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CONTRIBUTION OF LEAN PRODUCTION TO ENVIRONMENTAL PROTECTION IMPROVEMENT

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Abstract: Lean production is the most extended production concept currently applied in industry. Lean production is characterized by five principles (value, map the value stream, flow, pull and continuous improvement) and by the importance of reducing production waste (defects, waiting, unnecessary processing, overproduction, movement, inventory, unused employee creativity, complexity). Environmental concerns are a part of the Lean concept, although Lean production usually helps the environmental protection without really intending to. Emissions to air, water and soil, as well as waste generation, also represent a production waste (that is, no value to the customer). However, only recently conducted studies linked Lean production concept with environmental protection improvement. The main goal of the present study is to enlighten the contribution of Lean concept for achieving a better environmental performance of production systems.
Keywords: Lean production concept, environmental protection, waste

INTRODUCTION

Lean production became a leading production concept being applied in many sectors in the world, where improving product quality, reducing production costs, and being "first to market" and quick to respond to customer needs are critical to competitiveness and success [1]. Lean principles and methods focus on creating a continual improvement culture that engages employees in reducing the intensity of time, materials, and capital necessary for meetinga customer's needs. Fundamental focus of Lean production is on the systematic elimination of non-value added activity and waste from the production process. From this it can be concluded that the implementation of Lean principles and methods also results in improved environmental performance. However, only recently studies linked Lean production concept with environmental protection improvment. The relationship between Lean production concept and environmental protection has attracted much debate, and at the same time, the lack of empirical evidence leaves haphazard opinions on this matter [2]. A number of authors have proposed that the adoption of Lean production can directly improve the public good by improving the environmental performance of the adopting firms [3]. Some authors cited several organisations who have made economic savings through waste elimination and process improvements as part of their environmental programme [4]. They concluded that taking a Lean approach to waste elimination has considerable potential for environmental and economic sustainability. Also, other authors concluded that the pursuit of continuous improvement (Kaizen), created substantial opportunities for pollution prevention and waste and emissions reduction [5].

The main goal of the present study is to enlighten the contribution of Lean production concept for achieving a better environmental performance of production systems. Each of the production wastes that Lean attempts to reduce is somewhat associated with environmental performance. Hence, attention is focused on if and how Lean production creates more environment friendly production processes.

LEAN PRODUCTION CONCEPT

Lean production concept is developed as a generalisation of the Toyota Production System, which was an embodiment of previous production quality systems [6-7]. Generaly, This concept aims to reduce costs of production by eliminating waste and nonvalue-added activities and is a common underlying principle in many major businesses and production facilities around the world. In essence, Lean concept seeks to preserve value within an organisation with overall less work and thus maximising efficiency through the reduction of waste. Lean production paradigm can be accomplished by applying a wide variety of Lean production tools such as Heijunka, Six Sigma, Kanbans, First In-First Out (FIFO), Value Stream Mapping (VSM), Takt (from Taktzeit meaning cycle) time, Just In Time (JIT), Single Minute Dye Exchange (SMDE), and 5 S principles [7]. The essence of Lean production is to produce "more with les". This implies that Lean thinking organizations use less non-renewable resources in the form of raw materials and energy. This concept can be extended to determine whether Lean thinking can be applied to producing less pollution and emissions and whether Lean manufacturers are therefore more eco-friendly than traditional manufacturers [8].

Lean methods typically target eight types of waste: Defects, Waiting, Unnecessary processing, Overproduction, Movement, Inventory, Unused employee creativity, Complexity.

When companies implement several or all of these

Lean methods, several outcomes consistently result [1]:

- Reduced inventory levels (raw material, work-in-progress, finished product) along with associated carrying costs and loss due to damage, spoilage, off-specification, etc;
- Decreased material usage (product inputs, including energy, water, metals, chemicals, etc.) by reducing material requirements and creating less material waste during manufacturing;
- Optimized equipment (capital equipment utilized for direct production and support purposes) using lower capital and resource-intensive machines to drive down costs;
- Reduced need for factory facilities (physical infrastructure primarily in the form of buildings and associated material demands) by driving down the space required for product production;
- Increased production velocity (the time required to process a product from initial raw material to delivery to a consumer) by eliminating process steps, movement, wait times, and downtime;
- Enhanced production flexibility (the ability to alter or reconfigure products and processes rapidly to adjust to customer needs and changingmarket circumstances) enabling the implementation of a pull production, just-in-time oriented system which lowers inventory and capital requirements; and
- Reduced complexity (complicated products and processes that increase opportunities for variation and error) by reducing the number of parts and material types in products, and by eliminating unnecessary process steps and equipment with unneeded features.

LEAN PRODUCTION AND ENVIRONMENTAL PROTECTION

Successful implementation of the Lean concept undermines the elimination of production waste and which involves employees. While environmental waste (solid waste, hazardous waste, air emissions, waste waters, wastewater discharges) are not explicit targets or drivers for the implementation of the Lean concept, case studies and empirical evidence show that the environmental benefits deriving from the Lean concept are significant.

The application of the Lean production concept is often related to "flow and connectivity". Although not explicitly targeted, environmental benefits are embedded in the creation of this smooth and fast product flow through a production process with minimal defects, inventories, delays, and loss of movement.

For example, reducing defects eliminate negative environmental impacts associated with materials and processing used to create a defective product, as well as waste and emissions resulting from the processing or disposal of defective products. Likewise, reducing inventory and converting to a cellular production schedule reduces the need for space in the building, along with the use of water, energy and materials associated with heating, cooling, lighting and maintenance of the building.

Although negative environmental impacts, such as hazardous waste, air emissions and wastewater discharges, are often not directly identified in productive waste types that are targeted at Lean Initiatives, improvements in these areas are deeply embedded in other types of production waste. Table 1 lists the eight most common types of waste Lean concept works to eliminate, along with the environmental impact that often connects to each of them [1].

Table 1. Eight types of wastes targeted by Lean concept

Waste type	Examples	Environmental impacts
Defects	Production of off-specification products, components or services that result in scrap, rework, replacement production, inspection, and/or defective materials	— Raw materials and energy consumed in making defective products — Defective components require recycling or disposal — More space required for rework and repair, increasing energy use for heating, cooling, and lighting
Waiting	Delays associated with stock-outs, lot processing delays, equipment downtime, capacity bottlenecks	— Potential material spoilage or component damage causing waste — Wasted energy from heating, cooling, and lighting during production downtime
Unnecessary processing	Process steps that are not required toproduce the products	— More parts and raw materials consumed per unit of production — Unnecessary processing increases wastes, energy use, and emissions
Overproduction	Manufacturing items for which there are no orders	— More raw materials and energy consumed in making the unnecessary products — Extra products may spoil or become obsolete requiring disposal.

Table 1 (continuing). Eight types of wastes targeted by Lean concept

Waste type	Examples	Environmental impacts
Movement	Human motions that are unnecessary or straining, and work-in-process (WIP) transporting long distances	— More energy used for transport — Emissions from transport — More space required for WIP movement, increasing lighting, heating, and cooling demand and energy consumption — More packaging required to protect components during movement — Damage and spills during transport
Inventory	Excess raw material, WIP, or finished goods	— More packaging to store WIP — Waste from deterioration or damage to stored WIP — More materials needed to replace damaged WIP — More energy used to heat, cool, and light inventory space
Unused employee creativity	Failure to tap employees for process improvement suggestions	— Waste minimization opportunities
Complexity	More parts, process steps, or time than necessary to meet customer needs	— More parts and raw materials consumed per unit of production — Unnecessary processing increases wastes, energy use, and emissions

The cumulative effect of the concept of Lean production is a powerful means to reduce the overall environmental footprint of production and business operations, and at the same time is a significant driver for a sustainable and continuous improvement of the environment.

Figure 1 presents the relationship between Lean production's 8 types of waste and the 4 core dimensions to measure environmental performance.

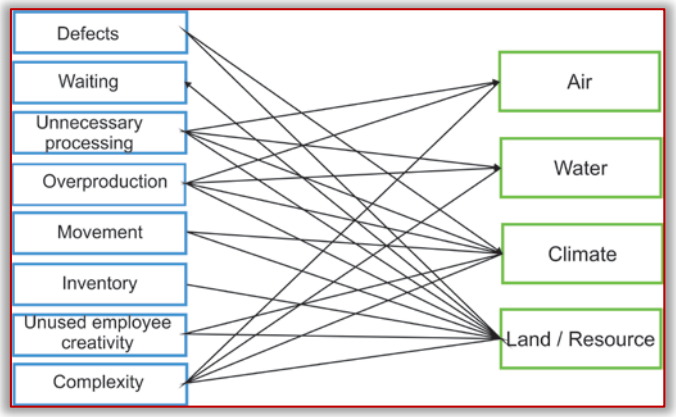

Figure 1. Relationship between Lean's 8 wastes and environmental performance measures

Some examples of positive contribution of Lean production towards environmental performance are:

— Usage of plastic pallet instead of wooden one was adopted under Lean due to short lifecycle and less durability of wooden pallet. This did improve environmental performance by utilizing reusable material (plastic) and preserving resources by not using wood and not burning it at the end of life cycle.

— Reduction in transportation of material has a dual effect. Positive effect by optimizing the operation time, reducing cost, as well as reducing emissions. But at the same time, lower inventory requires more frequent deliveries, thus an increase in emission, but it does balance itself by decreased/delayed resource extraction, and no stagnation of material in storage.

— The food industry greatly benefits from Lean concept, as by adopting JIT principles it minimize the obsolescence and wastage contributing to environmental pollutants.

— The indirect impact on environmental performance is through the utilization of Kanban systems to optimize information flow and reduce the usage of energy by avoiding over processing or incorrect processing.

— The design of assembly/production line affects efficiency. In general, a U-shaped assembly line system is given appraisal by participants, which is also highlighted by scholars [9]. It can improve efficiency by reducing motion within the processes, increase labor productivity by using less people to do the same work - so as to reduce the usage of natural resources and loss of other potential usage.

— By applying the TQM and Lean approaches, the possibility of defective product is minimized to the maximum possible extent, thus resulting in the preservation of natural resources and energy utilized for production.

In general, the environmental impacts of allocation of inventory, volume of production and defects have a strong linkage to the lean strategy [2].

CONCLUSION

Regardless of the lack of empirical data on the contribution of Lean production concept on environmental protection, but given that the essence of Lean production is to produce "more with less", implies that Lean thinking organizations use less non-renewable resources in the form of raw materials and energy and that Lean production is focused on the systematic removal of activities and waste that do not contribute to the value of the production process, which may imply that the application of Lean principles and methods also results in improved environmental performance.

Based on the presented analysis and avaliable examples from practice, it can be concluded that the Lean production concept contribute to the environmental protection. Generaly, two findings are imposed:

- Implementing Lean production concept does foster environmental protection.
- Environmental protection improvement is an added/bonus feature of Lean production.

Note:

This paper is based on the paper presented at DEMI 2019 – The 14th International Conference on Accomplishments in Mechanical and Industrial Engineering, organized by Faculty of Mechanical Engineering, University of Banja Luka, BOSNIA & HERZEGOVINA, co–organized by Faculty of Mechanical Engineering, University of Niš, SERBIA, Faculty of Mechanical Engeneering Podgorica, University of Montenegro, MONTENEGRO and Faculty of Engineering Hunedoara, Unversity Politehnica Timisoara, ROMANIA, in Banja Luka, BOSNIA & HERZEGOVINA, 24–25 May 2019

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ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering
ISSN: 2067-3809