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Poka-Yoke and Quality Control on Traub Machine for Kick Starter Driven Shaft

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Abstract: **This study was conducted in manufacturing environment and focused at machining operation. Fair Products India, which manufactures auto ancillaries, was selected for this research. Fair Products has been facing tremendous pressure of quality level and in house rejection due to under sizing of the parts manufactured on Traub Machine. After sometime the process begins to fail as number of defects begins to increase as such the management has thrown challenge to the manufacturing team to find ways to improve the outgoing quality at machining operation. Thus, Error Proofing method was adopted for implementation at Traub Machining operation. Experimental research was carried out to see the effectiveness of Error Proofing to parameters that are Control Charts (X-bar Chart, R-Bar Chart), Process capability indices, tolerance limit or sigma level. The findings revealed that all three manufacturing metrics improved after the implementation of Error Proofing Device.**

Keywords: **Under-Sizing, Error Proofing, X-Bar Chart, R-Bar Chart, Traub Machine, Error Proofing Device and Six Sigma Level.**

1. INTRODUCTION

This project title is Poka yoke and quality control on Traub machine for ring nut and kick starter shaft. A mistake is something that would inevitably lead to a defect unless one had a method to prevent or detect it within the manufacturing process. This section describe about an overview of Poka-yoke system, applications and implementations of Poka-yoke system, defect prevention by using Poka-yoke system.

R. R Inman (2003), in an article entitled "Poka-yoke" presented the meaning of Poka-yoke is a technique for avoiding simple human error in workplace. It also known as mistake-proofing, goof –proofing and fail-safe work methods, Poka-yoke is simply a system designed to prevent inadvertent errors made by workers or operators performing a process.

Grout John R. (2007) and has presented a Poka-yoke is the use of operation or design features to prevent errors or the negative impact of errors or defects of non-conformances. He also points out that mistake-proofing often involves the creation of process stoppages, and provides tools and methods for designing them.

In study **Chen et al. (1996)**, has also considers that a Poka-yoke is a mechanism for detecting, eliminating, and correcting errors at their source, before they reach the customer.

C M Hinckley (2003) although the occurrence of mistakes is inevitable, non-conformances and defects is not. To prevent defects caused by mistakes, our approach to quality control must include several new elements.

Manivannan S. (2007), have presented the ideally, Poka-yoke techniques ensure that the right conditions exist to make a good assembly, before a joining process is actually executed.

Stewart Anderson (2002), in control method Poka-yoke devices are regulatory in working which are installed on process equipment and/or work pieces which make it impossible to produce defects and/or to flow a nonconforming product to the next process. As like shut down method control method gives 100% defect free products.

2. MACHINE AND OPERATIONS

This study was conducted in manufacturing environment and focused at machining operation. Fair Products India, which manufactures auto ancillaries, was selected for this research. Fair Products has been facing tremendous pressure of quality level and in house rejection due to under sizing of the parts manufactured on Traub Machine. After sometime the process begins to fail as number of defects begins to increase as such the management has thrown challenge to the manufacturing team to find ways to improve the outgoing quality at machining operation. Thus, Error Proofing method was adopted for implementation at Traub Machining operation. Experimental research was carried out to see the effectiveness of Error Proofing to parameters that are Control Charts(X-bar Chart, R-Bar Chart), Process capability indices, tolerance limit or sigma level. The findings revealed that all three manufacturing metrics improved after the implementation of Error Proofing Device.

2.1 Traub Machine Technical Specification

Arrow make Traub machine was used by the company model no Arrow-25.

TABLE 1: Traub Machine Technical Specification

Round	42 mm
Hexagon	36mm
Square	29mm
Cross Slide Stroke	28mm
Max turning length with L.T slide	100mm
Max tail stock travel	150mm
Spindle speeds(12 steps)	200 to 2500 RPM
Products Rate	12to1245 Pieces/Hr
Work spindle motor	2.7/3.5 HP
Feed drive motor	0.75/1 HP
Net weight(Approx)	1200 Kg's
Packing dimension (in mm)	x 1800

2.2 Mathematical Formulas Used

Average or Mean

To compute the mean we simply sum all the observations and divide by the total number of observations.

(b)

Fig. 1. (a) Machine Floor; (b) Poke-Yoke Device Setup

The equation for computing the mean is

$$\overline{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

$\overline{x}$ = the mean
x_i = observation $i, i = 1, \ldots, n$
n = number of observations

The Range and Standard Deviation

The first measure is the range, which is the difference between the largest and smallest observations:-

Range= Largest Observation-Smallest Observation.

Another measure of variation is the standard deviation. The equation for computing the standard deviation is:-

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \overline{x})^2}{n - 1}}$$

σ = standard deviation of a sample
$\overline{x}$ = the mean
x_i = observation $i, i = 1, \ldots, n$
n = the number of observations in the sample

Average Chart or X-bar chart Formulas

$$\text{Upper control limit (UCL)} = \overline{\overline{x}} + A_2 \overline{R}$$
$$\text{Lower control limit (LCL)} = \overline{\overline{x}} - A_2 \overline{R}$$

$\overline{\overline{x}}$ = average of the sample means
$\overline{R}$ = average range of the samples

A_2= 0.58 (Constant as per IS: 397 for a sub group of 5)

Range Chart or R-Bar Chart Formulas

$$\text{UCL} = D_4 \overline{R}$$
$$\text{LCL} = D_3 \overline{R}$$

$\overline{R}$ = average range of the samples

D_3=0 (Constant as per IS: 397 for a sub group of 5)

D_4=2.33 (Constant as per IS: 397 for a sub group of 5)

Process Capability Formulas

$$C_p = \frac{\text{specification width}}{\text{process width}} = \frac{\text{USL} - \text{LSL}}{6\sigma}$$

C_p=Process Capability Index

USL=Upper Specification Limit

LSL=Lower Specification Limit

Cp = 1: A value of Cp equal to 1 means that the process variability just meets specifications.

Cp<1: A value of Cp below 1 means that the process variability is outside the range of specification. This means that the process is not capable of producing within specification and the process must be improved.

Cp>1: A value of Cp above 1 means that the process variability is tighter than specifications and the process exceeds minimal capability and process is satisfactory.

$$C_{pk} = \min\left(\frac{\text{USL} - \mu}{3\sigma}, \frac{\mu - \text{LSL}}{3\sigma}\right)$$

If $C_{pk}>1.33$ then Process capability is excellent.

If $C_{pk}>1$ Process capability is satisfactory.

If $C_{pk}<1$ Process is not capable, it needs to take corrective action.

Kick Starter Driven Shaft (Part No: - 11360-M92--3000-IK).

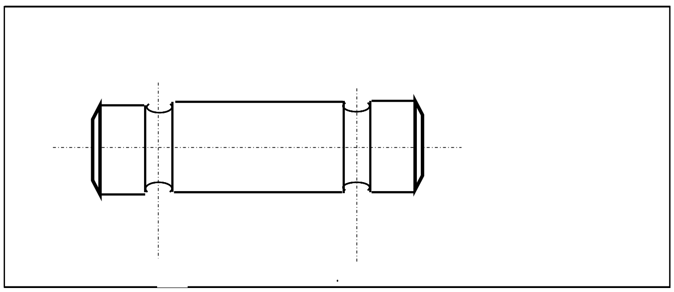


Fig. 2. Kick starter Driven shaft.

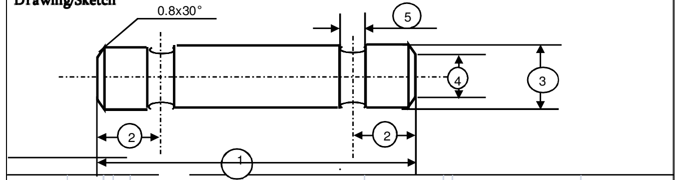
Another part which was facing the problem of under-sizing of length was Kick Starter Driven Shaft which was being manufactured for Mahindra Two wheelers for their Zing-80 model. Part was completed mainly on Traub Machine and further finishing of the parts were done on the Centre less Grinding in two stages firstly rough grinding and then finishing grinding to give the part extra surface finish and meet the desirable surface conditions as per the demands of the end customer.

TABLE 2: Traub Machine Specifications for kick starter driven shaft

Sr. No	Parameters	Dimensions(mm)
1.	Grooving	3
2.	Parting	Thickness 44.0±0.1
3.	Chamfering	0.8x30°
The Feed was set at 120 Parts per Hour i.e. 960 Parts per 8hr shift.		

INSPECTION STANDARD				
STAGE : PR-DISPATCH INSPECTION			Customer : MAHINDRA TWO WHEELERS	
PART NAME : KICK STARTER DRIVEN SHAFT			Model : ZING-80	
PARTNO : 11360-M92-3000-IK			: -	

Drawing/Sketch



SR. NO.	CHARACTERISTICS	ACCEPTANCE CRITERIA	MEASURING INSTRUMENTS	REMARKS
I	Appearance	No Burr, No Dent, No Crack, No	Visual	
II	DIMENSION(MM)			
1	Total Length	44±0.1	Digital Vernier	
2	Length	12	Digital Vernier	
3	Dia	Ø12/+0.038/-0.047	Digital Micrometer	
4	Dia	Ø11	Profile Projector	
5	Groove	3	Profile Projector	
6	Chamfer	0.8x30°	Profile Projector	
III	Material	Chemical Compositio	External test agency	
IV	Heat Treatment	HRC17-25	Rockwell hardness tester	
Remarks : 1. Part shall be clean, smooth, free from burrs & other harmful defects.				

PROCESS FLOW CHART				
CUSTOMER : MAHINDRA TWO WHEELERS			PFC No. : PFC/FPI/M2WL/03/00	
PART NAME : KICK STARTER SHAFT			PART NO. : 11360-M92-3000-IK	
Sr. No.	Operation Description	Process Flow	Reaction Plan	Remarks
00	Raw Material Receiving		Inform to Supplier	
1	Raw Material Receiving Inspection		Reject & Return to Supplier	
2	Parting, Chamfering, Grooving		Reset & Verify	
3	Heat Treatment		Reject & Return to Supplier	
4	Centerless Rough Grinding		Reset & Verify	
5	Centerless Finish Grinding		Reset & Verify	
6	Nitriding		Reject & Return to Supplier	
7	Final Inspection		Reset & Verify	
8	Packing		Seggregate and verify	
9	Dispatch		Repack & Verify	

DEFINITION	STORE	MOVE	INSPECTION	OPERATION	OPERATION & INSPECTION	IF NOT OK	CTQ
SYMBOLS	▽	⬇	◇	○			

Pre Installation Data

The following observations were taken at the time of production at random 25 samples were taken which were divided into subgroups of 5 as per the table below (All Dimensions are in mm).

USL (Upper Specification Limit) = 44.100.
LSL (Lower Specification Limit) = 43.900.
Tolerance=0.200.

TABLE 3: Pre Installation Observations

	Sub Group Numbers					
Observations	S. No	1	2	3	4	5
	1	43.96	43.98	43.98	43.98	43.91
	2	43.95	43.85	43.97	43.95	43.96
	3	43.97	43.98	43.89	43.96	43.95
	4	43.98	43.96	43.98	43.97	43.98
	5	43.99	43.79	43.98	43.96	43.99

Calculations for Control Charts, Process Capability Indices

TABLE 4: - Range Chart Calculations

`	1	2	3	4	5
Range	0.040	0.190	0.090	0.030	0.080

Average Range=0.0860
Range Chart UCL (Upper Control Limit) = Average Range x D_4. = 0.1815
Range Chart LCL (Lower Control Limit) = Average Range x D_3. = 0
Where D_4= 2.11 (Constant as per IS: 397 for a sub group of 5)
D_3= 0 (Constant as per IS: 397 for a sub group of 5)

TABLE 5: Average or X-bar Chart Calculations

`	1	2	3	4	5
Range	43.97	43.91	43.96	43.96	43.95

Grand Average= 43.9528
Average Chart UCL (Upper Control Limit) =Grand Average + A_2 x Average Range = 44.002

Average Chart LCL (Lower Control Limit) =Grand Average - A_2 x Average Range = 43.9020

Where A_2 = 0.58 (Constant as per IS: 397 for a sub group of 5)

Process Capability Indices Calculations

Quality Level or Sigma = Average Range / D_2 = 0.0369

Where D_2 = 2.33 (Constant as per IS: 397 for a sub group of 5)
6xSigma= 0.2215

Process Capability Index C_p= USL – LSL/ 6x Sigma = 0.9031

Upper Capability Index UCI for C_{pk}= USL – Grand Average/ 3xSigma = 1.3294

Lower Capability Index LCI for C_{pk}= Grand Average – LSL/ 3xSigma = 0.4768

C_{pk}= Min of (UCI: LCI) = 0.4768

Post Installation Data

TABLE 6: - Post Installation Observations

	Sub Group Numbers					
Observations	S. No	1	2	3	4	5
	1	43.96	43.95	43.96	43.96	43.96
	2	43.97	43.97	43.97	43.97	43.97
	3	43.97	43.98	43.98	43.98	43.98
	4	43.98	43.98	43.98	43.98	43.97
	5	43.98	43.96	43.99	43.96	43.99

Calculations for Control Charts, Process Capability Indices

TABLE 7: Range Chart Calculations

`	1	2	3	4	5
Range	0.02	0.03	0.03	0.02	0.030

Average Range=0.0260.
Range Chart UCL (Upper Control Limit) = Average Range x D_4 = 0.0549.
Range Chart LCL (Lower Control Limit) = Average Range x D_3 = 0.
Where D_4= 2.11 (Constant as per IS: 397 for a sub group of 5)
D_3= 0 (Constant as per IS: 397 for a sub group of 5).

TABLE 8: Average or X-bar Chart Calculations

`	1	2	3	4	5
Range	43.97	43.96	43.97	43.97	43.97

Grand Average= 43.9720
Average Chart UCL (Upper Control Limit) = Grand Average + A_2 x Average Range = 43.9893
Average Chart LCL (Lower Control Limit) = Grand Average - A_2 x Average Range = 43.9569
Where A_2 = 0.58 (Constant as per IS: 397 for a sub group of 5)

Process Capability Indices Calculations

Sigma= Average Range / D_2 = 0.0058.
Where D_2 = 2.33 (Constant as per IS: 397 for a sub group of 5)
Process Capability or 6xSigma = 0.0670.
Process Capability Index C_p= USL – LSL/ 6x Sigma = 5.7108.
Upper Capability Index UCI= USL – Grand Average/ 3xSigma = 3.8236.

Lower Capability Index LCI= Grand Average – LSL/ 3xSigma = 2.1508.
C_{pk}= Min of (UCI: LCI) = 2.1508

3. RESULTS AND DISCUSSION

Kick Starter Driven Shaft

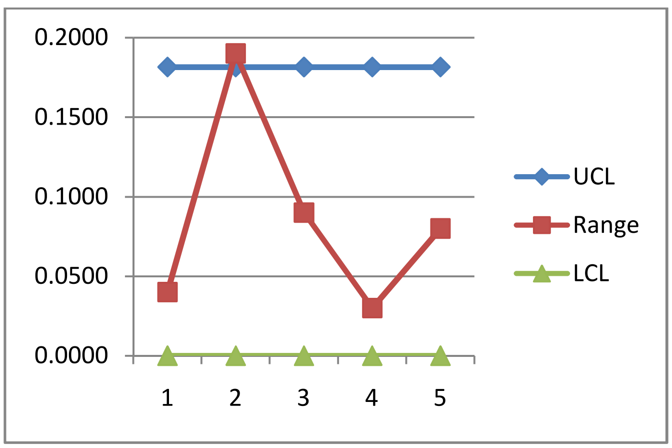
As clearly seen from the table 9 that errors or defects in the parts were detected in:

a) Subgroup No: 2 Sample No: 2 corresponding to reading 43.850.

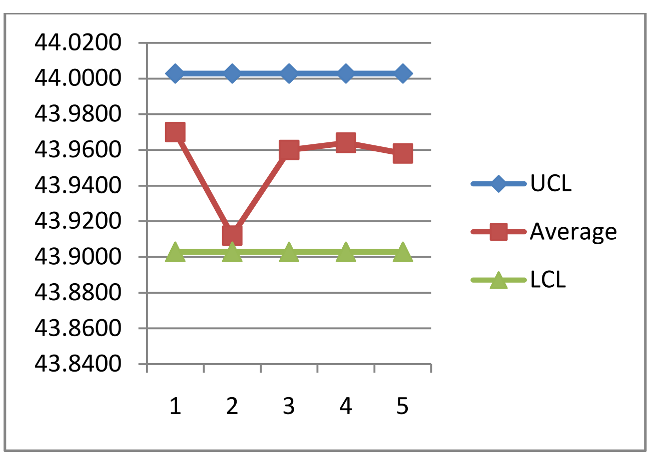
b) Subgroup No: 2 Sample No: 4 corresponding to reading 43.790.

c) Subgroup No: 3 Sample No: 3 corresponding to reading 43.890.

Pre Installation Control Charts (X-Bar and R-Bar Charts) &C_p, C_{pk}



Graph 1: - Range Chart



Graph 2: - Average Chart

As can be clearly seen from the both X-bar chart and R-bar chart that the average range is out of the control limits and also the range is falling below LCL. It indicates that process is not under the specified desirable conditions as in the range chart the Upper Control Limit is 0.1815and Lower Control Limit is 0.The Variation in range is seen in Subgroup no 2 as the range for that particular subgroup is 0.190causing variation in the range chart. And in the X-bar chart the Sub groups no 2 is falling just on the LCL which is 43.900 causing variations as seen in the chart. Also the variations in spread of both X-bar and R-bar charts are not close to the centre and are variations are casing the . Main strategy is to find the root cause of the errors that leads to defect in production system.

Also the most crucial parameters which include Six Sigma levels, Process Capability Indices shows undesirable results as the 6xSigma= 0.2215and corresponding C_p=0.9031and value of C_{pk}= 0.4768.According the Process Capability Standards.

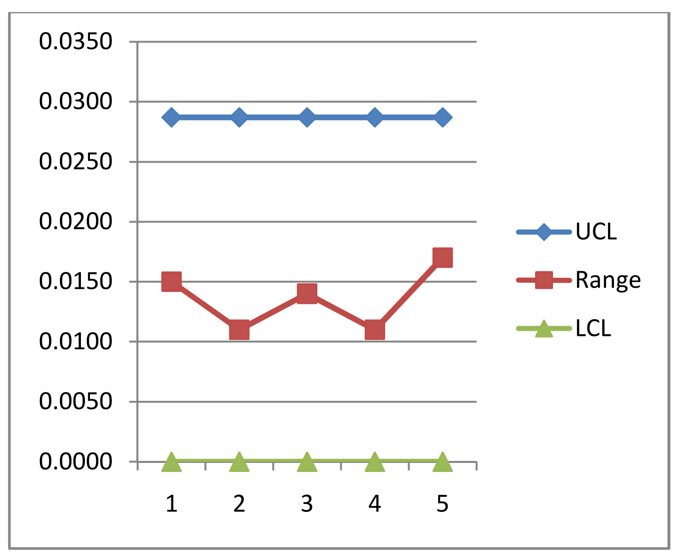
a) If C_{pk}>1.33 then Process capability is excellent.

b) If C_{pk} =1 Process capability is satisfactory.

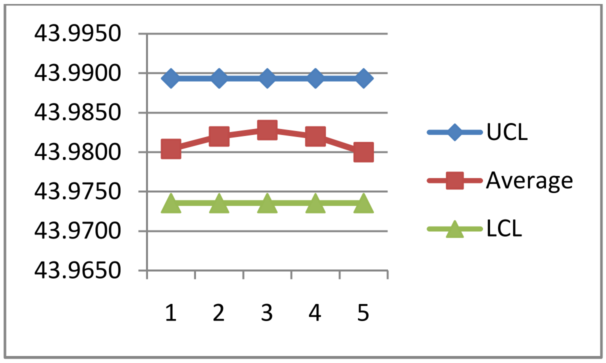
c) If C_{pk}<1 Process is not capable, it needs to take corrective action.

It clearly indicates that C_{pk}=0.1240 which is less than 1 that means that the process variability is outside the range of specification. This means that the Process is not capable of producing within specification and the process must be improved.

Post Installation Control Charts (X-Bar Chart and R-Bar Chart) &C_p, C_{pk}



Graph 3: - Range Chart



Graph 4: - Average Chart

As it can be observed clearly from the above range chart and average chart that the process is well within the control limits and parts produced are much more in tighter tolerances as desired from the system.

Also the most crucial parameters which include Six Sigma levels, Process Capability Indices shows undesirable results as the 6xSigma= 0.0112and corresponding C_p=2.98and value of C_{pk}= 2.1508. According the Process Capability Standards.

a) If C_{pk}>1.33 then Process capability is excellent.

b) If C_{pk} =1 Process capability is satisfactory.

c) If C_{pk}<1 Process is not capable, it needs to take corrective action.

It clearly indicates that C_{pk}=2.1508 which is greater than 1 that means that the process variability is inside the range of specification. This means that the Process is capable of producing within specification and the process capability is excellent.

4. CONCLUSION

The selected parameters for this study which were Control Charts (X-bar and R-bar chart), Six Sigma and Process Capability Indices has shown considerable improvements after the installation of the Error Proofing Device as can be observed from pre installation and post installation data of Kick starter driven shaft.

The under-sizing defect from the Traub machine was also eliminated from the system by the installation of Error Proofing Device. This proves that the experiment was successful and the applicability of the Error Proofing Device is justified.

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