constructive comments which helped

to improve the structure and quality of this paper. The authors are also express sincere thanks to the editor and his team for continuous guidance and support for this work.

6. REFERENCES

- [1] Asgharian, R., Salehi, M., Saleki, Z.S., Hojabri, R. and Nikkheslat, M. 2012. Green product quality, green customer satisfaction, and green customer loyalty. *International Journal of Research in Management & Technology*, Vol. 2, No. 5, pp.499-503. Available at: http://www.academia.edu/2673366/Green_product_quality_green_customer_satisfaction_and_green_customer_loyalty. Accessed on 15th June 2013.
- [2] Chang, Nai-Jen and Fong, Cher-Min. 2010. Green product quality, green corporate image, green customer satisfaction, and green customer loyalty. *African Journal of Business Management*, Vol. 4, No.13, pp. 2836-2844. Available at: <http://www.academicjournals.org/ajbm/pdf/pdf2010/4Oc/v/Chang%20and%20Fong.pdf>. Accessed on 15th June 2013.
- [3] Cherian, Jacob & Jacob, Jolly. 2012. A Study of Green HR Practices and Its Effective Implementation in the Organization: A Review. *International Journal of Business and Management*; Vol. 7, No. 21, pp. 25-33.
- [4] de Haan, J., Naus, F. and Overboom, M. 2012. Creative tension in a lean work environment: Implications for logistics firms and workers. *International Journal of Production Economics*, Vol. 137, No.1, pp.157-164.
- [5] Found, Pauline A. 2009. Lean and Low Environmental Impact Manufacturing. *POMS 20th Annual Conference*, Orlando, FL, U.S.A. Available at: <http://www.pomsmeetings.org/ConfPapers/011/011-0126.pdf>. Accessed on 15th June 2013.
- [6] Guerry, Steven and Boots, Seth. 2012. Green Manufacturing. In 'A Roadmap to Green Manufacturing in Los Angeles: Policies, Planning, and Partnership for Quality Jobs'. *A Comprehensive Capstone Project*. UCLA Luskin School of Public Affairs, Urban & Regional Planning, pp.62-69. Available at: http://dornsife.usc.edu/pere/documents/Comp_Project_Final_Report_web.pdf. Accessed on 15th June 2013.
- [7] Gustashaw, Dave and Hall, Robert. 2008. From Lean to Green: Interface, Inc., *Association for Manufacturing Excellence, Target Magazine*, Volume 24, No. 5, pp.1-14. Available at: http://www.leanfrontiers.com/leanandgreensummit.com/Lean_to_Green_Article.pdf. Accessed on 15th June 2013.
- [8] Kidwell, Mitch. 2006. Lean Manufacturing and the Environment: Ignoring the 8th Deadly Waste1 leaves money on the table. *Association for Manufacturing Excellence, Target*, Vol.22, No. 6, pp.1-18. Available at: <http://www.epa.gov/lean/environment/pdf/8th-deadly-waste.pdf>. Accessed on 15th June 2013.
- [9] Lee, Kun-Mo (Ed.).2008. Green Productivity and Green Supply Chain Manual. *Asian Productivity Organization: Tokyo*
- [10] Longoni, A., Pagell, M., Johnston, D. and Veltri, A. 2013. When does lean hurt? – an exploration of lean practices and worker health and safety outcomes.

International Journal of Production Research, Volume 51, No.11. pp. 3300-3320.

- [11] Miller, G., Pawloski, J., Standridge, C. 2010. A case study of lean, sustainable manufacturing. *Journal of Industrial Engineering and Management*, Vol.3, No.1, pp.11-32. Available at: www.jiem.org/index.php/jiem/article/download/156/50. Accessed on 15th June 2013.
- [12] Mollenkopf, D.A, Stolze, H., Tate, W. L., Ueltschy M. 2010. Green, lean and global supply chains. *International Journal of Physical Distribution & Logistics Management*, Vol.40, No. 1/2, pp. 14-41.
- [13] Oduoza, C. F. 2008. Lean thinking constrains in traditional batch manufacturing environments, *Advances in production Engineering and Management Journal*, Vol.3, No. 4, pp.181- 192.
- [14] Pampanelli, A.B., Poud, P. and Bernardes, A.B. 2011. A Lean and Green Kaizen Model. *POMS Annual Conference*, U.S.A, April 29 to May 2, 2011. Available at: <http://www.pomlearning.org/reno/fullpapers/020-0310%20A%20Lean%20and%20Green%20Kaizen%20Model.pdf>. Accessed on 15th June 2013.
- [15] Ravet, Denise . 2011. Lean production: the link between supply chain and sustainable development in an international environment. *Colloque Franco-Tchèque 2011 – “Trends in international business”*, Lyon : France
- [16] Rose, A.M.N., Deros, B.Md. and Rahman, M.N.Ab. 2010. Development of framework for lean manufacturing implementation in SMEs. *The 11th Asia Pacific Industrial Engineering and Management Systems Conference*. Melaka, 7 - 10 December.
- [17] Simons, D. and Mason, R. 2003. Lean and Green: ‘Doing more with less’. *ECR Journal*, Vol.3, No. I, pp.84-91. Available at: http://www.leanuk.org/downloads/general/lean_and_green.pdf. Accessed on 15th June 2013.
- [18] Singh, B.J. and Khanduja, D. 2010. DMAICT: a road map to quick changeovers’, *International Journal of Six Sigma and Competitive Advantage*, Vol. 6, No.1/2, pp. 31 - 52.
- [19] Tan, Jason and Zailani, Suhaiza. 2009. Green Value Chain in the Context of Sustainability Development and Sustainable Competitive Advantage. *Global Journal of Environmental Research*, Vol.3, No.3, pp.234-245.
- [20] Tan, X.C., F. Liu, H.J. Cao and H. Zhang, 2002. A decision-making framework model of cutting fluid selection for green manufacturing and a case study. *Journal of Materials Processing Technology*, Vol. 129, No.1–3, pp. 467–470.