Application of lean line feeding for increasing productivity: a case study

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Abstract

This article presents how the application of lean logistics principles to the line feeding of an assembly line contributed to the increase of productivity in a new truck plant in Brazil. A qualitative assessment on the shop floor identified a set of effective improvements and better results.

Keywords: lean line feeding, productivity; truck assembly line

Introduction

Lean production presupposes increased productivity, that means do more with fewer resources and eliminate sources of waste along the value chain (SHAH; WARD, 2003). Ohno (1988) pointed out that the lean philosophy applies to the whole company and each unit of the organization should contribute to the success of the system.

Lean production is a multidimensional management practice, including just in time, quality systems, teamwork, manufacturing cells, supplier management, among others, in an integrated system (SINGH et al., 2011). The scientific literature reinforces this approach with the growing importance of lean concepts being transferred to the administrative and production support areas, such as planning, quality, maintenance and logistics that add value to products or services, which are finally completed in the production area itself (DEIWIKS et al., 2008).

In this regard, it is possible to conceive the optimization approach called "line back", which runs the reverse order of the value added chain, starting optimizations from the assembly line (workstation), through line feeding towards suppliers.

This research addresses how Lean Production ideally connects to its supply chain making use of lean logistics with focus on shop floor level and has aimed to answer: What are the contributions of the application of lean logistics to the productivity increase of an automotive assembly line? What are the lean principles that guide the qualitative assessment of the application of lean logistics in the assembly line feeding?

The analysis and evaluation of the lean logistics supply were carried out on the shop floor of a truck assembly line of a new factory for commercial vehicles from a multinational automaker located in southeastern of Brazil.

The paper is organized to first clarify the contribution of lean logistics to increase productivity on operational level and present theoretical background based on literature. Following the research method, the case study and the results obtained are presented. At the end, the conclusions and considerations for this research are commented.

Background

Althof (2009) emphasizes that the isolated application of lean manufacturing concepts does not contribute to a systemic optimization and, not seldom, can jeopardize the operational system. The implementation of lean tools and methods in production processes influences anterior and posterior processes, such as the logistics ones (GÜNTHNER et al., 2011).

Making the manufacturing leaner in order to increase productivity implies raising the requirements for logistics processes. For example, a decrease in batch sizes requires smaller, more reliable and more frequent replenishments, which results in increased costs and change of transport processes like kitting, sequencing, picking and storage (WANNENWETSCH, 2010). Figure 1 illustrates the effect on costs:

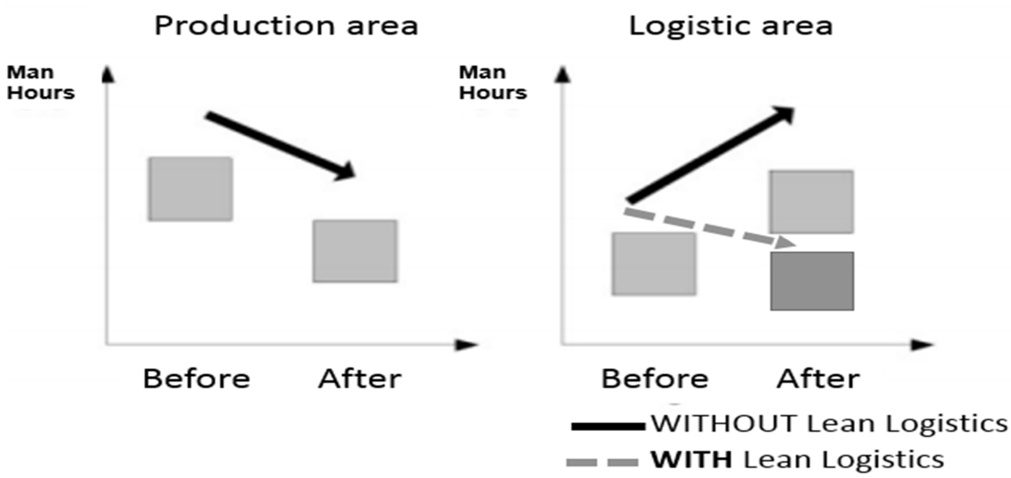

Figure 1 - Effect of the application of lean production on the logistics workload

Favaro (2008) points out that the scientific literature describes isolated implementation concepts of lean logistics on shop floor, but a proposal for a holistically sequenced deployment has not been submitted yet. A full optimization of the internal supply chain must necessarily occurs "inside out", following the so called the “line back approach” (Figure 2).

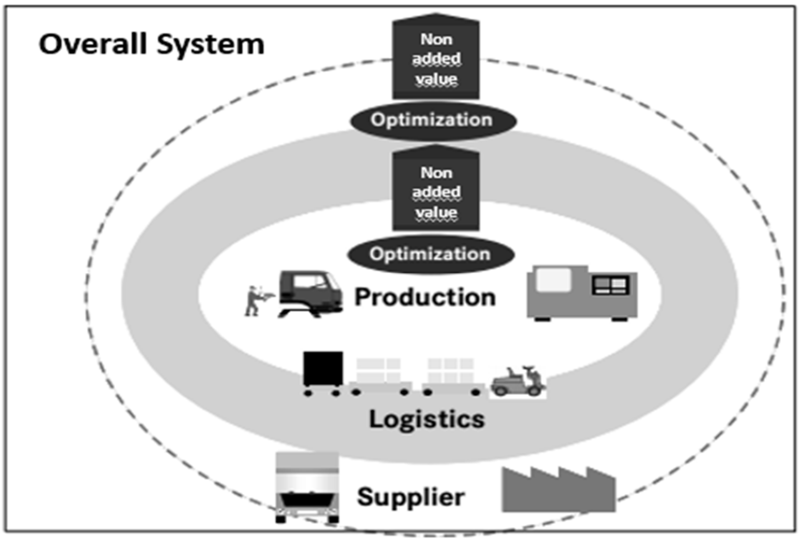

Figure 2 - Optimizations sequence according to the line back principle

This approach way runs the reverse order of the value added chain. It starts from the assembly line optimization (or workstation), eliminating waste and transferring activities, that do not add value to the product, to the next earlier stage in the value chain, for example, to the logistics supply. It continues with successive optimizations throughout the value chain various levels until reaching the suppliers level, for example, the supply of raw material.

According to the line back approach, the supply chain should be analyzed and planned retroactively, from the point of final use or assembly backwards to its origin in the suppliers, including all flows of materials and information included in the production process chain.

It should be noted, however, that before attempting to synchronize processes with partners in the supply chain, the own logistic processes must have reached sufficient maturity and stability in order to achieve a consistent target performance.

Many companies have already recognized that the implementation of a lean production requires the support of lean logistics and the interaction of both enables high efficiency gains (THOMAS, 2010). The greater standardization and stability of processes lead to lower production costs, while smaller and defined inventories improve the working capital. Thus, the increased productivity has a positive effect on profits, availability for sales and return on invested capital (REINHART, 2003; GEORGE, 2002; GOLDSBY; MARTICHENKO, 2005).

The scientific literature does not currently present any general framework of methods and tools for the lean logistics. The basic components are widely identified by the authors; however, the application of the individual components has a very different level of detail (BAUDIN, 2004; TRENT, 2008; TAYLOR; BRUNT, 2002; KERBER; DRECKSHAGE, 2011).

For the purposes of this research, the classifications described by Klug (2008) were adopted as reference, which differentiates the inner and outer areas of lean logistics. The internal ones concerning the following aspects: (a) workstation, (b) demand sign (notification) for materials replenishment, (c) materials presentation, (d) internal transport and (e) internal material turnover and storage. The external ones focus on all aspects of supplier management and transportation activities, transshipment and external storage.

The focus of this research remain on internal logistics, for which the most relevant principles are analyzed based on the current state of knowledge and the importance of the components inside the lean logistics on shop floor application.

To evaluate the conformity of the applicable lean logistic principles in the case study company the descriptions defined by Holtz (2012) were taken into account, as well as the five principles of lean thinking (WOMACK, 1996).

Method

In this research, the main goal was to investigate the contribution of the application of lean logistic principles to the productivity increase of a line feeding of a truck assembly line. The method of case study concerns the study of a problem seen through multiple perspectives and in its original context. The research was conducted as a single case study and the object of study was a new Brazilian plant of one of the leading truck manufacturer worldwide.

The main way of collecting data was through semi-structured interviews. Additionally, the research method included visits to the factory and observation on shop floor. Internal documents were consulted and selected to elaborate the questions for the interviews.

Case study

In the beginning of 2012 the production of the new truck plant from a multinational automaker of commercial vehicles has started, located in southeastern of Brazil and with about 600 employees.

A differential concept of production is to manufacture two completely different trucks (for light and extra heavy segments) on the same assembly line. Instead of using a fixed structure with a dragline, the plant has an exclusive innovative system based on automated guided vehicles (AGV) for carrying trucks between stations and facilitate assembly line changes in case of any expansion or producing new models. In addition, it allows making turns, which is essential in the assembly line adopted in a "U"-shape for reduced area utilization.

As noticed during a visit to the new plant, the internal logistics faces challenges to supply a wide variety of parts and components for various models of two lines of different trucks. To master this complexity, which would consume a huge array area of individual part numbers along the line, the solution adopted was the supply of kitting carts with defined parts per production variant, delivered to the marked assembly points in the workstations. Only fasteners and smaller parts are supplied in small packages and arranged on shelves along the assembly stations. In both cases, the delivery is accomplished by tugger trains in fixed routes and cadenced by the parts consumption in the line according to the required demand (takt time). Call of parts for replenishment occurs by scanning Kanban cards. All logistics activities are performed by a third party service provider, which includes kitting prepared according to the assembly sequence in an external building outside the plant. There is no forklift transit within the assembly building.

The existing operating system is based on the lean manufacturing, the well-known pulled production system of Toyota. Concepts of lean are well understood by the own and third party collaborators. There is no unnecessary stocks. For example, the production of finished cabs, performed on a different building, is fully synchronized and coupled to the vehicle assembly line, without the formation of intermediate stock, except the scheduled cabs in transit (pipeline).

The data for this research were collected from plant manager, final assembly manager – currently also responsible for line feeding, logistic area worker and an expert in lean manufacturing, active on shop floor projects. All of them very skilled and experienced in their areas of expertise and with deep knowledge of lean production philosophy and practices.

The researchers fulfilled a qualitative assessment of the application of selected relevant lean logistics principles applied to internal logistics. The information has been compiled and interpreted by the researchers and validated by the interviewers. The data collected were used to achieve the proposed objectives.

Final considerations

The Table 1 reports the results of the performed qualitative research based on theoretical aspects and principles and the case study as well. The main contributions and improvements observed in the studied company are presented with respect to the productivity issues from both production and logistic side.

In the Remarks column, a qualitative evaluation of the application degree of each principle was made according to a progression of phases as follows: “concept phase”, “planning phase”, “implementation phase” and “production maturity” (implemented).

Table 1 - Contributions of the application of the lean line feeding principles for increasing productivity

Aspect	Lean line feeding Princíples	Contributions to the productivity	Remarks
Workstation	Supply chain linked to takt time (customer demand)	Line feeding coupled to the whole supply chain and assembly pace allowing synchronization and best resources calculation	production maturity
	Materials in short-range reach distance	Kitting carts and shelves located to minimize movements of the assembly line worker	production maturity
	Area productivity	All materials and containers presented within the stations; kitting deliveries minimize area needs	production maturity
	Poka Yoke (mistake-proofing	Poka Yoke philosophy for logistics activities (e. g. kitting parts for variants) avoid defect products	planning phase
	Andon (status-display for abnormalities)	LCD-Displays along the line signalize also logistic problems (e. g. missed/wrong parts) and fast reaction to return to planned production output	production maturity
	Assembly triangle (walking way)	Material placed in workstation allowing single/ few picking before assembly work (less walking)	production maturity
Demand sign	Material call oriented to demand (pull)	Extensive use of eKanban (scanners and bar code plates) for efficient small containers replenishment	production maturity
	Visual management of areas and buffers	5S-methodology exemplary implemented for assembly and logistic needs. Detection and avoidance of wastes (e. g. searching time)	production maturity
Material presentation	Standard small containers	Smallest possible container for each item number (low inventory/space) placed acc. to use frequency and optimized ergonomics	production maturity
	Large parts presented without packaging	Kitting carts only with unpacked material; no unpacking by assembly worker (waste of time)	production maturity
	1:1 exchange of full and empty containers	Empty containers removed within the delivery route; reduced space requirement and efficiency	production maturity
	"One bin" principle	Lower inventories and area need: not in place, but feasible through the use of scanners	concept phase
	Kitting	First delivery choice; reduced waste from assembly side: additional logistic work to be compensated	production maturity
Internal transport	Forklift-free transport	No use in the assembly buildings: better safety & efficiency (no vertical transport, defined traffic)	production maturity
	Cycled tugger train oriented by takt time	Bigger transport capacities with defined delivery time; no searching time to look for material needs	production maturity
	Supermarkets near assembly area	Centralized kitting carts and small parts containers replenishment by third part workers outside plant	n/a
Int. storage	Material delivery near the point of assembly	Deliveries in every station as marked/ needed with less movement and walking for assembler	production maturity
	"Short trips logistics"	Full and empty kitting carts at one point (inside the assembly building): reliable deliveries, less missing /wrong parts	production maturity
	Visual management of material turnover (areas & storages)	Central replenishment area with shorter process time, clear material flow, less mistakes, better control	production maturity

Further research to evaluate quantitative figures and measure the improvement of key performance indicators is currently being conducted.

Conclusions

The assembly lines are nowadays suitable for producing a wide variety of models in almost limitless choices of combinations (mix), which translates into competitive advantage in the auto industry. This type of line requires a complex supply of various parts for each of the workstations that make up the assembly line and, often, an adjustment in the form and delivery amounts, originally received from suppliers, is required (BAUDIN, 2004).

Usually the area available near the workstations are scarce and insufficient to accommodate the diversity of materials. Assemblers can make use of parts, supplied preferably without packaging, and as specific sets (kits), arranged in the workplace by supply logistics workers, and consumed according the production orders.

The realization of productivity gains and competitive advantages can be achieved with the implementation of lean production. However, considering the whole system of production integrated actions are required with other sectors and disciplines participants of the system, such as maintenance, quality, plant and process engineering, production scheduling and, indispensably, logistics, either, supply (Inbound Logistics), plant or internal (In-plant Logistics) or distribution (Outbound Logistics).

Another important factor is that the improvement or optimization actions should be conducted “inside out", from the workstation (line back approach) and first privileging the application of lean principles ensuring a lean system with clear and stable processes, which is propitious for learning and motivating the employees involved in the change.

The application of lean principles for internal analysis showed that not only the sophistication and technology are needed to achieve good results, but much more the discipline and management, which are highly dependent on people.

This research aimed at a common understanding of concepts and principles that contribute to the implementation of a lean supply for line feeding, which will certainly lead to systemic productivity gains. Similarly, it gave support to a comprehensive qualitative assessment of the main internal lean logistics principles, which can offer evidence of the extent of implementation of the lean logistics on shop floor and serve as a parameter to focus improvement actions.

In this context, the case study contributed to the improvement of the lean logistics application in the host company and support the academic research, with access to information taken directly from the factory shop floor of an experienced multinational trucks manufacturer with leading edge lean production knowledge and best practices.

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