Six Sigma an Approach to Improve Productivity in Manufacturing Industry

Mohit Taneja[1], Arpan Manchanda[2]
Asstt. Prof.., Mechanical Engineering Department, R.I.M.T, Chidana, Sonipat, Haryana, India
Asstt. Prof.., Mechanical Engineering Department, R.I.E.T, Faridabad, Haryana, India

ABSTRACT

Simulation of business and manufacturing processes has been helping companies improve their operations for several decades. During that time, business improvement programs have appeared disappeared, grown and evolved. Six Sigma introduced another way of thinking about process improvement by focusing primarily on the financial impact and how defect reduction, customer satisfaction and improved processes all contribute. Only recently has Six Sigma broadly accepted the benefits and approach of simulation to streamline projects, improve results and in still a deeper understanding and appreciation of "the process." This paper begins with an overview of Six Sigma, followed by a description of the benefits of iGrafx Process for Six Sigma to a Six Sigma Black Belt and ends with an example of the benefits received by an organization through the use of simulation.

1. INTRODUCTION TO SIX SIGMA

Six Sigma is the powerful force by which leading corporations such as GE, Motorola and Ford are delivering staggering results to their bottom line and customer satisfaction through fundamental changes in the way they operate and an overall improvement in the products and services they deliver. These leading companies believe so much in Six Sigma that they are willing to invest 100's of millions of dollars in Six Sigma with the expectation to receive billions of dollars in return. Six Sigma places the emphasis on financial results that can be achieved through the virtual elimination of product and process defects. Gone are the days of quality at any cost. Today's quality improvement programs must deliver measurable results, short- and long-term, to operational effectiveness and the bottom line. The logical end of this approach is that as product and process defects are driven out, value for the customer goes up, customer satisfaction increases, the company captures the market with higher quality at lower price, and profits and company stakeholder value is maximized.

Sigma is a letter from the Greek alphabet used in statistics as shorthand for the ***Standard Deviation,*** one metric that describes the variability in a set of data. In Six Sigma, the focus is on the reduction of defects in a product or process. The measure is derived from the concept of a process predictably producing output that is about twice as good as that specified by the customer. At a "Six Sigma" level, a process predictably produces no greater than 3.4 defects per million opportunities (DPMO). A "defect opportunity" is defined as a chance for non-conformance or not meeting the required specifications. This assumes that the output is normally distributed and includes the assumption of a long term process shift of 1.5 to account for shift and drift of the mean. DPMO provides a base standard metric for comparing disparate systems in different industries. A Six Sigma Process; Output twice as Good as Customer Requirements Six Sigma has traditionally been and continues to be very statistics centric. Only recently, Six Sigma Black Belts have been introduced to the benefits that simulation brings to a Six Sigma project and many Black Belts now require a simulation solution as part of their Six Sigma toolkit. Black Belt is the common term for those experts within a company.

2.SIX SIGMA PHASES

Approaches to Six Sigma dictate the use of a model to drive a disciplined approach to the solution of quality problems. The most commonly used model is the five-phase model commonly known by the acronym DMAIC (Define, Measure, Analyze, Improve, Control). The model acts **as** a roadmap for improvement projects, leading the teams through:figure:1 shows how it works,

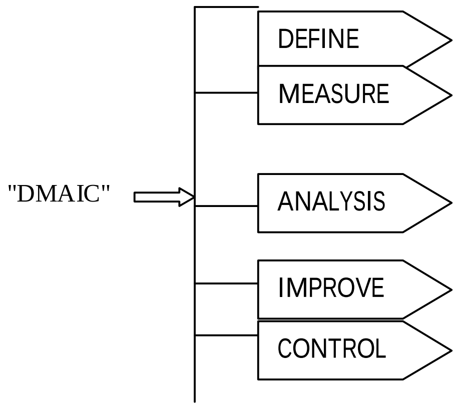

Figure: 1 Six Sigma Phases

*Defining the process or problem that forms the focus of the project;

*Measuring the key variables that drive process performance in order to find leverage points for improvement; *Analyzing the data to test hypothetical solution variables;

* Making improvements based on analysis and experimentation; and rolling the improved processes out on a large scale and implementing process management systems, both to hold the gains and identify further opportunities for improvement.

* Than control the system.

Modelling has been a vital contributor to process improvement since flowcharting was introduced in the 1950s. The additional capabilities provided by process simulation have added a powerful, dynamic dimension to what previ**ously** were flat, two-dimensional maps of processes. Mapping processes has traditionally been used in helping define processes and later, in setting up training and control plans as process improvements came online. Indeed, most of the "low hanging hit'' (easy but high-yield improvement opportunities) are found through the use of flowcharts. The dynamic aspects of **a** simulation environment, however, make the working model an important tool throughout the DMAIC Model. In the Define phase, adding resource and cost information, durations and decision statistics can help quantify the improvement opportunity beyond the capabilities of conventional

Financial analysis. Cycle time problems, system bottlenecks and hidden factories can be identified, leading to enhanced understanding of the current state of the system and more realistic prioritization of improvement initiatives. The model can also pinpoint areas for data collection and "quick hit" targets for improvement. Data collected in the measure phase may be used to update the model, allowing for more in-depth systems analysis, more true-to-life simulations and the ability to plan Designed Experiments. In the Analyze phase, multi-factor multi-level Designed Experiments may be carried out via simulation. The impact and interactions of many otherwise expensive improvement ideas can thus be tested at little to no cost or other risk, allowing effective screening out of those that clearly would yield no improvement and may sub-optimize the system. Additionally, some elements of an **FMEA**(Failure Modes and Effects Analysis) could be flexed in a simulation to point out mistake-proofing opportunities. In the improve phase, data from the improved process is used to update the model. Simulations act as validity checks of the model and its underlying assumptions. The new model provides input for a control plan and training plan. Some elements of a Critical Path for implementation might be experimented with in order to analyze risk and examine the need for resource levelling. The model will become an important piece of the plan for large-scale rollout in the control phase. A model that matches real-life process performance will serve as a documentation and standardization vehicle and a powerful training aid. By updating the model as the process changes, impacts in other parts **of** the system can be tracked and the system as a whole may be worked toward optimization.

Wessel and Burcher (2004) in their study identify the specific requirements for implementation of Six Sigma based on a sample of SMEs in Germany. This study also examines how Six Sigma has to be modified to be applicable and valuable in an SME environment. This is the first study of its kind to be carried out on Six Sigma survey in SMEs.

Burton (2004) proposes alternative Six Sigma deployment models that allow SMEs to implement Six Sigma at a pace where they can digest the methodology and achieve benefits, without significant resource commitment and overhead structure of the traditional Six Sigma. As a result, SMEs are sometimes able to achieve faster and more impressive benefits than their large customers. He also recommends an eight-step methodology for successful deployment of Six Sigma within SMEs.

3. Application of Six Sigma in an SME

Snee and Hoerl (2003) argue that there is nothing inherent in Six Sigma that makes it more suitable for large companies. They also suggest that the greatest barrier to implementation in small companies to date has been the way the major Six Sigma training providers have structured their offerings. More recently, as more and more sets of deployment guides and training materials have become available, the pricing structures have begun to change. Today, it is much easier for SMEs to obtain good external resources without a large up-front payment. Once an owner of the business (in small firms) is convinced of the advantages conferred by Six Sigma and visualizes the benefits, it is much easier to implement Six Sigma at smaller firms and to realize its benefits (Adams et al., 2003). They suggest that the initial focus on SMEs can be to reduce quality costs or waste in the system.

Effort and investment, as well as results in smaller companies, are more visible within a short time. Tennant (2001) argues that, in small organizations, if one visible and important person is actively against Six Sigma, then this attitude must change or the initiative must be a non-starter. In other words, in small companies, the top management team need to be visibly supportive of every aspect of Six Sigma initiative and they must demonstrate by their active participation, involvement and by their actions that such support is more than lip service. He also accentuates the point that it is far more important for small- and medium-sized enterprises to ensure that every iota of effort is directed exactly where it is needed for maximum benefit, so an overall quality strategy plan is vital right from the start of the Six Sigma initiatives. Six Sigma is about overall management strategy, culture and change, and the organization needs to build all of this into a sound corporate strategy plan.

Wilson (2004) identifies the following advantages for small-businesses embarking on Six Sigma initiative:

1. Stronger, more intimate relationships with customers.
2. A limited number of sites.
3. Fewer layers in the management hierarchy.
4. Faster and effective internal communication.
5. Strong owner influence.

4.About the study in Manufacturing Industry

Present study will let you know about the various steps to be considered while going through a case study in a manufacturing industry. For solving any problem, the methodology adopted must cover all possible causes of problem. If the methodology of problem solving is not comprehensive enough, the solution obtained at completion will not be correct and problem will resurface sooner or later. A process flow chart is to be prepared to proceed in a sequential manner and to present a one shot picture of the entire methodology, In this paper, the high rejection problem can be studied in depth and all the five phases in Six Sigma methodology, i.e. Define, Measure, Analyze, Improve and Control (DMAIC) can be successfully implemented to achieve the existing sigma quality level from 1.40s to 5.46s as explained below.

Define the problem and define what customer requires (Henderson and Evans, 2000). In define phase, process map and high-level process map – a SIPOC (Supplier, Input, Process, Output, and Customer) diagram should be drawn to understand the process. These diagrams were used to document manufacturing sequence of product and to identify the process or product for improvement.

Measure In measure phase, a measurement system analysis is conducted which includes the

Gauge repeatability and reproducibility (Gauge R&R) studies. The purpose of Gauge R&R study is to ensure that the measurement system is statistically sound. Gauge R&R studies determine how much of the observe process variation is due to measurement system variation. Two persons are needed to perform this experiment, which in case can be the operator on line and the investigator. The appropriate sample size must be taken say ten and two readings taken on each sample, thereby making a total of 40 readings. The gauge can be used for the experiment say a micrometer. From the results of Gauge R&R study, repeatability and reproducibility comes out

to be 27.02 percent and 0.00 percent and put the percentage study variation to be 27.02 percent, which is o30 percent, indicating that micrometer was correct.

Analysis According to Kapur and Feng (2005), the analyze phase examine the data collected in order to generate a prioritized list of source of variation.

Many statistical tools are used to carry out the analysis which are explained as follows.

Process capability analysis. Process capability analysis can be performed to find out actual state of the process. Rational sub-grouping can be done and 20 samples can be drawn, in a group of five. Can use Minitab to draw process capability analysis curve for product parameter analysis. Say Z – Bench sigma value of process found to be 1.40 and existing DPMO level of the process comes out to be 80,213.07, which is remarkably high and this shows that there are lot of opportunities for improvement in the process.

Fishbone Diagram. Using process capability analysis, the DPMO level and sigma level of the product parameter rejection is known. Now it is the time to find out the causes of bush rejection. Using expert experience and critical analysis of actual process, a Fishbone can be drawn to find out the causes of more product rejections.

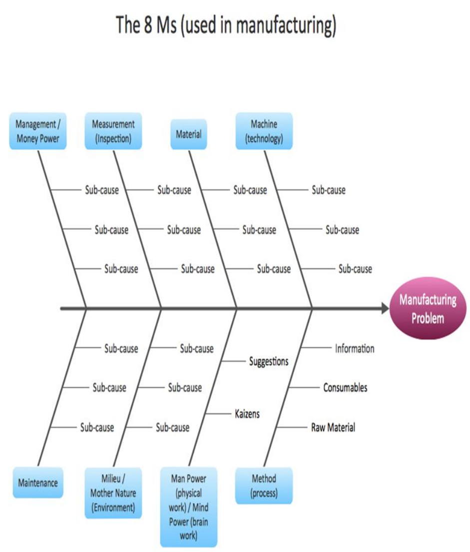

Figure: 2 Fishbone Diagram Showing 8 Ms Used in Manufacturing Industry

Two-sample t-test. The t-statistic was introduced in 1908 by William Sealy Gosset, a chemist working for the Guinness brewery in Dublin, Ireland ("Student" was his pen name). Gosset had been hired due to Claude Guinness's policy of recruiting the best graduates from Oxford and Cambridge to apply biochemistry and statistics to Guinness's industrial processes. Gosset devised the *t*-test as a cheap way to monitor the quality of stout. The t-test work was submitted to and accepted in the journal *Biometrika*, the journal that Karl Pearson had co-founded and was the Editor-in-Chief; the article was published in 1908. Company policy at Guinness forbade its chemists from publishing their findings, so Gosset published his mathematical work under the pseudonym "Student". Actually, Guinness had a policy of allowing technical staff leave for study (so-called study leave), which Gosset used during the first two terms of the 1906-1907 academic year in Professor Karl Pearson's Biometric Laboratory at University College London. Gosset's identity was then known to fellow statisticians and the Editor-in-Chief Karl Pearson. It is not clear how much of the work Gosset performed while he was at Guinness and how much was done when he was on study leave at University College London. In two-sample t-test four important factors were taken for study identified from Fishbone diagram.

In first case, two-sample t-test can be performed for operator skill (unskilled and skilled) by taking the sample size of 50 each for skilled and unskilled operator.

In second case, two-sample t-test was done for replacement (after 15 h and after 25 h) by taking the sample size of 50 each for rod replacement after 15 and 25 h.

In third case, two-sample t-test was done for regrinding of tool (after 20 h and after 30 h) by taking the sample size of 50 each for regrinding after 20 and 30 h.

In forth case, two-sample t-test was done for rod-holding mechanism (old and new) by taking the sample size of 50 each for old and new mechanism. Most *t*-test statistics have the form $t = Z/s$, where Z and s are functions of the data.

Typically, Z is designed to be sensitive to the alternative hypothesis (i.e., its magnitude tends to be larger when the alternative hypothesis is true), whereas s is a scaling parameter that allows the distribution of t to be determined.

As an example, in the one-sample *t*-test

$Z = \bar{X}/(\hat{\sigma}/\sqrt{n})$, where $\bar{X}$ is the sample mean of the data, n is the sample size, and $\hat{\sigma}$ is the population standard deviation of the data. s is the sample standard deviation. The assumptions underlying a *t*-test are that

- *Z* follows a standard normal distribution under the null hypothesis
- s^2 follows a χ^2 distribution with *p* degrees of freedom under the null hypothesis, where *p* is a positive constant
- *Z* and *s* are independent.

In a specific type of *t*-test, these conditions are consequences of the population being studied, and of the way in which the data are sampled. For example, in the *t*-test comparing the means of two independent samples, the following assumptions should be met:

- Each of the two populations being compared should follow a normal distribution. This can be tested using a normality test, such as the Shapiro–Wilk or Kolmogorov–Smirnov test, or it can be assessed graphically using a normal quantile plot.

First case: two-sample t-test for operator skill (skilled and unskilled)
Using Minitab, the two-sample t-test shows that as the p-value for product parameter comes out to be 40.05 therefore operator skill cannot be a factor for bush rejection.
Second case: two-sample t-test for replacement is since the p-value for replacement comes out to beo0.05 therefore this might be a factor for product rejection.
Third case: Two-sample t-test for tool regrinding. By Using Minitab, the two-sample t-test shows that as the p-value for tool regrinding out to be 40.05 therefore this cannot be a factor for product rejection.
Forth case: two-sample t-test for holding mechanism. Since the p-value for holding mechanism comes out to be o0.05, therefore this might be a factor for product rejection.

In Improve Phase, design of experiments can be done to find out the optimum conditions for the vital few factors can be found out after the two-sample t-test. These experiments were conducted to optimize the value of the parameters of Replacement and holding mechanism. A 2X2 experiment can be designed, i.e. an experiment with two factors each levels.
Control In control phase, X ‾ /R control chart can be drawn to visualize the presence of assignable cause of variation after implementing the changes in factors proposed by DOE and for ensuring that the process continues to be in a new path of optimization. A total of 100-sample size can be taken for drawing X ‾ /R chart.

5. Conclusion

Six Sigma for SMEs is an emerging topic among many academics and Six Sigma practitioners over the last two to three years. Very few studies have been reported about the successful applications of Six Sigma in SMEs. As small companies are more agile, it is much easier to buy-in management support and commitment, as opposed to large organizations. The education and training component is much harder for smaller companies. Moreover, small companies do not have the slack to free up top talented people to engage in training followed by execution of Six Sigma projects as they are crucial to the day-to-day operations and problem solving within the company. Being able to link compensation to Six Sigma implementation is much easier in small companies compared to a large company.
This paper is an attempt to justify the highly useful role of management techniques like Six Sigma for SME's, which are normally presumed to be in the domain of large industries. Product parameter variation is found to be a big problem in manufacturing industry.

6. References

[1]Adams, C.W., Gupta, P. and Wilson, C. (2003), Six Sigma Deployment, Butterworth-Heinemann, Burlington, MA.

[2]Behara, R.S., Fontenot, G.F. and Gresham, A. (1995), "Customer satisfaction measurement and analysis using Six Sigma", International Journal of Quality & Reliability Management,

Burton, T. (2004), "Six Sigma for small and medium sized businesses", available at: www.isixsigma.com/library/content/ (accessed June 20, 2008).

[3]Coronado, R. and Antony, J. (2002), “Critical success factors for the implementation of Six Sigma projects in organization”, The TQM Magazine, Vol. 14 No. 2, pp. 92-9. Goh, T.N. and Xie, M. (2004), “Improving on the Six Sigma paradigm”, The TQM Magazine, Vol. 16 No. 4, pp. 235-40.

[4]Harry, M. and Crawford, J.D. (2004), “Six Sigma for the little guy”, Mechanical Engineering, Vol. 126 No. 11, pp. 8-10.

[5]Harry, M.J. and Schroeder, R. (2000), Six Sigma: The Breakthrough Management Strategy Revolutionizing the Worlds Top Corporations, 1st ed., Double Day – A Division of Random House Publication, New York, NY.

[6]Kapur, K.C. and Feng, Q. (2005), “Integrated optimisation models and strategies for the improvement of the Six Sigma process”, International Journal of Six Sigma and competitive advantage, Vol. 1 No. 2, pp. 210-28.