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Lean Manufacturing Philosophy Implementation in Industry

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Abstract

Lean Manufacturing is a systematic approach to identifying and eliminating waste through continuous improvement. Lean is about doing more with less: Less time, inventory, space, people, and money. Lean is about speed and getting it right the first time. Lean production is aimed at the elimination of waste in every area of production including customer relations, product design, supplier networks and factory management. Its goal is to incorporate less human effort, less inventory, less time to develop products, and less space to become highly responsive to customer demand while producing top quality products in the most efficient and economical manner possible. Lean Manufacturing uses less of everything compared with mass production half the human effort in the factory, half the manufacturing floor space, half the investment in tools, half the engineering hours to develop a new product in half the time. Also it requires keeping far less than half the needed inventory on site results in, fewer defects .This is accomplished through Teamwork, Communication, and Efficient Use of Resources & Continuous Improvement. Lean Thinking methods are inclusive of all employees.

Keywords: *Lean Manufacturing, Industrial Applications, Gear Planning, Rack Generation.*

Introduction

Lean is simply about creating more value for customers by eliminating activities that are considered waste. Any activity or process that consume resources, adds cost or time without creating value becomes the target for elimination. One of the important aspects of Lean is the focus on 'system-level' improvements. The system-level work can dramatically improve a company's bottom line results. [5]

Lean is a mindset, or way of thinking, with a commitment to achieve a totally waste-free operation that's focused on our customer's success. It is achieved by simplifying and continuously improving all processes and relationships in an environment of trust, respect and full employee involvement. It is about people, simplicity, flow, visibility, partnerships and true value as perceived by the customer.

Lean manufacturing is a technique, which, by focusing on the overall picture and waste reduction and removal programs creates higher stocks and increases the bottom line profits. It is among one of the few programs that cover its impact on such a vast group. Lean manufacturing has its effect on the employees and the customers alike. The former are positively impacted by the motivational endeavors while the latter enjoy the increased value and customer services inherent in the program. The turnaround time or the cycle length is immensely reduced and the products reach the rack in a much faster time than anticipated, not to mention the increased quality and variety.

Lean manufacturing benefits out of the synergies between various departments. Instead of treating, each department as an individual firm the techniques tends to bind all concerned in one wrapper thereby working on the overall organization's performance. Some More Things to Consider

1. Reduces the administrative costs entailed in other popular methods.
2. Focuses on waste reduction.
3. Special emphasis on unnecessary cost generating points.
4. Imparts a better control over the day to day activities.
5. Reduces the cycle time.
6. Imparts the much sought variety and quality.
7. Socially answerable techniques.

8. Promotes environment friendly practices.
9. A definite superior over the MRP based systems and the relevant counterparts

The entire offerings can be simply summed up as "satisfied customers and pleasing profits", that is what lean manufacturing is all about. [28]

Lean methods typically target eight types of waste. These waste types are listed in the Table 1. It is interesting to note that the "wastes" typically targeted by environmental management agencies, such as non-product output and raw material wastes, are not explicitly included in the list of manufacturing wastes that lean practitioners routinely target.

Table 1: Eight Types of Waste Targeted By Lean Methods

Defects	Production of off-specification products, components or services that result in scrap, rework, replacement production, inspection, and/or defective materials
Waiting	Delays associated with stock-outs, lot processing delays, equipment downtime, capacity bottlenecks
Unnecessary Processing	Process steps that are not required to produce the product
Overproduction	Manufacturing items for which there are no orders
Movement	Human motions that are unnecessary or straining, and work-in-process (WIP) transporting long distances
Inventory	Excess raw material, WIP, or finished goods
Unused Employee Creativity	Failure to tap employees for process improvement suggestions
Complexity	More parts, process steps, or time than necessary to meet customer needs

Case Studies

Methods of Manufacturing Gears:

An involute profile gear teeth are made by the following processes:

1) Forming the gear teeth by using milling
2) Generating the gear teeth by gear planning or rack
3) Generating the gear teeth by gear shaping
4) Generating the gear teeth by gear hobbling

1. Gear Milling

In Gear Milling process, an involute form-milling cutter, which has the profile of the space between the gears, is used to remove the material between the teeth from the gear blank on a horizontal milling machine. Gear milling is a multipoint machining process in which individual tooth spacing are created by a rotating multiage cutter having a cross-section similar to that of the generated teeth (involute). After cutting each space, the gear is returned to its original position, and the gear blank is indexed for the next cut.

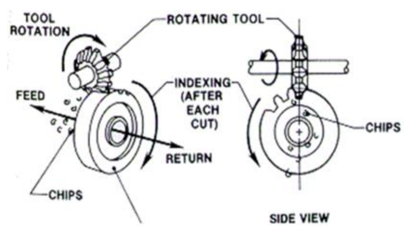

Figure 1: Gear Milling

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2. Gear Planning or Rack Generation

This is used for mid volume production. A rack, which may be considered to be a gear of infinite radius, is used as the cutter. It is constructed of hardened steel with cutting edges round the teeth boundaries. The rack which is given a reciprocal lateral motion equal to the pitch line velocity of the gears slowly fed to the slowly rotating gear blank. In this way, the material between the teeth is removed and the involute teeth are generated.

3. Gear Shaping

The cutter is a circular pinion-shaped cutter with the necessary rake angles to cut as shown. Both the gear blank and cutter are set in a vertical plane and rotated such as that the two are like gears in mesh. Gear shaping is faster than gear planning because the cutting process is continuous and the cutter does not have to be stepped back. Another field of application is gear manufacturing in low lot volume, since the purchase cost of gear shaping tools are significantly lower than the prices of hobs.

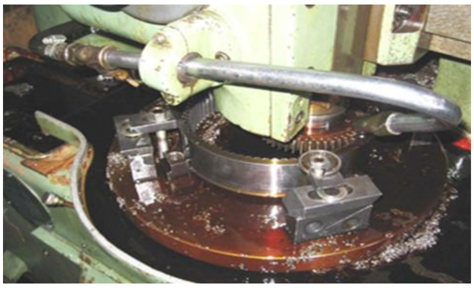

Figure 2: Gear Shaping

4. Gear Hobbing

The hob is used to generate the involute teeth here. The hob is basically a straight cylindrical tool around which a thread with the same cross section as the rack tooth has been helically wound. This hob is then rotated with the gear blank fed onto the hob according to the depth of cut. The helix pattern of hob as it rotates is the same as that of the rack moving laterally.

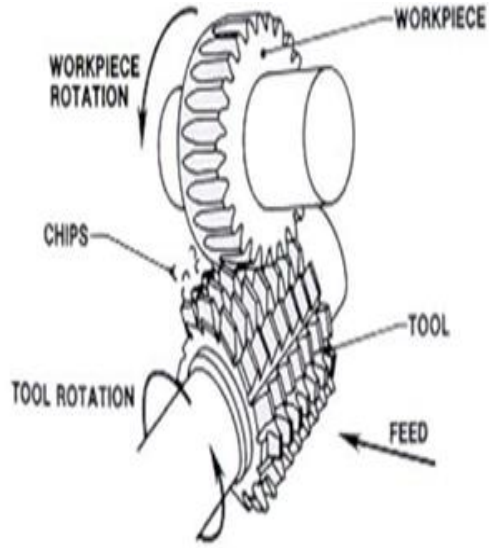

Figure 3: Gear Hobbing

Kaizen Methodology

Problem: To avoid the problem of wastage of broaching oil during the reloading the component in trolley after broaching.

Kaizen: To avoids broaching oil wastage.

Theme: Russian Horizontal Broaching machine.

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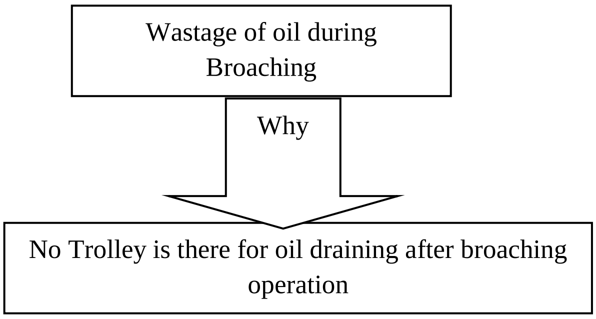
Analysis:



Solution– An oil trolley is placed near the machine, which operators are instructed to keep the job after broaching or soaking broaching oil and then they are reloading, during the trolley.

KAIZEN SHEET BHARAT GEARS PVT. LIMITED		
KAIZEN THEME: Avoids broaching oil wastage.		**M/C:** Russian Horizontal Broaching machine. Target Date: 10/12/2012
Problem: Wastage of broaching oil during reloading of components in trolleys after broaching.	Counter Measure-An oil trolley is placed near the machine on which operators are instructed to keep the job after broaching after soaking of broaching oil they are reloaded.	
Analysis Why No Trolley is there for oil during after broaching operation	**Before Counter Measure** Broaching oil wastage as oil is not being soaked from the job after broaching.	**Benefits/Results after implementation** Reduction in broaching oil consumption and saving 3 lit. /day
Root Case: No place was provided on the machine by manufacturer, on which job can be kept after operation for oil draining	**After Counter Measure:** Wastage of broaching oil get reduced to minimum	**Scope & Plan** Same procedure can be used on other machine.

Six- Sigma Methodology

Problem: To eliminate the problem of rejection and rework due to teeth span size variation of Transmission Gears (GG 1491/1) after shaving.

Process Flow Chart:

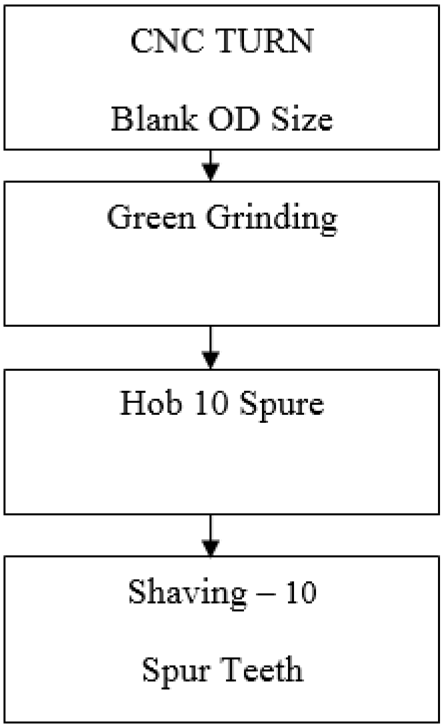


Figure 4 Flow Process Chart

Solution by DAMIC methodology:

Phase -1: Define the problem

1) Problem Statement**: Teeth Span Size Variation.**
2) Response to be measured**: Teeth Span Size (For Component to Component) and Teeth Span Outness.**
3) Instrument used to verify the Response: **Teeth Span Micrometer.**

Phase -2: Measure and analysis (Data collection planning & execution)

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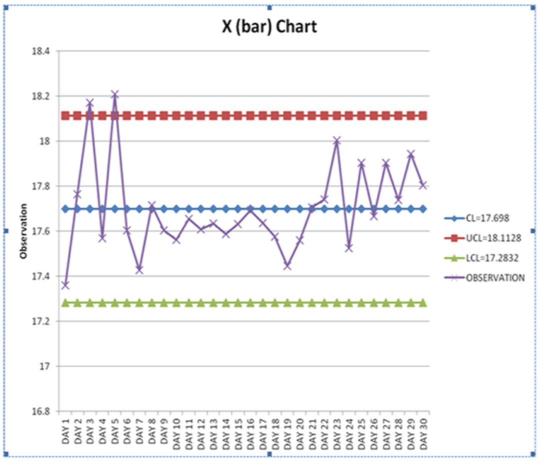
Sample of 9 pieces was taken each day for 30 days. The Variation is as given below. All data in mm.

Control Charts for Variables: Teeth Span Size Variation

S.No.	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7	DAY 8	DAY 9	DAY 10
1	17.19	17.44	18.69	17.3	17.99	17.13	17.24	17.35	17.35	18.65
2	17.22	18.26	18.65	17.25	17.78	18.69	17.23	17.39	17.29	17.5
3	17.12	17.45	17.77	17.46	18.89	17.45	17.26	18.3	17.34	17.51
4	17.25	17.54	17.87	17.48	17.79	17.26	17.3	17.35	17.45	17.44
5	17.15	17.43	18.39	17.31	18.51	17.78	17.32	18.01	17.44	17.43
6	17.15	17.78	17.98	17.45	17.78	17.12	17.33	18.3	17.43	17.29
7	17.23	18.21	17.89	17.45	18.69	17.22	17.35	17.36	17.42	17.41
8	17.9	18.19	18.36	18.19	17.89	18.23	17.41	17.35	18.01	17.43
9	18.03	17.57	17.94	18.22	18.56	17.55	18.4	18.03	18.7	17.4
X(bar)	17.360	17.763	18.171	17.568	18.209	17.603	17.427	17.716	17.603	17.562
Range	0.910	0.830	0.920	0.970	1.110	1.570	1.170	0.950	1.410	1.360

S.No.	DAY 11	DAY 12	DAY 13	DAY 14	DAY 15	DAY 16	DAY 17	DAY 18	DAY 19	DAY 20
1	17.22	17.4	18.01	17.39	17.25	17.2	17.23	17.35	17.24	18.65
2	17.2	17.39	17.19	17.4	17.26	17.39	17.59	17.16	17.27	17.5
3	17.17	17.45	17.41	17.41	17.27	18.3	17.45	17.34	17.26	17.51
4	17.16	17.46	17.43	17.43	18.01	17.35	17.46	17.45	17.28	17.45
5	18.02	18.01	17.45	17.44	18.02	18.01	18.01	17.44	17.32	17.43
6	18.04	18.37	17.46	17.45	18.65	18.23	18.59	17.43	17.33	17.27
7	18.05	17.45	18.01	18.78	17.4	17.36	17.45	17.42	17.35	17.41
8	18.65	17.46	18.3	17.49	17.41	17.35	17.46	18.01	17.41	17.42
9	17.39	17.49	17.45	17.5	17.42	18.03	17.49	18.59	18.56	17.4
X(bar)	17.656	17.609	17.634	17.588	17.632	17.691	17.637	17.577	17.447	17.560
Range	1.490	0.980	1.110	1.390	1.400	1.100	1.360	1.430	1.320	1.380

S.No.	DAY 21	DAY 22	DAY 23	DAY 24	DAY 25	DAY 26	DAY 27	DAY 28	DAY 29	DAY 30
1	18.01	18.3	18.29	17.56	17.58	18.01	17.45	17.16	18.78	17.26
2	17.59	18.68	17.65	17.5	17.46	17.17	17.42	17.29	17.56	18.23
3	17.5	17.28	18.52	17.51	18.29	17.41	17.43	17.45	17.59	17.35
4	17.2	17.16	17.53	18.23	18.23	17.9	18.56	18.24	17.16	18.24
5	17.45	17.36	17.54	17.43	17.44	17.42	18.23	18.59	17.56	18.2
6	17.46	17.56	17.45	17.25	18.54	17.46	17.98	17.23	18.42	18.15
7	18.01	17.45	18.28	17.41	17.54	18.01	18.23	18.23	18.39	17.29
8	18.69	17.59	18.23	17.43	17.42	18.16	17.56	17.89	17.63	17.3
9	17.45	18.29	18.54	17.41	18.63	17.45	18.28	17.56	18.4	18.22
X(bar)	17.707	17.741	18.003	17.526	17.903	17.666	17.904	17.738	17.943	17.804
Range	1.490	1.520	1.090	0.980	1.210	0.990	1.140	1.430	1.620	0.980



Graph for X (Bar) Chart

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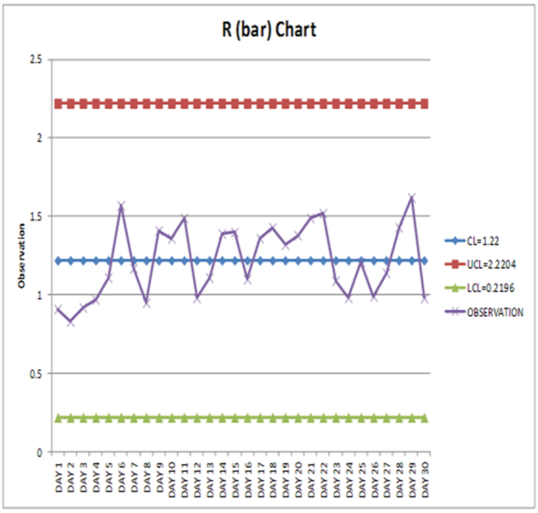


Graph for R-chat

Phase 3: Analysis

➢ FISH-BONE DAIGRAM(CAUSE-EFFECT DAIGRAM)

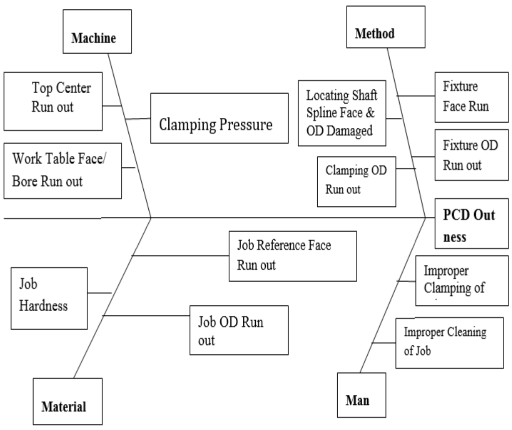


Figure 4.3.4 Cause Affect Diagram

Phase 4: Control:

While checking the Machine, fixture for pitch circle diameter outness it was found that lot of chips during hobbling were deposited on the fixture center.

It was found that these chips were entering due to the higher gap between the job clamping outer diameter and the fixture's cap. To correct this problem fixture design was modified by modifying the cap design - the clearance was reduced.

Design the New Fixture

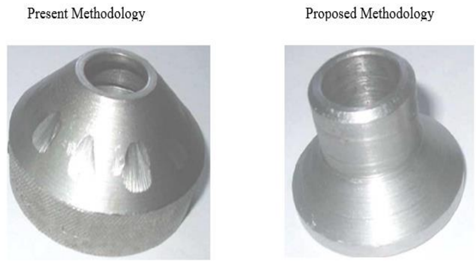


Figure 4.3.5 New Fixture Design

After Improve phase Re-check the all statistical process controls. Sample of 9 pieces was taken each day for 30days. The Variation is as given below. All data in mm.

S.No.	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7	DAY 8	DAY 9	DAY 10
1	17.7	17.87	17.58	17.66	17.83	17.33	17.54	17.4	17.86	17.46
2	17.69	17.56	17.56	17.77	17.79	17.58	17.3	17.41	17.56	17.47
3	17.68	17.79	17.87	17.91	17.6	17.86	17.31	17.43	17.57	17.5
4	17.67	17.78	17.45	17.83	17.89	17.74	17.39	17.45	17.52	18.32
5	17.69	17.93	17.93	17.92	17.76	17.34	17.45	17.46	17.59	17.6
6	17.65	17.82	17.53	17.69	17.67	17.54	17.56	18.12	18.46	18.2
7	17.56	17.81	17.78	17.71	17.95	17.61	17.58	17.69	17.63	17.68
8	17.69	17.82	17.83	17.89	17.95	18.31	17.31	17.42	17.68	17.45
9	18.1	17.44	17.65	18.3	17.81	17.54	18.29	17.46	18.11	17.46
X(bar)	17.714	17.758	17.687	17.853	17.806	17.650	17.526	17.538	17.776	17.682
Range	0.54	0.49	0.48	0.64	0.35	0.98	0.99	0.72	0.94	0.87

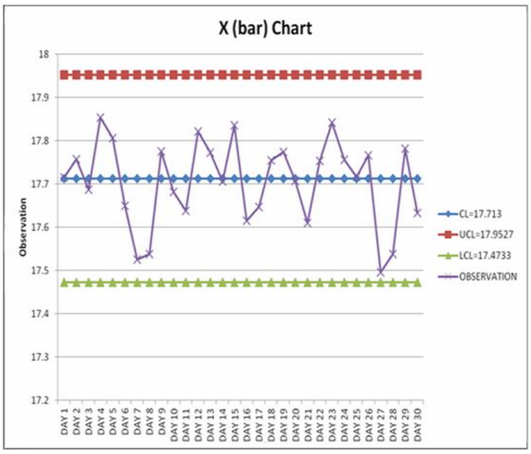
Teeth Span Size variation

S.No.	DAY 11	DAY 12	DAY 13	DAY 14	DAY 15	DAY 16	DAY 17	DAY 18	DAY 19	DAY 20
1	17.65	17.43	17.75	17.46	17.65	17.56	17.56	17.56	17.53	17.43
2	17.49	17.64	17.76	18.31	17.76	17.36	17.47	17.95	18.23	17.48
3	17.5	18.19	17.8	17.58	17.77	17.91	17.56	18.1	18.2	17.53
4	17.53	17.68	18.29	17.6	17.78	17.58	18.13	18.05	17.45	17.59
5	17.54	17.7	17.46	17.65	17.8	17.23	17.6	17.34	17.56	18.1
6	17.55	18.1	17.71	17.66	17.81	17.9	18.2	17.56	17.58	17.56
7	17.6	17.72	17.72	17.68	17.82	17.59	17.39	18	17.9	17.43
8	17.61	17.73	17.73	17.7	17.83	17.85	17.45	17.99	17.56	18.1
9	18.27	18.2	17.74	17.71	18.3	17.56	17.46	17.24	17.96	18.15
X(bar)	17.638	17.821	17.773	17.706	17.836	17.616	17.647	17.754	17.774	17.708
Range	0.78	0.77	0.83	0.85	0.65	0.68	0.81	0.86	0.78	0.72

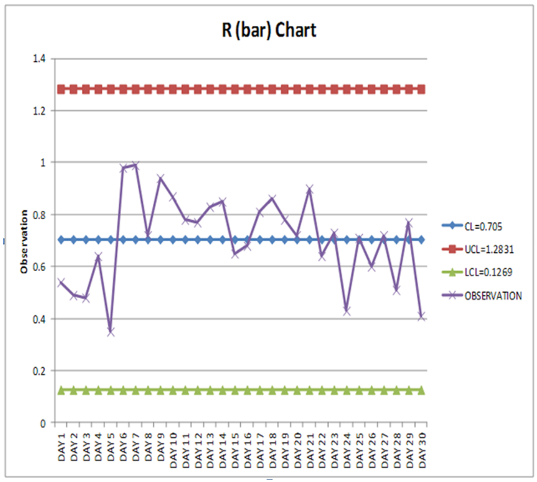
Teeth Span Size variation

S.No.	DAY 21	DAY 22	DAY 23	DAY 24	DAY 25	DAY 26	DAY 27	DAY 28	DAY 29	DAY 30
1	17.45	17.82	18.23	17.53	17.89	17.56	17.56	17.56	17.68	17.65
2	17	17.65	18.27	17.86	17.56	17.76	17.95	17.47	17.76	17.49
3	17.9	17.89	17.89	17.56	17.57	17.77	17.23	17.45	17.34	17.5
4	17.23	18.23	17.56	17.95	17.9	17.65	17.53	17.56	17.78	17.53
5	17.53	18.29	17.59	17.93	17.43	17.78	17.29	17.6	17.9	17.53
6	17.89	17.8	17.54	17.96	18.14	17.81	17.56	17.9	17.81	17.9
7	17.9	18.23	17.95	17.56	17.45	17.58	17.26	17.39	17.82	17.6
8	17.69	18.16	17.9	17.89	17.65	17.83	17.84	17.45	17.83	17.61
9	17.9	17.73	17.65	17.56	17.86	18.16	17.24	17.46	18.11	17.89
X(bar)	17.610	17.978	17.842	17.756	17.717	17.767	17.496	17.538	17.781	17.633
Range	0.9	0.64	0.73	0.43	0.71	0.6	0.72	0.51	0.77	0.41

Teeth Span Size variation



Graph for X (bar) Chart



Graph for R-Chart

Results and Conclusion

S.No.	Parameter	Before	After
1	Cpk	0.4690	1.0011
2	Process Stability	No	Yes
3	DPMO	41250	9375
4	Sigma Level	3.3	4
5	Area Under Curve	0.68	0.6876
6	Cost Saving	....	2.8 Lac.

Use of Lean tool Kaizen, avoided the problem of wastage of broaching oil during reloading the component in trolley after broaching. Kaizen drive Bharat Gears employees to look out for new opportunities to improve their work, workplace resulting in productivity improvement.

The results of the case study indicate that the sigma level substantially improved from 3.3 to 4. From Six Sigma it has been found that the results are consistent- better customer satisfaction .In other words, create more value for customers at much lower cost to eliminate the problem of rejection and rework due to teeth span size variation of Transmission Gears after shaving.

Future Scope

For Future prospective utilize same kaizen process in other problems such as coolant delivery after marching, improved coolant flow, eliminating tooth rounding vibration problem etc. With the help of 5S arrange cutting tool divisions so that tools can be easily identified and prevented from damages. In this dissertation, Six- Sigma is applied for quality improvement of the product. There are many other potential areas where Six- Sigma can be effectively applied such as problem of rejection and rework due to bore size variation in finish grinding operation, problem in face out ness, problem of rejection & rework due to size variation and outer diameter out ness in hard turning operation on turning centre.

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