Increase Plant Productivity Using an OEE Approach: An Application

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Abstract

European refrigerated food companies must be highly efficient under a very competitive environment. That is the case for one of the leading conglomerates based on Spain. After an unfortunate event where the group´s largest frank production plant was unable to continue working, the company adopted a sense of urgency to achieve customer demand increasing the efficiency of the rest of its production network by 25-30%. The current study has the purpose of describing the experience of applying the concept of Operational Equipment Effectiveness in a Spanish frankfurter plant. This approach is imbedded into a Theory of Constraints scheme that insures a positive contribution to the objective of increasing productivity with each initiative implemented. A description of the results achieved is provided.

Keywords
productivity; theory of constraints; efficiency; availability; performance; quality

1. Introduction

Evolution towards a global economy plunge companies to a highly competitive environment. To maintain a certain level of competitiveness, firms aim for productivity and strive to exceed customers' expectation. As noted by Dollar et al (1993), the best overall measure of competitiveness is one that hast long been used in international comparisons: productivity. Additionally, Fleisher et al., (2006) state that the competitiveness of manufacturing companies depend on availability and productivity of their facilities. This means companies nowadays are forced to innovate, work faster and offer perfect choices at a glance. Huang et al., (2003), due to intense global competition, companies are looking for opportunities to improve and optimize their productivity to remain competitive.

The previous situation has been the case for a European corporate company that manufactures refrigerated and frozen products. After an unfortunate event where the group´s largest frank production plant was unable to continue working, the company adopted a sense of urgency to achieve customers demand by increasing other plants production in the very short term by 25-30%. Making this happen required bottle neck elimination and productivity raise. This situation led to the need for a performance measurement system that account for the different important elements of productivity in a manufacturing process.

According to Nakajima (1998), Overall Equipment Efficiency (OEE) is an effective way of analyzing - efficiency of a single machine. As Hansen (2002) states, OEE has been recognized as a fundamental method for measuring equipment performance. The OEE measure attempts to identify wastes and the costs associated with a piece of equipment. However, as Scott et al., (1998) point out the gains made in OEE at the equipment level, are not enough. It is necessary to focus beyond - performance of individual machines towards - performance of the whole factory. The main goal is owning a very efficient integrated system.

This suggested scheme is based on Theory of Constraints and the OEE concept. The following paper shares an approach based on overall equipment effectiveness (OEE) to achieve the desired results with the purpose of increasing productivity at plant level for an international frank production company. The document is divided into various sections. The following section makes a review of relevant literature. Then, a description of the suggested scheme is given in section three. Section four provides a summary of the application of the scheme in the Spanish company. Finally, the last section provides conclusions and suggestions for future research.

2. Relevant Literature

There is considerable amount of literature on manufacturing system productivity measurement and improvement. The total productive maintenance (TPM) concept, proposed by Nakajima (1998) can also be used as the basis for defining productivity improvement strategies. This concept suggests a quantitative metric called Overall Equipment Effectiveness (OEE) for measuring productivity of individual equipment in a factory. It identifies and measures losses of important aspects of manufacturing operations such as availability, performance and quality rate.

As suggested by Iannone et al., (2013), OEE is not only a metric, it also provides a framework to improve the process. A well-done model for OEE points out aspects involved in the process that can be improved, this means the identification of losses that keep equipment from achieving maximum effectiveness is crucial. The OEE tool is designed to identify losses that impact on equipment effectiveness. The six big losses considered by OEE are breakdown losses, Set-up and adjustment losses, idling and minor stoppage losses, reduced speed losses, quality defects and rework, and finally, reduced yield during start-up.

The three concepts (availability rate, performance rate and quality rate) captured by the OEE measure indicate the degree of satisfaction to output requirements. As pointed out by Williamson (2006) the OEE measures the degree to which the equipment is doing what it is supposed to do based on availability, performance and quality rate. The value of OEE, which is a function of availability (A), performance (P) and Quality rate (Q) is obtained by the product of their values.

2.1 Evolution of OEE

In a lean environment, the negative consequences of machine breakdowns and production disruptions cannot be accepted as they prevent the creation of value for customers and cannot be compensated anymore. Thus, a rigorously defined performance measurement system is indispensable to control such kinds of losses. This is the origin of the Total Productive Maintenance (TPM) concept launched by Nakajima (1998) the objective of TPM is to achieve zero breakdowns and zero defects related to equipment, which could lead to improvements in the production rate, reduction in inventory, reduction in costs and eventually increases in labor productivity.

OEE was first described as a central component of TPM by Nakajima (1998), it was well-known as the basis for developing productivity improvement strategies. According to Huang et al, (2003) though the OEE tool has become increasingly popular, it is only limited to measure productivity behavior of individual equipment. As mentioned before, the gains made in OEE at the equipment level, are not enough. (Scott et al., 1998) It is necessary to focus beyond the performance of individual machines towards the performance of the whole factory to achieve an efficient integrated system.

As reference Oechsner et al., (2003) state, the final goal of any factory is to have a highly efficient integrated system. This weakness of the OEE tool has led to its modification to fit different and broader perspectives in the manufacturing systems. Therefore, different modified formulations have emerged in the literature. Some of these are the Total Equipment Effectiveness Performance (TEEP) proposed by Invancic (1998) and the

Production Equipment Effectiveness (PEE) formulated by Raouf (1994). The OEE concept was extended by Oechsner et al., (2003) to measure the factory level effectiveness, where several production steps or machines are included to form a production process. The authors suggested a new measure called overall factory effectiveness (OFE).

Another approach proposed by Huang et al., (2003) considers simulation analysis as the most reliable method in studying the dynamic performance of manufacturing systems. On the other hand, overall throughput effectiveness (OTE), developed based on OEE metric, for complex connected manufacturing systems.

3. Description of Improvement Scheme

The improvement scheme considered in this work mainly considers availability and performance pillars from OEE, together with an improvement procedure based on Theory of Constraints (TOC). As Goldratt et al., (2014) suggest, the productivity of the manufacturing system is determined by a bottleneck or the most constrained capacity resource. According to Huang et al., (2002) state that this type of resource is the one with the highest OEE value.

As a matter of fact, Goldratt et al., (2014) developed an improvement cycle of 5 easy steps in which TOC and OEE manage to increase the productivity of the manufacturing system under study. The first two steps consist on estimating OEE values for each of the production resources involved in the manufacturing system under analysis. After that, the third step lays on identifying the most constrained resource or bottleneck by identifying the one with the highest OEE value. When you finally have this information, any losses and wastes present in the system must be identified. Wastes found are directly associated with availability, performance and quality efficiency factors of the bottleneck. Finally, all information needed in order to define projects and specific actions is gathered and in order to eliminate the wastes found, actions must be repeated until the constraint is broken and becomes desirable to continue improving productivity of the system.

To achieve the results wanted in the previous procedure, all OEE values per capacity resource of the operations system must be known, therefore the identification of the bottleneck may be done. Without OEE information, the correct identification of the bottleneck cannot be guarantee. In this paper, the procedure applied is most likely the same. The procedure is described as follows:

(1) Elaborate a data analysis for the process of interest.
(2) Identify the three production lines in worst conditions and estimate its OEE index and corresponding efficiency factors.
(3) Identify the bottleneck or more restrictive resource.
(4) Identify specific actions in order to eliminate wastes found, implement them.
(5) Repeat previous step until the constraint is broken or a new bottleneck is found, continue working till it improves the production system. In case a new bottle neck is found, continue to step 3. Otherwise, the process is over.

4. Implementation of the scheme

This section is focused on the application of the previous scheme to a Spanish plant that is part of the manufacturing network of an international frank producer. This plant produces 160 different SKUs in nine lines. The process followed in the frank production process goes as follows:

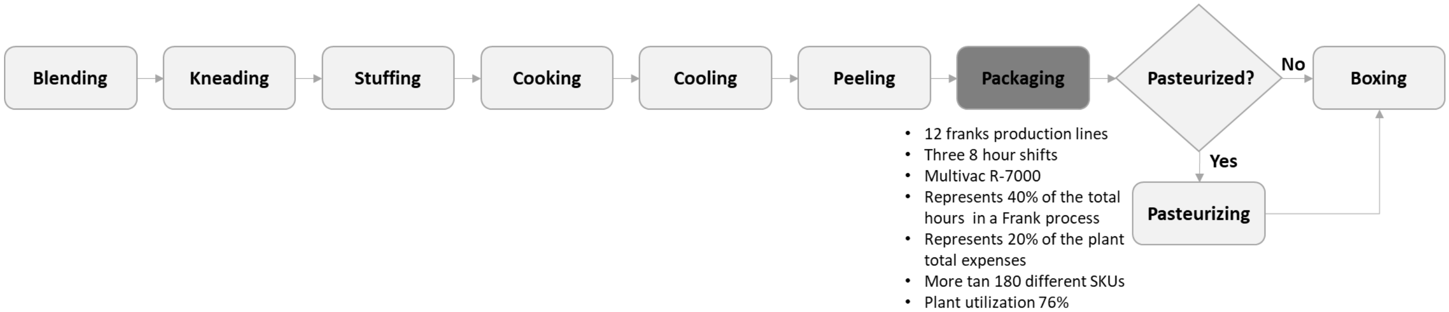

Figure 1. Franks Production Process

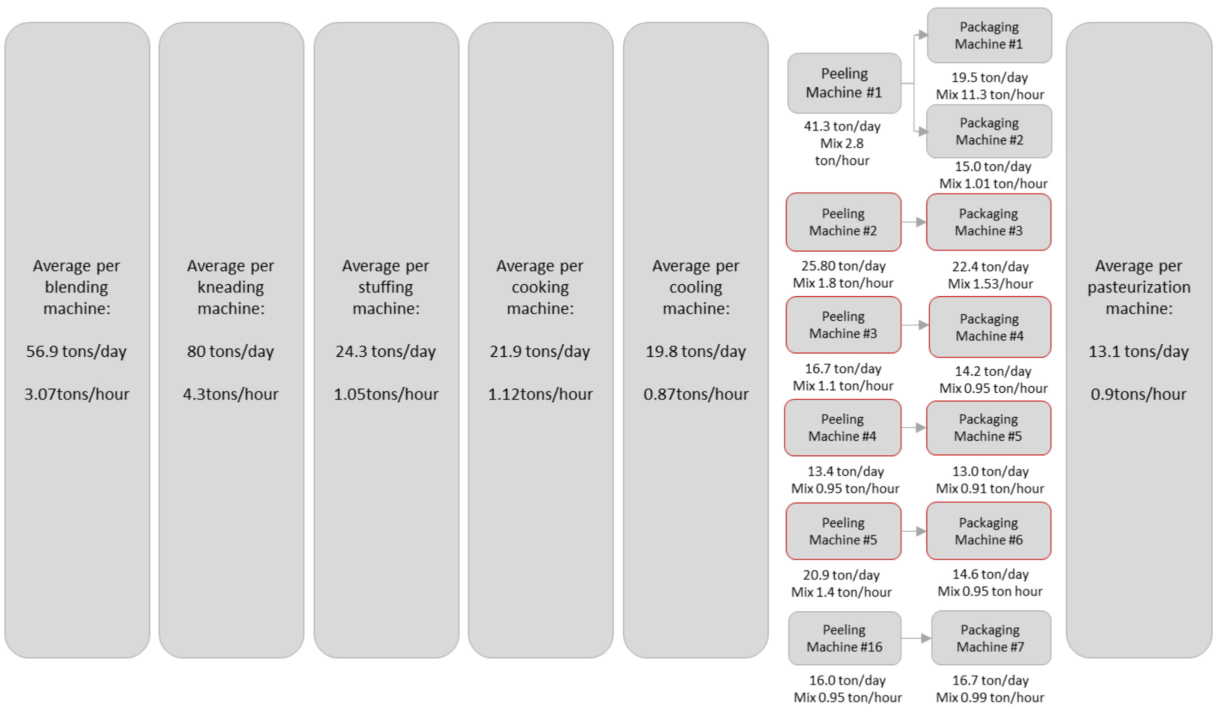

Figure 2. Franks Production Bottlenecks

The process began with the blending of all ingredients needed, some of the many SKUs made contained different kind of species and flavors, even some of them were made up of pure vegan ingredients. After everything was correctly mixed the kneading began and as it came out of the process it went directly to one of the production lines to proceed with the stuffing process. As the racks came out of the stuffing process, personal took the cars into the cooking cameras and continued to the cooling process once cooked. After a couple of hours in the cooling rooms it was time for peeling the franks for them to be packed.

For this project three of the four red outlined lines signaled in Figure 2 were selected, two of the lines continued their process going through a pasteurizing process, the other one continued directly to the last process in which all franks are placed in boxes either by an automatic machine or manually. The packaging process is colored in yellow since it was the process selected to develop this project. One of the main reasons why this process was selected is that it represents 20% of the plant´s expenses. On the other hand, corrective maintenance is frequently required for this part of the process.

As mentioned before, three franks production lines were selected after a deep analysis which demonstrated 40% of total working hours in a year came from these lines plus, they represented some of the most important SKUs, which came in different formats, including franks filled with cheese, German style franks, regular hot-dog and jumbo franks. The layout of each of the three selected lines area illustrated in Figure No. 3., No. 4., and No. 5.

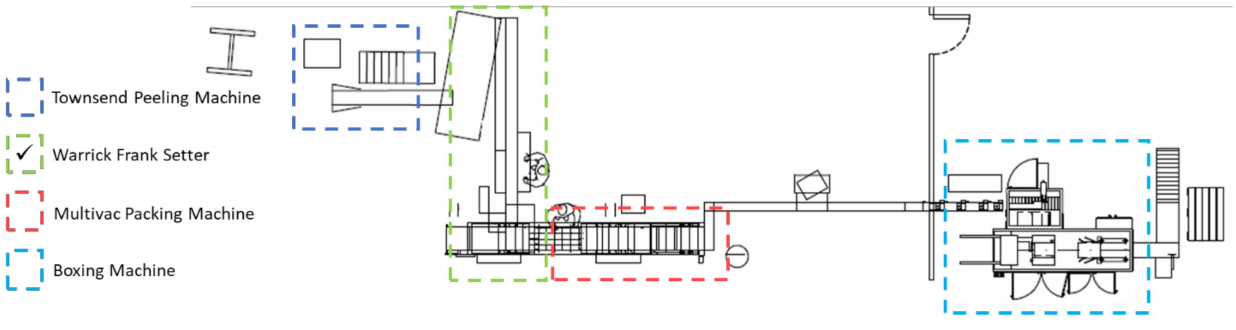

Figure 3. Layout Line 3

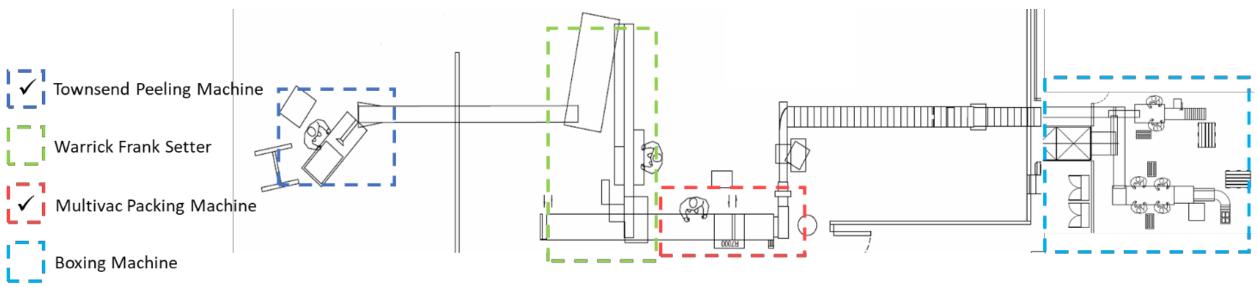

Figure 4. Layout Line 7

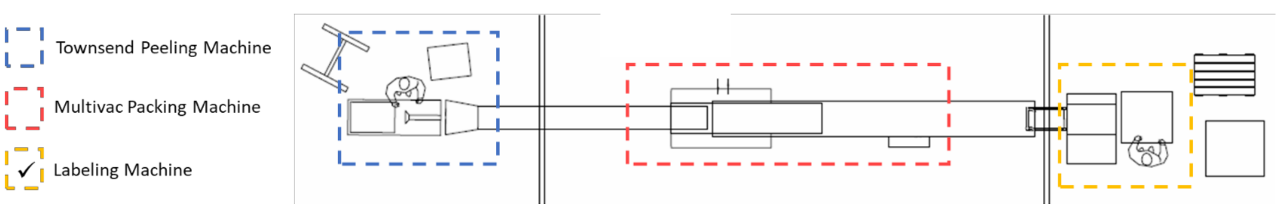

Figure 5. Layout Line 9

This suggested scheme is based in OEE, TPM and TOC concepts. What must be done was clear, focus on increasing production by reducing downtime occurrences per week, as well as set-up times and frequency. The most important question was “how?”, and clearly OEE was going to be the main player, after having the results for each line, bottle necks were defined (marked with a check mark in Figures above) and problem solving began.

The initial stage of the proposed approach consists in elaborating a deep analysis in order to understand the overall context of the problem of concern. Production volume, understanding company´s demand behavior, among other general aspects studied. A deep analysis was done for each of the 9 production lines in the factory, this is essential as it provides the foundation to decision making. As illustrated in Figure 6, three of the production lines were selected considering total working hours, downtime and corrective maintenance interventions. This is a fundamental aspect of the TOC approach to understand the overall context of the system under study (Goldratt et al., 2014), and in this case, to determine the production lines with worst performance and which were required to improve to cover the demand and satisfy certain criteria of performance.

As the approach suggests, once production lines are selected, estimation of OEE index and efficiency factors per line was done and identification of bottleneck began. The bottleneck in each of the lines is signaled with a check mark in the layouts above. This data allowed to start taking records of the lines behavior and begin optimizing the work place. Implementation of 5-Ss and Visual Cues should be the first effort of mobilization as Smith, et al., (2004) state, the creation of efficient work environments facilitates lean vision, or the ability to "see" the waste more clearly.

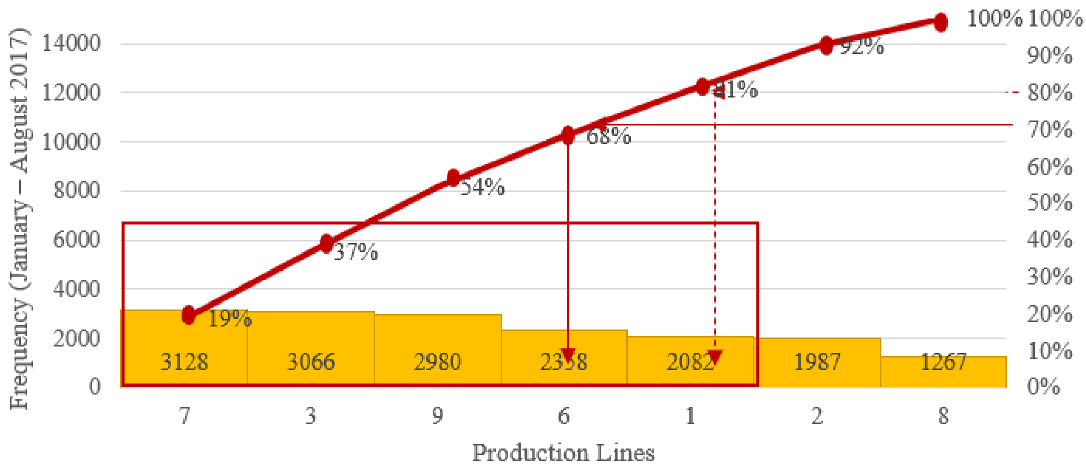

Figure 6. Frank production lines downtime frequency

Once bottlenecks were identified per line, specific actions were defined and tools as SMED were implemented. In the case of Multivacs, the trouble was with the film and the transversal cutting knives, since they were not well sharped, and the line had to stop several times to un tangled a set of final product packages. The solution consisted in implementing a preventive maintenance routine and an inspection before and after production.

On the other hand, Warrick machine had trouble at setting franks the right way and some springs damaged franks and broke them, the franks came out and went directly to rework. The machine had to be reset, and a lot of time was lost, plus corrective maintenance interventions were required at least 3-4 times in 8 hours shift. Benchmarking with Mexican plants helped to understand the way a Warrick required treatment, preventive maintenance routines were implemented, and new parts were required as a deep inspection was made.

The results were better than expected, a combination of actions that attacked downtime frequencies and duration time, well organized work place, line breakdowns, corrective and preventive maintenance routines, autonomous maintenance performance and efficiency together, improved the OEE index in around 5% and reduced more than 15% of breakdown time that was previously lost and affected production.

Lines efficiency improved by 9%. For line 3, OEE went from 53.7% to 67.8%, for line 7 OEE went from 51.1% to 63.1% and for line 9 OEE went from 59.1% to 64.3%. This improvement led to an increase of franks production of 17.5 tons per week.

5. Conclusions

With the 15 hours week gained after the implementation of the previous described scheme, the plant was able to produce 17.5 tons per week. Lines efficiency went up by 11%, this had not been reached since the production had risen in a 28%. Sharing best practices lead to the implementation of better maintenance routines that provided better equipment efficiency and resulted in a better working environment. The combination of important tools such as OEE and TOC, resulted in important factory level discoveries, its easy replication allowed the factory to continue a horizontal deployment to the rest of 9 franks production lines.

A highly efficient integrated system is possible; with the help of a combination of TPM tools, results were exceeded. As mentioned in the introduction, the gains made in OEE at the equipment level, are not enough, Scott et al., (1998). TPM, TOC, OEE plus operators' knowledge where the key ingredients for success, considering best practices shared by operators in plant around the world gave this project the extra needed to perceive results.

Some further recommendations would include considering TPM by itself is already a powerful set of tools that are proven to work, but an operator's knowledge should never be less important than any tool. Consider the amount of time a day some operators share with a production line, they know and understand, any little noise or vibration made by a machine. Sometimes, given competition and time pressure, people forget the most important resource in a plant is human resource.

Once again literature is proven right, the results of TPM and its combination with almost any other engineering tool are real. Having the opportunity to read, understand and apply what learned in real life was such a delight, what is next is to share this practice to other plants for them to learn from what done with these franks production lines and start working for results.

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