Productivity Improvement in a Sugar Company: A Lean management approach

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Abstract

This article analyzes the factors that generate low productivity in the sugar cane juice extraction area of a sugar mill in northern Peru. It focuses on determining how the production process is being carried out and the time wastes that generate economic losses. The objective is to determine the overall efficiency of the equipment and apply improvement strategies to increase the availability, efficiency and quality of the process. The company is currently grinding an average of 3603 tons of cane per day, but its installed capacity is approximately 4800 tons of cane per day. The cane juice extraction area is the starting point for the sugar plant to achieve the best yields within its manufacturing process. The strategies applied in the cane juice extraction area allowed increase the sugar production.

Keywords
Productivity, availability, efficiency, quality, production.

1. Introduction

The juice extraction area is responsible for preparing the cane for milling, but there are always stops during the process. These stoppages are due to a lack of cane for milling and lost time in the extraction process, such as derailments in the feeder table, failures in the conductors and in the chains that feed the cane to the conductors. There are also problems in the transmission belts. The shredders have hammers that help break up the cane; these hammers also suffer damage when a metal piece passes through the cane or when stones are present. The mills also break down when metal debris is inserted into the extraction grooves, causing the mills to shift off-center and causing stoppages. Even with these failures and stoppages, the company only applies corrective maintenance and stops the entire process. All these failures and breakdowns reduce extraction efficiency or productivity. The sugar cane juice extraction area has a production capacity of 4800 tons. The extraction system has an extraction mill consisting of a tandem of 7 mills (the 5th mill is currently cancelled). Each mill is driven by a variable speed DC motor. The design speed of the mills is 54 ft/minute. The extracted juice is sent to the elaboration area following the sugar elaboration process, the by-product bagasse is obtained and used in the power plant to generate steam and electricity for the agro-industrial plant.
This paper presents a case study of a company dedicated to the sugar production where one of the losses of time and efficiency in the juice extraction area is caused by extended machine breakdown time. However, the company has high machinery downtime, which directly impacts production, generating economic losses: raw materials that are rejected and the payment of penalties for non-compliance with delivery deadlines (Glock, 2013). The aim of this study is to measure, analyze, and developing strategies to increase productivity by making reductions on waste time and adjustment on capacity flow. For this, the company decided to consider the basic principles of lean management such as the 5s and to evaluate the efficiency of the machinery, in addition to training the workers.

2. Methodology
The first thing is to make a diagnosis of the production process: through machine performance observation-monitoring to verify unplanned stoppages, identify the waste, implementing 5S and improve the processes to reduce wastes. The five S's allow to engage workers in achieving the goal of improving productivity. The second step is identifying the Overall Equipment Effectiveness (OEE) which allows us to know the real situation of the machinery and equipment and to be able to determine the frequency of failures and waste times (Yakusawa; Brown; and Black, 2014). Waste in a process (easier to understand with the labor productivity is you can think about wasting time), anything that is not contributing to the output is considered a waste. And it also results in inefficiencies. Waste reduces productivity. But what is more important for those involved in the operations and driving lean production is that the reduction of waste means understanding the operations.

2.1 5S principles
The 5S as a methodology is very helpful for improvement processes in short time due to its practicality and simplicity. In this sense, the flow of activities is clear and efficient. (Bayo; Bello; and Merino, 2010). The 5S is a strategy that help to modify and clean the shop floor but at the same time allows the identification of waste times that generate non-value added activities (NVAA) (Barcia; Hidalgo, 2006).

<table>
<thead>
<tr>
<th>Steps</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sort (Seiri)</td>
<td>Sort is the process of removing all the items not needed for current production from the workspace. An effective tool that will help you with your sort process: red tags (identify objects that need to be removed from the workplace)</td>
</tr>
<tr>
<td>Set in order (Seiton)</td>
<td>Set in Order is the process of putting everything in a place that is easy to get to. All items should be clearly marked so anyone can easily find its proper home</td>
</tr>
<tr>
<td>Shine (Seiso)</td>
<td>Shine means removing all the dirt and grime and keeping the workplace clean on daily basis. You want to get it clean and keep it clean</td>
</tr>
<tr>
<td>Standardize (Seiketsu)</td>
<td>Standardize creates a system of tasks and procedures that will ensure the principles of 5S are performed on a daily basis.</td>
</tr>
<tr>
<td>Sustain (Shitsuke)</td>
<td>Sustain gives your staff the commitment and motivation to follow each step, day in and day out.</td>
</tr>
</tbody>
</table>

2.2 Overall Equipment Effectiveness (OEE)
The Overall Equipment Effectiveness (OEE) is a performance indicator used to measure equipment utilization. OEE is calculated by three index: availability (A), performance (P) and quality (Q) (Fig. 1). The OEE, which focuses on measuring the effectiveness level to prevent the loss of production time caused by breakdown on the machine, at the same time it can be used to identify where to focus resources.

The sugar company utilizes OEE to monitor and improve process efficiency considering a scale of priorities of availability at 90%, performance at 95%, and quality at 99% (Willomtt; McCarthy, 2000).
2.3 Capacity analysis
The capacity analysis allows to calculate resource capacity in a process of one type of flow unit and then identify the process bottleneck and calculate the overall process capacity. This mean to determine the flow time and the flow rate of the process, and calculate process utilization and utilization of the resources in the process (Cuatrecasas, 2017).

3. Result and discussion
In the case of the sugar company, data were collected from the sugar cane juice extraction area, where the main failures that cause system stoppages were considered. The results of the months of study are presented in Fig.2, Fig. 3, Fig. 4:

![Figure 2. Overall Effectiveness Equipment – Month 01](image)

<table>
<thead>
<tr>
<th>Time</th>
<th>Waste time reasons</th>
<th>Index OEE = A * P * Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loading time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downtime losses</td>
<td>Equipment failure</td>
<td>Availability(A) = Operating time / loading time</td>
</tr>
<tr>
<td></td>
<td>Setup/Adjustment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Idling/Minor stop</td>
<td>Performance(P) = Net operating time / Operating time</td>
</tr>
<tr>
<td></td>
<td>Reduced speed</td>
<td></td>
</tr>
<tr>
<td>Net operating time</td>
<td>Speed losses</td>
<td>Quality(Q) = Valuable operating time / net operating time</td>
</tr>
<tr>
<td>Valuable operating time</td>
<td>Defect losses</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reduced yield</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Index of Overall Equipment Effectiveness (Singh, et al., 2013)
This evaluation was carried out with the purpose of determining the efficiency of the equipment by means of availability, efficiency and quality indicators, and thus be able to propose the respective corrections to improve the whole process of cane juice extraction. With the data obtained, the three-month average of the overall effectiveness of the equipment was determined, resulting in an average of 72.66%. The value obtained is not the best or the worst, but it is an indicator to be improved in order to increase the productivity of the sugarcane juice extraction area.

With a failure frequency of 39 and 30.27 hours that the machinery was stopped is the failure of the cane conveyor, followed by mechanical failures in the crane (8.47 hours) (Fig. 5). At the second month the cane conveyor had a failure frequency of 23 and 19.13 hours stopped (Fig. 6). In the third month, the main failures were in the cane conveyor, shaft breakage, mechanical problems in the gears and cane jamming in the conductors (Fig. 7).
Figure 5. Downtime in the month 01

Figure 6. Downtime in the month 02

Figure 7. Downtime in the month 03
In the three months the accumulated failure hours in the cane transport is 57.41 hours and in the rest of the machinery is 93.97 hours. Consider that we are only taking into account the failures of the main equipment and based on this, implement improvement strategies.

The first action was to select qualified personnel to operate the machinery and equipment. Then the selected personnel were trained in the 5’s methodology, machinery operation and maintenance.

Maintenance training was carried out with personnel specialized not only in technical-operational aspects but also in promoting teamwork and multidisciplinary work (Foon; Terziovski; 2014). As a result, multidisciplinary work made it possible to star solving and eliminate the root causes of the most representative failures in the process. In that sense, technical training, teamwork, motivational workshops and the use of 5’S as a basic lean manufacturing tool increase productivity related to an improvement of the levels of the OEE. With the improvement objectives focused on the area with the longest downtime, the OEE value has been increased by up to 85% (Table 1).

![Table 1. Overall Effectiveness Equipment (OEE)](image)

<table>
<thead>
<tr>
<th>Month</th>
<th>Month 01 Before</th>
<th>Month 01 After</th>
<th>Month 02 Before</th>
<th>Month 02 After</th>
<th>Month 03 Before</th>
<th>Month 03 After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>84.305%</td>
<td>94.65%</td>
<td>74.335%</td>
<td>90.44%</td>
<td>81.376%</td>
<td>92.02%</td>
</tr>
<tr>
<td>Performance</td>
<td>94.833%</td>
<td>95.40%</td>
<td>96.391%</td>
<td>96.74%</td>
<td>96.188%</td>
<td>96.81%</td>
</tr>
<tr>
<td>Quality</td>
<td>93.385%</td>
<td>94.14%</td>
<td>95.988%</td>
<td>97.14%</td>
<td>95.230%</td>
<td>95.48%</td>
</tr>
<tr>
<td>OEE</td>
<td>74.662%</td>
<td>85.00%</td>
<td>68.779%</td>
<td>85.00%</td>
<td>74.542%</td>
<td>85.00%</td>
</tr>
</tbody>
</table>

4. Conclusion
After OEE had been implemented, the overall equipment effectiveness was 85%. All improvement efforts have focused on the sugarcane juice extraction area. The application of the 5’s, the training of operators in specific maintenance and teamwork has allowed a gradual improvement in the efficiency of the equipment. The challenge ahead is to maintain the improvement that has been achieved and expand the strategy to other areas of the company.

References


Biographies
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