Six Sigma Methodologies and its Application in Manufacturing Firms

Mudit M. Saxena
Assistant Professor, Department of Mechanical Engineering, IIT, Indus University, Ahmedabad, Gujarat, INDIA

Corresponding Author: mms.saxena@gmail.com

ABSTRACT
Six Sigma is a methodology for process improvement as well as a statistical concept that looks for to determine the variation intrinsic in any process. Six Sigma represents process, that is having 3.4 defects per million opportunities. i.e. 99.99966% of the products from a Six Sigma process are perfect. Firms can impact their sigma level by combining main principles from the Six Sigma methodology into leadership styles, process management, and improvement activities. Main principle of the technique is a focus on the customer. There are many challenges in the implementation of Six Sigma. A well-run manufacturing team can make the entire firm more successful through cost-saving measures, increased quality and a larger inventory of products that the company can market. The Six Sigma objective is to make sure the process has minimum defects (3.4 defects per million chances). Every aspect of the process must be carefully planned and documented in detail in order for manufacturing to go efficiently. The main aspect of Six Sigma for enhancement in the manufacturing industry is to maximize the financial returns.

Keywords: Challenges, Manufacturing, Six Sigma, Tools and Techniques

1. INTRODUCTION
Six Sigma is a methodology for process improvement as well as a statistical concept that looks for to determine the variation intrinsic in any process. Output product defects whether in a tangible process or a service cause deprived customer satisfaction. By reducing variation and opportunities for error, the Six Sigma technique lessens process costs and elevates customer contentment.

Six Sigma is a methodology and a strictly controlled, data-driven approach for eradicating defects in any process. The goal of this Six Sigma method is the implementation of a measurement-dependent approach that put stress on improvement of process and deviation attenuation throughputting into effect Six Sigma methodology. Two Six Sigma sub-methodologies: DMAIC and DMADV are used for accomplishment of it. The DMAIC process which stands for (define, measure, analyze, improve, control) is an enhancement technique for on hand processes falling under specification and seeking step by step progress.

The process of DMADV which stands for define, measure, analyze, design, verify is an enhancement system applied to develop new processes or products at Six Sigma quality standards.

1.1 Data Driven Approach
In Past, many business leaders made decisions dependent on intuition or knowledge. In spite of some common viewpoint in a variety of industries, Six Sigma doesn’t take away the require for knowledgeable leadership, and it doesn’t cancel out the significance of intuition in any process. In its place, Six Sigma works next to other skills, experience, and knowledge to offer a statistical foundation for making decisions. Knowledge might say a process isnot working; statistics prove that to betrue. Perceptual might guide a project manager to consider a particular change could improve output; Six Sigma tools help organizations confirm those suppositions.

1.2 Decision Making
Without proper measurement and analysis, decision making processes in an organization might proceed as follows:

Someone with power in the firm has a superior idea or takes interest in other’s idea. Based on past knowledge, decision makers within an organization believe the plan will be successful. The plan is implemented; now and then it is implemented in beta mode so operating cost and risks are decreased. The accomplishment of the idea is measured after its implementation; problems are tackled after they put impact on products or processes in some way in the present or the future. Sometimes Beta testing is used in a Six Sigma process, but the idea or change in question goes viatethrough analysis and data testing first. The drawback of putting ideas into beta—or to an entire population--without applying a Six Sigma methodology is that organizations can experience inadvertent consequences from changes, spend money on ideas that don’t end up working out as intended, and impact customer perceptions through trial-and-error periods extensive with opportunities for error. In many cases, firms that don’t trust on data make enhancements without primarily understanding the true gain or loss associated with the change. Few improvements may appear to work on the surface without actually impacting customer contentment or profit in a positive way.

The Six Sigma technique lets organizations recognize problems, validate assumptions, brainstorm solutions, and plan for implementation to avoid inadvertent consequences. By applying statistical analysis and process mapping to problems and solutions, teams can imagine and foresee outcomes with a high-level of exactness, let leadership making decisions with not as much of financial risk.
Six Sigma methods do not suggest a crystal ball for firms, though. Six Sigma also provides for control methods: once teams implement changes, they can control processes for a fraction of the cost of traditional quality methods by continuing the use of Six Sigma tools and statistics.

II. DEFINING SIX SIGMA

Six Sigma methodologies for process development involve a vast variety of tools and knowledge. There are only 3.4 defects per million opportunities, in a Six Sigma process.


As per [5] Chakrabarty and Tan, 2007, Six Sigma is also a functional philosophy of management which can be shared by customers, shareholders, employees and suppliers beneficently. As stated by [6] Yang et al. (2007), it is useful to put into effect additional disciplined approach for supply chain projects to execute them more meticulously. According to [7] Mahanti and Antony, 2005, Six Sigma can also be taken as a versatile, customer focused, systematic, structured, proactive and quantitative philosophical approach for business improvement to increase quality, speed up the deliveries and reduce costs.

Further Six Sigma is explained as a business culture. This stream argues that the success of Six Sigma does not rely on statistical tools and techniques but also on the commitment of the top management to guarantee the involvement of the employees in the organisation. [8] Markarian (2004) considers Six Sigma as a rigorous top-down methodology which demands detailed analysis, fact based decisions and a control plan to ensure ongoing quality control of a process. This organisational aspects also shown in the work of [9] Pheng and Hui (2004), who define Six Sigma as a ‘cultural land belief’ system which guides the organisation in repositioning itself towards world class business performance by enhancing factual decision making. Similar definition is given by [10] Schroeder et al. (2008) who consider Six Sigma as an organised structureusing process improvement specialists with the aim of achieving strategic objectives.

One more definition refers Six Sigma to as an analysis methodology that uses the scientific methods. [11] Banuelas and Antony (2004) and [12] Thawani (2004) consider it as awell structued continuous improvement methodology to reduce process variability and remove waste within the business processes. [13] Black and Revere (2006) support this by claiming Six Sigma as a popular and widely used quality improvement methodology. [14] Kumar et al. (2007) argue that Six Sigma is an extension to quality improvement initiatives such as the Total Quality Management (TQM) because of the similarities between the Six Sigma method of Design, Measure, Analyse, Improve, Control (DMAIC) and the Deming’s PDCA (Plan, Do, Check and Act). Using the DMAIC method sequentially can help integrate human aspects (culture change, training, customer focus) and process aspects (process stability and capability, variation reduction) within the Six Sigma implementation (Antony et al., 2005).

III. SIX SIGMA IMPLEMENTATION

Three possible approaches an organisation can take to implement Six Sigma as stated by [15] Al-Mishari & Suliman (2008). One is a business alteration approach where an organisation experiences total change to convert its conventional method of working in order to resume lost customers and overcome the huge losses. The tactical improvement approach restricted to one or two significant business needs focusing on main opportunities and weaknesses is the second. Problem-solving technique which stresses only on persistent problems is the third one.

A lot many of the studies suggest the DMAIC and the DFSS methods as the two most general tactics to put into practice Six Sigma, yet the main objectives of the two techniques are quite different stated by [16] Edgeman and Dugan (2008).

A problem solving method is DMAIC which targets at improvement of the process DFSSIs explained as “a process to define, design and deliver innovative products provide competitively attractive value to customers in a manner that achieves the critical-to-quality characteristics for all the significant functions” by [17] Watson and DeYong (2010). Hence DFSS is used in the background of new product development that focuses on quality from the initial stages stated by [16] Edgeman and Dugan, 2008. It is believed by [18] Mader (2006) that firms with sturdy market growthand competitive position will be better-off with DFSS (focusing on product development and innovation), while for firms with sluggish market or relatively less competitive, DMAIC is generally a more favourable choice focusing on cost reduction.

Applying the these two approaches in diverse parts of the business at the same time is possible. Many organisations as a general movement have now extended DMAICto include DFSS according to [18] Mader, 2006. Likelybasis is that a lot of firms normally train their workforce in DMAIC first then enlarge it to DFSS which is made to the context of new product.[11] Banuelas and Antony (2004) in this context, stated that in order to attain the Six Sigma of 3.4 parts per million of defects is to remodel products, key processes and services by applying DFSS. This argument is arguable as not any literature obviously accepts or rejects this theory. Explained by [16]
Edgeman and Dugan (2008) both DMAIC and DFSS are strongly rooted in the scientific method and are in many ways similar to the recognizable approaches used by the hypothesis testing as well as the iterative experimental design.

There are some variations for DMAIC such as P-DMAIC (Project-DMAIC), E-DMAIC (Enterprise-DMAIC) and DMAIC(R) (DMAIC Report). The differences are mostly in terms of the number and type of phases, rather than the tools used.

There are no significant differences amongst them. The selection of themethodology, in the end, depends on the specific requirements [5] (Chakrabarty and Tan, 2007) and some companies implement Six Sigma not only at the project level but also at the enterprise level [19] (Ward et al, 2008). In these instances, either P-DMAIC or E-DMAIC approach is generally used (Breyfogle III, 2008)[20]. An alternative approach to DFSS is provided by [17] Watson and De Yong (2010).

IV. SIX SIGMA TOOLS AND TECHNIQUES

According to Halliday (2005)[21] many tools and techniques that can be useful to Six Sigma projects are available in the literature. As argued by van Iwaarden et al, 2008[22], Six Sigma gives a customer focused, well explained methodology given by an obvious set of complete tools for improvement of process. Fundamental tools of DMAIC, include flowcharts, check sheets, Pareto diagrams, cause/effect diagrams, scatter diagrams, histograms and Statistical Process Control according to Ferrin et al, 2005[23]. At the Black-Belt level further advanced tools such as regression analysis (e.g. withindifferent variables, curvilinear regression and logistic regression), hypothesis testing, control charts and Design of Experiments are there. It further implies Six Sigma may be taken as a blend of existing tools and techniques available well before Motorola developed this approach (van Iwaarden et al, 2008)[22].

As per (de Koning and de Mast, 2006)[24] tools are also accessible in various forms such as models, analysis templates and procedures and it is this value of techniques that makes difficult the process, making the want of a robust set of what are vital improvement tools to be used within the DMAIC process more obvious according to Brady and Allen, 2006[25]. One central aspect to think when going on board any Six Sigma projects that tools will have to adapt and develop as the project completes. As per Raja, 2006[26], time and again, simple tools are enough to reduce the defects of a complex manufacturing system in the initial stages. To apply Six Sigma it is essential the right tool in the rightsituation ought to be applied to attain victorious results. According to Hagemeyer et al., 2006[27]; [14] Kumar et al., 2008a; Williams, 2009[28]; de Koning et al.[23], 2008 there is a lack of standardised procedures for decisions to choose the precise tools in a particular circumstance. Companies have applied various techniques into the methodology of Six Sigma in past years, to make them efficient and to remove potential gaps after application. Such techniques include statistical tools as well as and analytical tools (Bunce et al, 2008)[29]. According to Maciel Junior et al, 2005[30] these tools augment the practical approach with a sturdyspeculative basis which is attainenhancedequipment and utilisation of resources. DFSS normally comprises innovation tools like the creative problem solving and self-evident design which is not by DMAIC; yet it could, as stated by Chakrabarty and Tan (2007)[5].

Simulation is an emerging technique that can play a vital role in Six Sigma scheme today and is considered by some authors, to be “vital tho long-term success of Six Sigma projects” (McCarthy and Stauffer, 2001)[31]. Computer tools has enabled the Analyse and Improve stages, as it allows major savings in the DOE, phase by testing before execution (Gladwin, 2003)[32]. Few authors such as McCarthy and Stauffer (2001)[31] state in their text that Six Sigma has already given important outcomes without the benefit of simulation.

As per [1] Goh and Xie, 2004; [2] McAdam and Evans, 2004, Six Sigma can also be defined as a group of statistical techniques taken on within the quality management to build a framework for the improvement of process. Statistical techniques find the major quality indicator i.e. PPM of defective products [23] (Mitra, 2004). According to Coleman, 2008[3]; Anand et al, 2007[4], in a Six Sigma a process must generates outputs with less than 3.4 defective PPM.

According to [5] Chakrabarty and Tan, 2007, Six Sigma can also be defined as a management’s functional methodology which can be collective beneficially by customers, shareholders, employees and suppliers. As per [7] Mahanti and Antony, 2005, Six Sigma is a customer focused, methodical, ordered, proactive and quantitative speculative approach for businessaugmentation to augment quality, go faster the deliveries and reduces costs. Six Sigma application is not restricted merely to manufacturing but can be used to the entire supply chain which comprise the services too. As per to [6] Yang et al (2007), helpful to apply a more disciplined methodfor supply chain projects to describe and carry out them meticulously.

We can explain Six Sigma as a business practice. It elucidates that the attainment of Six Sigma not only depend on statistical tools and techniques but on the top management commitment to make sure the workersparticipation in the firm. considers Six Sigma is explained by [8] Markarian (2004) as a meticulous topdown approach which requires detailed analysis, information based decisions and a control plan to make sure continuing process quality control. [9] Pheng and Hui (2004) also support this aspect. [10] Schroeder et al (2008) consider Six Sigma as an unplanned structure applying specialists of process development with the aspire of attaining strategic goals.

V. COMMON SIX SIGMA PRINCIPLES

Firms can impact their sigma level by combining main principles from the Six Sigma methodology into leadership styles, process management, and improvement activities.

5.1 Customer Focused Improvement
Six Sigma practice doesn’t just make developments for the sake of driving up sigma levels. A most important principle of the method is focus on the customer. By adding that knowledge with measurements, statistics, and process improvement methods, organizations augment customer contentment, finally boosting profits, customer retention, and loyalty. A thorough comprehending of the customer and customer requirements not only lets businesses customize product offerings and services, but it also lets firms offer additional elements customers desire and are ready to pay for, prioritize product development to meet current needs, develop new ideas based on customer feedback, understand changing trends in the market and identify areas of concern.

5.2 Continuous Process Improvements
The Six Sigma process doesn’t just make improvements for the sake of driving up sigma levels. Main principle of the technique is a focus on the customer. By combining that knowledge with measurements, statistics, and process improvement methods, organizations increase customer satisfaction, ultimately boosting profits, customer retention, and loyalty. A detailed understanding of the customer and customer desires not only lets businesses customize product offerings and services, but it also lets organizations earn more profits.

5.3 Variations
To reduce the variation in the process is one of the ways to continuously improve a process. All process contains intrinsic variation: in a call center with 20 employees, variation will exist in each phone call even if the calls are scripted. Inflection, accents, environmental concerns, and caller moods are just some things that lead to variation in this circumstance.

By providing employees with a script or suggested comments for common scenarios, the call center reduces variation to some degree.

5.4 Removing Waste
Items, actions or people, that are unnecessary to the outcome of a process has to be recognized and eradicated. It reduces processing time, opportunities for errors, and overall costs. Since waste is a major problem in the Six Sigma technique, the concept of waste comes out from an approach Lean Process Management.

5.5 Equipping People
Organizations equip their workforce working with processes to examine and sustain improvements. In most of the firms, process improvement comprises a two-way approach. First, a process improvement team having of project management, methodology experts, and subject-matter experts define, plan, and implement an improvement. That team then equips the employees who work straight with the process daily to control and manage the process init’s improved state.

5.6 Process Controlling
Six Sigma improvements often address processes that goes out of control. Out of control processes meet specific statistical requirements. The aim of improvement is to bring the process back within a state of statistical control. After that improvements are implemented, measurements, statistics, and other Six Sigma tools are used to ensure the process remains in control. Part of any incessant improvement process makes sure that such controls are put in place and that the employees who are hands-on with the process on a regular basis know how to use the controls.

VI. SIX SIGMA IN MANUFACTURING

Manufacturing is the biggest sector. Abad manufacturing process have that products take more time to make, and the quality of those products is not good. Hence, fewer finished products reach to the market, dropping the revenue brought in the by the firm, which in turn causes the company to make cuts in other areas. The spreading-down effect of a manufacturing process extensive with defects, or even occasional inefficiency, can turn a successful business into a struggling one without warning. An effectual manufacturing practice opens a variety of doors for the firms. If the manufacturing team functions at maximum efficiency, the firm will gain savings in terms of both workforce and resources. It also allows the organization to notice any defects that may enter the usual process. The characteristic manufacturing process involves converting raw materials into finished goods. The work generally performed by machinery but manual involvement is necessary for the machines to function productively. When the process is over, products finished during a given time period will be put into a definite batch so that the management knows what products were made during different points in time. From each batch a sample is tested so that it can be identified, any issues before those products are shipped to retailers. If there is a problem with one of the samples, the whole...
batch will be checked, and other batches from similar time periods may also be evaluated to make sure that the defects did not go into other batches.

Every aspect of the process must be carefully planned and documented in detail for manufacturing to go efficiently. It is the only way to keep checks on not well performing process areas. A lot of production processes experience bottlenecks, where production significantly sluggish down, generating a backlog that adds to the firm’s lead time.

VII. BENEFITS OF APPLYING SIX SIGMA

7.1 Examine Existing Processes

The previous phases of any Six Sigma project require the project team and its stakeholders to define the scope of it and evaluate the existing processes. Since it is the crash of these processes that have required the Six Sigma project, it’s quite significant to evaluate all aspects of each stroke taken by the firm. Manufacturing is all of the little things that make the process happen, and often, it’s the smallest things that make the major difference. Something like the need to clean a machine on a standard basis may cause severe delays, mainly if it’s found that the machine is being cleaned too often, or that it’s not being cleaned at a satisfactory level. The Six Sigma project may reveal that a more systematic cleaning done less frequently can add to production significantly.

These discovery steps highlight the require to break down every aspect of the manufacturing process. Six Sigma can help firms eradicate inefficiencies and redundancies, but it can only do so if these smaller parts of steps are documented and checked. A number of employees may not feel it’s worth bringing up these minor parts of their job; they may also be unwilling to talk about aspects of their job that they don’t handle particularly well. Yet, by discussing these issues, they can take a hands-on approach in developing a better process that increases productivity as well as makes the work of staff-level workers easier.

7.2 Restore Processes to Increase Productivity

One of the most difficult parts of monitoring the quality of a manufacturing operation is that even if the it is noticed that a part of the process that isn’t working, it’s quite difficult to fix that job. Since the firm requires that products continue to be produced, shutting down operations to make an efficiency-based fix is nearly impossible. That’s why a lot of firms continue to operate in the way they’ve always done things, even if it comes at the cost of increased productivity.

Six Sigma gives companies the momentum to make large changes to processes wherever required. When a change is proposed to the stakeholders of a Six Sigma project, there is supporting data that proposes the quantum by which the company may be benefited. It can help out decision makers to consider the true impact of the change. Due to the reworking of the process even if a short-term decrease in productivity occurs, the total benefit will recompense for the diminished efficiency many times over. A process having a lesser lead time, will of course produce more products than the prior method of operation. With time, this augmented pull can lead to a great deal of greater amount of products produced, providing the company the capability to either sell the more amount or save on labor costs by lessening the time the production plant works each day.

7.3 Identify Cost Savings Opportunities

The great benefit of producing more products is the financial impact of extra inventory on hand at virtually no cost. As these extra items will be made by the same labor and resources as the typical load in the preceding system, the only extra cost comes in the form of raw materials. This greater than before productivity can have huge implications for the firm. For any business, internal improvements that save money ought to end up in a cheaper product for the customer. If a firm discovers a way to produce a cheaper product, the margins of company on those products boost. Passing these savings to the client is a big way to increase market share and give the firm with extra revenue income beyond what the firm would get with the previous process.

The normal employee might not be worried with the price the customer pays for a product produced by him. Yet considering the big picture is a significant part of any Six Sigma program. If the firm is able to show production employees how their money-saving efforts can benefit the business - and ultimately, themselves - they’ll be that more supposed to sustain the project.

VIII. CHALLENGES OF APPLICATION OF SIX SIGMA

8.1 Diverse Array of Processes

Generally manufacturing is often taken as a singular function. Anyone who has ever seen a manufacturing process up close knows, the steps required to create each unique product is different. Even different product lines of the similar item that have diverse features can have unique processes. This reveals a problem as it relates to Six Sigma. Since the distinctive project scope of a Six Sigma scheme is restricted to one process, a firm with many products and multiple incompetent manufacturing processes - may have trouble drawing conclusions on a big scale. Also, the outcomes they find as a result of the project may not be able to be extrapolated to other production processes. In most of the cases, since at least one faulty process can be serviced, the project is still worth doing. While the whole outcome cannot be copied in every other process gone the production team, the lessons learned along the way may be appropriate to other activities that require upgrading.

8.2 Outdated Machinery

Six Sigma can achieve several things, but the analysis by itself is not able to change an organization. It takes strict observance to the suggestions of the project to

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see outcomes, and at times the execution of a restored process needs an investment of finances. Even if a business is capable to employ a project team to run Six Sigma, there might be shortage of money to do what’s essential to see the project through to its ideal result.

In production, it’s common to observe outdated and obsolete equipment in use. Due to the high-priced cost of upgrading machinery, many firms attempt to get by with the equipment they have used for long time. It’s easy to find that a Six Sigma project might spot this old machinery as the bottleneck for a part of order process. Therein there is the dilemma. The project makes it sufficiently clear that the firm will benefit extremely from augmenting its machinery. The workers, saturated of using old equipment to carry out new tasks, are excited to see this new technology that will make their work easier. And yet, it can never come to final result because the firm simply can’t have enough money to procure new machines.

The impact is a two-pronged effect. Since the old equipment has been sequestered as the bottleneck, the company observes that its efficiency won’t improve unless the augmentation is made. Also, employee morale is likely to go down as people realize that their jobs won’t get easier in coming time. The firm will be having a serious problem - either continue with the process as is and continue to face problems, or go into considerable debt to procure a machine that may not pay for itself for much time.

Yet the project has attained its primary objective of finding the weak link in a process, it eventually fails because the solution is not possible to attain. It’s a risk that producing firms take every time they go on board on a Six Sigma plan.

8.3 Encouraging Buy-In

Implementing Six Sigma in a manufacturing firm always looks like a good scheme. At management level, the only thing that’s obvious is the advantage that will be attained from implementing a project and upgrading an inefficient process. Yet, at workforce levels, workers might not be so keen about the plan of a Six Sigma mission. One of the major aspects of any Six Sigma scheme is that it must receive complete buy-in if the project is to be a victorious. In a manufacturing industry, it can be seen that the staff manning the machines are the people with the real power in any project.

If the lowest-level workers want it to succeed, the Six Sigma initiative can only work. As it might not be obvious to the management, these workers may have few good basis why they don’t desire a more proficient process. Around the globe where outsourcing and downsizing are feared in every firm, production employees may be frightened that a more efficient process could mean that their services would no longer be desirable. That may be all the drive these workforce need to oppose against this initiative that seems like a threat than an asset.

Project team has to well explain to the employees that any alterations that occur as a result of a Six Sigma project will finally be to their advantage. Also, these workers need to comprehend that they will also be a vital part of generating the solution. At last, the ultimate goal of a Six Sigma project based around a manufacturing process is to make the jobs and lives of those workers executing the process easier. If they understand that, they are more receptive to change they will make positive contributions to the Six Sigma project.

IX. SUGGESTIONS FOR USING SIX SIGMA IN INDUSTRIES

A well-run manufacturing team can make the entire firm more successful through cost-saving measures, increased quality and a larger inventory of products that the company can market. Choosing a manageable and purposeful scope for the project is essential when implementing Six Sigma. Yet the solution can’t be applied everywhere, a project that comes to a successful result will give in positive insights that can impact other sections of the manufacturing operation. These results will make subsequent Six Sigma projects within that company easier to administer. Getting workers involved early and often will help out them to take pride of the initiative.

Following all data is a keystone of any Six Sigma project. That’s particularly correct in the production firm, where something minor can end up being the bottleneck that disrupts an entire process. No data is too unimportant to track, and no potential solution is in addition simple to consider.

X. CONCLUSIONS

In current time in the application of Six Sigma principles there has been a lot of awareness. A lot many papers have been published on this Six Sigma validating the significance of applying Six Sigma to get better process performance. In this study the major focus is on implementation of six sigma in manufacturing. It is carried out to spot the most recent trends, a variety of approaches, tools and techniques and advantages of Six Sigma. The main objectives of Six Sigma, remain unchanged, i.e. improving competence, profitability and efficiency of the process. A lot many of tools and techniques within Six Sigma are there. Existing studies traditionally categorizes the Six the critical goal of Six Sigma is to mark bottlenecks and find solutions that allow the entire process to function efficiently.

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