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Increasing productivity and energy efficiency in cement industry by using VSM

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Abstract

In the conditions of the energy crisis due to the war in Ukraine, the ever-increasing price of the electricity, it is very important to save electricity, through the use of new technologies, products, services and innovative solutions. The cement industry is one of the most important industries with high consumption of thermal and electrical energy in Albania. The aim of the paper is to show that using the Value Stream Mapping and Lean thinking method of the production system in cement industry, will ensure good opportunities to improve the production system and reduce the energy consumption. The cement factory in Fushe Kruje, Albania is taken as a case study in this paper. Recently, as the cement demand rose, the factory has encountered with long-waiting lines at the loading facilities. The plant loading facilities are capable to serve pallet loading, bulk loading, and floor loading trucks. The paper is focused on pallet loading facility, as it is the easiest one to be modified. Thus, the goal of the study is to redesign the loading facility and change the packing process in order to reduce the overall waiting time of the system, electricity consumption and increase the production capacity.

Introduction

Fushe Kruja cement factory is one of the largest producers of Cement industry in Albania and has an annual capacity of 1.3 million tons of cement and meet global standards for environmental protection. Achieving high process energy efficiency and ensuring high product quality are the main duties of the cost-effective cement production in Fushe Kruja cement factory.

The packing plant is one of the key sectors when cement dispatches to clients on 50 kg and 25 kg paper bags. There are installed two Roto Packers 8 spout, which feed two palletizers with a capacity of 2400 bags/hour with 50 kg each or 2700 bags/hour with 25 kg each. The challenge is to upgrade the existing palletizer system to grow production capacity in order to reduce the waiting time for consumers and energy consumption. The possibilities to fulfill all the market requests for packet cement would be easier and in a short time with lower cost. Much less time of operation for the same production has a great impact on technical aspects and energy consumption. So, the availability of the machinery will be higher and it will be more time for service.

The analysis of existing packing system based on Value Stream Mapping and Lean thinking methods helps to find what can be modified in order increase the production capacity, using line automation flexibility without sacrificing quality, reduced the energy consumption and other costs of the system.

Two main factors are taking in consideration during the study: 1) time of production process, which is converted in increasing palletizing system efficiency, and 2) reducing cost of production. Proposed PLC programming modification will ensure maximum robustness and maximum operational reliability combined with excellent palletizing quality. This will benefit to the company in increasing two times its palletizing system capacity, increasing resource utilization in distribution facility, reducing production costs and gaining customers' satisfaction.

Material and Method

Value stream mapping and Lean thinking are methods used in this study. VSM is a systematic method to identify wasted time and actions in a manufacturing process. In more recent times VSM it has been used to re-engineer businesses because it identifies unnecessary effort and resources to permit simplification and streamlining of operations processes [1-2]. VSM is used to investigate processes to identify improvement opportunities lying in their wastefulness and lack of fluidity. In VSM method the process is followed from start to finish monitoring and measuring what happens within, and between, each step of the process. For each step of the process are recorded the variety of resources used in the step, the amount of their usage and the range of times each resource is in use as a block of information specific to that step.

Lean thinking is a highly involved method of managing an organization to improve the productivity, efficiency, and quality of products [2]. Lean Manufacturing is the systematic elimination of waste from all aspects of an organization's operations, where waste is viewed as any use or loss of resources that does not lead directly to creating the product or service a customer wants when they want it. Lean thinking relies on recognizing the "seven wastes" [3]: over-production, over-processing, inventory, motion, scrap, waiting and transportation. Some benefits of lean manufacturing stated by [4-5] are: help to produce business outputs as fast as possible; able to produce work faster, can do more with the same resources as machineries and people. As a result of waste reduction, improvements emerge in reduction of operating cost, productivity, and quality and on-time delivery of products.

It is clear that value stream mapping is a process designed to reduce lead-time to make product flow and to eliminate waste, non-value-added operations or activities. All for purpose of meeting customer demand at the lowest cost and with the highest quality [6].

The goal of study is to reduce the costs by eliminating waste and to produce in time with customer demand and value stream mapping is an essential tool used.

Analysis of the conditions in palletizing system

First of all, it is created the value stream map based for the current palletizing system based on procedure stated on [1, 2, 3] as:

a. *The Current State Value Stream Map*: - Select the product family that will be mapped; - Decide what the goal for improvement will be done; - Form a team to collect data and map the selected value stream; Walk the flow and collect data on the value stream; - Value Stream Map terminology; - Value stream map standard symbols; - Draw a map of the value stream; - Analysis the Current conditions; - Identify value added and waste; - Choosing appropriate waste reduction methods and reconfigure process to eliminate waste and maximize value
b. *Take actions and create the Future State Value Stream*

The worth of VSM becomes self-evident during the analysis phase. The first analysis performed is to compute a ratio of total customer-value-adding time to total process time to see how customer effective is the process [7]. Other important factors to identify during the analysis are the variability between good and poor performance in each of the process steps.

Process flow analysis can quickly lead to an understanding of where inefficiencies exist and how to eliminate them [8-9]. After analysis based on VSM created based on the current conditions of packing system and identification of value added and waste, the changes are proposing that need to be done in order to reduce time and costs of the production. First of all, on current palletizer should be made some mechanical modifications and a new pneumatic system or a motorized system to divide the bag path on two paths. So, it will have a bigger capability to position the bags on a layer and can support a bigger capacity of coming bags. Based on VSM created the proposed modifications are shown in Table 1.

Results

The future state map is implementation plan that highlights what kind of lean tools are needed to eliminate the waste, and where they are needed in the product value stream. Creating a future state map is done through answering a set of the questions concerning issues related to building of the future state map and technical implementation related to the use of lean tools. After creating the future state map, the last step is to carry it out by trying to implement the different ideas generated by the future state map on the actual value stream [7, 8, 9].

In the new palletizing system are proposed to have two independent feeding paths, which can be made possible through the dividing system of bags. For this reason, two bags are selected to go straight and after bags are moved by the lower layer feeder in front. Three bags after them are turned by 90^0 and create a layer that is moved in front by upper layer feeder. So, it is created the layer without usage of lower layer feeder because the bags come in the

right positions. Also, this system does not need to rotate the layer since the combination of bag is made on the layer.

All layers except the last one is turned by 180^0 making a combination of bags in a way that the pallet is more compact and solid one. One pallet has 7 layers (5 bags) and one special layer 4 bags in the top.

All the modifications of the proposed new palletizing systems will be performed in PLC program. The proposed changes in current palletizing system will bring:

1. Arrival time of bags sequence will be done: 30s/39bags = 0.77s/bag
2. Time of completion of 7 layers (a pallet) = 7 x 5 x 0.77 =27s/layer
3. Time of completion of special layer 4 bags is 4 x 0.77 = 3.08s/layer
4. Production for one hour in new palletizing system is 4800 bags/hour; 4800/39= 120 pallets/hour or 4800bags/hour = 1.33bags/s

Table 1. Impact of lean thinking in palletizing system of cement factory in Fushe Kruja

Proposed modification	Reason	Results
Bag Divider System	This system will route cement bags on two paths.	Increase the capacity of processing cement bags to create a layer feed from two different paths.
Bag selector system (straight/turn 90^0) for the new path	As on the new system will be two independent paths there are need for two independent bag selectors.	This will make possible to reduce a complex process of turning layers on lift.
Mechanical modifications of the belt conveyors	Fill out the conveyors to create two different paths.	Create a new path for bag processing.
Create and modify PLC program for the New Bag selector, bag divider, turning layers	As we have changed the logic of palletizing process, we have to interpret this at the automation system	Create a new logic control for the proper devices
Modify the control law of frequency converters	It will be needed to change the speed of the motors on the same processes to respond the new system.	The system will work correctly with higher efficiency.

Discussion

The selected improvements are included in the redesigned 'future state map' of the process. Identifying less obvious improvements is helped by simplify the process into function blocks as shown by the variable blocks in Figure 1.

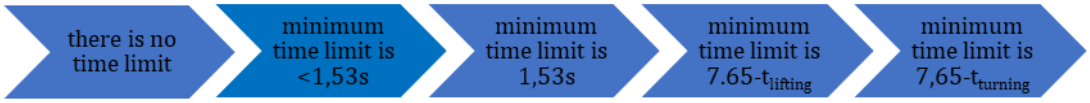

Figure 1. Current state functioning block diagram of palletizing system

By taking the process back to its most basic components, it is possible to redesign the process by removing, combining and overlaying its basic functions to arrive at a simplified and higher customer-value-added operation. Figure 2 shows the palletizing process with increased value-added and inventory speed achieved by halving two paths for bags in palletizing system instead of one path for bags as in current one is.

Figure 2. Proposed state functioning block diagram of palletizing system based on VSM method

It is clear that after applying the modifications the efficiency of palletizing system will be increase and the cost of production will be decrease. The calculation results for new palletizing system are:

1. Time of completion of a pallet is decrease two times from 53.84 s/layer to 27 s/layer. This will bring the reduction of the production cost.
2. The production time for one hour, which is converted in palletizing system efficiency, is increased two times from 60 pallets/hour to 120 pallets/hour.

In new palletizing system is proposed to replace two complex systems, as the Lower Layer Feeder with two electrical motors, one is synchronous motor with frequency converter and the other is induction motor, with two pneumatic systems. The other system proposed to replace is the 180^0 rotating system, which has also two similar motors. These complex systems have a very big spare parts cost and need a costly maintenance. The results from calculations have shown clearly that the modified palletizing system can increase the productivity twice and reduce energy consumption average 34%.

Conclusion

This paper demonstrates that using VSM method in packing system can quantify both the operational and financial benefits during the early planning and assessment stages of lean implementation. Simulation can be considered an integral part of VSM and can be used as a visual tool to convince management to adopt lean from both operational and financial perspectives.

The implementation of proposed modification of current palletizing system will bring potential economic, technical and quality benefits for Cement Company, increasing the production twice per hour and reduction of costs. So, the same personnel are used to produce a higher quantity of pallets. Reduction of some processes will require less electricity too, for the same production quantity.

Totally integrated automation of the palletizing systems makes possible to be very flexible on changing and testing it very easy and with a low cost. The system can be programmed and integrated on the existing project only doing same modifications to the main functions of the programmable logical controller program.

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