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Original Research Article

Implementation of Six Sigma to Reduce Rejection Rate in Screw

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Abstract The six sigma methodology is most powerful quality improvement technique which is used for achieving, maintaining and maximizing the business success. Six sigma is based on understanding the customer needs and expectation. This study mainly focused on six sigma quality philosophy and other related philosophy that is implemented in these studies to identify the rejection problem which are facing by a manufacturing industry. The six sigma philosophy provides a step-wise quality improvement methodology in which statistical techniques is used for check the changes in the process.
Keywords: six sigma, customer, expectation

INTRODUCTION

Six sigma methodology is a group of techniques and tools which is used for improvement in the process [1-4]. Six sigma was firstly introduced in 1986 by Mr. Bill Smith & Mikel J Harry when they were working with Motorola Company. In the year of 1995 Jack Welch use six sigma for his business program .It is used for quality improvement of the process and process output is identify and remove the causes of defects and minimize variability in manufacturing and business program.

Six sigma aiming at the reduction of defect rate to 3.4 defects for every million opportunities [5-8]. Six sigma as a project based methodology for solving specific performance problems recognized by an organization. Doing things in best possible way and keeping it in right direction by six sigma [9]. Kaushik gives a definition for six sigma" methodology that offers reliability and giving approach to solve the problem by team and a management system that helps in making leadership and give authority for problem solving in industry " [10]. Six sigma helps in attracting the manufacturing sector for improving the quality of final product.

Six sigma projects methodology:
Six sigma projects follow two methodologies. These methodologies are DMAIC and DMADV.
DMAIC: - Aim of this process is improving an existing business processes.
DMADV: - Creating new product or process designs by this process.
In this paper we will discuss about DMAIC methodology:

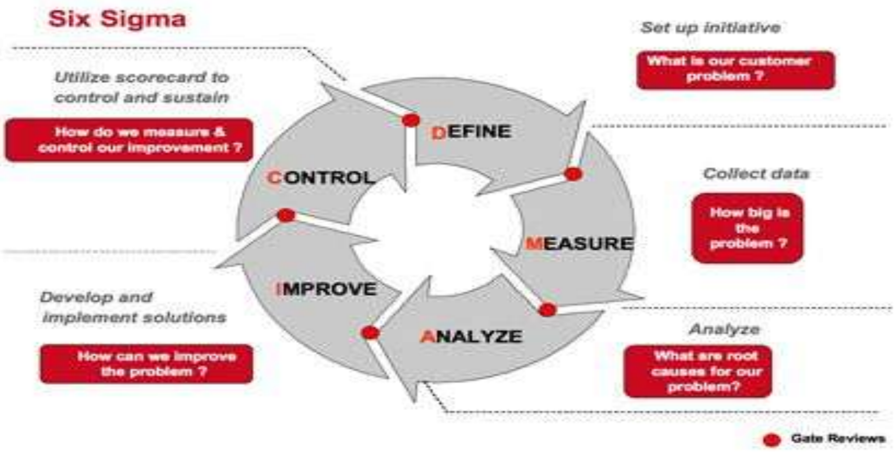

Fig-1 (Six Sigma methodologies)

In this methodology has five phases:
#Define: In this phase consider, voice of the customer and about their requirements, and define goals of a projects.
#Measure: In this phase measure gauge repeatability & reproducibility of the running process and check the process capability of a project.
#Analyze: Data is collected and develop a flow of process to analyze and verify cause-and effect of a process and what is the root cause of this defect.
#Improve: Improve the running process based upon data analysis using techniques such as DOE, FMEA, Pareto chart is used for improvement.
#Control: Standardize and documented the improvement of the process control chart is a tool which is used in this phase to check the process problem is shift or not.

LITERATURE REVIEW

Now days six sigma has been widely used by different industries. Six Sigma is a methodology that can help an industry to achieve expected goals through continuous project improvement [11]. Six sigma is a methodology which minimize the mistakes and maximize the quality value of the process. Six sigma has been most successful business improvement strategy developed during the last 50 years [12]. Management experts like Walter Shewhart, Joseph Juran gives the idea about continuous process improvement [13]. The example of Process improvement methodology is the Deming cycle of plan-do-check-act [14-16].The need for continuous improvement within the organization is necessary to sustain in the global market [17]. For this purpose, a number of continuous improvement methodologies were developed based on production system, process improvement, waste minimization and quality improvement [18-22].

According to [23,24] six sigma is most effective quality improvement technique. Six sigma methodology is used for improve productivity in manufacturing industry. DMAIC is the model compatible for nourishing the benefits of six sigma in manufacturing, service and other unconventional sectors [25].

CASE STUDY

Problem formulation:

The study was completely about fasteners(nut bolts) manufacturing industry located in ROHTAK (HARYANA).Project identified is Major Diameter rejection of 4.8×16 Hi-Lo self tap screw is contributing 83% of the problem. The screw major diameter U/S and O/S limit is 4.70-4.90. starting of the project with Initial observation which shows very high rejection due to " Major diameter problem ".The DMAIC methodology was adopt for solving the project Initial observation of project showed very bad results and the staff member and management was wants to reduce the rejection rate and implementing these changes.

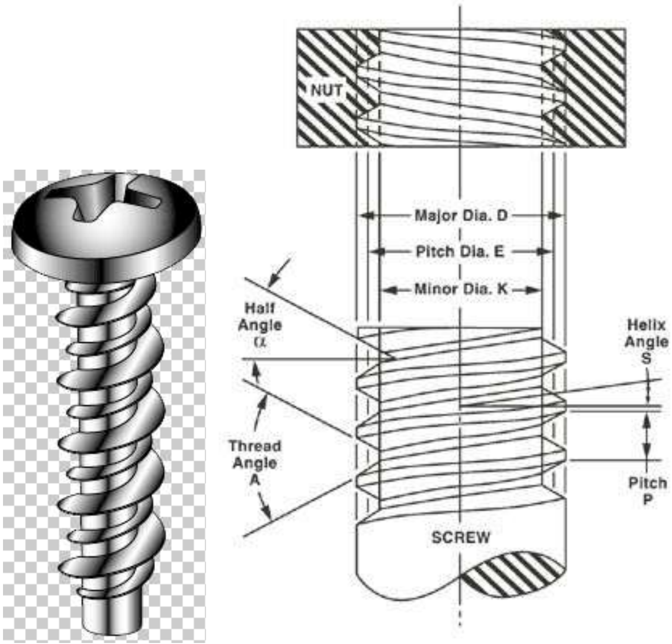

Fig: 2(Hi-Lo self tap screw)

About Organization:

Lakshmi Precision Screws is a ISO-9002, QS-9000, ISO-14001 certified company .Lakshmi precision screws(LPS) ltd. is a fasteners(nut, bolt) manufacturing industry which was established in 1972. The company which is providing fastening technology globally.The company is located in ROHTAK(Haryana).The company is one of the global leaders for manufacturing fasteners and cold forged components.

Study and Analysis of the 4.8×16 HI-LO Self Tap Screw rejection due to Major Diameter Problem utilizing six sigma DMAIC Methodology: DMAIC is problem solving methodology is used for problem analysis. (M. Shanmugaraja and M. Nataraj) (2011)

The Rejection rate of HI-LO Self tap screw was 1052 PPM (Parts per million) due to the Major Diameter problem. That's why reduced rejection of screw was necessary. The rejection rate of 4.8×16 HI-LO self tap screw reducing by using six sigma. In Six sigma DMAIC methodology was used to solve screw rejection problem and to achieve the quality level of 3.4 PPM from the present level which is 1052PPM.

The registration of a project was the first activity, which showed approval from the management to start the project. Without their help & support it was never possible to involve people and implement suggestions. The rejection problem of HI-LO self tap screw was studied and the five phases of six sigma(DMAIC) methodology i.e.(Define, Measure, Analyze, Improve and Control) have been successfully implemented to achieve the quality level of 5.79σ from 1.12σ (as explained below in fig 7 & 10).

Define

In Define phase, where define the voice of customer and goals of a project [26]. Tool used for defining project was used process flow diagram and a SIPOC diagram were drawn for HI-LO self tap screw (as shows in fig 3 & 4). Process flow diagram shows the various stages of the inherent operations and the flow of material within the shop. The SIPOC diagram shows the information flow within the industry as well as the role of customer and manufactures.

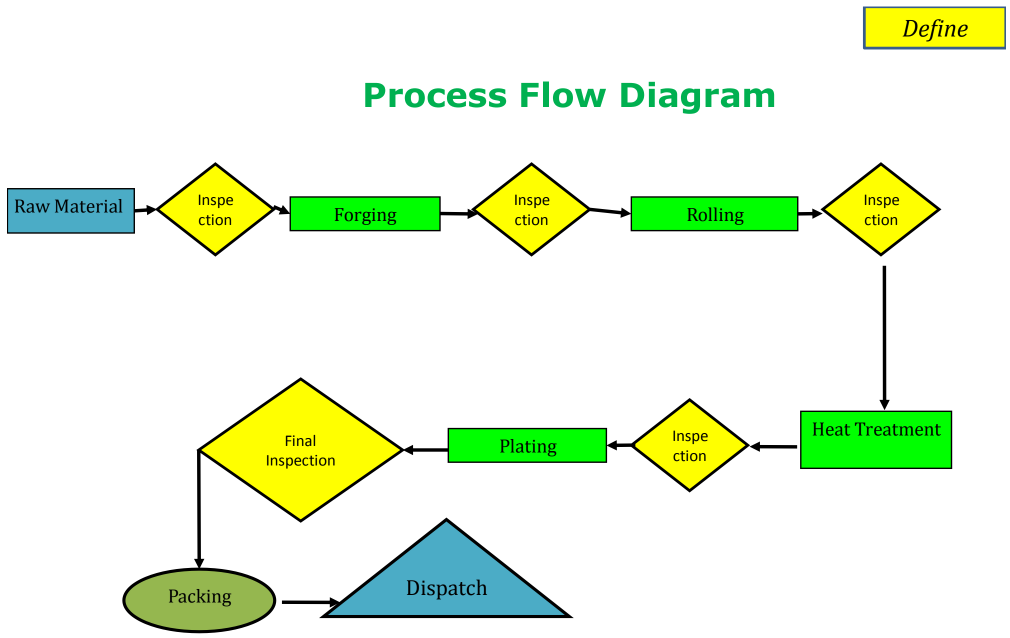

Fig-3: (process flow diagram for screw)

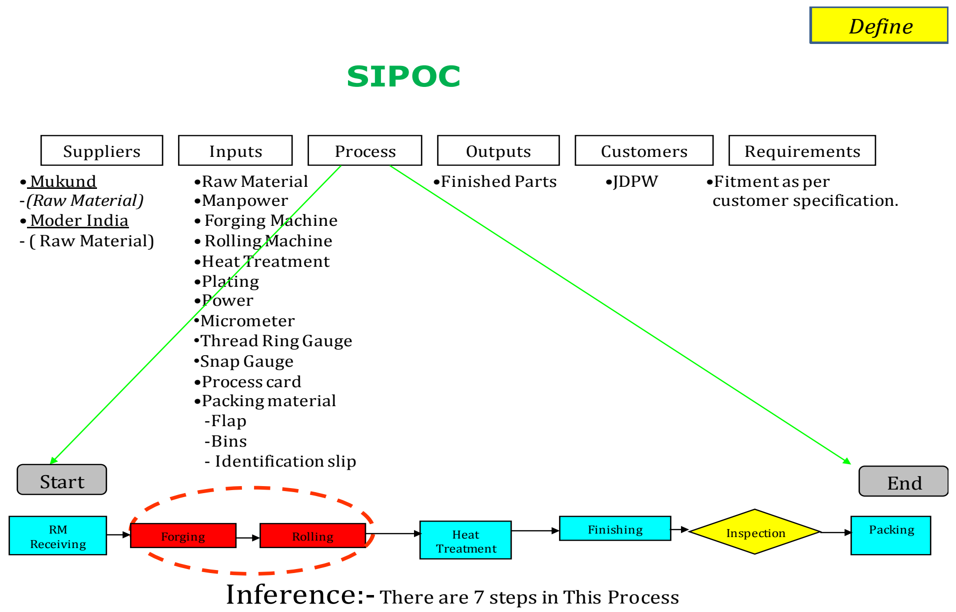

Fig-4: SIPOC diagram for screw

Measure

In measure phase, a measurement system analysis (MSA) is used by its accuracy, precision and stability (capacity of the measurement system). In MSA includes a statistical tool which is Gauge R&R (Gauge repeatability and reproducibility) studies. Gauge R&R study where the amount of variation arising from the measurement device measure. In this experiment Two persons are required for perform this experiment, which in this case were the inspector and the investigator. The sample size was five and two readings were taken on each sample, thereby a total no. of readings is 50. The gauge which is used for this experiment was a micrometer.

In this experiment Gauge R&R study, which gives result to be 26.03 percent and 0.00 percent of repeatability & reproducibility and put the percentage study variation to be 26.03 percent, which is < 30 percent, means that micrometer was correct.

Analysis:

The analyze phase where investigation of the data collected. In this phase Process capability analysis was performed to find the actual state of the process. Sub-grouping of sample was done and ten samples were drawn in a group of five. Minitab software was used to check the process capability analysis (which is shown in fig 7v&10)

In analysis phase where analyzing 4 factors; (1) TRD (Thread rolling diameter). (2)Total length (3) Gap b/w die. (4)Machine speed.

Quick wins in FMEA (which improve product quality and reduce rejection rate of screw)

1. Training to operator
2. Die life to be set.
3. Pusher life to be set
4. Preventive maintenance of machine
5. Profile projector to be used for setting approval
6. MSA to be done after every six months
7. Work instruction for setting of machine

Analyze

FMEA

Process or Product Name:	Rolling,D4.8X16 self tapping screw	**Prepared by: Anil K. Verma,Amit Sharma**	**Page ____ of ____**
Responsible:	Sachin Dharane/Amit Sharma	**FMEA Date (Orig) ____________ (Rev) ____________**	

Process Function	Characteristic of Input (KPIV / X)	Potential Failure Mode (How the X fails?)	Potential Effects of Failure (Y or Mini-Y)	SEV	Potential Cause(s)/ Mechanism(s) of Failure (Sub X's)	OCC	Current Process Controls	DET	RPN	Recommended Action(s)	Responsibility	Completion Date	Action Results: Actions Taken	SEV	OCC	DET	RPN
The highest value process steps from the C&E matrix.	The shortlisted X's from the C-E Matrix	In what ways might the process potentially fail to meet the process requirements and/or design intent?	What is the effect of each failure mode on the outputs and/or customer requirements? The customer could be the next operation, subsequent operations, another division or the end user.	How Severe is the effect to the cusotmer?	How can the failure occur? Describe in terms of something that can be corrected or controlled. Be specific. Try identify the causes that directly impacts the failure mode, i.e., root causes.	How often does the cause or failure mode occur?	What are the existing controls and procedures (inspection and test) that either prevent failure mode from occurring or detect the failure should it occur? **Should include an SOP number.**	How well can you detect cause or FM?	SEV x OCC x DET	What are the actions for reducing the occurrence, or improving detection, or for identifying the root cause if it is unknown? **Should have actions only on high RPN's or easy fixes.**	Who is responsible for the recommended action?	What is the completion date for the recommended action?	List the completed actions that are included in the recalculated RPN. Include the implementation date for any changes.	What is the new severity?	What is the new process capability?	Are the detection limits improved?	Recompute RPN after actions are complete
Rolling	Operator	Untarined Operator	Major dia O/S	7	Eneffective Training	5	Training to operator	6	210	Effective monitoring of training	Process Owner	28/10/12	Training has been monitored with taking exam	7	4	3	84
		Setting not proper	Major dia O/S	7	Untarined Operator	5	Training to operator	4	140	Training to operator	Process Owner	28/10/13		7	3	3	63
Rolling	Die life	Die life has not set	Major dia O/S	7	New set of die used	2	No control	10	140	Die life to be set	Tool room	5/11/2013	Die life set	7	4	2	56
		Die fial before set life	Major dia O/S	7	Die life has not set	3	No control	10	210	Die life to be set	Tool room	5/11/2013	Die life set	7	3	3	63
Rolling	Pusher	Pusher worn out	Major dia U/S	7	Pusher life not set	2	No control	10	140	Pusher life to be set	Production	3/11/2013	Pusher life set	7	3	3	63
Rolling	Speed	Speed high/ low	Major dia O/S	7	Speed not optimized	7	Check sheet	7	343	DOE planned				7	7	7	343
Rolling	Maintenance	Preventive maintenance not done	Major dia O/S	7	Frequency of maintaince	4	Check sheet	5	140	Preventive maintenance planned	Maintnenace	26/10/13	Done	7	3	2	42
			Major dia U/S	7	Frequency of maintaince	4	Check sheet	3	84								
Rolling	Die	Die worn out	Major dia O/S	7	Die Life not set	4	No control	10	280	Die life to be set	Tool room	5/11/2013	Die life set	7	3	3	63
			Major dia U/S	7	Die Life not set	4	No control	10	280	Die life to be set	Tool room	5/11/2013	Die life set	7	3	3	63
Rolling	Rolling die pressure	Rolling die pressure more	Major dia U/S	7	No control to set the pressure	7	No control	10	490	DOE planned				7	7	10	490
		Rolling die pressure less	Major dia O/S	7	No control to set the pressure	7	No control	10	490	DOE planned				7	7	10	490
Rolling	Tightening bolts	Tightening bolt threads worn out	Major dia O/S	7	Excessive use	4	No control	10	280					7			7
Rolling	Pickling time	Pickling time maximum during plating	Major dia O/S	7	Manual input of parameter	4	Check sheet	3	84					7			7
Rolling	Initial setting	Initial setting not proper	Major dia O/S	7	Eneffective Training	5	Training to operator	4	140	Effective monitoring of training	Process Owner	28/10/12		7			7
Rolling	TRD	Established TRD not adequate	Major dia O/S	7	Drawing specifiaction not up mark	7	Forging drawing	7	343	DOE planned				7	7	7	343

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Fig-5: (FMEA diagram for identifying possible failures of screw design process)

Analyze

FMEA

Process Function	Characteristic of Input (KPIV / X)	Potential Failure Mode (How the X fails?)	Potential Effects of Failure (Y or Mini-Y)	SEV	Potential Cause(s)/ Mechanism(s) of Failure (Sub X's)	OCC	Current Process Controls	DET	RPN	Recommended Action(s)	Responsibility	Completion Date	Action Results: Actions Taken	SEV	OCC	DET	RPN
The highest value process steps from the C&E matrix.	The shortlisted X's from the C-E Matrix	In what ways might the process potentially fail to meet the process requirements and/or design intent?	What is the effect of each failure mode on the outputs and/or customer requirements? The customer could be the next operation, subsequent operations, another division or the end user.	How Severe is the effect to the cusotmer?	How can the failure occur? Describe in terms of something that can be corrected or controlled. Be specific. Try identify the causes that directly impacts the failure mode, i.e., root causes.	How often does the cause or failure mode occur?	What are the existing controls and procedures (inspection and test) that either prevent failure mode from occurring or detect the failure should it occur? **Should include an SOP number.**	How well can you detect cause or FM?	SEV x OCC x DET	What are the actions for reducing the occurrence, or improving detection, or for identifying the root cause if it is unknown? **Should have actions only on high RPN's or easy fixes.**	Who is responsible for the recommended action?	What is the completion date for the recommended action?	List the completed actions that are included in the recalculated RPN. Include the implementation date for any changes.	What is the new severity?	What is the new process capability?	Are the detection limits improved?	Recomkpute RPN after actions are complete.
Rolling	WIP	WIP more	Major dia O/S	7	Eneffective production planning	4		3	84					7	4	3	84
Rolling	Forging die	Ovality in forging die	Major dia O/S	7					0					7			7
Rolling	Cleaning	Before setting cleaning not done	Major dia O/S	7					0					7			7
Rolling	Total length	Total length US	Major dia U/S	7	Forging in put parameter changed	8	Control plan	7	392	DOE planned				7	8	7	392
		Total length OS	Major dia O/S	7	Forging in put parameter changed	8	control plan	7	392	DOE planned				7	8	7	392
Rolling	Mixings of high and low TRD	Mixings of high and low TRD	Major dia O/S	7	Forging in put parameter changed	7		7	343	DOE planned				7	7	7	343
			Major dia U/S	7	Forging in put parameter changed	7		7	343	DOE planned				7	7	7	343
Rolling	Materail	Burring of material during Heat treatment	Major dia O/S	7	Due to sharp edges on threads	4		3	84					7	4	3	84
Rolling	Die make	Supplier A fail to supply	Major dia O/S	7		4		2	58					7	4	2	54
		Supplier B fail to supply	Major dia O/S	7		4		2	54					7	4	2	57
Rolling	Hardness of die	High Hardness of die	Major dia O/S	7		2		2	28					7	2	2	28
		Low hardness of die		7		2		2	28					7	2	2	28
Rolling	Instrument	Error in the instrument	Major dia O/S	7	Calibration frequency not effective	4		3	84					7	4	3	84
Rolling	Checking aid	Checking aid not adequate	Major dia O/S	7	Micrometer used	4		5	140	Profile projector to be used	QA		Cobmination of microemter with profile projector used	7	4	2	56
Rolling	Ring gauge	Ring gauge worn out	Major dia O/S	7	Excessive use	4	Calibration frequency not effective	2	56					7	4	2	56
Rolling	MSA	MSA has not done	Major dia O/S	7	Frequency of MSA	4	No control	10	280	MSA to be done after every six months	QA		MSA done	7	2	3	42
			Major dia U/S	7	Frequency of MSA	4	No control	10	280	MSA to be done after every six months	QA		MSA done	7	3	3	63

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Fig- 6:(FMEA diagram)

Process capability analysis:

It is important techniques which is used to determine how well a process meets with specification limits. Process capability analysis check the actual state of the process. Sub-grouping of sample was done and ten samples were drawn, in a group of five. Minitab software was used for draw a process capability analysis curve (which is shown in fig)

Z-Bench sigma:

Z-Bench sigma value was found in this analization to be 1.12 and existing DPMO level of the process which is 132044.64.so opportunity for improvement in the process is higher.

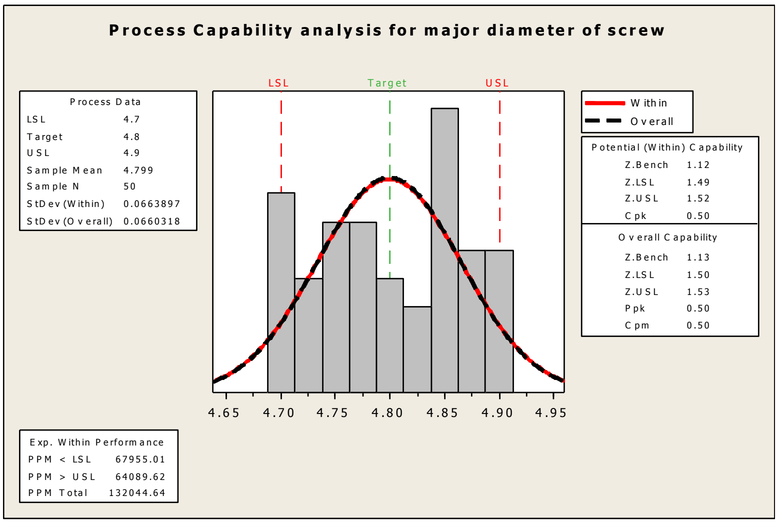

Fig-7 :(Process capability

Analysis of screw major diameter rejectionata before implementing DEMAIC methodology)

Fishbone diagram.

DPMO level and Z-Bench of major diameter rejection of screw was known by process capability analysis. Now it was the time to find out the more causes of rejection of major diameter of screw .A Fishbone diagram (as shown in fig. 8) was drawn to find out more causes of screw rejections.

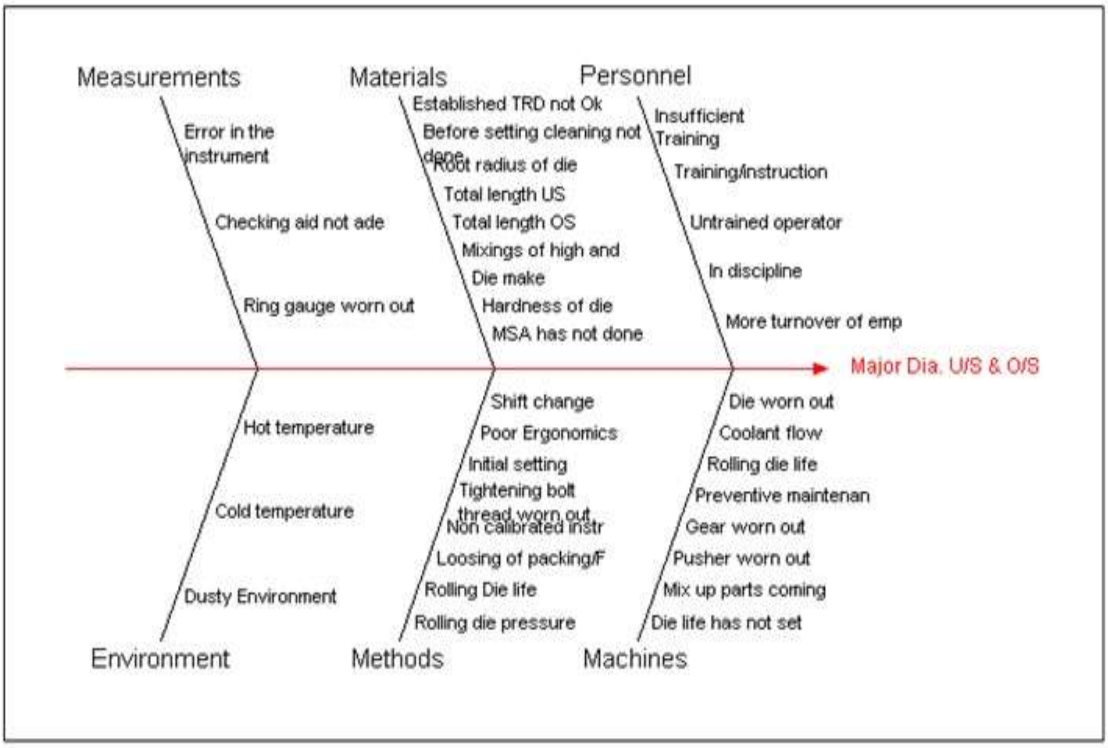

Fig-8: **(fishbone diagram)**

Improvement results

Improve the process to remove cause of defects. This is the stage where the root cause of the problem is removed and the solution is standardized.

In improve phase, The two factors that comes out to be the key reasons for the high rejection of Hi – Lo self tap screw rejection are TRD and speed of machine.

Table: 1(which showing two factors and about action for improvement and their benefits)

S.NO	INPUT VARIABLE	ACTION	BENEFIT
1.	Thread rolling diameter	TRD has been revised from 3.45-3.48 to 3.47 -3.50	Major diameter found within specification
2.	Speed	Speed of AF-6 machine kept 190 RPM	Major diameter found within specification

CONTROL

In control phase, X bar/R control chart was drawn. to check the possible cause of Variation after implementing the changes in TRD and Machine speed and ensuring that the process continues to be in a new path of optimization. Size of 50 sample was taken for drawing X bar/R chart (as shown in fig 9).

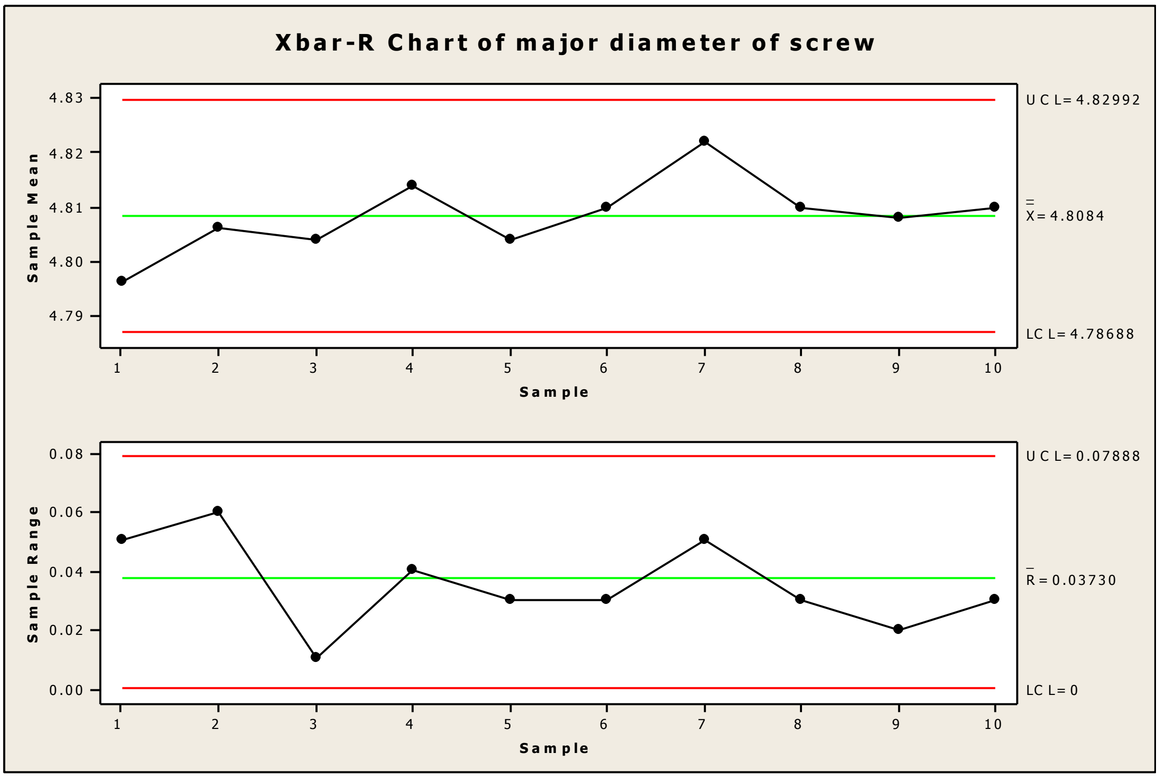

Fig-9: (X/R charts for screw major diameter after improvement)

RESULTS

Sigma level which improve up to 5.79 from 1.12 (as shown in fig 10).Application of six sigma is successfully implemented in this case study which definitely encourage the other manufacturing industry to use six sigma to reduce the losses in their processes.

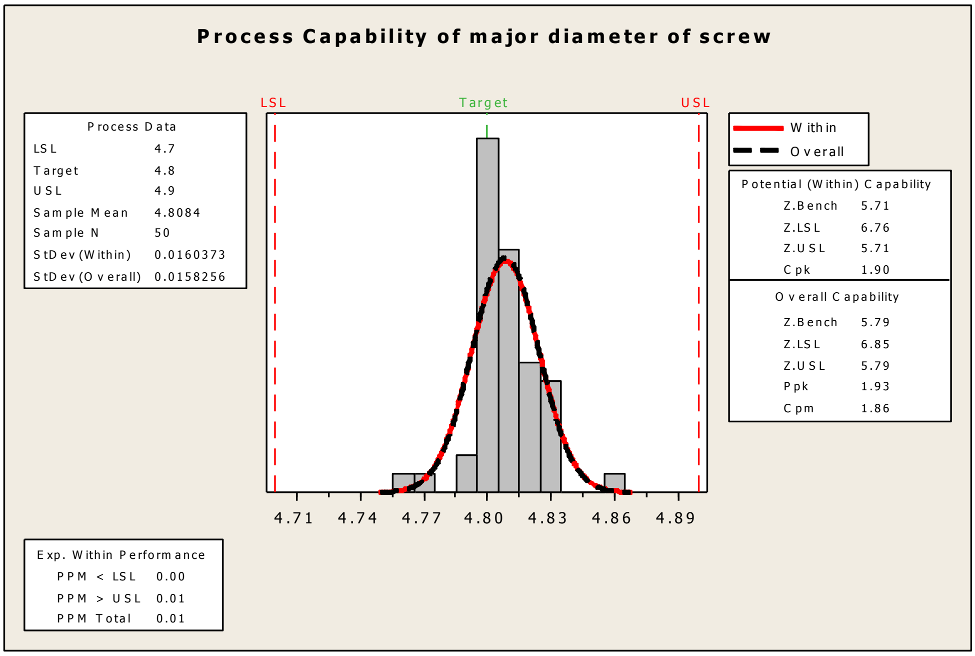

Fig-10: Process capability chart of screw major diameter rejection data after implementing DMAIC methodology)

CONCLUSIONS

Various case studies have been reported by different industrialists and researcher that show the capability and the remarkable results of applying six-sigma methodology. The above case study was also one of them but different in some context. As the study used a mixed approach in usage of the tools i.e. tools used are of mix category. There is the use of Minitab software which requires a high skill level and some tools as fishbone diagram process flow, FMEA etc. which is comparatively low skill level. The aim of the study was to reduce the rejection PPM of the industry which fulfilled by improving the sigma level of the process.

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