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Disquisition on Green Impact of Lean Six Sigma: A Review

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Abstract - *The term Lean Production was first coined by John Krafcik in his 1988 article 'Triumph of the Lean Production System', Lean is a set of tools that assist manufacturing and helps in elimination of waste. Lean Production has been an obstacle in mass production practices in automotive industry for improving quality and diminishing defects. Research identifies the recent surge in manufacturing as the key to improving production and reducing dispensable items. Harnessing the production will be revolutionary for both customers as well as suppliers. Lean Six Sigma will help manufacturers to provide exceptional quality and refined work to customers. This paper seeks to present Lean, Six Sigma and their combination as a notion and discuss its effect on environment and resources in various forms. This paper also sheds light on the findings and research done on Lean and Six Sigma's methods which enhances product quality for customer's satisfaction as well as sustainable environment.*

Key Words: Lean, Six Sigma, Lean Six Sigma, Quality, Environment

1. INTRODUCTION

Lean and Six Sigma were proposed in 18th century and are still acquiring consequential recognition from then. Both the terms are oft-times used together as Lean Six Sigma. Year after year many organisations have inculcated these methods all over the world which are progressively utilised for ameliorating quality and performance. Lean concentrates on curtailment of waste [1] and recognising ventures that are futile for the product [2]. Additionally, Six Sigma distinguishes and banishes faults, flaw or breakdown that may hamper the process [3]. The aim and attributes can stimulate deliberation on effect of these methods on environment.

Six Sigma is quality enhancement process discovered by Motorola for improvement of various procedures [4]. Six Sigma has expeditiously procured recognition and acceptance around the world as it focusses on proliferation of productivity and cost effectiveness [5]. It is very important to understand the needs of customers so that six sigma can be implemented properly. After this, methods like DMAIC (Define, Measure, Analyse, Improve, and Control) and DMADV (Define, Measure, Analyse, Design, and Verify) are applied [6]. DMAVD which is also named as DFSS (Design for Six Sigma) [7] is bring into effect when there is discontentment in customers as the processes are unable to achieve goals. So DMADV is used for conceptualisation of new processes [8]. While DMAIC improves the ongoing processes. Hence, DMAIC is a better option as DMADV is an alternative. Organisations diagnose their problems associated with quality and amend their issues accordingly. Let us take a look at the signification of acronym:

D: Defining enhancement required process
M: Measuring integral factors responsible for respective procedure
A: Analysis for betterment of quality
I: Improving at every stage
C: Control for Enhancement and successful implementation

Similarly for DMADV:
D: Defining aim for customer satisfaction
M: Measures to be taken for quality improvement
A: Analysis of alternatives
D: Designing of methodologies
V: Verification of process before implementation

Lean or majorly known as Lean Manufacturing or Lean production acquired by various manufacturing firms for refinement in their respective processes and production by curtailment of futile and feckless items. Lean Manufacturing invented by Toyota Production focuses on recognising and adding value elements to manufactured items. It is also concerned with curtailment of non-essential elements which results in reduction of unwanted production resources [2]. Reduction of dispensable items is the main objective of Lean [1]. Nevertheless, it also emphasis on limiting the cost and enhancing quality of the desired product [9]. Inspite of this, its priority is to fulfil customer's demands and necessities. Lean comprises of handling following types of wastes - wastage of time, redundancy of production, excessive inventory, human movement, non-essential processing, importance to product in transportation and removal of material due to defects. These are the seven types of wastes which was introduced in Lean Production. One more type of waste was introduced recently by Womack and Jones in year 2010 which was regarded as disarrangement of outcome and requirements of customers [10].
The Lean follows 5S System, Kanban, SMED (Single Minute Exchange of Die) systems.

Therefore, Lean Manufacturing and Six Sigma both are quality and process enhancement which play an important role in TQM. Even if they are originated from different seeds [11], their outcomes focuses on same agenda. Lean Six Sigma was discovered in 1997 by a firm in India [12] which concerns on mitigating the defects for augmentation of processes.

2. LEAN SIX SIGMA

Combination of Lean and and Six Sigma can be used in many ways like one of the method is given by Pojasek (2003) known as System Approach. PDCA (Plan, Do, Check, Act) used with DMAIC is also used for application and implementation of Lean Six Sigma [13]. Let us talk about PDCA, it is a cyclic method for planning the objectives, executing them, corroborating the efficacy and then acting according to the process for appropriate results. Now the combination of PDCA and DMAIC together is like icing on the cake. PDCA and DMAIC are recurrent process till the aim is achieved. Now it becomes significant to infer the effects of these methods on environment and society as ministry around the globe are deploying new directives and principles. Lean focuses on economising the resources which makes it an ecofriendly process which is why the term 'Green Lean' was coined [3]. Curtailment of flaws and defects is the main objective of Six Sigma. These both can be combined as reduction of defects and can lead to saving of resources which is an indispensable part for development of feasibility of abruptly diminishing resources. It results in attaining proliferated speed of delivery with cost optimisation and depleting the defects [14]. Lean simplifies the issue of waste but do not take into account for modification and diversification. Six Sigma harmonises with lean to tackle the problems [15].

3. APPROACH

This exploration emphasis on examining the prevailing literature in production and quality for impact of Lean Six Sigma on Environment. This research focuses on the void between environmental sustainability and Lean Six Sigma correlation, and tries to fill it.

It follows structured literature review modus operandi which consist of gathering and scrutinising published articles. According to the studies [16] [17] [3] there are main four steps:

- Determining component of analysis
- Classification
- Analysis of Material
- Gathering Journals

Determining component of analysis: Qualitative analysis of high ranked papers in Lean Six Sigma, Lean and Six Sigma.
Journal :

- Operations Management
- Production Management
- Operation and Production Management
- Total Quality Management
- Service Quality
- Supply Chain Management
- Cleaner production

Keywords used: Lean, Six Sigma, Lean Six Sigma, Environment, Quality, Green Lean

Classification is done on the following: Ideology, Relevance, Application, Both

From the review paper by Chugani N.; Kumar V. et al, 2016, it is reviewed that major papers were on Lean i.e. 76%, 20% on Six Sigma, and 4% on Lean Six Sigma [18]. By this result we get to know that Lean is more popular than Six Sigma for which assumptions can be made as Lean's objective was to reduce waste and whereas Six Sigma's was to curtail flaws [1].

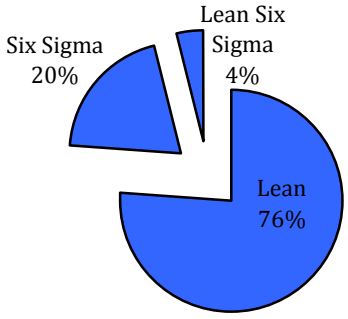

Chart -1: Classification of terms

4. RESEARCH

To balance out benefit and protection of environment, Green Lean is an ideal example which firms are implementing [19].Markets which have adopted 'Green Lean' which is a combination of green directives and Lean principles, have proved to work much superior than others [20]. According to the theory of Bergmiller and Mccright, 2009, firms with only Lean principles work less efficiently than firms with 'Green Lean' directives. The research also shows that firms with Green Lean are working finer and of higher quality because 'Green Lean' applies combination of lean as well as green which focuses on not only waste reduction but also greener supply with techniques of curtailment of waste [22].

The combination of Lean and Green imposes and emphasis on methods like 5S System, Kanban System etc [23]. Albeit, keeping in mind how Lean is predominantly contingent on adroitness of developer implementing the processes, Green Lean will also fulfil the requirements of the customers when the initiators are ecofriendly with active participation of employees in their firm. In defiance of the interrelationship between reduction of defects and preservation of resources, there is not much awareness of consequences of Six Sigma on environment. The utilisation of Six Sigma for betterment of productivity of energy can be seen in Lee at al. (2014) which also demonstrates that Six Sigma is vital for environment. The indispensability of firm to execute eco activist programmes is because of persuasion of governmental and non-governmental organisation that substantiate Lean principles [24].

Hence, Six Sigma can be considered as vital method for firms to embrace for betterment of quality and production and simultaneously have an eye on environmental practices. It is discernible from reviews that Lean Six Sigma's perspective is profitable as it defeats the aspects that is often disregarded when implemented one at a time [25]. Inspite of the fact that both the methods have their own limitations; Lean do not consider variable products and Six Sigma does that. Thus execution of Lean Six Sigma can pave the way for an organisation to obtain and secure a perpetual competitive perk as sustained advancement and development is favoured.

5. FOOTPRINTS

5.1 Lean's Effect on Resources

Lean's directive and principle guide for the firm to banish waste. There is a paucity of natural resources and raw materials so lean can give a hand in preservation of resources as it eradicates the unwanted material. Value Stream Mapping (VSM), 5S, cellular manufacturing, Total Productive Maintenance (TPM) and Single Minute Exchange of Die (SMED) are the tools studied under Lean tools [26]. VSM distinguishes scrap from production ameliorating firms to conserve materials. Similarly, 5S can contribute in recognising holes and overflows thus resulting in diminution of unwanted resources [27]. A term was developed 'Ecosphere of Lean' that helped organisations to arrange for required resources and manage time to ensure Lean principle for reduction of waste. Similarly, a model was developed for enhancement of Lean system using diversified environmental transmogrification [28].

According to the work of Matt (2014), Value Stream Mapping (VSM) comes to the aid of company to recognise the errors such as late submissions, extra inventory deliveries that were defects during processes [29]. It obviates unnecessary time, cost and resources after amelioration of errors. Failure mode and Effects Analysis (FMEA) approach is used for recognition and banishing of unnecessary materials, unwanted prolonged production, excessive time, faults and inefficient resources [30]. Main objective of rectifying these intricate problems show its ability to step towards sustainable environment.
FMEA approach consists of mainly four significant members to run this system:

1. Staff
2. Machinery and Equipment
3. Resources for production
4. Scheduling

In the study of 5-why analysis, application or use of Pareto Chart is showcased [31]. 5-why analysis is an important tool to reach to the conclusion of optimised resources and defect free production. Pareto chart in 5-why analysis came up with 'Zero Scrap', which resulted as the beneficial practice for encouraging eco-friendly production. The budding combination of 'Lean and Green' have been emerging and spreading worldwide. Green in itself focuses on eradication of following main waste - Redundant usage of water, unwanted power, unnecessary wastage of water, pollution, garbage, green house effects and excessive richness of nutrients. Governmental organisations have started to include Lean method as a way to ensure cleaner and greener production

5.2 Preservation of Lean and Energy

Lean assimilates the utilisation of Kaizen Theory which stimulates uninterrupted enhancement throughout an organisation. Kaizen is widely used throughout the world and hence is a significant application of Lean [32]. It shows the operation of Lean in energy providing industries like power industries can help in conservation of energy and resources in corporation with technique enhancement function. Another study concludes the reduction of energy upto 5-10% in energy flow of cell which encompasses how Lean and Green can pave way to sustainable environment by reducing energy exhaustion. Lean also contain 5S system with Kaizen Theory for creating an ideal work space. It substantiate more well organised functions which culminates in banishing energy used [27].

According to the discussions discussed above we come to the result that the combination of Lean and Green fits each other perfectly. Lean's principle is of diminishing waste and that of Green's is to lessen the consumption of energy which together leads to sustainable environment.

5.3 Lean's Effect – Pollution and Global Warming

Being a greenhouse gas, carbon dioxide contributes to the change in climate and is of global concern. One of the solutions to Global Warming and Pollution is to reduce the emission of carbon dioxide into atmospheric [18]. Similarly Piercy and Rich (2015) synthesised the research which demonstrated the lessening of pollution from vehicles and production through Lean [33]. Carbon value efficiency metric was invented from Lean Green principles which was aid to mitigate the carbon content which also demonstrates that Lean can pave way for better and cleaner environment. In production and manufacturing industries, it is a fact that greenhouse gases and toxic gases are emitted into atmosphere enormously. Precaution becomes necessary to get a grip in emission and henceforth organisations should participate in project preventing discharge of pollution

5.4 Six Sigma's Aftermath

Six Sigma's impetus of mitigating errors and faults inhibit exhaustion of resources. Worldwide, now almost every organisation is putting Six Sigma into play for limiting the usage of resources. According to the production, customer's requirements are examined and adjusted which greatly lend a hand in conserving resources and enhancing the process [34].

There is a conjecture that advanced technologies like Six Sigma can be highly expensive which can only be afforded by large firms where financial plan is not an issues. Despite that, usage of Six Sigma showed a tremendous opportunity for conserving resources in a small bicycle chain manufacturing firm.

5.4.1 Aftermath on Energy Management

Main objective of Six Sigma is to eliminate defects in production. DMAIC methods demonstrates that Six Sigma is meant for saving energy which in turn converts Six Sigma into an eco-friendly method [24]. Study not only verifies that it saves energy but also mends the damaged machines, lessen the utilisation of light and simultaneously increasing the usage of energy saving components. Eberly (2006), studied the reduction of utilisation of energy and innovating ideas via Green Belt [35]. From all the research and studies done by various researchers around the globe, it can be concluded that Six Sigma can be implemented by various organisations to take a step towards greener and cleaner world.

5.5 Lean Six Sigma Aftermath

Recognition is been gained by Lean Six Sigma these years [36]. Six Sigma can help in alleviating financial as well as economic decline. It also culminates waste and enhances operations. Refinement of speed and accuracy of processes can also be seen with the help of Lean tool. Lean Six Sigma strives for sustainable environment as its components achieve similar outcomes. Lean Six Sigma's objective is on deciphering quality and operatives management issues [37]. It can be used to solve problems on low productivity and recognising unnecessary elements. As Lean Six Sigma is an energy saving method also, this further helps firms to switch to Lean Six Sigma for conserving their energy [36].

6. CONCLUSIONS

An overview of Lean and Six Sigma have been examined in this study which shapes into a bedrock for this theory. Analysis of Lean Six Sigma i.e the combination of Lean and Six Sigma; has also been done in this study with its various effects on environment. Different review papers analysed in this study have gathered details including effect of various methods on environment. It is concluded from the article that Lean and Six Sigma as a matter of fact are very salient techniques in corroborating conservation of resources, inhibiting global warming and preserving energy.

Inspite of this it is perceivable that more research needs to be done on Six Sigma as only few articles are found. There is a paucity of research in articles containing Six Sigma's effect on environment. The pros and cons of application of Six Sigma is yet to be studied. Roadblocks in implementation of Lean Six Sigma like questions are yet to be answered.

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