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Lean toolbox for seasonal process industries: A nougat fabrication case study

Tanco M[1], Santos J[2], Rodríguez JL[1], Reich J[1]

Abstract: Although lean production tools are considered an urgent prerequisite for producers everywhere, in the process industry, and particularly the seasonal process industry, there is surprisingly little use of these techniques. The aim of this paper is to analyze and facilitate the implementation of the core tools for lean in the seasonal process industry. The second part of the paper presents a brief case study of a nougat fabrication company to show the applicability of this proposal. Although process industries may need to adapt the traditional lean tools to better fit their circumstances, the case study will show how, with slight modification, several tools were applied successfully and with great impact.

Keywords: Lean Manufacturing, Process industries, Case Study, Value Stream mapping, Simulation

1.1 Introduction

During the second half of the last century, industrial companies worldwide have adopted continuous improvement systems to improve their competitiveness. Initially driven by the automotive industry, continuous improvement has expanded rapidly over the past 30 years.

One of the most widespread proposals for continuous improvement is the Lean Manufacturing philosophy, which was derived mostly from the Toyota Production System (TPS). Lean is a method for thoroughly eliminating waste and enhancing productivity (Ohno 1988). The literature defines waste as everything that increases cost without adding value for the customer (Ohno 1988).

[1] Martin Tanco, José Luis Rodriguez, Juan Reich
CITEM, Universidad de Montevideo, Luis P. Ponce 1307, 11300 Montevideo, Uruguay

[2] Javier Santos (✉)
Departamento de Organización Industrial, Tecnun (Escuela de Ingenieros – Universidad de Navarra) Pº Manuel Lardizabal 13, 20018 San Sebastian, Spain
e-mail: jsantos@tecnun.es

There are seven types of waste (Ohno 1988): overproduction, waiting, transportation, inadequate processes, excess inventory, unproductive movement and defective products. Recently, an eighth type of waste was added (Bicheno and Holweg 2008): unused human talent. Through the effective use of human talent the company can engage in the elimination of other types of waste more easily (Womack and Jones 2003).

These types of waste are very common in all types of businesses. Consequently, the main purpose of any lean tool is to draw attention to waste, by giving workers the tools to solve problems in any type of business.

However, there is still surprisingly little use of lean manufacturing techniques in the chemical and process industries (Melton 2005; Floyd 2010). This is mainly due to the fact that the process industry needs a special version of lean manufacturing because there are critical differences between process manufacturing and mechanical manufacturing (Floyd 2010).

Since there is little research available in the scientific literature on applying lean manufacturing techniques in food industries, the aim of this study is to expand the body of knowledge on lean manufacturing by focusing on the applicability of lean tools to process industries, particularly seasonal industries, using a chocolate factory as a case study. Once the lean toolbox for the seasonal process industry is set, several lean tools were applied to an important SME company from the chocolate industry in South America.

2.1 Lean Manufacturing in Seasonal Industries

In recent years a wide range of literature associated with lean production has emerged, beginning with the study by Womack and Jones (1990) that looked at the differences between mass production and lean production and highlighted the advantages of the latter. Several books were later published, presenting the whole system or specific Lean tools from a theoretical and practical perspective (Rother and Shook 1999; Liker 2004; Santos, Wysk et al. 2006; Shook 2008; Hoeft 2010; Wilson 2010, Womack and Jones 2003; Womack and Jones 2005).

With each year, an increasing number of research papers related to Lean have been published although most of them are about the use of Lean in highly automated repetitive production environments.

However, there are few publications dealing with the application of Lean Manufacturing to seasonal industries, and to the food industry in particular. Alfnes et al. (2000) proposed lean production as the solution to the flexibility requirements in the food industry. Fuentes et al. (2007) studied the applicability of lean production in the egg industry, concluding that it was indeed possible. Finally, Zokaei and Simons (2006) studied the implementation of Lean in the UK red meat industry. Unfortunately, no article related to the chocolate industry or nougat production was found in the literature.

2.1.1 Lean Toolbox for Seasonal Process Industry

The lean principles proposed by Womack and Jones (Womack and Jones, 2003) can be grouped into different aspects that are focused on production improvement. All of them suppose employee participation in eliminating waste. This section analyses the applicability of these principles to the seasonal process industry and chooses a group of tools to facilitate the implementation of lean principles.

2.1.1.1 Identifying the Value Stream

The first group of tools are oriented towards distinguishing between value and waste. Their objective is to identify the sources of waste and variability in the transformation process. These tools can be applied in any process, including the seasonal process industry, and the most useful tool is Value Stream Mapping.

Value Stream Mapping (VSM). VSM is a visual tool that helps managers to see and understand the material and information flow as the product passes through the value chain. The key benefit of value stream mapping is that it focuses on the entire value stream to find system-wide waste and tries to avoid the pitfall of optimizing some local situations at the expense of the overall optimization of the entire value stream (Wilson 2010).

Through the analysis of the value stream, a company can understand customer demand and provide value-added activities in order to meet customer demand. There are some applications of VSM in the literature, although it is most frequently applied in highly automated processes or in assembly environments (Hines, Rich et al. 1998; McDonald, Aken et al. 2002; Braglia, Carmignani et al. 2006; Abdulmaleka and Rajgopalb 2007; Sahoo, Singh et al. 2008; Alvarez, Calvo et al. 2009; Liu and Chiang 2009).

2.1.1.2 Improving Materials Flow

There are several explanations for the high levels of inventory in the process industry. For example, most of the raw material must be purchased in large quantities so as to supply the entire season with a single order because providers necessarily provide smaller amounts when needed. As a result, reducing the inventory of raw materials and packaging material must not be emphasized. However, reducing Work-in-Process and finished products is within the scope of most companies and therefore it should be done.

At the same time, in the process industry material flow is determined by batch size and thus it is not possible to propose a one-piece-flow strategy in the same way proposed for the assembly lines. However, there are many movements involving workers that can be analysed using tools such as Spaghetti Diagrams.

Spaghetti Diagram. The spaghetti diagram is a simple yet powerful tool for visualizing movements and transportations (Wilson 2010). When the transportation paths are seen, it is often easy to spot opportunities to reduce these wastes. It is especially useful to follow and draw worker movements to try to find and remove unnecessary movements. Moreover, analysing the current situation can be useful when comparing it to the proposed improvements.

2.1.1.3 Increasing Equipment Effectiveness

The main set of lean tools is focused on increasing equipment effectiveness (SMED, Poka-Yoke, TPM, Jodika, etc.), and all of them can be applied to any type of company. In this toolbox, the OEE rate, which is included in TPM philosophy, is proposed as the key tool for equipment improvement.

OEE (Overall Equipment Efficiency). This is an equipment efficiency indicator, developed by Nakajima (Nakajima 1988). The objective of OEE is to numerically describe production effectiveness. It can be used for value stream or individual workstations. OEE is characterized by the key production losses. Figure 1 illustrates how these six main losses are grouped together. In addition, the grouped losses define three basic indicators: availability, performance and quality, all of which lead to an expression for overall equipment efficiency (OEE).

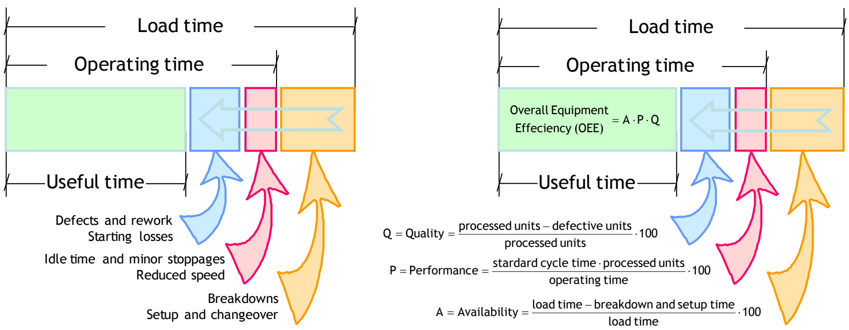

Fig. 2.1 Grouping causes to obtain the useful time (left) and the three main rates (right)

2.1.1.4 Rationalizing Work Balance

Work balance refers to a situation where all the operators along the production line require the same amount of time to perform their tasks. Ideally, the work content is distributed evenly between workstations to meet the Takt-time. The idea is to balance the assignment of operations to workstations so that idle time and the number of people working on the line are minimized (Liu and Chiang 2009).

Time study. A time study can be defined as the methodology used to determine the time that is required for a skilled operator to perform a specific task, working at a normal pace during the work day (Niebel and Freivalds, 2003). A time study provides information that can be used to minimize idle time and balance the production line.

2.1.1.5 Simulation for the Analysis of Proposed Improvements

The main problem in seasonal production is the limited amount of time available to implement improvements when the floor is running. Similar to an F1 race, where drivers use simulators to obtain information in several trials before the actual race, in the production floor of a seasonal factory, the improvements to be tested in the "trial" had to be chosen so that they could be implemented with the available resources. Consequently, simulation software is recommended to present the current state of the factory and try to define as many experiments as possible to determine the best production flow.

3.1 Case Study

The case study was carried out at a major chocolate plant in the Mercosur region (the economic and political agreement among Argentina, Brazil, Paraguay and Uruguay). The aim was to improve the productivity of the nougat production processes in the plant through the application of the proposed lean toolbox.

The first tool that was applied was a “door to door” VSM of the nougat production process. The entire nougat production could be considered as a single product family since it passes through similar processing steps and common equipment in the downstream processes (Braglia, Carmignani et al. 2006).

The current state VSM shows the actual process is as follow: The mass of nougat obtained from the "pot" is then used in the so-called “kitchen” so that after several processes nougat bars are fashioned. They are cooled to room temperature and then each one can be dipped in chocolate and directly packaged into flow packs. After this the nougat bar is placed inside a cardboard case. The latter two processes are carried out with machinery (called cartoners), while the processes in the kitchen are manual.

Figures 3.1 and 3.2 show the current and the future VSM. The size of the figures is too small to be read but they are included simply to compare visually both situations. The following paragraphs will summarize the improvements to achieve this future state. Due to the length of the present paper it is not possible to describe in detail the applications of those tools, but the results will be presented.

By comparing future state lead time with the current state, an expected decrease from 18 to 3 days can be demonstrated. This major improvement of 15 days is mainly brought about through lower WIP inventories before going to the cartoner and smaller finished product inventories waiting for expedition. This reduction in lead time could easily translate to lower financial costs and lower inventory management cost.

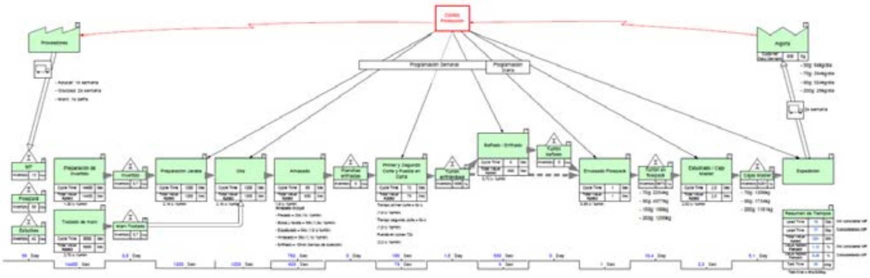

Fig 3.1 Current state VSM

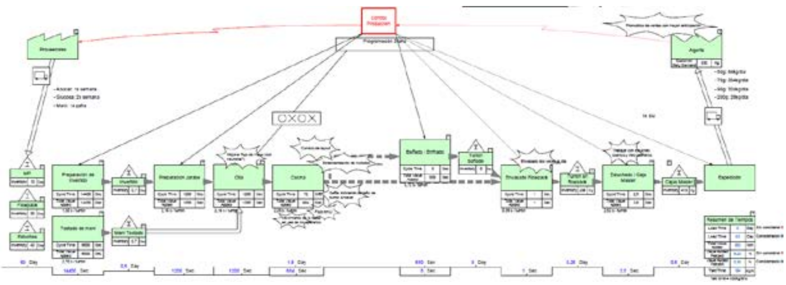

Fig. 3.2 Future State VSM

In addition, a metric to measure the efficiency of an organization in delivery value added is called Work Cycle efficiency (WCE), and it can be easily obtained from the VSM (Ballis 2001). WCE can be defined as the amount of Value-adding time divided by the total cycle time. The WCE for the current situation was extremely low: 1.17%. This means that the rest of the time, that is 98.83%, does not add value to the final product. The future state VSM shows a big but not yet sufficient improvement in the WCE metric.

This metric also indicates where attention should be directed in order to significantly improve the percentage of value added time. Consequently, the value stream map allowed us to identify the major non-value added steps, concluding that the days of stock generated prior to using the cartoner have the most influence on WCE. The generation of high stock levels before using the cartoner can indicate that it is the bottleneck in the chain, so we undertook an analysis of this machine.

The cartoner's average values for the OEE rates for this period were Q = 98.9%, P = 64.0% and A = 89.9%. As Figure 3.3 shows, both the quality and availability of the machine are close to target levels. However, performance is the element that is detrimental to the OEE.

Initially we studied the effect of case quality and the number of operators on the performance metric, obtaining an effect of 20% and 28%. However, we decided to study how production is affected by these two factors together. Therefore, a General Linear Model (GLM) was used to analyse this issue. This model, developed with Minitab®, clearly illustrates how the use of high quality cardboard cases and three operators leads to an improvement of about 48%, as compared to the performance obtained by using two operators and bad quality cardboard cases.

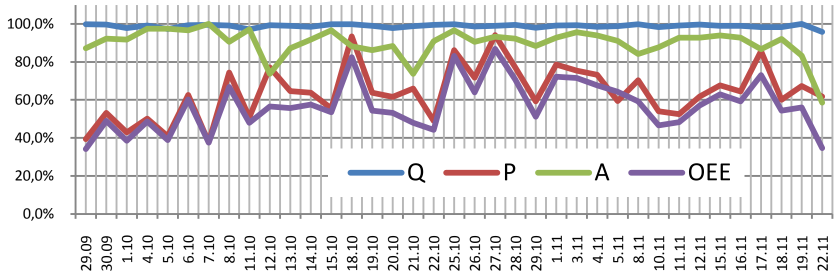

Fig. 3.3 Evolution of the OEE rate

Once the cartoner was analysed and improved—improvement was soon noted since the WIP upstream had decreased—the bottleneck moved to the "kitchen" production process. In this case, once the time study was carried out, a balancing diagram and a spaghetti diagram could be constructed with this data. An analysis of this diagram indicated that several of these movements could be reduced by making improvements to the layout.

Those improvements where tested in several experiments simulated with Arena®, a software application that simulates discrete events. After implementing the proposals the number of kilograms produced daily in the simulation differed 6% from the real values. Since the value added time remained constant and lead time was reduced, the improvement of WCE went from the initial 1.12% to 6.23%.

6.1 Conclusions

This paper presented a lean toolbox for seasonal industry and applied it in a case study. This application has demonstrated that although process industries need a special version of the lean manufacturing tools, several lean manufacturing tools could be applied in the traditional seasonal industry. Several techniques and analyses were carried out through this case study such as Value Stream Mapping (VSM), implementation of the Overall Equipment Efficiency (OEE), Spaghetti diagrams, Work Balance, and discrete event simulation (those last three tools were not been presented in the paper). This case study presented promising improvements mainly in lead time and Work Cycle Efficiency.

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