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IMPLEMENTING SIX SIGMA FOR MANUFACTURING SECTOR IN INDIA- A MODEL BASED ON A STEEL INDUSTRY

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ABSTRACT

Most fertile opportunities to implement Six Sigma in India can be observed in Agriculture and Manufacturing sectors looking at the present crisis and opportunities available. However, large chunk of focus of application of Six Sigma in India is observed in IT and IT enabled services including BPOs. Larger cross sections of the clients of IT and BPO industries of India are USA and Europe based and it is insistence of these clients who motivated to go in for application of Six Sigma apart from, of course, the industries have got their own reason to go in for Six Sigma. Six Sigma in manufacturing sectors in India today are mostly limited to medium and large manufacturing houses and to their related supply chain network members. Even these industries have set major objective to go in implementing Six Sigma towards cost reduction and customer satisfaction. Success stories of implementing Six Sigma in these industries are also shared in multiple forums of award winning competitions within Organization, inter-Organizations, Inter- state, national and international platforms. Even these industries could not significantly bring about the benefit of application Six Sigma to their other stakeholders including Government on compliances, Suppliers to improve mutually beneficial long-term dependency, Financial/ leasing institutes or banks to improve good credit rating image, Society to appreciate better visibility on the contribution of the Organization, Intellectual community in terms of high value and high esteemed Intellectual Property Rights and the likes. This paper proposed a model to take Six Sigma to address overall sensitivity to all the stakeholders for manufacturing industries in India, following the approach of RDMAICSI. The model is also demonstrated in a steel industry of India.

Keywords: Six Sigma, RDMAICSI, DMAIC, DFSS

1. INTRODUCTION

1.1 Manufacturing Sectors in India

a) Manufacturing Industry & Six Sigma

The terminologies associated with manufacturing industry like the terms linked with statisticalmodeling of manufacturing

processes originated the term Six Sigma. A sigma rating candescribe the maturity of a manufacturing process by showing its percentage of defect free products created or its yield. As per , basics of the doctrine of Six Sigma the success of a company vitally depends upon regular efforts for achieving stable manufacturing processes .The prime objective of Six Sigma methodology is to make sure that the manufacturing process has minimum defects. Six Sigma is a business improvement strategy implemented by companies all over the world which will reduce the process variation drastically and increase effectiveness of the businesses. Since its inception Six Sigma has been largely confined to the domain of only the big companies with good resources. But, this breakthrough methodology is equally applicable to the small and medium size enterprises (SMEs) also for improving their bottom- line (Raghunath and Jayathirtha, 2013).

Manufacturing managers in Indian companies are faced with global competitive strategies because of the shift of many multinational companies to India. They are forced to excel in all the domains of manufacturing, *i.e.*, quality, cost and delivery. The days of trading off among these three domains are gone and the manufacturing managers should have best quality

processes and procedures; at the same time they must be able to produce goods at cost effective level, and most importantly have flexibility and accuracy in deliverable terms. Six Sigma is a structured problem-solving tool used to improve products, processes and services by eliminating quality problems before they occur, which saves valuable corporate resources and improves work. The issue of Six Sigma has become a main strategy in production management in recent years (Radha Krishna and Dangayach, 2007).

b) Automobile Industry

Automobile manufacturers seeking to adopt Six Sigma methodology would do well to follow the lead of organizations that have implemented Six Sigma successfully. Six Sigma must be more than just a passing fad promoted by management. Ford demonstrated its long-termycommitment to Six Sigma b implementing it at the highest levels of senior management. 350 of Ford's executives, including the CEO, received Six Sigma training or certification. During the first two years of the initiative, Ford trained more than 10,000 employees in the roles of Six Sigma, including Master Black Belts, Black Belts, and Green Belts.

c) Chemical Engineering

Although Six Sigma has been so successful in many organizations, the successful applications of Six Sigma are rare for the chemical processes due to highly nonlinear causality. In the last century, there has been a tremendous evolution of the ideas to improve quality in any organization. Conventional tools for product quality improvement, such as quality control (QC), total quality control (TQC), and total quality management (TQM), concentrate on reducing off-specialties of the final products rather than on removing defects during a process of production. In the chemical process, many kinds of factors have been shown to influence quality of the final products. The traditional quality improvement methods of chemical process can be enhanced by athe use of Six Sigma strategy. Many of the chemical processes are already being used by systems engineers including cost modelling, multivariate statistical an lysis, Design of Experiment, and design for manufacturing and assembly. Integrating these and other standard tools into an effective cost reduction discipline is a job best performed by systems engineers (Kim E tal.2003).

d) Steel Industry

Indian industrial sectors such as Iron & Steel and Cement manufacture products for equitable growth but at the same time consume huge amounts of energy. India's total final energy consumption was estimated at 449.27Mtoe of which the industrial sectors consumed about 30%. The Iron & Steel sector is one of the most energy intensive manufacturing industries, consuming about 25% of the total industrial energy consumption. The Indian Iron and Steel industry is vital to the nation's development efforts and to support the required rapid economic growth. Steel finds its application in a wide range of sectors such as automobile, power, machine goods, and infrastructure. The industry has taken several initiatives to conserve energy at each sub process by adopting best technologies and innovative process operations or the usage of alternate materials. The National Steel Policy has been framed by the Ministry of Steel, Government of India for long-term objectives of improving production, consumption, quality nd techno-economic efficiency, environmental and social sustainability. By applying Six Sigma principles, the firm can identify the current situation that operations are in. Six Sigma DMAIC methodologies can be used in the project to determine the project's critical to quality (CTQ) characteristics. It defines the possible causes as a first step of implementation and then identifying the probable causes goes to the sources of variation. Paper can be useful for any company that needs to find the most cost efficient way to improve and utilize its resources through the reduction of defects. The research findings will be disseminated among industries, policy making bodies, financial institutions and related stakeholders to enable them to contribute to the development of a globally competitive industry by enhancing energy efficiency while increasing environmental sustainability (Jadhav E tal, 2014).

1.2 Registered manufacturing companies in India

The total number of registered companies in the country has crossed 13 lakh mark, but 1.44 lakh of these firms are 'dormant' and have not filed their annual returns for past three years. As on 31st May 2017, there were 13.21 lakh companies registered with Ministry of Corporate Affairs. Of these, as many as 2.6 lakh companies have been closed for various reasons including courtorder and voluntary winding up, while another 30,435 firms are in the liquidated (PTI, 2013).

1.3 Manufacturing sector's contribution to GDP in India

The contribution made by the manufacturing sector in India's real gross domestic product has increased over the years. However, the rate of growth has not been at par with expectations. In the planning process of India's economic development a lot of emphasis was given on the heavy industries and this led to greater expectations from the manufacturing sector. In 2007, the manufacturing sector contributed 34 percent to China's GDP while its Indian counterpart accounted for 16.1% in 2009-10 fiscal. In the last few years, India's registered manufacturing sector has made better contributions than the unregistered sector. The East Asian countries like China have had similar levels of planning but have performed better in the global arena with their manufacturing sector. This has been discovered in a RBI Development Research Groupstudy on productivity, competitiveness, and efficiency of India's manufacturing sector(Business Maps of India, 2012).According to experts India is well on course to increasing the share of manufacturing sector to 25 per cent of GDP from the existing 17 percent. The manufacturing sector's growth, which stood at 9 per cent of India's GDP in 1950-51, stagnated at 15 per cent level for over 2 decades. In the last two years, it has improved to 17.1 per cent and this is primarily due to the 'Make in India' drive. But we are still low compared to our neighboring countries such as

- Thailand (where 35 per cent of GDP is from manufacturing)
- China (32 per cent)
- Philippines (30 per cent)
- Indonesia (29 per cent)

We have a long way to go. 'Make in India' is not about getting foreign companies or large corporate to set up business in India. Not only can such big companies create jobs, but also the small and medium enterprises (SMEs) can create jobs. The target under Make in India is to create 10 crore new jobs by 2020. This can be achieved only by taking the manufacturing sector's

growth to 25 per cent of the country's GDP (Shah, 2017).

1.4 Manufacturing Sectors in India: Evaluation

Service sector showing tremendous progress in India, As far as manufacturing sector is concern it also gathering pace. With the 'Make in India' campaign India plans to be the leader of the manufacturing sector in the world. As per research, current manufacturing strategies implied by India for its growth in the manufacturing sector; International Monetary Fund (IMF) raised a concern about the pace of the reforms which are being passed. They pointed out that Indian economy is facing "decelerating pace of reforms". Recently the long waited GST bill had been passed by the government of India which would enable an easy and a cost cutting flow of goods across different states of the country. It presents a wonderful opportunity for the manufacturing sector to re-establish the logistic sector of the country. A strong infrastructure is an essential ingredient for any manufacturing sector to grow. Keeping that in mind the government of India is investing a lot of funds in building a strong network of roads, rails and transport to foster the growth of the manufacturing sector. As many industrial corridors and road networks rapidly are being formed.

In recent years the manufacturing sector has been the major focus for the government of India. Realizing the importance of manufacturing sector and the amount of employment it can generate, many initiatives are being taken up by the current government to foster the growth of this sector. Having the benefit of a high amount of educated population & skilled labour, there is enough scope for the manufacturing sector to further develop in the country. The 'Make in India' campaign started by the current government is one of the biggest initiatives taken by any government in order to attract foreign investors to invest and start manufacturing in India. The government is providing adequate infrastructure like electricity and strong network of roads and railways for easy transportation of goods and services. Many laws favouring the labours and land acquisition are being implemented so that it is easier for the foreign investors to start their business in India. Their main motive is to manufacture goods with zero defects so that none of the exported goods are returned back to India. With 'Make in India' campaign, the government doesn't want to compromise on the environmental standards. Some of the major industrieswhich are on a high rise are the automobile industry, electronic & semiconductor industries, machinery, chemical, pharmaceutical industries and aviation industries. Many foreign investors are looking to invest in the defense sector of the country as well. Along with foreign investors, domestic companies having good leadership and manufacturing technology are also encouraged to invest, so that they can compete with the global leaders (Mehta & John, 2017).

1.5 Manufacturing Sectors in India: Challenges

Logistic Problems

Logistic sector in India contributes to around 14% of the total GDP of the country, which is higher than USA and many European countries. When we compare with BRIC nations, the ranking for other countries in the logistic sector index is constantly improving. According to the World Bank's 2014 logistics performance India is positioned at 54 much below than other countries like South Africa. There are a plenty of reasons for the poor showing of India in this department. Poor networks of roads, inadequate air & sea port capacities along with undeveloped railway networks are hindering the growth of this sector. This leads to slow & inefficient delivery of the product to the customers. The turnaround times are also high due to heavy congestion on berths and slow evacuation of cargo unloaded at berths. High cost of fuel & high waiting times negatively impact the logistic sector. The transportation industry is also severely un-organized (Mehta & John, 2017).

Lack of availability of skilled labour

The fact is that India is facing the shortage of skilled manpower. According to a lot of surveys and researches done in the last one year, the statistics have proved there are so many different sectors in India like the Information technology, construction, mining etc. Not only this, the country is facing skilled manpower shortage in the field of media and film industry. The reports have shown that there are a significant number of departments where there is an absolute necessity of skilled manpower. The question that arises at this point is why there is a shortage of skilled manpower in India. There are so many reasons that could be attributed to it.

The lack of skilled labor can create innumerous problems for a nation. If there is no adequate labor class in a country, the country's GDP and economic progress will incur heavy losses.

Lack of infrastructure facilities

Economic infrastructure includes five sectors namely electricity, banking, irrigation, transportand communications. Social infrastructure includes two sectors education and health. Botheconomic and social infrastructure indices are combined to construct an aggregate index of infrastructure. Above content of infrastructure facilities are not performing well as per requirement.

1.6 Role of Six Sigma to meet the challenges and difficulty faced.

A) Lack of Leadership Commitment

A successful Six Sigma project requires leaders who are willing to dedicate resources of time, talent and money to the project. The important issues in deploying Six Sigma comes when

management decides which employees will be dedicated to the project. Selecting fast trackers from their current work to deploy Six Sigma projects is a short-term sacrifice, but can unlock the benefits of Six Sigma over the long term.

B) Lack of awareness of Six Sigma Methodologies

To get the benefits of the Six Sigma methodology, some organizations rush in to go for such activity required for successful Six Sigma implementation. This can occur when companies implement Six Sigma simply to keep up with the competition, or to impress shareholders by being able to use continuous process improvement terminology in company documentation. Organizations that deploy Six Sigma without proper homework are facing many failures.

Companies can overcome this obstacle by committing fully to the process and employing and supporting Six Sigma experts to ensure that the company is deploying the methodology and not just using the terminology. These experts also keep the project focused on core operations where they can make the most difference.

C) Poor Execution

Even under the expert guidance of project Champions and Master Black Belts, Six Sigmaquality improvement projects can get failures if they are not properly executed. Poor execution happens when process improvements are not aligned with the organization's goals, when the project is based on reactively solving problems instead of meeting strategic objectives or when the quality improvement project focuses on the output of the process instead of the inputs. When companies understand that Six Sigma methodologies are not intended to operate in a vacuum but that they work best when aligned with the goals and objectives of the organization, they are more likely to stay on target. Organizations that find they are not getting the productivity gains or financial savings they anticipated from employing Six Sigma methodology are notdisappointed because the methodology is ineffective. The most likely source of theirdisappointment is that the projects lack effective leadership and are managed inefficiently. When leadership is committed to applying the Six Sigma methodology, assigns top talent to project teams, puts the project through a formal selection and review process, and provides the required resources, the odds of Six Sigma success increase dramatically (Munk,2013).

1.7 Limitations of Six Sigma implementation:

· Six Sigma is costly tool for implement at small organization. It requires employees must obtain training from certified Six Sigma Institutes in order for an organization to receive Six Sigma certification.

· Six Sigma is applied to all aspect of the production and planning process, it may create rigidity and bureaucracy that can create delays stifle creativity.

· Insufficient or ineffective allocation of human resources.

· Lack of visible senior leader sponsorship.

· Failure to link project to bottom line impact.

Hence there is a need of adapting the Six Sigma approach to suit to Indian manufacturing sectors.

2. LITERATURE REVIEW:

This research work (Chiarini, 2015) is illustrated the use and project management of Six Sigma tools and Lean Production by discussing a case study dedicated to the improvement of overall equipment effectiveness. The case study conducted in a medium-sized company which produces injection moulded parts in plastic using several presses. One of these machines had a poor OEE with a large variability. The poor OEE led to high costs in terms of work-in-process and re-inspections of the products. Following DMAIC pattern, a dedicated team of the companydefined the set-up times and the internal diameter of the product as critical to quality characteristics (CTQs). The root causes of the variability of the CTQs were identified through a cause-effect diagram and a Chi-square test afterwards, the team removed the root causes and improved the CTQs which have increased the OEE from 40% to 61%, reducing its variability.

Research work is done by (Singh and Singh, 2014) is to reduce quality rejection of crankshaft P19 by implementing DMAIC approach in a systematic manner on the shop floor of the manufacturing unit of northern India. After implementing DMAIC methodology, results obtained the decrease in quality rejection level from 11179.87 to 28.69 ppm, which results in net saving of 17.66 lakhs per year.

The research work is deals with the application of six sigma based methodology in eliminating an engine overheating problem in an automotive company. The DMAIC approach has been followed here to solve an underlying problem of reducing process variation and the associated high defect rate. The research (Antony Et al, 2005) explores how a foundry can use a systematic and disciplined approach to move towards the goal of six sigma quality level. The application of the six sigma methodology resulted in a reduction in the jamming problem encountered in the cylinder head and increased the process capability from 0.49 to1.28.

This research is concentrated on deploying Six Sigma methodology with Taguchi robust design approach, for finding the root causes that eliminates the variations and embarks the customer satisfaction, quality of the shock absorber manufacturing. In (Srinivasan et al, 2014) research, major focus

on reduction/elimination of two imperative responses in spray painting process producing shock absorbers, namely peel off and blisters. In Improve phase, concentrated on optimizing the vital root causes which impact the responses by using the Taguchi design approach. The L27 orthogonal array had been constructed with three factors and levels, results of experimentation had been analyzed by using ANOVA and multivariate regression which identifies the condition of optimality on peel off and blisters in the pretreatment process. In control phase, the confirmation run with optimality conditions were conducted, the results obtained from runs are satisfied which embarks the sigma level 3.31 to 4.5.

In this research, Six Sigma project was done within company for production automotive parts, which deals with identification and reduction of production cost in the deburring process for gravity die-casting and improvement of quality level of produced parts. The objectives are achieved by systematic application of DMAIC tools and methodology within an automotive parts production results with several achievements such as reduction of tool expenses for 40 %, cost of poor quality 55 % and labour expenses 59 % (Sokovic E tal,2006).

The (Saudi Apak Et al,2012) research aim is to assemble public and private sector officials in an international strategic planning process to advance the efficient development of a hydrogen economy infrastructure and to understand Six Sigma methodology and its contribution to energy efficiency. In this paper, Six Sigma methodology that uses data and statistical analysis tomeasure and improve performance has been applied to hydrogen energy to boost energy efficiency and to emphasize the importance of exploring potential future sources of sustainable, reliable and competitively priced energy.

Six Sigma methodologies has been attempted to a process industry and taken the case of thermal power plant. The CTQs selected for this Six Sigma application, is to reduce the consumption of DM (de-mineralized) water input in a thermal power plant .In their research, (Kaushik and Khanduja, 2009) studied the process and implemented recommendation and improvement action plans and also reduced the mean make of water from 0.9 % to 0.54% with energy saving of nearly Rs 296.09 Lakhs per annum.

This research (Sri Indrawati and Muhammad Ridwansyah, 2015) is conducted in Iron Ore Industry using lean Six Sigma method. The first part was focused on waste analysis using process activity mapping. Then manufacturing process capabilities evaluated. Further failure mode and effect analysis is used as a basic consideration in developing the continuous improvement programme. The research shows that the quality performance is in level of 2.97 Sigma. There are 33.67 % non value added activity and 14.2 % non necessary non value added activity that occurs during the manufacturing process. Based on the analysis, product defect inappropriate processing and waiting are type of manufacturing waste that frequently occurs. A continuous improvement programme is developed to overcome the problem.

The research is conducted at Steel bar manufacturing Industry Pakistan and production parameters of a steel bar manufacturing is optimized by using DMAIC. Optimization of a manufacturing process results in higher productivity and reduced waste. The significant factors are controlled to optimized level using two level factorial design methods. A regression model is developed that helps in the estimation of response under multivariable input values. Model is tested, verified and validated by using industrial data collected .The sigma level of manufacturing process is improved to 4.01 from 3.58 (Naeem Khawar , Ullah Misbah, Et al, 2016).

The purpose of(Kamran Nourbakhsh E tal,2013) research is to investigate the influence of implementation six sigma project in commodity management unit in Khorasan steel plant to explore the main reasons of the defects in determining the purchase order amount and inventory control to generate the improvement in the processes and also the profitability through increasing the defects in the purchase orders amount and inventory control.By applying Six Sigma project seven strategic points which had significant influence were found and through the improvement implementation, the Sigma level 1.944 amount increased.

Lean Six Sigma tools of DMAIC is applied to determine wastage and to reduce the cycle time of production in a biopharmaceutical operation. The data were analyzed using functional process mapping and value analysis. The significant result was obtained where approximately 54% of the overall production cycle is considered as waste or non value adding activities that are eliminated. For better result and sustainable improvement a few activities have been introduced (Abdullah Ismail et al, 2013).

The research presented by (Pavlovic and Bozanic, 2010) is that application of basics of lean and Six Sigma concepts in pharmaceutical industry together with harmonization with legal regulation represented by requirements good manufacturing practice, in order to work smarter, more cost-effectively and avoid wasting time and other resources.

3. SIX SIGMA STRATEGIES, APPROACH, TOOLS, TECHNIQUES, AND PRINCIPLES IN MANUFACTURING SECTOR:

The fundamental principle of Six Sigma is to take an organization to an improved level of Sigma capability through the rigorous application of statistical tools and Techniques (Antoney E tal, 2003) .It generally applies to problems common to production. Table 1 summarizes Six Sigma business strategies, tools techniques and principles.

Table1: Six Sigma strategies, principles, tools and techniques

Six Sigma business strategies and principles	Six Sigma Tools and Techniques
Project Management	Statistical process control
Data based decision making	Process capability analysis
Knowledge discovery	Measurement system analysis
Process control planning	Design of experiments
Data collection tools and techniques	Robust design
Variability reduction	Quality function deployment
Belt system(Master, Black, Green, yellow)	Failure mode and effect analysis
DMAIC process	Regression analysis
Change management tools	Analysis of means and variances Hypothesis testing Root cause analysis Process mapping

The (Kwak and Anbari, 2002) pointed out that six sigma is more comprehensive than prior quality initiatives such as Total Quality Management and Continuous Quality Improvement. The six sigma method includes measured and reported financial results, more advanced data analysis tools, focuses on customer concerns, and uses project management tools and methodology. He summarized the six sigma management method as follows:

Six Sigma = TQM + Stronger Customer Focus + Additional Data Analysis Tools + Financial Results + Project Management

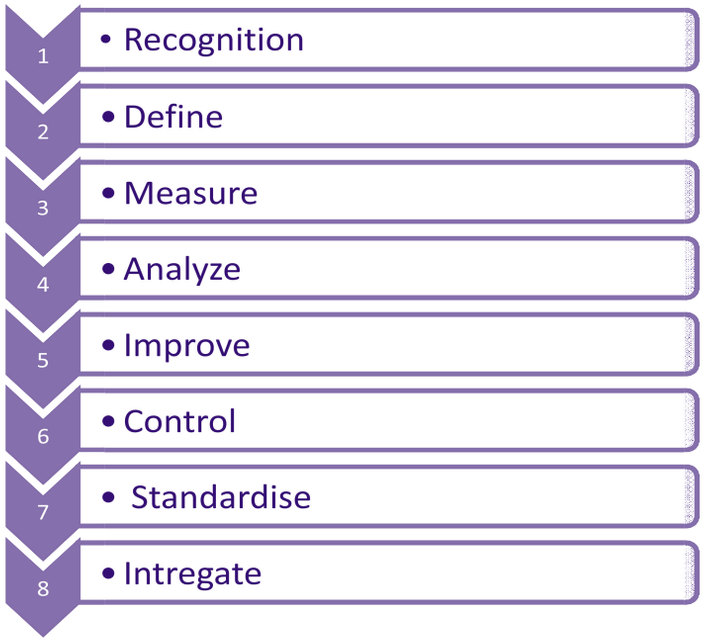
DFSS Process

Design for Six Sigma (DFSS) is a systematic methodology utilizing tools, training and measurements to enable the organization to design products and processes that meet customer expectations and can be produced at Six Sigma quality levels.

DFSS is potentially far more effective than DMAIC as its application is in the early stage of new product/process development, thus the papers under this category aim to provide an explanation of DFSS and why it is different from DMAIC. For example, Mader explains the DFSS methodology, its key aspects and how it enhances the design process, improving New Product Development (NPD). Antony presents DFSS using the Identify, Design, Optimize and Validate (IDOV) approach. Treichler et al. discusses the use of DFSS in the design function ofmajor US corporations and Koch et al. explain DFSS in detail, using as an example the application of DFSS in automotive crashworthiness under an engineering design context. All of these studies of DFSS have been undertaken in a manufacturing context. Hence, there is a need for more extensive study to consider new areas of DFSS application, such as how DFSS can be applied to nonmanufacturing processes (Wang, 2008).

4. MODEL TO IMPLEMENT SIX SIGMA IN INDIAN MANUFACTURING SECTOR:

Following RDMAICSI model is to be implemented in manufacturing sector of India



Recognition:

The role of six sigma recognition phase is to create a theme for six sigma to see that is imagine as a future possibilities like vision and deploy the same. In this case the steps used as, create organization for six sigma, link six sigma to business objective .Develop the strategies and finalize business level dashboard and identify the issues for improvement. Create project hopper and select the project.

Define:

The purpose of define phase are as under: make sure that the project is important, identify the stakeholders and understand their concerns requirement connected to the problem. Define the measures to represent the requirement of the project in terms of critical to quality (CTQs) in terms of the problem of the project and its consequences .Map the macro level process which consist of the causes and the effect in terms of Ys and the consequences of Ys in terms of Zs.

Measure phase:

In the measure phase, it is to be ensured that the measurement uncertainty of CTQ's data isknown and suitable and set

up baseline process capabilities. In this case

the performancestandard of the process is verified and establishing the baseline for improvement. The step includes

a. To prepare data collection plan.

b. Measurement system analysis.

c. Base lining by using various method.

d. Process capability analysis including sigma level estimation.

This step includes, the data is to be collected of CTQ's and drill down parameters of CTQ's. To prepare a data collection, which would be the amount by which something is increased in the CTQ tree itself.

Analyze phase:

It is stage where the team is finding the root causes of the poor signal level of the CTQ's and confirms the real or root causes. Initially team analyses the problem and status of the problem as chronic, sporadic and unstable by using control charts, I-MR chart, P-chart, C-chart. Next process is to analyze the process to identify process flow and related to real causes using process map, perceived process, As-is process etc. Conclude the real causes by conducting test of hypothesis, ANOVA, Chi-square test, T-test, Linear Regression. Also select the high risk causes by considering the process failure mode and effect analysis (FMEA), cause and effect diagram.

Improve Phase:

In improve phase act on real or root or high risk causes. This stage statistically reviews the variations in the process and determines the factors significantly contribute the output. Design of experiments, ANOVA and Taguchi techniques are useful for the same.

Control Phase:

In control phase, to sustain the improved status and set up the control plan and handover the same to the process owner.

Standardization Phase:

Standardization is what allows high quality to happen on a reliable, sustained basis.

Integrate Phase:

Standard management system for the organization as the single system to follow for routine business management.

Table 2 shows the RDMAICSI model which can be implemented in Steel Industries.

Phase	Purpose	Sr. No.	Steps	Tools
Recognition	Connect Six Sigma to Business	1	Create a theme for Six Sigma to envision the vision and deploy the same	Sustainable (sensitivity to stakeholders), predictable(statistics), desirable (cross-domain knowledge) growth in profit FOLLOWING THE LAWS OF THE LANDS
				Business Level Dashboard
				Champion Level Dashboard
				Balance score card
				Hosin Kanrie
		2	Orient the organisation amenable to deploy Six Sigma	Leadership Team of Six Sigma
				Sponsor
				Champion
				Six Sigma Leadership Team
				Master Black Belt
				Black-Belt/Green-Belt
				Yellow -belt
		3	Create issue/opportunity hopper, select projects	DMAIC/LSS/DFSS
				Opportunity hopper
				Project Prioritisation Matrix
				Pareto diagram
				List projects

For each project (DMAIC)				
		1	Ensure that the project is important	Project charter
			Identify the stakeholders in connection the problem/s,	Requirement gathering:
				What they (Stakeholders) say:
				Voice of Customer/Voice of Stakeholders
				Reactive- Lagging indicator
				Proactive- Leading indicator:
				- Survey

Define		2	understand their concerns or requirements, consolidate and classify the	- Focus group
				What they do:
				Contextual enquiry:
				Go to customer's place
				Map customer's process
			requirements and translate the requirements to Critical to qualities	Intervene or make your product to work in customer's process
				Observe the requirements and collect
				VoS template
				Kano Model
				CTQs
				T-C-Z-Y-Ys-X
		3	Initiate CTQ Drill-down tree	CTQ Tree
		4	Map the process in macro level	Map the process in macro level
		5	Plan to collect data	Quality Control Support System
				Type of data
				Unit of Measures
				Type of Specifications
				Upper Specification Limit
				Target
				Lower Specification Limit
				Min. freq. of data
				Defect definition
				Record ref.
				Responsibility
				Measurement Support System:
				Instrument:
				Least Count
				Operational definition of the measurements
				Continuous:
				Accuracy

Measure		6	Ensure that measurement uncertainty is known and suitable	Bias
				Linearity
				Stability
				Precision
				%ge Repeatability & Reproducibility (<=10%)
				%ge Repeatability
				%ge Reproducibility
				standard deviation of R&R
				Attribute:
				Agreement %
				Kappa value
		7	Collect data, baseline and assess baseline process capability	No of observations
				Time Series Plot
				Histogram
				Normality test
				Average
				standard deviation
				Population drift – Delta
				Required sample size
				Cp: process capability
				Cpk: Process capability Index
				defects per million opportunities
				Sigma Level-Short Term
				Sigma Level-Long Term
				Control chart for normal
				LCL (xbar-3s.d.), CL (xbar), UCL (x bar +3s.d.)
				Construction of Control limit wont accommodate any sporadic problem.
				Sporadic problem must be visible in the control chart
				Control chart is permitted to be constructed as long as sporadic problem is <20%
				Process of homogenization is to filter out sporadic problem.
				Control chart has be in the progression of time line

Analyse	Identify all possible causes and confirm real or root or high risk causes	8	Isolate special causes from common causes	Variable Control chart used different situation
				I-MR Chart used if Only one data at a time point
				x bar - R Chart used if 2-10 data at a time
				x bar-S Chart used if >10 data at a time point
				Attribute control chart:
				Defectives
				Fixed Sample Size :np chart
				Varying Sample Size: p-chart
				Defect
				Fixed Sample Size or Irrespective of Sample Size : c-chart
				Varying Sample Size : u-chart
				Run chart for non-parametric
		9	Introspect the processes and identify the causes	BFC (Basic Flow Chart)-SIPROC
				AFC(Activity Flow Chart)Perceived
				AFC-As-Is
				DFC(Deployment Flow Charts)
				OFC (Opportunity Flow Chart)
		10	Confirm real causes with estimated confidence	Test of Hypothesis:
				Normality test
				1 Sample t-test
				1 Sample Sign Test
				2 Sample t-test
				Paired t test
				F-test/ Bonet's Test
				Levenez Test
				Mann-Whitney Test
				One Way ANOVA (Analysis of Variance)
				Bertlette's test/ Multiple Comparisons

Analyse	Identify all possible causes and confirm real or root or high risk causes			Levenez Test
				Kruskal Wallis Test
				Mood's Median Test
				1 Proportion test
				2 Proportion test
				1 Sample Poisson rate
				2 Sample Poisson rate
				Chi-square test
				Correlation & Regression:
				SLR(Simple Linear Regression) & MLR (Multiple Linear Regression)
				Nature of Relationship
		11	Confirm real causes by exploring relationship	Correlation Coefficient
				Significance of Correlation (SLR) & Regression for MLR
				Relationship
				Strength of the relationship- R^2
				Purity of the relationship-
				Precision of the relationship- S
				Coefficient table
				VIF
		12	Identify all pending potential causes, evaluate risk and select high risk causes	Process FMEA (Failure Modes and Effects Analysis)
				C-E (Cause and Effect Diagram)
				Pareto Diagram
				List of Real or root or high risk causes
Improve	Act on real or root or high risk causes	13	Act on real or root or high risk causes	PFMEA Follow up
				Project management Plan
				SPM (Solutions Prioritisation Matrix)
				DoE (Design of Experiments)
				Piloting

Control	Sustain the improved status	14	Collect data after improvement and test for significance	Before-After ToH (Test of Hypothesis)
				One Sample ToH against target
		15	Assess capability of improved process	
		16	Ensure control online with improved status	Control chart-online
				Trouble shooting checklist
		17	Explore and implement "best way to control is to eliminate the need for control	Japanese Management System
		18	Estimate Benefit	Cost Benefit Estimation
		19	Develop Control Plan and handover to the process owner	Project document template
				Control plan
Standardise	Standardise the way of problem solving for the Organisation	20	Standardise the way of problem solving for the Organisation	
Integrate	Make this standard management systems for the Organisation as the singular umbrella platform to represent the routine business management system	21	Make this standard management systems for the Organisation as the singular umbrella platform to represent the routine business management system	

5. CONCLUSION

Impulsive changes are occurring in industry globally. A critical review of industrial changes indicates that more and more people are turning to Six Sigma approach for improving productivity. The future of Six Sigma depends on keeping it relevant to current business needs and to continue to enhance and expand the traditional Six Sigma toolkit. Six Sigma continues to be a predominate target to try and obtain a competitive advantage. However, not all companies are successful in implementing many of these quality improvement strategies. Although many companies attribute their success to following a quality improvement program such as TQM and Six Sigma, there are a significant number of companies that fail to gain any measurable benefit after implementing these quality strategies. Six Sigma in industries such as IT,BPO, Agricultural sectors are also shared in multiple forums of award winning competitions within Organization, inter-Organizations, Inter-state, national and international platforms. Even these industries could not significantly bring about the benefit of application Six Sigma to their other stakeholders including Government on compliances.

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