Review Study of Six Sigma Implementation in Manufacturing Industries

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Abstract : In present age of competition and economic turbulence, all types of organizations are striving hard to control costs, maintain high levels of productivity, meet changing expectations of the customers and attain quality benchmarks to sustain in the market. Six Sigma is a powerful world class improvement business strategy that enables companies to use simple but powerful statistical methods to define, measure, analyze, improve and control (DMAIC) processes for achieving operational excellence. The Six Sigma method is a complex and flexible system of achieving, maintaining and maximizing the business success. Six Sigma is mainly based on understanding the customer needs and expectation, disciplined use of facts and statistics analysis, and responsible approach to managing, improving and establishing new business, manufacturing and service processes. Six Sigma's role in all of this is to help management produce the maximum value while using minimum resources. It does this by rationalizing management. It means that it applies scientific principles to processes and products. By using the Six Sigma DMAIC approach processes or products are improved in the sense that they are more effective, more efficient, or both. If no process or product exists, or if existing processes or products are deemed beyond repair, then Design for Six Sigma (DFSS) methods are used to create effective and efficient processes or products. Properly applied, Six Sigma minimizes the negative impact of politics on the organization. Of course, in any undertaking involving human beings, politics can never be completely eliminated. Even in the best of Six Sigma organizations there will still be the occasional Six Sigma project where data-based findings are ignored because they conflict with the preconceived notions of a powerful figure in the organization.

Keywords : Six Sigma, FMEA: Failure Mode and Effect Analysis, DMAIC: Define Measure Analysis Improve Control, RPN: Risk Priority Number, Margarine Production, World Class Manufacturing, DOE: Design of Experiment, CSM: Current State Map, FSM: Future State Map

Introduction

Six Sigma is a business strategy that enables organizations to increase their profits by optimizing their operations, improving quality and eliminating defects. Six-Sigma theme pivots on drastic reduction of variability in the processes. The companies that adopt Six Sigma approach will have to reduce the process variation to such a level that the number of defective parts per a million of produced parts would be less than 3.4. Embarking on a Six Sigma program means delivering top-quality products and service while virtually eliminating all internal deficiencies. Six Sigma projects and activities are linked to the top level goals of the organization. The goals of any organization come from its three major constituencies: customers, investors and employees. Senior management translates these stakeholder based goals in to proper metrics. These goals and metrics are then mapped to a strategy for achieving them. By addressing all business processes and treating manufacturing as part of a larger system Six Sigma provides multiple benefits to customers. When product design cycle shortens and operations become more cost-effective, the owners or investors will automatically reap more benefits. When employees become more productive naturally their monetary package will get better. So, adoption of Six Sigma means higher benefits to all stakeholders in the organization. Six Sigma implementation uses five step DMAIC (Define, Measure, Analyze, Improve and Control) methodology, somewhat similar to Plan-Do-Check-Act problem solving methodology defined by Deming. DMADV (Define, Measure, Analyze, Design and Verify) methodology is adopted for new product developments. From the viewpoint of the customer of a product or service, 'value' can be defined as any action or process that the customer would be willing to pay for.

Taiichi Ohno, developer of the Toyota "Just-in-time" Production System in the 1950s, defined waste as any human activity which absorbs resources but creates no value. Lean is a production practice that eliminates waste. At the beginning of the twentieth century the automobile industry started mass production as an alternative to craft production. The mass production had many advantages like high volume, low-cost, less skilled operators, etc. But, it also had some disadvantages like very high cost of machinery, less variety, excess supplies, need of more workers, need of extra space to ensure smooth production, etc. Lean production came as an alternative to mass production combing the advantages of both craft and mass production.

James P. Womack, et al. in their book 'The Machine That Changed The World' (1990) says that: Lean production should be viewed as a strategy for achieving value leadership. It goes well beyond cost cutting. First, lean production dramatically raises the threshold of acceptable quality to a level that mass production, cannot easily match. Second, lean production offers over-expanding product variety and rapid responses to changing consumer tastes, something low-wage mass production finds hard to counter except through lower prices. Lean production dramatically lowers the amount of high-wage work needed to produce a product and keeps on reducing it through continuous incremental improvement. Lean production can fully utilize automation in many ways which mass production cannot. Lean Six Sigma is the combination of Lean production and Six Sigma approach. It draws the philosophies, principles and tools of both in its approach. Lean focuses on elimination of waste and non-value added activities by

process optimization while Six Sigma focuses on reduction of process variation and hence drastic reduction of defects and meeting the requirements of all the stakeholders. Lean and Six Sigma compliment and reinforce one another. Only lean will not bring the process under statistical control to meet the quality targets whilst Six Sigma alone will not reduce waste in the processes. Currently, Lean Six Sigma is an internationally established methodology for improving the organizational effectiveness

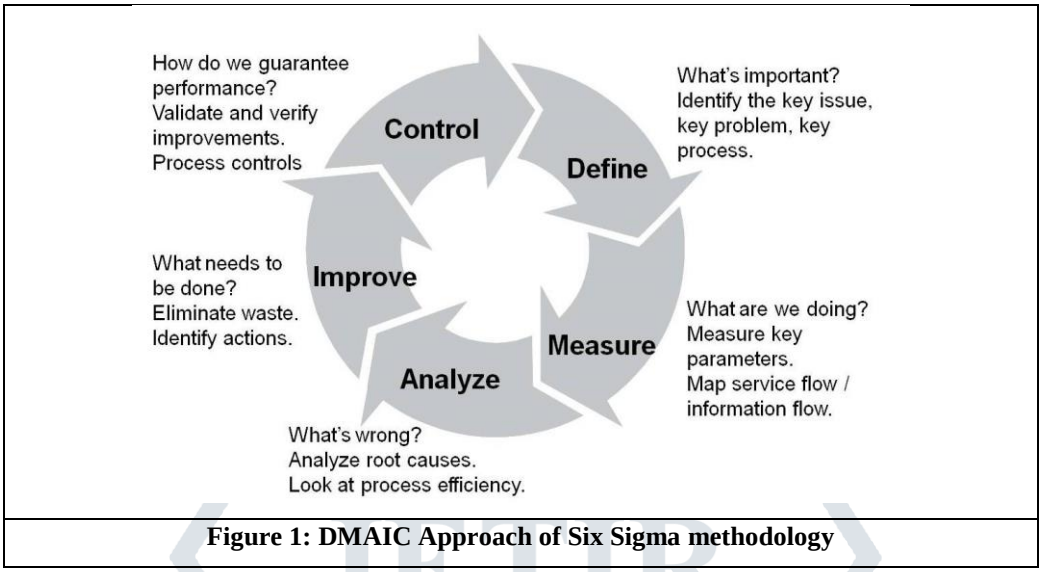


Figure 1: DMAIC Approach of Six Sigma methodology

DEFINE ***the problem and scope the work effort of the project team.*** The description of the problem should include the pain felt by the customer and/or business as well as how long the issue has existed. Hence, identify the customer(s), the project goals, and timeframe for completion. The appropriate types of problems have unlimited scope and scale, from employee problems to issues with the production process or advertising. Regardless of the type of problem, it should be systemic—part of an existing, steady-state process wherein the problem is not a one-time event, but has caused pain for a couple of cycles.

MEASURE ***the current process or performance.*** Identify what data is available and from what source. Develop a plan to gather it. Gather the data and summarize it, telling a story to describe the problem. This usually involves utilization of graphical tools.

ANALYZE ***the current performance to isolate the problem.*** Through analysis (both statistical and qualitatively), begin to formulate and test hypotheses about the root cause of the problem.

IMPROVE ***the problem by selecting a solution.*** Based on the identified root cause(s) in the prior step, directly address the cause with an improvement. Brainstorm potential solutions, prioritize them based on customer requirements, make a selection, and test to see if the solution resolves the problem.

CONTROL ***the improved process or product performance to ensure the target(s) are met.*** Once the solution has resolved the problem, the improvements must be standardized and sustained over time. The standard-operating-procedures may require revision, and a control plan should be put in place to monitor ongoing performance. The project team transitions the standardized improvements and sustaining control plan to the process players and closes out the project.

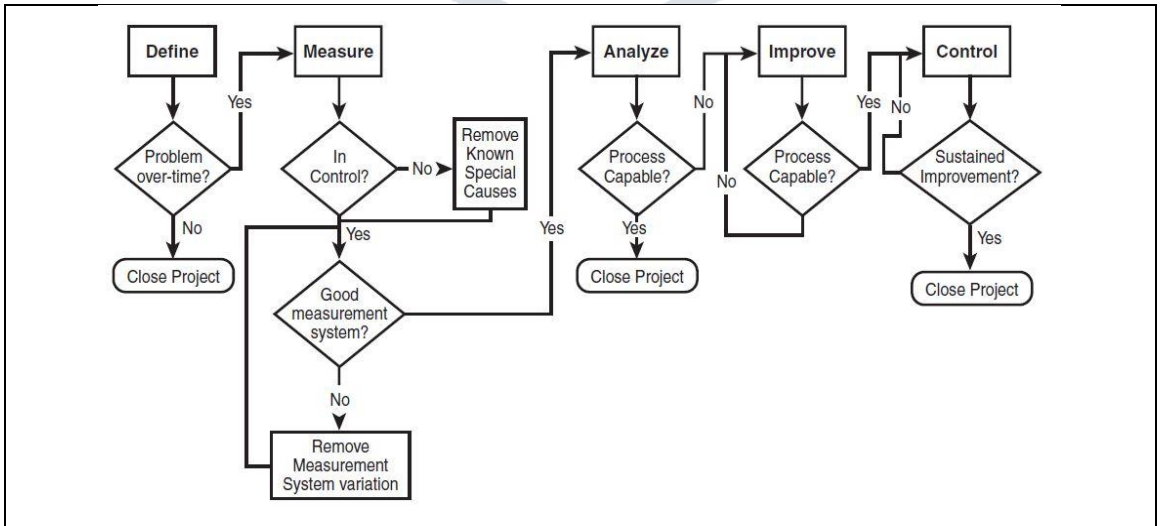


Figure 2: DMAIC Process Flow

Review of Research Papers

S.M.Balaji Paramesh (2013) has implemented Six sigma methodology at cable harness manufacturing industry.The cable harness manufacturing industry has been growing in a fast pace during the recent years in India. Cable harnesses are used to link together all the electrical components scattered throughout any electrical equipment. Cable harness manufacturing involves a series of operations which are to be carried out in a proper sequence to make a good quality harness. In real time scenario, high volume production of cable harness with consistent good quality is a difficult target to achieve. Here, the efforts are intended to improve the quality of cable harness manufacturing using six sigma methodologies. It includes collection of defects data, analysis of the defects data using FMEA methodology, determining the causes and taking corrective actions to eliminate the defects. Process flow chart and manufacturing lead time are determined and lean tools such as one-piece flow and job instruction are implemented. There were total 29 problems found out of cable harness rejection using FMEA and again their RPN values are improved as shown here:

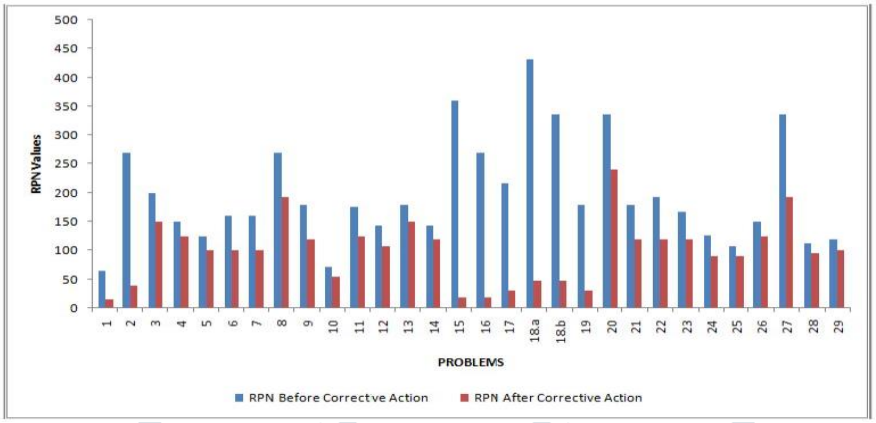


Figure 3: Bar chart showing RPN values for problems before and after improvements at cable harness Manufacturing

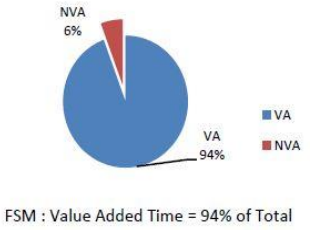
M Naga Phani Sastry, M. Devaki Devi and E. Siva Reddy (2011) implemented Six sigma methodology on process improvement and variation reduction with the application of DMAIC. It shows the application of Six Sigma in Amara Raja Batteries manufacturing to reduce the production defects like paste rejection. Six Sigma simply means a measure of quality that strives for near perfection at many organizations. Six Sigma is a disciplined data driven approach and methodology for eliminating defects in any process from manufacturing to transaction and from product to service. It is a known fact that Battery is an inevitable accessory for all automobiles, as it is the source of power for ignition, lighting and other external accessories. It is a practical work done at Amara Raja Batteries,Tirupati where initially the percentage of paste rejection was nearly 3.09%,which drastically reduced to about 2.26%within two months by applying the six sigma. Proposals have been made at the firm to install the sensors like paste sensor, jam detecting, door sensors to reduce the scrap further. Tableshows the improvements obtained after implementing corrective action plans. By applying Six Sigma (DMAIC), by December, paste rejection has been drastically reduced from 3.09% to 2.26%.

Sr.No	Month	Paste produced(Kg)	Paste rejected(Kg)	% paste Rejected	Target
1	OCT	1551658	48092	3.09	3.00
2	NOV	1513158	40187	2.65	2.75
3	DEC	1217252	27237	2.26	2.5

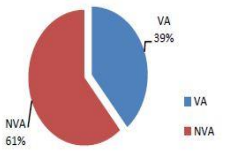
Figure 4: Improvements after DMAIC Application at Amara Raja Batteries,Tirupati to reduce paste rejection

W.M. Goriwondo and N. Maunga(2012) implemented DMAIC principles to margarine manufacturing. The Value Stream Mapping tool is used to map the processes and the Six Sigma's Define, Measure, Analyze, Improve and Control (DMAIC) methodology applied to attain improvements. The Current State Map (CSM) is drawn and using the DMAIC methodology, the Future State Map (FSM) is drawn. The production line ultimately achieves improvements in cycle times and in Value Added time ratio from 39% to 94%. There are envisaged improvements of up to 86% on cycle times for individual processes. The production lead time for the FSM is 5.62hrs with 5.3 hrs of Value Added Time. This then gives the percentage Value Added ratio of 95%. The comparison of the results analysis between Value Added Times of the CSM and FSM are shown below in Figure.

	Pasteurizer	Master Churn	Feed Tank	Wrapping & Packaging Machine	Packaging and Transportation
CSM Cycle Times (Hours)	2.75	2.1	1.75	2.85	0.5
FSM Cycle Times (Hours)	1.35	0.85	0.25	2.35	0.5
%Improvement	51%	60%	86%	18%	0%



FSM : Value Added Time = 94% of Total



CSM : Value Added Time = 39% of Total

Figure 5: Comparison of CSM and FSM cycle times at margarine manufacturing, Zimbabwe

Neha Gupta and Dr. P.K.Bharti (2013) presented a quality improvement study applied at a yarn manufacturing company based on six sigma methodologies. More specifically, the DMAIC (Define, Measure, Analyze, Improve, and Control) project management-methodology & various tools are utilized to streamline processes & enhance productivity. Defects rate of textile product in the yarn manufacturing process is so important in industry point of view. It plays a very important rate for the improvement of yield & financial conditions of any company. Actually defects rate causes a direct effect on the profit margin of the product & decrease the quality cost during the manufacturing of the product. By checking & inspection of defects of product at different point in production where more defects are likely to happen. A thousand defects opportunities create in the final package of yarn. That's why it is decided to do work & implement DMAIC methodology in winding departments where the final package of yarn is make.

Mamatha K,Mr.H.V Vasuki, Mr.Jagdish MogaVeera, Dr.C.K.Nagedra Guptha (2014) implemented Six-sigma methodology in reducing rework of the components which occur due to non-conformance with respect to the required standard specifications in the fabrication shop. This results in higher rework time; rework cost and lowers customer satisfaction. The Six-sigma DMAIC (Define, Measure, Analyze, Improve, and Control) approach has been used for the process improvement. This results in reduction of the rework time and cost. An increase in the sigma level from 2.30 to 3.28 and from 3.00 to 3.10 for Left hand and Right hand Deck respectively was achieved. Six Sigma improves the process performance which leads to predictable input and predictable output, leading to better utilization of resources, decreases variations resulting in continuous improvement and maintains consistent quality of the process output. Figure 6 shows identification of root causes by using cause – effect diagram through which using FMEA one can focus on potential failure mode of highest RPN.

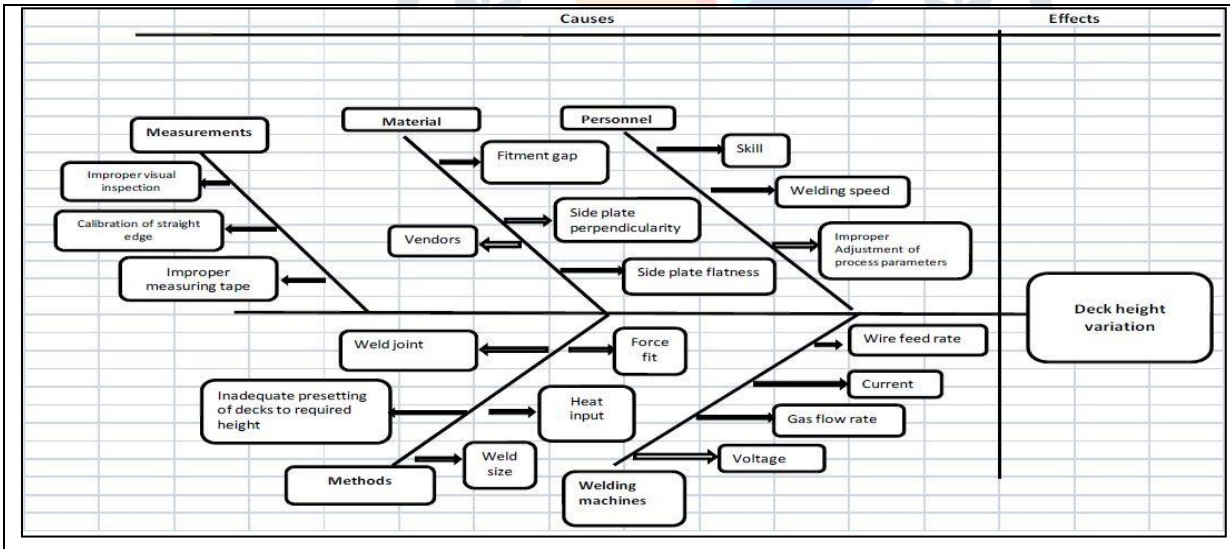


Figure 6: Cause - effect diagram for Deck Height Variation for Earth Moving Equipment

Review Remarks

It is concluded that Process mapping, FMEA, Pareto Charts, Sampling Plan, Kaizen and Check Lists are highly used tools of DMAIC approach in Manufacturing Industries [3,6]. The tools including Benchmarking, Affinity diagrams, ANOVA, Taguchi's experiment, Standard operating Procedure are highly difficult to implement [4,5]. Manufacturing organizations are facing maximum degree of difficulty in implementing analyze phase and least degree of difficulty in implementing control phase [3]. Less educated workforce due to inadequacies of training is the most important barrier in implementing DMAIC approach. The results of correlation analysis indicate that DMAIC approach is significantly used to improve the quality of products. It has been also concluded that maximum benefits are achieved in maturity phase as compared to developing and introductory phase which shows that Six-Sigma DMAIC approach is still growing in manufacturing organizations.

Conclusion

1) Six sigma methodology is useful for various objectives in several types of industries. This strategic tool can be used according to preset objectives and need of industry. The review indicates that the six sigma strategy is used for to reduce rejection, to improve design, to reduce cycle time and to improve quality of the products.
2) It is observed that Six sigma methodology is implemented by use of any quality control tools like cause and effect diagram, Pareto diagram, FMEA, DOE etc. in the measure phase and analysis phases.
3) Six sigma strategy should start with measurement of initial sigma level and after implementation phase once again sigma level should be evaluated, so net improvement in sigma level can be achieved.
4) By review of these papers it was observed that Six sigma is highly flexible strategy which can fit to any problem of manufacturing industry and by appropriate implementation phases and control expected results are derived.
5) Project by project application of Six Sigma in Manufacturing sector can strengthen the understanding about this strategy along with consolidating gains from it. Six Sigma among the small industries is a much awaited movement, which can strengthen their bottom lines besides contributing to uplifting global economy. The real requirement is to believe in Six Sigma and prepare a road map for its implementation and proceed earnestly to derive benefits out of it in real sense.

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