Six Sigma with innovation tool kit of TRIZ

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Abstract: Six Sigma is a proven strategy for creating maximum value for its customers, employees and shareholders. Still, it is noticed that a lot of recourses are normally consumed to deploy Six Sigma in organisation, which is associated with risk involved in its success. There is a need to review and enhance the tool kit of Six Sigma for making it more effective. Theory of Inventive Problem Solving (TRIZ) plays an important role for this purpose. This paper discusses about tool kit of TRIZ which is used to enhance the success of Six Sigma implementation. An integrated tool kit has been developed and tested during a live Six Sigma project in a manufacturing industry. A questionnaire-based survey has been conducted to validate the benefits of this integrated tool kit. It has been observed that users of Six Sigma are not very much familiar with TRIZ tools. It is also established that TRIZ can improve the effectiveness and efficiency of Six Sigma tools. This paper is of great value to various industries, researchers, managers and engineers involved in Six Sigma implementation/research. This paper provides insight into the actual benefits of deployment of TRIZ in Six Sigma projects in a manufacturing environment.

Keywords: Six Sigma; DMAIC; define, measure, analyse, improve, control; TRIZ; Theory of Inventive Problem Solving.

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1 Introduction

Six Sigma is a new star in the quality world (Tennant, 2001). Six Sigma is a data driven process improvement approach that uses both the scientific and the statistical methods to achieve bottom-line results. Motorola coined the concept of Six Sigma and General Electric popularised it (Reddy and Reddy, 2010). Six Sigma uses conventional and advance tools of quality management to reduce process variation. The methodology helps to remove root causes through well-structured data-based approach. Motorola originally developed Six Sigma in 1987 and targeted an aggressive goal of 3.4 parts per million (ppm) defects (Barney, 2002). In 1994, Larry Bossidy, CEO of AlliedSignal, introduced Six Sigma as a business initiative to produce high-level results. This was followed by the well-publicised implementation of Six Sigma at General Electric beginning in 1995 (Slater, 1999). During the decade after the birth of Six Sigma concept, Motorola saw a five-fold growth in sales, with profits climbing nearly 20% per year; cumulative saving based on Six Sigma efforts was at $14 billion, stock price gains compounded to an annual rate of 21.3% (Pande et al., 2000). General Electric and Honeywell had also shown great financial successes based on Six Sigma methodology. Singh and Khanduja (2010) reported a study carried out in light alloy foundry on how define-measure-analyse-improve-control-technology transfer approach of Six Sigma concept has decreased the die changeover times effectively. Hung and Sung (2011) explore how a food company in

Taiwan used a systematic and disciplined approach to move towards the goal of Six Sigma quality level.

Six Sigma seems to be clear winner for quality improvement but many times it has been felt that intensive data-oriented approach of Six Sigma project kills the momentum and initiatives of innovation. Six Sigma makes good use of logical-brain but keeps innovation solution at a relatively lower level. Various problems faced during Six Sigma projects include poor problem formulation, time consuming data collection and measurement, failure in finding root causes, lack of innovation tools, slow or delayed progress of projects, psychological inertia of the project team not to think beyond the boxes. Companies are willing to introduce better technologies and new innovations to gain consumers' interest (Kiurunen, 2009). Innovation is of vital interest to companies and countries across the globe and much has been written about techniques to stimulate and manage the process (Dershin, 2010). Piperopoulos and Scase (2009) present a hypothetical, descriptive two-dimensional model of innovation and business clusters. Lanskoronskis et al. (2009) discussed the influence of university research management on institutional competitiveness, international visibility and fund-raising. Filippetti (2011) conducted an empirical literature to investigate innovation modes, by exploring the role of design as a source of innovation. To enhance the innovation in Six Sigma, some special tools and techniques are essential (Averboukh, 2003). The issues of interest are to know how to take decision for generating director of innovation and what can be ideal innovation generation process. This paper presents use of the Theory of Inventive Problem Solving (TRIZ) to enhance Six Sigma tool kit. A synchronised effort of implementation of Six Sigma with TRIZ can provide breakthrough results in problem solving. This paper has following objectives:

1 development of TRIZ integrated tool kit for Six Sigma projects
2 validation of TRIZ integrated Six Sigma tool kit through case study
3 to validate the hypothesis that the success of TRIZ integrated Six Sigma tool kit is independent of team selected.

2 Literature review

Six Sigma is a well-established approach that seeks to identify and eliminate defects, mistakes or failure in business processes or system by focusing on those process performance characteristics that are critical to customer (Snee, 2004). It has proved to be successful in manufacturing, marketing, research and development, healthcare, banking, administrative, finance and in many other business processes (Antony, 2004; Antony et al., 2008; Snee and Hoerl, 2003). Six Sigma focused on defects as opportunities in a process or product through well-structured project handling methodology (Soti et al., 2010). One of the main barrier against Six Sigma deployment is 'poor understanding of tools', which causes the complete failure of Six Sigma system (Soti et al., 2011). Hence, understanding and use of right tool for right purpose is the key for success of Six Sigma projects. Six Sigma tools include team tools, process tools and statistical tools (Henderson and Evans, 2000). Team and process tools are used to prepare the Six Sigma project leader with the required team building and leadership skills for the implementation of project. Both statistical and process tools can be used to ensure that the correct data is collected and transformed into solutions which can be used to assist with the decision-making process (Antony et al., 2006). Hagemeyer et al. (2006) addressed the issue related to tools of Six Sigma in detail and classified 20 key tools of Six Sigma to develop problem solving matrix. Snee (2004) discussed the mainly used tools of different phases of Six Sigma projects; he also pointed out that there is a need to improve the Six Sigma methodology and develop new and better method in future.

Six Sigma is based on statistical thinking and grounds on the logics of data to take decision; however, innovation is equally or more desirable for breakthrough problem solving. There are number of researches on innovation throughout the world. A system model of China's national innovation system is presented by Zhu and Tann (2009). Bewoor and Pawar (2010) presented the relationship between quality management system and Six Sigma. Czuchry et al. (2009) presented approach that can be applied to large businesses as well as small- to medium-sized firms to manage the rapid growth in their demand through innovation and innovative strategies. Foulds and West (2006) discussed how to improve e-procurement process by innovation. Bresciani (2009) presented the relationship between creativity and innovation within firms in the Piedmont area. Improvement of the identified variables can be achieved using inventive problem solving combined with traditional engineering methods (Malinin, 2010).

To achieve breakthrough results through Six Sigma projects, innovation is required to be a part of solution. TRIZ, the Russian acronym of the 'Theory of Inventive Problem Solving', is a useful tool that can solve the problem of 'how to do' effectively in the innovative design process (Wang et al., 2005). Many of the roadblocks of Six Sigma can be eliminated with use of TRIZ (Averboukh, 2003). TRIZ is known as a powerful method in solutions generation in the design problem solving process (Hua et al., 2006). It is a methodology based on USA patent system and can effectively bring out innovation logically. It is needed, as the theory based on the features of great inventions and the pattern of evolution of systems (Rantanen and Domb, 2008). Through TRIZ, it is possible to generate concept for improvement of system by reducing negative effects. Based on the study of number of patents, Altshuller summarised 40 fundamental solutions and named them the 40 inventive principles. TRIZ is based on the concept that the problems of one area can be addressed by inventions in other technological areas (Terninko et al., 1998). The earlier obtained solutions can help to solve present problems, is the key of TRIZ. There is a gap in the literature on research related to use of systematic innovation in Six Sigma projects. Integrating Six Sigma with TRIZ can produce impressive improvements in Six Sigma projects.

3 Research methodology

Case study research excels at bringing us to an understanding of a complex issue or object and can extend experience or add strength to what is already known through previous research. Case studies emphasise detailed contextual analysis of a limited number of events or conditions and their relationship. Researchers have used the case study research method for many years across a variety of discipline. Researcher, Yin (1989), defines the case study research method as an empirical inquiry that investigates a contemporary phenomenon within its real life context, when the boundaries between the phenomenon and the context are not clearly evident, and in which multiple sources of evidence is used.

The method of case study is used to understand implementation of define, measure, analyse, improve, control (DMAIC) model and its limitations in a live project. Further, application of TRIZ integrated tool kit is also tested by hypothesis testing. Method of case study is used, as it is one of the best methods to experimentally test newly developed conceptual model. The methodology adopted is suitable as it can provide quick and clear response. The method of case study is used to find the output of newly devised tools set, whereas hypothesis testing validates the results with three teams. The purpose of hypothesis testing is to check whether the proposed model is satisfactory for different teams or success depends on a specific team only.

4 A case study of an electronics Manufacturing Company

The Manufacturing Company (MC) under study is the manufacturers of a wide range of electronics display devices. The group employs over 6,500 people in nine world-class factories and has an annual turnover of Rs. 14 billion. MC is established in with a vision to create world-class organisation. Since inception, MC is a leader in the country to implement advance methodologies. MC has strong quality history. The lists of quality initiative taken by MC are exhaustive but the ultimate approach is customer focus.

The company management understands the role of employees in organisational development. The management is aware of that anything can be achieved through involvement of people. Therefore, all the quality movements in MC were focused on involvement of people. The company launched quality circle in 1981, when it was quite new in the country. From 1981 to 1985, statistical quality control, house-keeping and company-wide quality management were implemented. Total productive maintenance (TPM) was implemented and ISO-certification was also achieved in 1985. Quality improvement programs were continuously adopted and consolidated.

4.1 Need for Six Sigma

There were many external factors which induced management of MC to adopt Six Sigma. The main external factors were globalisation, country's tariff structure and technology trend. The merger of two business giants, the Philips and the LG, worked as a great threat to MC. There was tremendous pressure on MC to lower the cost, improve quality and reduce product launch time. There was a strong need for high degree of consistence in product quality and delivery. There was a fear of loss of market and some special efforts were needed to keep market share. Inspired by, success of Six Sigma, the company started deployment of Six Sigma. MC became one of foremost company of the country to attempt for highest quality level.

4.2 Assessment of MC

A number of authors (Banuelas and Antony, 2002; Eckes, 2001; Pande et al., 2000) have written about success factors for Six Sigma in world-class organisations. The main components for success of any quality management system are visionary leadership, well-established organisational structure and committed employees. The key characteristics of these three components in MC were found as:

Leadership: the leadership is supporting for quality movement. Though, the effective leadership MC is able to position itself at winner in most streams at national level.

Organisation: MC found to be a vertically integrated group of companies. The processes in different units varied a lot. Few processes were complex, whereas some were simply assembly processes.

Employee: MC had qualified and skilled human resource. There were talented and achievement-oriented people at all levels. There were people who spent considerable amount of their life in MC and there were people who had joined from outside at all levels. People were trained and aware of many quality tools. They had been an element in deployment of number of quality initiatives. People had extensive exposure to various management, quality and behavioural training.

4.3 Objectives of Six Sigma at MC

The main strategies focused at output level were error-free processes, defect-free products and services. The target objectives of Six Sigma deployment were to reduce new product launch time from 20 months to 4 months, to improve the capability of core manufacturing process from 2/3 sigma level to 4/5 sigma level, to reduce field failure rate from 700/800 to 10 ppm and to reduce warranty returns from 10,000 to 100 ppm.

4.4 Six Sigma deployment in MC

Special Six Sigma cell with number of Six Sigma experts was established at corporate level. The people were trained for different roles in Six Sigma projects. The deployment cycle found in practice is shown in Figure 1. The trainings were focused at champion level, black belt level, green belt level and corporate level. To develop the competencies in the organisation, training sessions were arranged for at least two champions in each unit, more than 100 black belts and more than 1,000 green belts in the company. The special trainings were conducted regularly based on the role of individual in the organisation as shown in Table 1.

Excellent results can be achieved by using Six Sigma methodology for problem solving. It is worth mentioning that every unsuccessful project reduces the commitment of management most of times because of high cost involved per project. There is a need to integrate Six Sigma with other quality tools to improve its ability and to solve problem more economically. Many researchers had felt the need to improve Six Sigma by integrating it with other quality tools. The TRIZ is one of such powerful methodology.

Figure 1 Deployment cycle of Six Sigma in MC (see online version for colours)

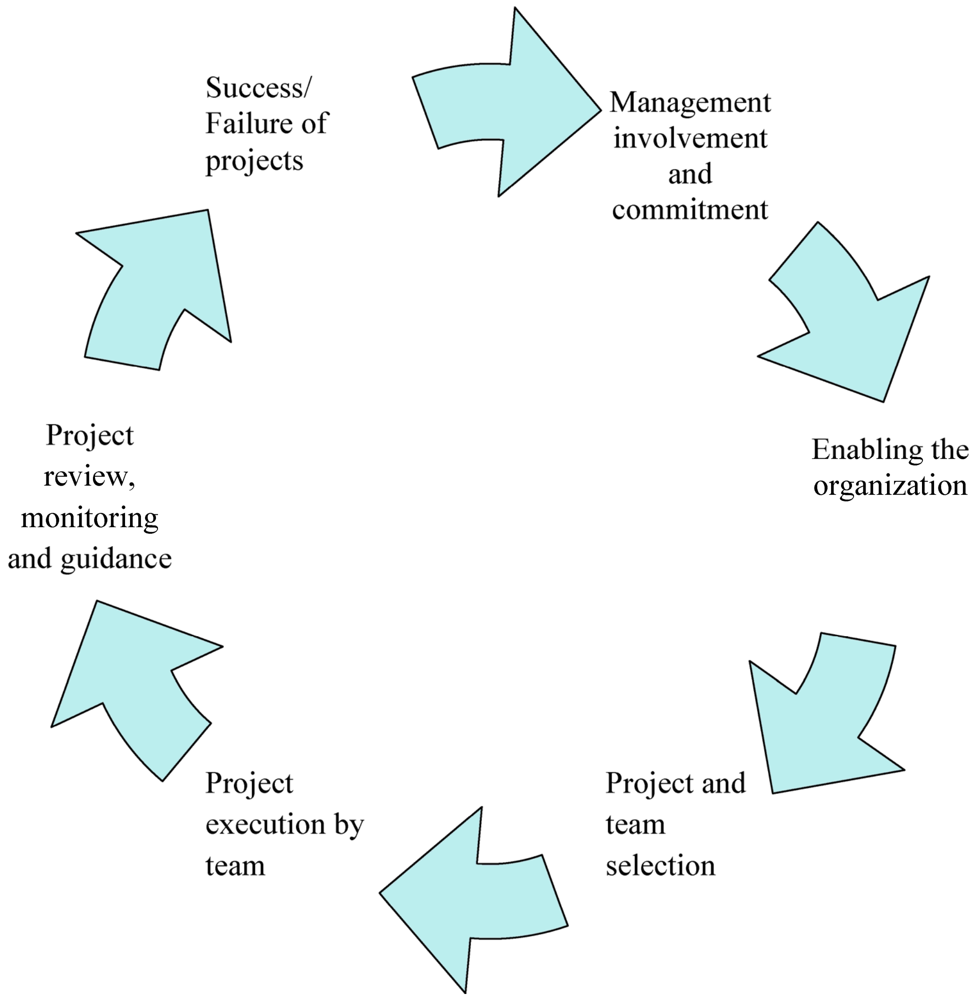


Table 1 Develop Six Sigma competencies

Training purpose	*Skill to develop*
Champion level	
Six Sigma concepts, tools and methods	Asking right question at each stage
Statistical thinking	Data-based decision-making
Project/people selection	
Project review	
Black belt level	
Six Sigma concepts, tools and methods	Communication skills
Project management	Presentation skills
Advanced statistical tools	Interpersonal skills
	Team skills/training and facilitation
	Analytical skills
	Mentoring/coaching
Teams/green belt level	
Six Sigma concepts, tools and methods	Team skills
Basic statistical tools	Active participation
Creative tools	Data collection
Corporate group	
Six Sigma concepts, tools and methods	Networking
Statistical thinking	Training skills
Project management	Consulting skills
Statistical tools	Influencing skills
Statistical and project management software	
Latest methodologies	

5 Need for TRIZ integrated Six Sigma

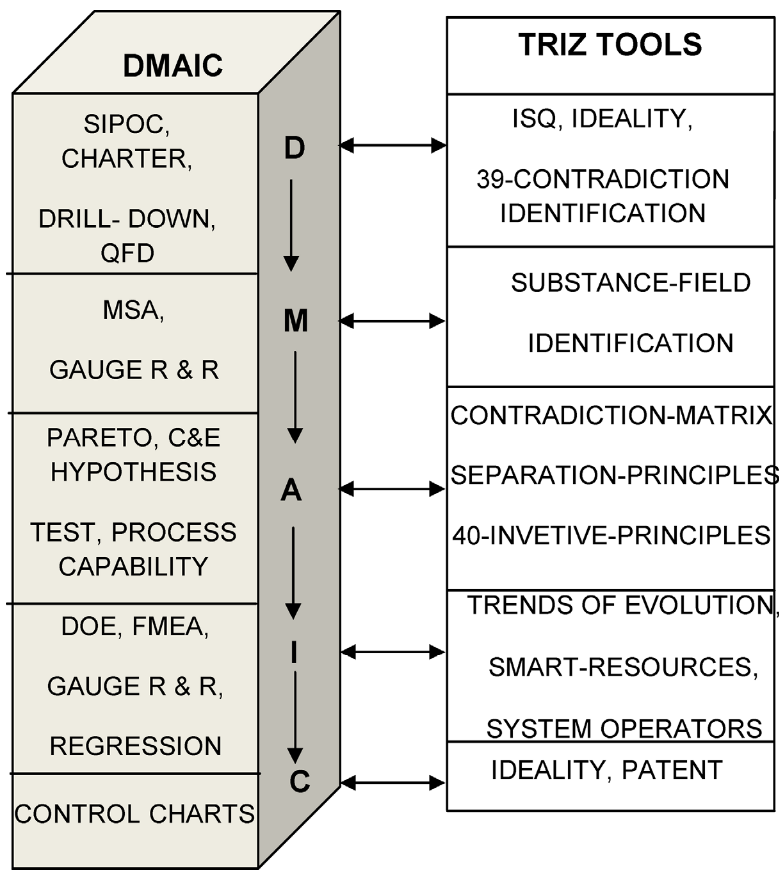
A questionnaire-based survey of 90 black belts of Six Sigma is conducted to find the status of Six Sigma in India. The questionnaire is designed based on literature survey and experts opinion. The questionnaire tools of Six Sigma are divided into two parts: first one is statistical and graphical tools and second is of innovation tools. In all, the questionnaire inquired for 51 tools, out of which 7 tools are innovation tools. It is inquired that whether one is familiar with particular tool or not; whether the tool has been used or not, in which phase the tool has been used and the frequency of the use of the tool on a scale of five points. The respondents selected are experienced implementers of Six Sigma. The data obtained indicates that not even 1% of Six Sigma users are aware of innovation tools of TRIZ. The average frequency for use of seven innovation tools is found to be approximately a value of 1, whereas most of statistical and graphical tools have frequency of use more than 3. It indicates that awareness of innovation tools of TRIZ required to be improved in quality management. It is interesting to know what TRIZ is and how TRIZ tools can be integrated with Six Sigma. Six Sigma is one of the most systematic approaches of problem solving, whereas TRIZ contains best possible solution set of historical problems.

5.1 Development of TRIZ integrated Six Sigma tool kit

The Russian scientist and engineer Genrich Altshuller originated TRIZ, a Russian acronym for 'the Theory of Solving Inventive Problems'. After scanning ~200,000 patents, Altshuller selected 40,000 patents as representing of the most effective solutions and developed the TRIZ (Terninko et al., 1998). The tools developed can be of great help to bring innovation systematically in framework of Six Sigma. Based on the study of properties and ability of TRIZ tools, a DMAIC integrated tool kit is developed as shown in Figure 2.

Previously, methodology to implement TRIZ is confined to design problems; however, TRIZ tools can be of great help in manufacturing processes. Some of TRIZ tools help to think beyond the boxes which accelerate thinking process.

Figure 2 Integrated model of Six Sigma and TRIZ (see online version for colours)



5.2 Deployment of TRIZ integrated tool kit

TRIZ tools were explained to three Six Sigma teams in the MC. Teams were requested to use tools of TRIZ in their Six Sigma project. The brief report of one of the project is discussed here.

The project was related to productivity improvement of laser welding machine. Laser welding is an important process in many assembly operations. The manufacturing organisation under study required to improve the productivity of semi-automated laser welding machine. The problem was attempted with help of DMAIC model of Six Sigma along with selected feasible TRIZ tools. The case summary in DMAIC framework is described in Sections 5.2.1–5.2.5.

5.2.1 Define

It was required to increase the productivity of G5 Laser machine from 5,500 component per shift to 7,000 component per shift. Critical to quality had been identified as ‘machine cycle time’ and ‘utilisation time’. The conventional Six Sigma tools of define phase are process map, project charter, drilldown tree, Pareto chart and quality function deployment. The process map was made as shown in Figure 3. The TRIZ tool innovative system questionnaire (ISQ) helped to define problem more precisely. Innovation system questionnaire helps to understand the system and its surroundings at the initial phase. The ISQ provides the much-needed structure for gathering information necessary to reformulate a problem and then break it down into smaller problems (Terninko et al., 1998). The identification of name of the system, primary useful function of the system, elements of the system, system environment and availability of the resources made problem definition more clear. TRIZ works on management of contradiction. A contradiction is a conflict in a system, identification and management of such conflicts is the key of TRIZ. The contradiction parameters for the problems under study were identified as:

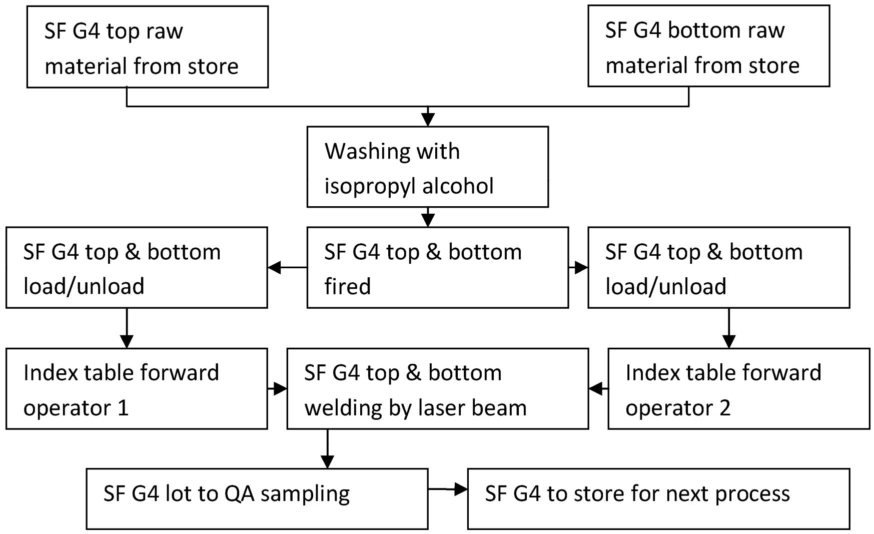
1 productivity vs. accuracy of manufacturing

2 productivity vs. manufacturability

3 productivity vs. level of automation

4 productivity vs. length of moving object.

Figure 3 Process mapping



5.2.2 Measure

The purpose of measure phase is to ensure that project team is using right metric and the measurement system is capable for intended purpose. During the measure step process, time of each and every activity had been noted as shown in Tables 2 and 3.

Table 2 Utilisation time

S. no.	*Activity*	*Time (average per day in minutes)*
1	Lunch time	30
2	Tea break time	20
3	Machine set-up time	5
4	Time loss	
	Data recording for parallelism	5
	Electrical/mechanical breakdown	5
	Late starting	10
	Material handling	15

Table 3 Cycle time

S. no.	*Activity*	*Time (sec)*
1	Component pickup time	4.3
2	Pairing time	2.4
3	Unloading time	1.6
4	Loading time	1.1
5	Process time	5.1

Based on gauge repeatability and reproducibility test, the measurement system was found satisfactory. No significant difference had been noted between different operators at machine. Substance field analysis is another TRIZ tool which can be used to analyse modelling variables. Substances are objects of any complexity, whereas fields show the action or mean to accomplish the action. The substances and fields of the problem had been defined. TRIZ tool substance field analysis had been used to understand functional relationship between various substances. The main substances in the project were machine, component and operator. The fields identified were air-cylinder, leaser, programmable-logic-controller programming and electric supply. The environment for the process was found to be jigs and fixtures.

5.2.3 Analysis

The following causes of time loss had been identified after three brainstorming sessions. The only tools could be applied by the project team were brainstorming and cause effect diagram; however, the substance field analysis and identified contradiction of TRIZ were found very useful. The contradiction matrix of TRIZ helped to determine standard principles to solve the contradictions. The following general time loss factors and machine cycle time loss factors had been identified.

General time loss factors

1. The number of inspections for parallelism was high. Prior action on work piece could reduce number of inspections as recommended in contradiction matrix.
2. Machine input supply failure due to electrical wiring was another issue. Standard principle local quality could be useful.
3. Operators were not fixed at machine. TRIZ standard principle of local quality was useful.
4. Unskilled operators were deployed on the machine. TRIZ standard principle of local quality was found useful.
5. The machine operator lacked of training for checking of the fitness of machine.
6. TPM scheduling of machine was not done.
7. Poor spare part planning was another issue of concern.
8. The operator lacked process awareness.
9. There was delay at the staring of shift because of searching for duster and finger tip at the starting of the shift.

Loss in machine cycle time

1. Heavy movement of air cylinder due to leakage and bent-shaft of air cylinder.
2. Sensor alignment found disturbed.
3. Air solenoid valve was found choked.

From TRIZ tools, the standard principles had been checked and implemented based on earlier identified contradictions as shown in Table 4.

Table 4 Contradictions solved

Contradiction parameters	*Applicable standard principles through contradiction matrix*	*Used/not used*
Productivity vs. accuracy of manufacturing	18: Mechanical vibration	Used
	10: Prior action	Used
	32: Changing the colour	Not used
	1: Segmentation	Not used
Productivity vs. manufacturability	35:Transformation of state	Not used
	28: Replacement of mechanical system	Not used
	2: Local quality	Used
	24: Mediator	Used
Productivity vs. level of automation	5: Combining	Used
	12: Equipotentiality	Used
	35:Transformation of state	Not used
	26: Copying	Not used
Productivity vs. length of moving objects	18: Mechanical vibration	Used
	4: Asymmetry	Not used
	28: Replacement of mechanical system	Not used
	38: Use strong oxidiser	Not used

5.2.4 Improve

The improve phase identifies and fixes the root cause of the problem. The following improvements had been done in improve phase:

1 reduced inspection time because of less number of inspections

2 redressing of machine input supply wires

3 effective administration of time from the starting of shift

4 operator deployment plans were made in advance (prior action)

5 training of operators (local quality)

6 improved TPM implementation

7 improved spare part management

8 implementation and training on 5S at work place (local quality)

9 reduced movement of air cylinder through preventive actions

10 sensors alignment done regularly

11 scheduled preventive maintenance of solenoid valve (mechanical vibration)

12 modification in the programme of machine for slide movement as per set benchmarked time instead of operator requirements

13 pre-aligned of components at machine (prior action and combining)

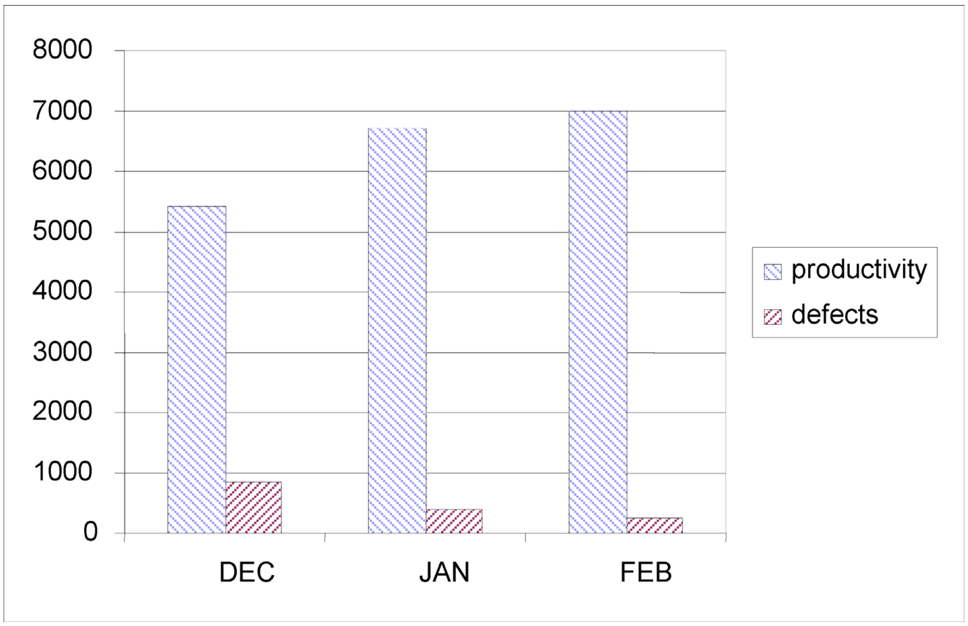
14 input level increased to machine operation level (mediator and equipotentiality).

The outcome achieved through above-mentioned improvement actions are shown in Table 5 and Figure 4:

Table 5 Improvement achieved

Month	*Productive (series 1)*	*Defects (series 2)*
December 2007	5,446	844
January 2008	6,699	402
February 2008	6,986	247

Figure 4 Productivity and defect status (see online version for colours)



5.2.5 Control

The control phase fixes the root cause forever. The following actions had been taken to fix the problem permanently:

1 at the workstation deployed operators were trained in multi-skills

2 updating the knowledge of operators about setting for parallelism and off centering on regular basis

3 increases in general awareness of the operators about material handling and rejection accountability

4 regular clearing of air solenoid valve to avoid chocking of airflow

5 air cylinder checks and change at regular basis

6 electrical wiring monitoring and dressing

7 re-planning TPM activities

8 mandral diameter checking system in monthly TPM

9 availability of critical spare parts

10 ensuring input quality before starting of machine

11 maintaining part level in plastic boxes.

The project of productivity improvement of laser welding machines proved that the Six Sigma tools can be enhanced through TRIZ tools. The key benefits of TRIZ tool observed by project team were as follows:

1 help in better problem formulation

2 reduce the time for data collection and measurement by considerable amount

3 facilitate in finding root causes of problems

4 introduce systematic innovation through innovation tools

5 reduce time for solving projects in Six Sigma framework

6 remove the psychological inertia of the project teams to think beyond the boxes.

5.3 Validation of model

The TRIZ integrated tool kit was used and found useful by three of the Six Sigma team in MC. A survey was conducted about the success of TRIZ integrated tool kit in their projects. Three teams of eight persons each were asked to rate success of their projects on a scale of five categories; excellent, very good, good, fair and poor. All the teams were consisting of one black belt, a process owner and six other green belt members. The teams were from different kind of project areas: the first team 'T1' was from assembly division, the second team 'T2' was from process division, whereas the third team 'T3' was from production division of MC. All the team members were having good experience of quality tools of Six Sigma.

The purpose of the survey was to validate that success of integrated tool kit was independent of particular project or team. The purpose of hypotheses testing was to check whether integrated tool kit improves the results for all project teams or it had occurred by chance. As data collected was discrete in nature, chi-square test was the appropriate test for hypotheses testing. Hence, the following hypotheses were formulated and tested:

Null hypothesis (H_0): The success of TRIZ integrated tool kit was same for all teams, i.e. all teams using newly developed tool kit got same results.

Alternate hypothesis (H_1): The success of developed tool kit was not same for all teams, i.e. results of application of new tool kit depend on teams and they were not same for all teams.

Out of total 20 members' response, 15 had reported 'excellent' results, 6 respondents stated 'very good', whereas only 3 said 'good' results from integrated tools. A chi-square test was conducted using Minitab-14 software, which provided the following output (refer Table 6):

As the *p*-value of the test was 0.493, H_0 was accepted. Hence, the result obtained from chi-square test suggests that benefits of TRIZ integration with Six Sigma were not dependent on the team implementing the tool. The different teams selected for sampling did not affected the conclusion that TRIZ integration provided significantly better results. Each of the team under study produced satisfactory results. This might be due to fact that Six Sigma and TRIZ are well-structured approaches such that the three different teams performed successfully irrespective of their application area in manufacturing industry. The *p*-value obtained from chi-square test indicates that integration of TRIZ tools with Six Sigma will improve Six Sigma tool kit. The need of using TRIZ with Six Sigma is useful to achieve breakthrough success economically, effectively and efficiently. It can be concluded from the results that TRIZ-based solution is very well valid and applicable to manufacturing problems. The management should get their Six Sigma teams trained for TRIZ tools for quick and better solution. TRIZ tools should be used as natural ingredient for Six Sigma deployment.

Table 6 Output of chi-square test

	T1	*T2*	*T3*	*Total*
	4	5	6	
Excellent	5.00	5.00	5.00	15
	0.200	0.000	0.200	
	2	3	1	
Very good	2.00	2.00	2.00	6
	0.000	0.500	0.500	
	2	0	1	
Good	1.00	1.00	1.00	3
	1.000	1.000	0.000	
Total	8	8	8	24
$\chi^2 = 3.400$, d.f. = 4, p-value = 0.493				

6 Conclusion

The research survey reveals that there is limited use of innovative tools in Six Sigma projects. TRIZ integrated tool kit is developed and used by one of Six Sigma team of the MC. Team has reported a number of benefits, they achieved through this new tool set. The productivity of laser welding machine is improved from 5,446 components per shift to 6,986 components per shift in a very short span of time. It has been observed that TRIZ integrated Six Sigma tool kit enhances the tools of Six Sigma. The improved tool kit is helpful to reduce efforts and project time. It also provides better solution by identifying root cause of the problem. The project team becomes better focused in define phase through identification of contradictions. The inventive principles of TRIZ give many workable ideas to solve the problem in a lesser time. Historical data of patent in terms of inventive principles helps the project teams to remove root cause more effectively. The well-structured DMAIC model of Six Sigma with systematic innovations tools of TRIZ can do better than simply using DMAIC approach. Scientifically developed TRIZ tools can effectively handle the psychological inertia of human mind. Development and application of TRIZ integrated Six Sigma in an industrial problem is the unique contribution of this paper. The successful application of TRIZ within DMAIC model demonstrates that innovation can build systematically in any manufacturing process. The future scope of research includes application of TRIZ integrated Six Sigma in variety of projects. Simplification and standardisation of the tools integration can also be attempted in future. If understood and implemented properly, methodology of Six Sigma with innovation of TRIZ can produce great results for most of quality-related problems.

Note

The identity of the company has been withheld due to confidentiality reasons and further applications are currently underway.

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