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Augmentation of Service Quality and Customer Satisfaction in Earth Digger Service Centre by Using DMAIC Integrated Triz Methodology

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Abstract:
The excellence in quality and price tag minimization is key factor to mobilize the business and there is diversity of Industrial Engineering philosophies and techniques are being implemented. To categorize the real-time outcomes, case studies have been conducted in an Earth Digger service center. In the course of the study it was found certain problems and out of which the concentration given in the area of reducing the time taken for repair works and also to improve customer satisfaction. Hence it has proposed to apply six sigma DMAIC and TRIZ methodology to explore the root causes to get the solution to overcome it. The various techniques such as project charter, data collection, time study, Prioritization matrix have been applied under DMAIC phases. The reasons are arrived through root cause analysis, the problems are ranked and solutions are suggested. The synergic approach of six sigma, DMAIC with TRIZ have results a worthy solution.

Keywords: *Six sigma, TRIZ, Cause and effect analysis, DMAIC, Customer satisfaction.*

I. INTRODUCTION

At the moment, the industrial administrations have involved a comprehensive variety of supervision platform can augment contention and goalmouths to raise output and efficiency by shrinking the process variation, defects reduction and a massive increase in profit and product quality. Presently, Six Sigma and Lean Manufacturing are commercial technique.

Six Sigma is a technique for the detection and corre ction of defects based on well developed and valida ted statistical methods of quality control, data analy sis and systematic preparation of the entire compan y staff involved in the process system.
This approach does not provide many tools to remo ve these shortcomings or to solve the productivity problem.

Lean Manufacturing is a strategy that reduces wast e by cutting costs in production, service and manuf acturing labour utilization.

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Figure 1 Steps in DMAIC methodology

II. LITERATURE SURVEY

The DMAIC is the fundamental tool which is used to enterprise Six sigma projects for the process enhancement in manufacturing and service industries.Even though six sigma has been magnificently implemented in many manufacturing industries, its application in the service sector is still somewhat limited due to several constraints (Antony, 2006). Training is a significant success factor in applying six sigma plans successfully and must be part of an incorporated approach. Partakers need to be well educated of the latest trends, tools, and practices of six sigma, and communicate with real data analysis. The Training program must start from the top and be applied to the entire organization (Young HoonKwakan and Frank T. Anbarib, 2006). TRIZ is a technique
to study, apply and train workers indoors through ha nd-on training courses.
In business, there is a huge contradiction between th e time needed to learn TRIZ and the time the manag ement can wait for the results (Ismail Ekmekci&EmineElifNebati, 2006). In manufacturing sector lean wastes are reduced in terms of resources, time and movement, a s well as improving ergonomically appropriate activi ties and ending with environmentally destructive mat erials (Mayur Mahajan et al., 2019). Implementation of lean technologies & techniques el iminates waste and consistently addresses defects tha t improve product quality
and process in the manufacturing sector (Krishna Priya, S., Jayakumar, V., & Suresh Kumar, S. 2019).

The DMAIC cycle is well explained in the below figure 1. Various functions of each phase in DMAIC methodology is explained in Table 1.

Table 1 various functions of each phases in DMAIC methodology

S.no	Phase	Function
1	Define	This stage express problem, target, potential resources available and scope of the project. Those information's are captured and composed together in a project charter document. The records collected are problem, voice of customers, critical to quality. This phase is considered as most important in DMAIC cycle since it helps to identify which is the most prioritized project for the company been selected.
2	Measure	Data collection (heart of DMAIC process) by measuring the process capabilities in an industry.
3	Analyze	This is the most important phase in a DMAIC process. Here usually root cause of variation and poor performance has been identified using quality tools. The large number potential root causes are identified and validated for elimination.
4	Improve	Here creative solutions are identified to eliminate the root cause of a problem to achieve the best performance of a process.

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5	Control	Developments are monitored to guarantee the performance's continuous and sustained success. Usually control charts can be used to access the steadiness of the improvements.

III. PROBLEM STATEMENT

Case 1: It was observed that time spent for repair works is more and hence it causes increased idle time during the repair process. Increased idle time results in underutilization of resources used in the repair works.

Case 2: In addition to the above it was also revealed that customer's satisfaction is very low. Customer satisfaction and retention is the main key to improve the business process.

IV. RESEARCH METHODOLOGY

The research methodology followed consists of five phases in DMAIC six sigma methodologies. Those five phases are given below the following. The list of tools such as Project charter, data collection plan, Time study, Cause and effect analysis, Prioritization matrix are used. Tools used in each phase of the research are listed in the below Table 2.

Table 2 Six sigma framework

Phases	Tools
Define	Project charter, Problem Definition
Measure	Data collection, Time Study
Analysis	Cause and effect diagram, Prioritization matrix
Improve and control	Suggestion of remedies and solution

4.1 Define

Initial step in six sigma method is project charter that uses DMAIC Method. It is an indispensible part of the six sigma project and the foundation of succession of the project. The various elements included in project are business case, problem statement, goal statement, projected benefits etc. project charter is given in the below Table 3.

Table 3 Project Charter

S.No	Elements	Description
1	Business case	Research is Earth Digger Service Center
2	Problem statement	Case 1: Delayed Delivery time Case 2: Poor Customer satisfaction and Retention
3	Projected Benefits	Reduction in time taken for delivery of vehicle, Increased customer satisfaction
4	Goal Statement	Improvement in delivery related issues and solving customer issues
5	Project Scope	Implementation of DMAIC methodology results in increased efficiency

4.2 Measure

It is the second phase of the project. Moreover the main objective of this phase involves in measurement of the current performance of the repair process and the calculated maximum production capacity of the plant using time study calculation formula. The actual achieved production level is given in table 5 for the month of June to November 2019.The data collected for number of repair works recorded during service work is listed in the below table 4

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Table 4: Data collection on number of vehicles taken for service and number of vehicle delivered

S.NO	MONTH	NUMBER OF VEHICLES ENQUIREDFOR SERVICE	NUMBER OF VEHICLES CAME FOR SERVICE	NUMBER OF VEHICLES COMPLETED SERVICE	EFFICIENCY
1	June	12	08	05	63
2	July	08	09	05	56
3	August	14	11	07	64
4	September	11	07	04	57
5	October	07	06	04	67
6	November	13	08	06	75
TOTAL		65	49	31	63.66

Table 5: Data collection through Time Study during repair works

S.NO	TYPE OF WORK	STUDY 1	STUDY 2	STUDY 3	AVERAGE
I	POCKLINE BUCKET REWORK	779	771	770	773.33
II	EXCAVATOR WORK	1102	1106	1105	1104.33
III	REAR CYLINDER WORK	147	139	145	143.67
IV	FRONT CYLINDER WORK	197	196	202	198.33

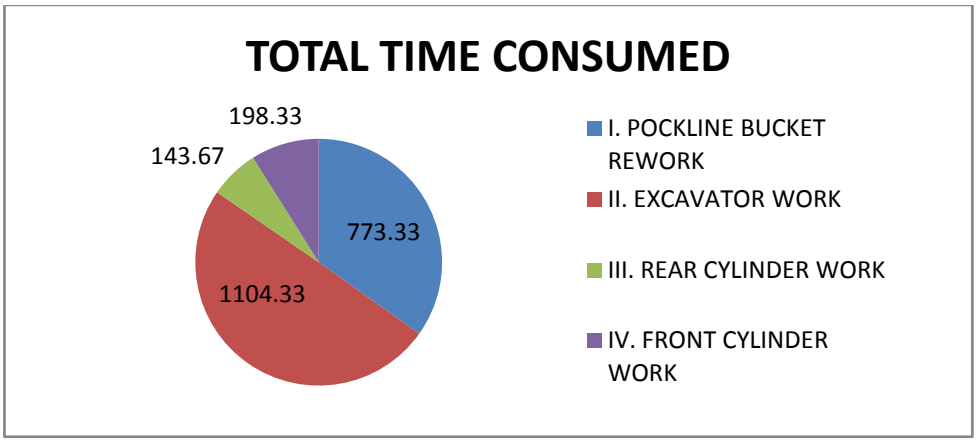

Figure 2. Total Time Consumption

Table 6: Time Study reports during repair works

I	**POCKLINE BUCKET REWORK**	**STUDY 1**	**STUDY 2**	**STUDY 3**	**AVERAGE**
A	REMOVAL OF WORE METAL IN BUCKET				
	1.GAS CUTTING	45	44	47	45.33
	2.CHIPPING OF WASTE	30	27	29	28.67
	3.GRINDING THE WELD AND WASTE	45	42	44	43.67
	4. NEW PLATE FIXING	40	43	41	41.33
	5. BENDING OF PLATE	55	57	53	55.00
	6.WELDING	90	86	92	89.33
	7.GAS CUTTING OF BUCKET BUSH	20	21	18	19.67

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	8.BORE GRINDING	45	46	44	45.00
	9.NEW BUSH FIXING	20	18	19	19.00
B	HARD FACING:				
	1.HARD FACING	90	87	89	88.67
C	TEETH ADOPTER AND CUTTER				
	1.REMOVING	42	40	41	41.00
	2.GRINDING	18	18	19	18.33
	3.NEW ADOPTER,TEETH AND SIDE CUTTER FIXING	32	35	31	32.67
	4.WELDING	29	32	30	30.33
D	MS BAR OUTER BENDING & WEDING	178	175	173	175.33
	TOTAL TIME CONSUMED	779	771	770	773.33
II	**EXCAVATOR WORK**				
A	FRONT BOOM,LINK,BORE AND WELD	56	55	53	54.67
	1.BOOM WELDING(4 BORE)	87	85	87	86.33
	2.LINK WELDING	124	121	125	123.33
	3.BOOM BORING	84	85	82	83.67
	4. LINK BORING	116	115	117	116.00
B	REAR BOOM,KING POST,STICK REWORK				
	1.BOOM WELDING	54	55	53	54.00
	2. BOOM BORING	73	75	71	73.00
	3.BUSH FIXING	29	31	33	31.00
	4.KING POST WELDING	112	116	115	114.33
	5. KING POST BORING	148	149	151	149.33
	6. BUSH FIXING	26	29	25	26.67
	7.STICK WELDING	51	49	50	50.00
	8.STICK BORING	84	82	86	84.00
	9. BUSH FIXING	58	59	57	58.00
	TOTAL TIME CONSUMED	1102	1106	1105	1104.33
III	**REAR CYLINDER WORK**				
	1. TWO CYCLINDER DISMANTLING	53	50	51	51.33
	2. REMOVAL OF OLD ORING,OIL SEAL AND REPLACE	45	42	44	43.67
	3. INSTALLING	49	47	50	48.67
	TOTAL TIME CONSUMED	147	139	145	143.67
IV	**FRONT CYLINDER WORK**				
	1.FOUR CYCLINDER DISMANTLING	86	82	85	84.33
	2. REMOVAL OF OLD ORING,OIL SEAL AND REPLACE	59	60	62	60.33
	3.INSTALLING	52	54	55	53.67
	TOTAL TIME CONSUMED	197	196	202	198.33

4.3 Analysis

Analysis phase is the most important step of this project. In the preceding phase datas are collected and analyzed in order to discover and categorize the various root cause of the issue. The various root causes of delayed delivery time is listed in the diagram (figure 3).

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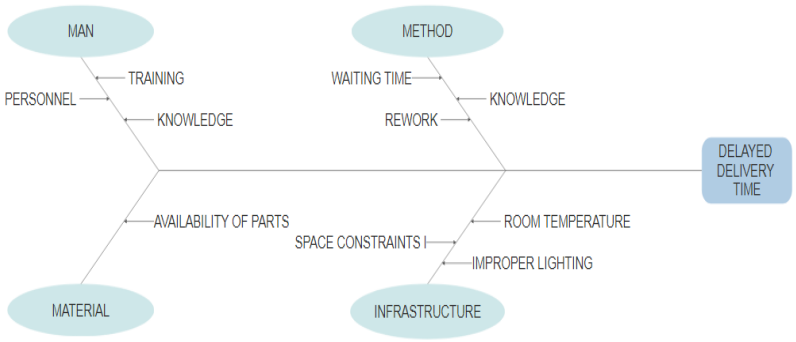


Figure 3 Cause and Effect Diagram for Delayed delivery time

Table 7: Customer feedback through questionnaire

Rating of the customer		5	3	1	Total Rating	Rank
S.NO	Particular					
1	Service Quality	6	2	2	(6x5)+(2x3)+(2x1)= 38	3
2	Cost of Service	7	2	1	(7x5)+(2x3)+(1x1)= 37	2
3	Delivery rating	2	4	4	(2x5)+(4x3)+(4x1)= 26	6
4	Employer Interaction related to repair issues	2	5	3	(2x5)+(5x3)+(3x1)= 28	5
5	Customer handling	5	2	3	(5x5)+(2x3)+(3x1)= 34	4
6	Amenities provided to customer during waiting time	7	3	0	(7x5)+(3x3)+(0x1)= 44	1

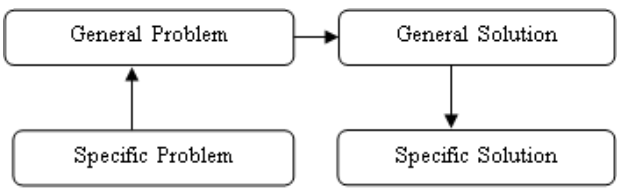
4.4 Improve and Control

The function this phase is to identify, testing, put them into practice of alternative solutions to the problem in part or in whole. The objective is to provide promising solutions to reduce the key root causes of the issue with the aspire to fix and put a stop to the process problems. Here solutions have been given for the two problems, one is delayed delivery time and other is poor customer satisfaction. Improvement can be achieved by implementing the suggestions of Remedies given below the following Table 10. Whereas for delayed delivery time Solution is arrived through TRIZ Methodology.

4.4.1 Solution for Delayed Delivery time

To find the solution the Russian Inventive Concept TRIZ is applied.

TRIZ (Theory of Inventive Problem Solving) a method based on logic and data to solve the problems using imagination (Katie Barry, domb and Michael, 2006-2012). The basic procedure and steps are given below.



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TRIZ with Lean is discussed and applied in fabrication shop by (muruganantham, 2013) and in machine shop during 2012 and it had proven the benefits of this synergistic approach. Combination of TRIZ and Analytical Hierarchy Process for automated manufacturing system design has given a good result (Tesheng Li, 2010). In short, to prepare automotive design alternatives, TRIZ is employed and AHP is used to evaluate and select the best feasible alternative under multiple criteria.

Functional Analysis involves abstraction of t he general task, confirmation of the solution to this

Problem and presentation of the input constraint

function and its five decomposition steps (Yuan Feng., Wang Tai-Yong and NIE Hui-Juan, 2006).

The implementation of TRIZ principles was explore d in Electrical Discharge Machining (EDM) (Sreebalaji.V.S andSaravanan.R, 2009).

In this work, it describes that by modeling an advanced design called Ultrasonic Electrical Discha rge Machine (UEDM) with the aid of TRIZ, the para meter vibration can be integrated into EDM.
TRIZ was used for a systematic creative process (SI P) that recognizes business opportunities and allows the incorporation of various tools and knowledge (Daniel sheu and HeiKuang Lee, 2011).

Application of TRIZ for the solution.

The problem is identified in delayed delivery time. The time had to be reduced and as well the investment and running time and cost should not be more comparing to the present. The contradiction is found and is tabulated as follows in the Table 8.

The objective is to improve productivity with minimum time and energy. From the explanation of 39 features (Altshuller 39 features, 1998), the relevant improving factor was the 34. Ease of Repair, the corresponding worsening factor has been taken as 38.. Extent of Automation and the corresponding principles were obtained as follows from the matrix (Altshuller Contradiction matrix, 1997b).

Table 8 The Contradiction identified For Delayed Delivery Time

Worsening Feature / Improving Feature	Extent of Automation (Contradiction No:38)
Ease of Repair (Contradiction No:34)	Principle No: 34 Discarding & Recovering Principle No: 35 Parameter Changes Principle No: 07 Nested Doll Principle No: 13 The Other Way Round

The explanations (Altshuller 40 Inventive principles, 1997a) for the above principles were taken and the most appropriate principle was selected as Principle Number 13 The Other Way Round, which says to Invert the action(s) used to solve the problem.

• To loosen stuck parts, cool the inner part instead of heating the outer part.

• Bring the mountain to Mohammed, instead of bringing Mohammed to the mountain.

Make movable parts fixed, and fixed parts movable.

• Rotate the part instead of the tool.

• Moving sidewalk with standing people.

• Treadmill.

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Turn the object upside down.

• Turn an assembly upside down to insert fasteners .

• Empty grain from containers by inverting them.

After careful study and references, adopted with all sort of variant processes, Hence it is suggested to make vehicle in a fixed place and all other equipments are handled through automatic weight handling tools and motorized equipments. Automation reduces the time nearly half than the manual as result productivity can be improved.

4.4.1.1 Suggestions to reduce Delayed Delivery Time

Table 9 Suggestions to reduce delivery time by improving productivity

S.NO	ELEMENTS	PARTICULARS	SOLUTIONS
1	MAN	PERSONNEL	Improved efficiency can only be accomplished when the greatestla bor-administration coordination occurs.
		TRAINING	To augment employee productivity, one way is to educate them for their individual jobs. Organizations should encourage their employees to take an active part in the teaching programs held by them. They should spend a substantial amount of money to afford training to the employees
		KNOWLEDGE	It can be achieved by giving proper training to employees.
2	METHOD	WAITING TIME	It is important to spot and realize bottlenecks before making decisi ons about improvements.
		REWORK	Development and adaptation to new technologies and systems is n ecessary to more effectively meet customer demands and to stay a head of the competition.
		KNOWLEDGE	It can be achieved by giving proper training to employees. Motion study can be implemented to find out better method of doing a work.
3	MATERIAL	AVAILABILITY OF PARTS	Sufficient rates of safety stock allow business operations to contin ue according to their plans.
4	INFRASTRU CTURE	SPACE CONSTRAINTS	Space Management and Planning is a part of Facility Management (FM), which is a technical sector covering everything related to the physical premises occupied by a company.
		ROOM TEMPERATURE	Control of temperature and stability are important to manufacturin g processes as they directly affect cycle times and production.
		IMPROPER LIGHTING	Employee morale is always on managers ' minds as a happy emplo yee will be more successful and efficient.

4.4.2 Suggestions for Customer Satisfaction

Table 10 Suggestions to improve customer satisfaction

S.NO	Particular	Suggestions
1	Service Quality	Service quality can be improved by following the below mentioned points • Evaluate regularly • Establish clear KPIs • Take a team approach to eliminate bias
2	Cost of Service	Cost of Service can be reduced by following the below mentioned

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		points • Review expenses regularly • Barter with businesses • Outsourcing Lead generation • Cut production costs • Modernize your marketing methods • Avoid interest at all costs
3	Delivery rating	Delivery rating can be improved by following the below mentioned points • Focus on quality • Usage of efficient time strategies • Automate time-consuming tasks
4	Employer Interaction related to repair issues	Employer Interaction related to repair issues can be improved by hearing and collecting customer feedback.
5	Customer handling	• By acknowledge and offering solution to a problem
6	Amenities provided to customer during waiting time	• Cleanliness and janitorial/Maintenance • Providing Refreshments

V. Conclusion

Minimizing Production time during repair process is the most important for guarantee the quality and also to eliminate the opportunities of time consumption during repair work. The various root causes had been identified and vital factors which causes the time consumption is mentioned. It was concluded that the remedies mentioned above are suggested to be put into practice during repair works to achieve the best results. It is recommended to install automaton wherever possible and also to give proper training to workers to reduce delivery time Even though by following the suggestion to improve customer satisfaction still there is a possible chances for occurrence unsatisfied customer due to poor service and so it is important to give quality service to the Customer

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