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LEAN SIX SIGMA IMPLEMENTATION IN CEMENT GRINDING PROCESS – "ABC" PLANT CASE STUDY

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Abstract

A project of Lean Six Sigma (LSS) takes place in a cement manufacturing plant; the ultimate goal was to develop the performance of the final product properties based on real customer needs. Success of implementation DMAIC methodology had been proved to formalize a problem statement, discover all potentially causes and prioritize them. Statistical analysis was used to distinguish irrelevant causes from critical ones. The project team together with the plant team prepares list of alternatives to satisfy business customers, designed experiments takes place to choose the optimum solution. Implementing the selected alternative improves product quality and performance, returns the lost sales and gives net present value of 2000,000 $ within the first three years of implementation.

Index Terms— Cement, Clinker, Customer, DMAIC Methodology, Grinding, Lean, Six-Sigma.

INTRODUCTION

Concrete is the most widely used building material at present. Its properties greatly depend on the proportions and properties of its constituents. Cement is the major component of concrete. In 2011, the global cement market size was about 237.15 billion U.S. dollars; expanded to 394.35 billion U.S. dollars by 2016 (66% growth). Such enlargement in market size can tell better about the importance of cement. Implementations of LSS as a breakthrough methodology have been profitable in many business fields such as information technology, pharmacology and many other fields of services and manufacturing. Due to their nature of operation, LSS application still falls away from mass production plants especially those who continue stream production. This makes this project one of the fewest implementations in such fields generally and in cement manufacturing specially. The hypotheses question in the research was, whether the implementation of LSS methodology will improve the cement production process or not? To answer the previous question, a project took place in "ABC" cement manufacturing plant, in response to a voice of customer that demands improvement of the product mechanical properties in the early age of use. A project team was chosen and project charter was made by a six sigma black belt consultant.

METHODOLOGY

This research is a hypothesis testing research, aiming to answer the question of whether implementing of lean six-sigma methodology in cement plant, will improve the product specification and supports the overall process improvement. The targeted processes result shows the expected success. Which extends those processes but exceed it to the overall process. Using the famous five steps, Define, Measure, Analyze, Improve & Control (DMAIC) methodology was the road map of the project guided by the black belt consultant and leaded by project and plant teams. The top management goal was clearly saving the company's market share by satisfying the plant customers.

DISCUSSION

The improving process in "ABC" plant was made using lean six-sigma (LSS) methodology starting from acquiring customer's complaints to analyzing voice of customer (VOC) using brainstorming technique followed by X-Y matrix relationship , which translated to critical to quality (CTQ's) for product attributes. The CTQ's properties were prioritized, evaluated & studied to identify the root cause of customer's dissatisfaction and how to overcome it by using the necessary quality tools such as quality function deployment (QFD), meetings, brainstorming, deployment flowchart, fishbone diagram and design of experiment (DOE). Basic Lean tools (5S+Safety), visual factory and value stream mapping (VSM) were used as a project starting point to help the project team understanding the process and clearly identify the process boundary. Samples had been collected, analysis was performed and data had been generated, analyzed and interpreted. At the end, the project team came out with two problems; clinker storage time and production rate targets. Alternatives had been suggested & rated according following matrix.

Table 1 Elaualtion matrix

Evaluation Matrix Key		Criteria's			Overall
		Hierarchy	Cost	Difficulty	
Ideas	Build a clinker storage	Eliminating the clinker / water contact	Budget needed	Based on project	Accepted
	Install clinker silo	Eliminating the clinker / water contact	Budget needed	Based on project	Accepted
	Implement just in time (JIT) system	Reducing the clinker / water contact	Operational cost	Complex	Refused
	Implement supermarket pull system - Kanban	Reducing the clinker / water contact	Operational cost	Moderate	Preferred

The above table (1), it's clear that "Implement supermarket pull system – Kanban" was the preferred idea to by apply, the execution cost preventing the building of clinker storage and the installation of clinker silo. While the difficulty of execution preventing the "Implement just in time (JIT) system" due to multi factors such as; huge quantities of clinker need to be transferred, the transportation system (Train) which has high delay time in average and the long distance between the supplier and the plant. Implementation of "Supermarket pull system (Kanban)" was decided to reduce the storage time of the incoming raw material (Clinker). The full factorial design was used in to decide the optimum targets to be used giving the maximum production rate, two factors were examined; specific surface area (SSA) and the residual of 45 micron sieve (R45). Three levels of targets were the tested for each factor, what generates: (levels) (factors) = (3^2) = 9 trials.

RESULTS

Cement production process in "ABC" company can divided into three main processes, grinding process, packing process & shipping process. There was storage before each process to guarantee the continuity of the production process, which have a big impact on the lead time leaving it 33 days long. The overall process was running under push system, voice of process (VOP) was louder than voice of customer (VOC). The daily priority was communicated to each process separately, what makes them working as isolated islands. Supermarket pull system applied in the raw material storages working by withdrawal Kanban from the grinding process to report at the end of each working day the consumed clinker amount. A production Kanban will be sent to the production control unit on the next day by the storage team, on weekly basis forecasting to the clinker supplier to provide the plant with the real needed clinker amount. The future state map removes the non-value added communications between the production control unit and packing & shipping processes, to guarantee the work flow, and reduced lead time to 11 days.

Table 2 DOE Results

SSA-Target	R45-Target	Result (Ton/hour)
3900	9.00	84.11
3900	10.00	86.77
3900	11.00	89.91
4000	9.00	84.66
4000	10.00	86.72
4000	11.00	88.88
4100	9.00	82.24
4100	10.00	83.37
4100	11.00	85.03

The data in the above table (2) are the averages production rate in each trial an operation of 60 hours (three working days).It's appear that the most efficient combination targets between SSA & R45 which resulting the highest production rate is (3900 cm2/g) & (11%) respectively.

CONCLUSION

Along the research, the researcher aims to answer the research's questions about the cement production sigma level, source of variation, if the implementation of lean six-sigma methodology will improve the process and reduce the non-conformance or not. By using the right quality tool and effective data analysis it enables the researcher to answer such questions during implementing lean six-sigma methodology. But the last and most important question was why to use LSS methodology rather than other methodologies or even use six-sigma only or lean manufacture system only, the answer of this question is about the integration between the two world class methodologies of six-sigma & lean manufacturing. In "ABC" plant case, the variance of early strength was due to variance of the clinker tri-calcium silicates (C3S), which found to be caused by partial hydration of the stored clinker resulted from exposure to rain water. The implemented solution was applying supermarket pull-system. Although the problem was high variance and many non-conformances, which classified as six-sigma typical case, the solution was to apply supermarket pull-system, which is a lean tool. Integration of the two methodologies will enable the uses of more tools even to define, analyze, improve or control a process. The researcher tries to investigate whether; applying Lean Six-Sigma Methodology will improve the performance of the product and reduce non-conformance or not through the next hypotheses:

The First Hypothesis (Ho):- Applying Lean Six-Sigma Methodology is sufficient to improve sigma level for the cement production process & reduce the non-conformance.

The Second Hypothesis (H1):- Applying Lean Six-Sigma Methodology is insufficient to improve sigma level for the cement production process & reduce the non-conformance.

Following bar chart figure (1) shows the improvement in the studied parameters (quality specification concerning the internal plant targets and the rate of production regarding to equipments capacity) regarding the sigma level measured before (red bars) and after (green bars) project implementation, As figure (1) illustrate, there is a quite improvement in the sigma level of the product quality specification from 1.43 to 2.69 sigma level, which drop the defect per million opportunities (DPMO) from 500,000 to below 130,000 and increase the process yield to above 87% from below 50%. Significant increase on the production rate was noted, from 2.33 to 3.0 sigma level which impacted the total production capacity on annual basis by 5000 tons with an average 750,000 USD profit. The researcher fails to reject the null hypothesis (Ho), and rejects the alternative hypothesis (H1). The implementation of lean six-sigma methodology or the combination of them (Lean Sigma) will enhance the business effectiveness and improve the over all process. The results of this research can be extended to other processes and sub-processes in cement manufacturing.

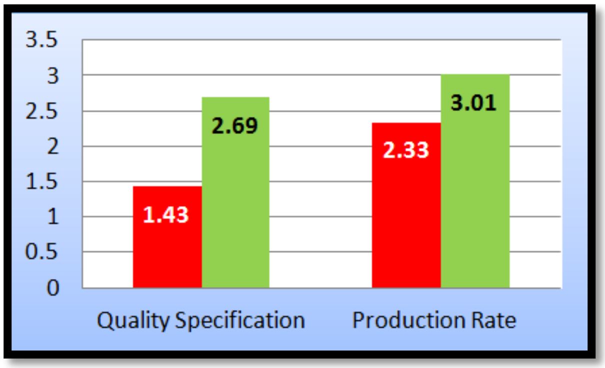

Figure 1 Sigma level Improve

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