STUDY OF LEAN MANUFACTURING PHILOSOPHY IN GEAR MANUFACTURING COMPANY

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ABSTRACT

U.S. manufacturers have always searched for efficiency strategies that help reduce costs, improve output, establish competitive position, and increase market share. Early process oriented mass production manufacturing methods common before World War II shifted afterwards to the results-oriented, output-focused, production systems that control most of today's manufacturing businesses- 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. 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. From an operations perspective, Lean is helpful in cutting production cuts costs & inventories rapidly to free cash, which is critical in a slow economy. It also supports growth by improving productivity and quality, reducing lead times and freeing huge amounts of resources. 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.

Keywords: *Reduces the cycle time, Socially answerable techniques, Focuses on waste reduction, avoidance, removal of waste, reduced cycle length.*

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INTRODUCTION

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 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. . But lean manufacturing questions the role of inventory and defines as a waste it self and also as the reflector of the imperfections a system has. This example, itself shows the conceptual deference between the traditional manufacturing system and lean manufacturing system.

2. METHODS TO IMPLEMENT LEAN

While most of these lean methods are interrelated and can occur concurrently, their implementation is often sequenced in the order they are presented below. Most organizations begin by implementing lean techniques in a particular production area or at a "pilot" facility, and then expand use of the methods over time. Companies typically tailor these methods to address their own unique needs and circumstances, although the methods generally remain similar. In doing so, they may develop their own terminology around the various methods. There are numerous methods and tools that organizations use to implement lean production systems. Eight core lean methods are described below:

1) Kaizen
2) 5S
3) Just-in-time Production
4) Total Productive Maintenance (TPM)
5) Cellular Manufacturing / One-piece Flow Production Systems
6) Kanban
7) Six Sigma
8) Pre-Production Planning (3P)

2.1.2 Method Description

2.2.1 Kaizen

Kaizen, a Japanese term that basically translates to 'continuous improvement' or 'change to become good', is a management concept originated by the Japanese in order to continuously effect incremental changes for the better, involving everybody within the organization from workers to managers. Kaizen is aimed at producing more and more value with less and less wastes (higher efficiency), attaining better working environment, and developing stable processes by standardization.

2.2.2 5S

5S is a Japanese methodology for workplace organization. As the name implies, it is a five-step technique for changing the mindsets of the staff and involving the entire organization in improvements. To some, this methodology may appear to be a housekeeping approach, but it actually delivers much more. The 5S concept was popularized by Taiichi Ohno, who designed the Toyota Production System, and Shigeo Shingo, the Japanese practitioner who put forward the concept of poka-yoke. When Japanese organizations embark on a quality journey, typically they commence with 5S deployment and then move on to higher methodologies. In the manufacturing World, 5S is used as a housekeeping tool while deploying Total 5S is an approach to quality improvement that can take an organization to new heights when implemented effectively. Simple and immensely practical, this methodology can transform the fabric of a company.

2.2.3 Just In Time Production

Just in Time (JIT) is the backbone of the lean manufacturing system. Initially Toyota production system is known as the JIT system due to this reason. All the basic concepts which lately became lean manufacturing developed in Toyota for this system. For an example, concept of producing things when they need, pull scheduling and kanban are few things developed here. [16]

Initially JIT aimed at manufacturing process improvement. Therefore even today people call JIT as JIT manufacturing. But actually JIT consist of three main parts. They are known as JIT purchasing, JIT manufacturing and JIT distribution.

2.2.4 Total Productive Maintenance (TPM)

Total Productive Maintenance (TPM) is an initiative for optimizing the effectiveness of manufacturing equipment. TPM is team-based productive maintenance and involves every level and function in the organization, from top executives to the shop floor. The goal of

TPM is "profitable PM." This requires you to not only prevent breakdowns and defects, but to do so in ways that are efficient and economical. To achieve this goal we will need to master five techniques-

1. **Preventive maintenance** - It is a daily maintenance (cleaning, inspection, oiling and re-tightening), design to retain the healthy condition of equipment and prevent failure through the prevention of deterioration, periodic inspection or equipment condition diagnosis, to measure deterioration. It is further divided into periodic maintenance and predictive maintenance. Just like human life is extended by preventive medicine, the equipment service life can be prolonged by doing preventive maintenance.
2. **Periodic maintenance** (Time based maintenance - TBM) - Time based maintenance consists of periodically inspecting, servicing and cleaning equipment and replacing parts to prevent sudden failure and process problems.
3. **Predictive maintenance**-This is a method in which the service life of important part is predicted based on inspection or diagnosis, in order to use the parts to the limit of their service life. Compared to periodic maintenance, predictive maintenance is condition based maintenance. It manages trend values, by measuring and analyzing data about deterioration and employs a surveillance system, designed to monitor conditions through an on-line system.
4. **Corrective maintenance** -It improves equipment and its components so that preventive maintenance can be carried out reliably. Equipment with design weakness must be redesigned to improve reliability or improving maintainability
5. **Maintenance prevention** - It indicates the design of new equipment. Weakness of current machines are sufficiently studied (on site information leading to failure prevention, easier maintenance and prevents of defects, safety and ease of manufacturing) and are incorporated before commissioning a new equipment. Breakdown maintenance repairing after breakdowns occurs.

2.2.5 Cellular Manufacturing / One-piece Flow Production Systems

Cellular manufacturing is a technique, which eliminates waste by matching the appropriate production equipment and sequencing in order to produce a selected product family. It is a technique that is often imitated, but seldom implemented correctly. To avoid the pitfalls of poor implementation one must first understand the philosophy behind the practice. Designing a manufacturing cell is more complicated than simply arranging equipment into a U-shape. The selection and sequencing of the equipment must be arranged so that the cell layout encourages the lean principles of communication, single-piece-flow, flexibility, waste reduction, and elimination of unnecessary transport. Although the U-shape is often advocated the shape of the cell is not as important as the principles behind the layout.

2.2.6 KANBAN PUSH/PULL SYSTEM

The concept of pull in lean production means to respond to the pull, or demand, of the customer. Lean manufacturers design their operations to respond to the ever-changing requirements of customers. Those able to produce to the pull of customers do not need to manufacture goods that traditional batch-and-queue manufacturers must rely on. The planning for delivery of product to customers is less troublesome, and demand becomes more stable if customers have confidence in knowing that they can get what they want when they want it.

Kanban is a Japanese word that means "instruction card". Kanbans are manual pull devices that allow an efficient means to transfer parts from one department to another and automatically reorder products using minimum/maximum inventory levels. A Kanban is a signal, such as an empty container returned to the start of the assembly line that signals the need for replenishment of materials to a user.

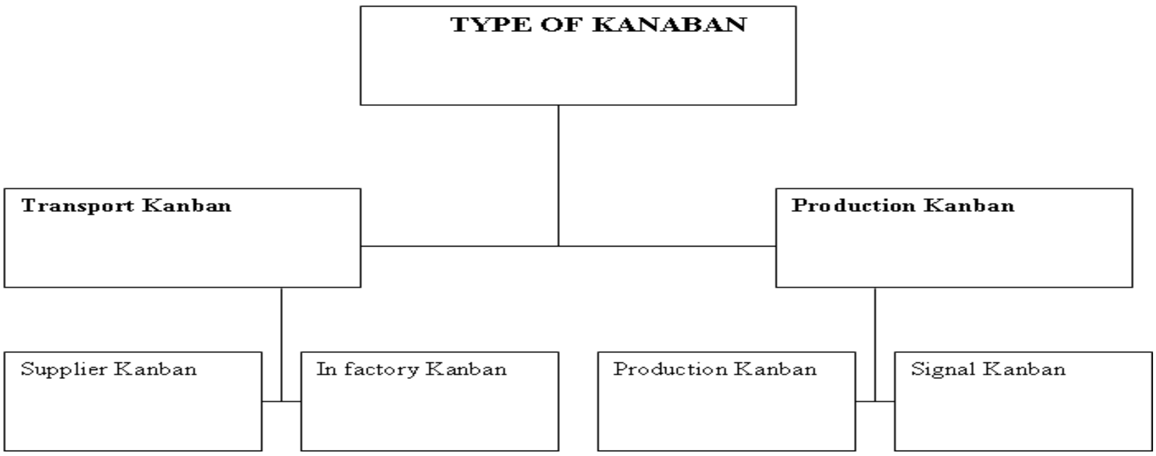

Figure 2.2.6 Type of Kanban

2.2.7 Six-Sigma

Six-Sigma is a rigorous, disciplined, data-driven methodology that was developed to enhance product quality and company profitability by improving manufacturing and business processes. Six-Sigma uses statistical analysis to quantitatively measure how a process is performing. That process can involve manufacturing, business practices, products, or service.

To be defined as Six Sigma means that the process does not produce more than 3.4 defects per million opportunities (DPMO) – which translates to 99.9997% efficiency.

2.2.7.1 Six-Sigma Implementation

To achieve Six Sigma performance, the causes of manufacturing and business process defects and variation must be identified and eliminated. Two Six Sigma sub-methodologies were developed for this purpose:

1. DMAIC (Define, Measure, Analyze, Improve, Control) and
2. DMADV (Define, Measure, Analyze, Design, Verify).

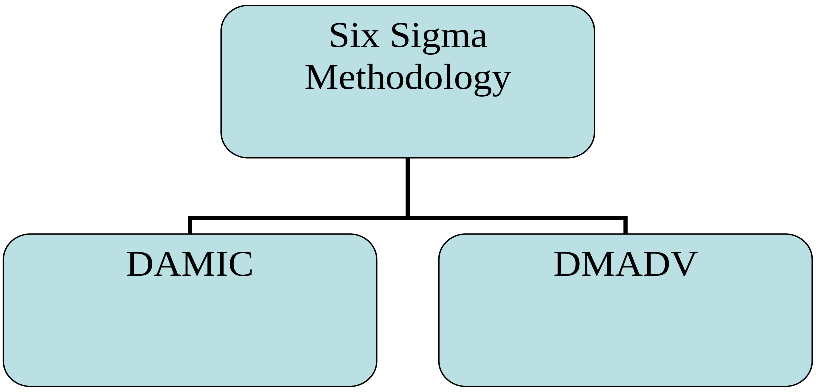

Figure 2.2.7.2 Six Sigma Methodology

2.2.8 Pre-Production Planning

Pre-production is the process of planning the recording. It's our chance to make sure that no time and money is wasted, either by us or by the people paying for it all.

Pre-production takes the form of meeting to discuss the project. The following outline is a workable way to cover all the bases. If possible, hold the pre-production meetings in the studio. This gives the artist a chance to get used to the environment, helping them to be less nervous when recording starts.

Whereas other lean method s take a product and its core production process steps and techniques as given, the pre production planning (3P) Focuses on eliminating waste through ‘’Greenfield’’ product and process redesign.3p represents a key pivot point, as organizations move beyond a focus on efficiency to incorporate effectiveness in meeting customer needs. Lean experts typically view 3P as one of the most powerful and transformative advanced manufacturing tools, and it is typically only used by organizations that have experience implementing other lean methods. 3P seeks to meet customer requirements by starting with a clean product development slate to rapidly create and test potential product and process design that require the least time, material, and capital resource.

3 SIX SIGMA

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3.1 Six Sigma Calculations

The term "Six Sigma" comes from process capability studies, which measure the extent to which a process meets customer requirements, specifications, or product tolerances. Sigma represents the standard deviation (variation) from the process mean of a statistical population. There are two common measures of process capability: Cp and Cpk. These measures compare the variation within the output of a process with the specification limits for the product being produced or in other words they simply measure a process's capability to produce what was designed. Cp is a ratio, which equals six standard deviations of the measured output divided by the tolerance range. [30]

The process capability index is computed using the following formula,

Where C_p = process capability,

USL = upper specification limit,

LSL = lower specification limit, and

σ = sigma:

$$C_p = \frac{USL-LSL}{6\sigma}$$

Where σ = (R bar/d2)

As the equation indicates, higher C_p values are found in more capable processes. As the process standard deviation goes up, or the mean of the process moves away from the center of the tolerance, fewer standard deviations will fit between the mean and the nearest specification limit, thereby decreasing the sigma number and increasing the likelihood of items outside specification. Numerous process sigma calculators are available on the Internet that provides quick calculation of how a particular process is performing with regard to the Six Sigma goal. The calculation of a sigma level is based on the number of defects per million opportunities (DPMO). [24]

The formula to calculate DPMO is:

$$\textbf{DPMO} = \frac{\textbf{(Number of defect} \times \textbf{1,000,000)}}{\textbf{((Number of opportunities/unit)} \times \textbf{Number of units)}}$$

3.2 USING SIX SIGMA IN GEAR COMPANY

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

Process Flow Chart-

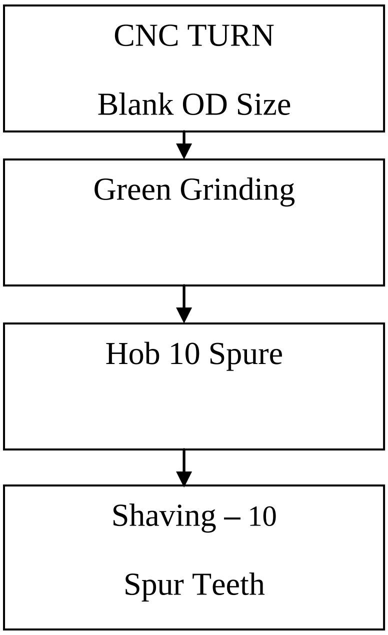


Figure 4.3.1 Flow Process Chart

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)**

Before Improve phase Re-check the all statistical process controls. Sample of 9 pieces was taken each day for 6 days. **The value of six sigma- 3.3** (by company)

Phase -3:

After Improve phase Re-check the all statistical process controls. Sample of 9 pieces was taken each day for 6 days. The Variation is as given below. All data in mm.

Control Charts for Variables: Teeth Span Size Variation

S.NO.	DAY1	DAY2	DAY3	DAY4	DAY5	DAY6
1	17.7	17.87	17.58	17.66	17.83	17.33
2	17.69	17.56	17.56	17.56	17.79	17.58
3	17.68	17.79	17.87	17.91	17.19	17.86
4	17.67	17.78	17.45	17.83	17.89	17.74
5	17.69	17.93	17.93	17.92	17.76	17.34
6	17.65	17.82	17.53	17.59	17.67	17.54
7	17.09	17.81	17.78	17.71	17.95	17.61
8	17.69	17.82	17.83	17.89	17.95	18.31
9	17.7	17.44	17.65	17.57	17.81	17.54
X(bar)	17.61778	17.75778	17.68667	17.73778	17.76	17.65
R(bar)	0.61	0.49	0.48	0.36	0.76	0.98

Table - Teeth Span Size Variation

Note: In Microsoft word I use special notation are **X (bar), X (Double bar),** Sigma etc. So please consider that.

X (bar) And R Chart:

Now, X (double bar) =∑X (bar) / N ……..Where N= 6

X (double bar) = (17.61+17.75+17.68+17.73+17.76+17.65)/6

=17.7018

Range=R (bar) = ∑ R/N

=0.61+0.49+0.48+0.36+0.76+0.98/6

=0.6133

For X (bar) chart:

UCL for X (bar) = X (double bar) +A_2R (bar)

=17.70+ (0.34×0.61)

=17.91mm

LCL for X (bar) = X (double bar) - A_2R (bar)

= 17.70- (0.34×0.61)

= 17.49 mm (A2=0.34 for subgroup of 9 from table appendix-1)

For R chart

UCL For R = D_4R(bar)

= 1.82×0.61 (D4= 1.82 for subgroup of n = 9 from table Appendix-1)

= 1.11

LCL For R= D_3R(bar)

= 0.18×0.61 (D3= 0.18for of n = 9 from table Appendix-1)

=0.109

X (bar) Chart

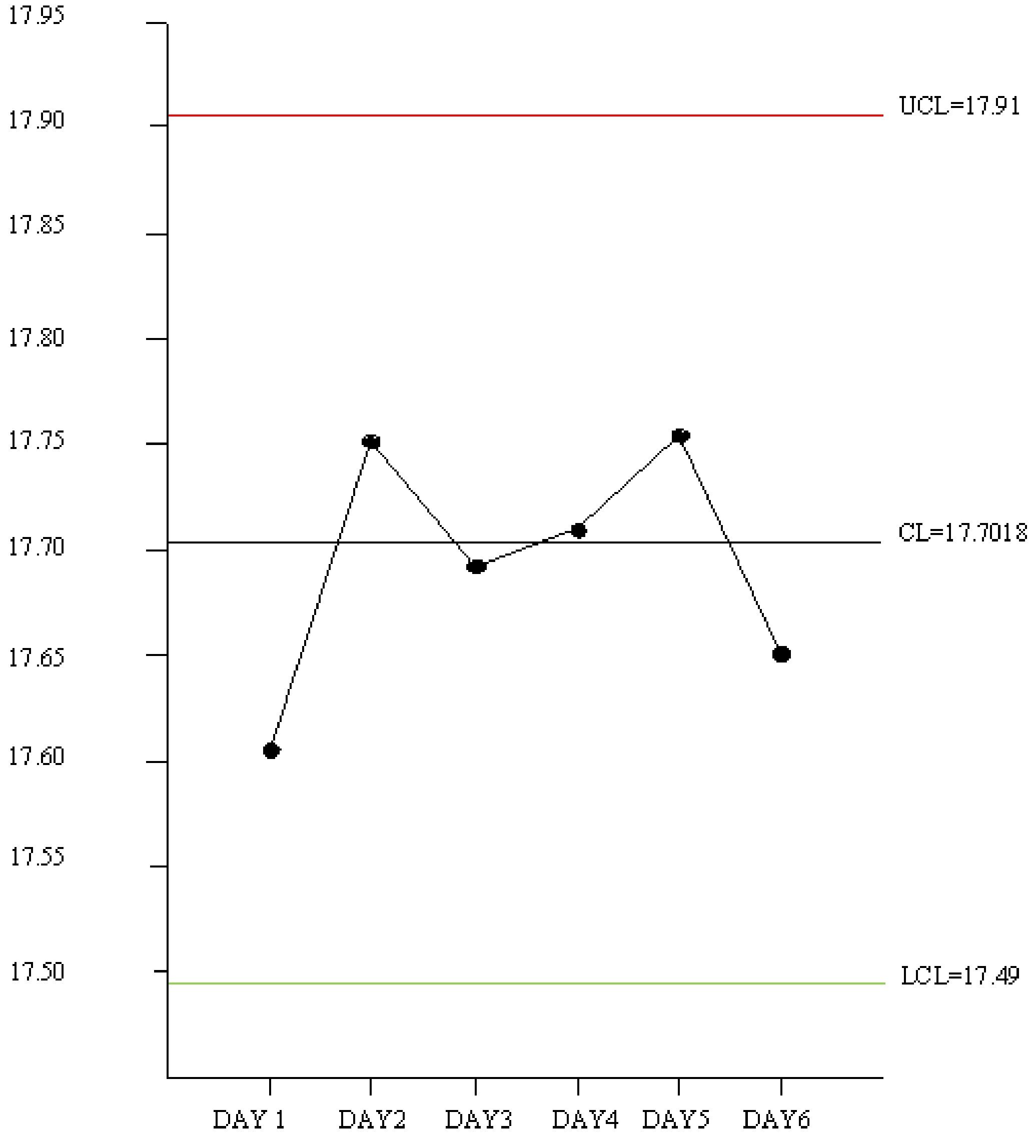


Figure 4.3.6 Graph for X (bar) Chart

R Chart

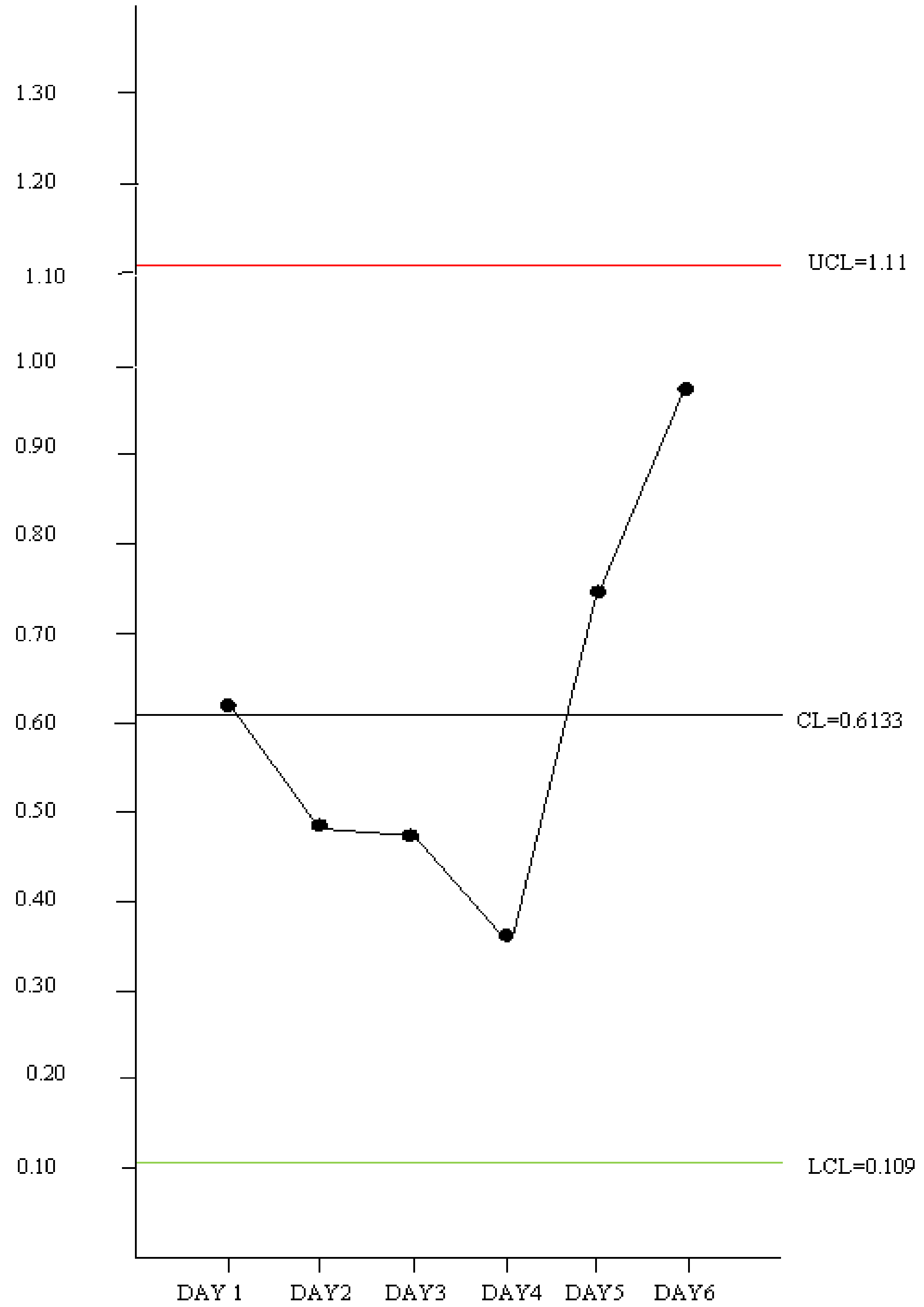


Figure 4.3.7 Graph for R-Chart

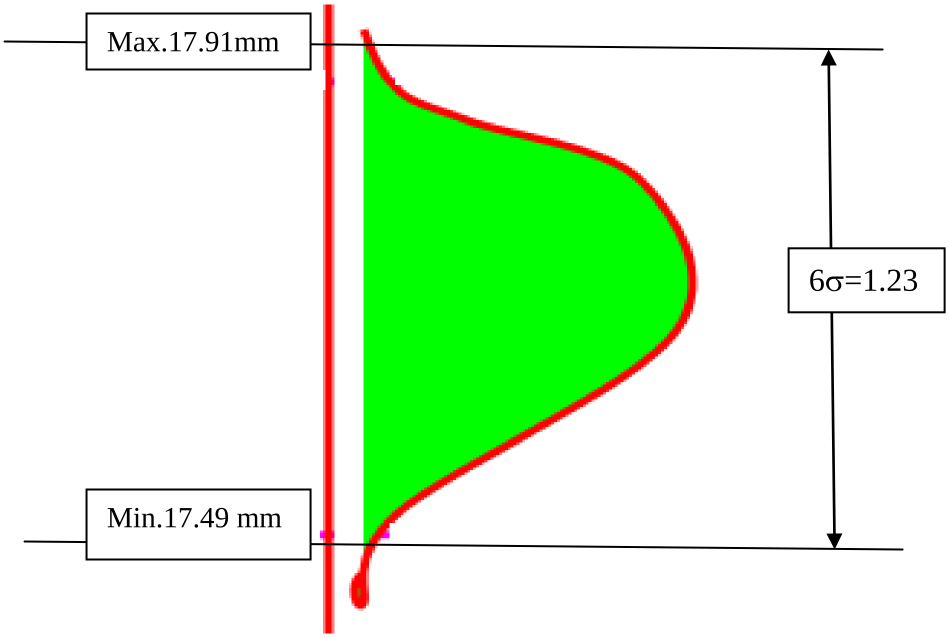
σ=R (bar)/d_2

=0.61/2.97

=0.20538

6σ=6×0.20538

=1.23



Area under Curve:

X (double bar) =17.70mm

X max. =17.91 mm

Xmin. =17.49mm

Z_1=Xmin. - × (double bar)/ σ

= 17.49-77.70/0.205

=-1.02

A_1=0.15386 (A_1= 0.15386 for Z_1 =-1.02 from Reference 21)

Z_2=X max- X (double bar)/ σ

=17.91-17.70/0.205

=1.05

A_2=0.853149 (A_2=0.853149 for Z_2 =1.05 from Reference 21)

Area under Curve=A_2-A_1

=0.853149-0.15386

=0.6992

Process Capability Cp=USL-LSL/6σ

=18.32-17.09/ (6×0.2053) =1

Process Capability index Cpk=Min, {X (double bar)-LSL/3σ }, {USL-X (double bar)/3σ}

= Min.{17.70-17.09/3×0.2053}, {18.89-17.77/3×0.2053}

= Min.{0.61/0.61}, {0.62/1.061}

=Min. {1.00}, {1.016}

=1 **{ The process is capable (Cpk>, = 1)}**

Calculating a Sigma Level

Defect=15

Opportunity per unit=4

Defect per unit (DPU) =400/15

=0.275

Defect per unit opportunity (DPO) =15/400×4

=0.009375

Defect per million opportunity (DPMO) =DPOX1000000

=0.009375×1000000

= 937

Sigma Value =4 (Sigma= 4 form Appendix-2)

4 RESULTS:

S.No.	Parameter	Before	After
1	Cpk	0.612	1.00
2	Process Stability	No	Yes
3	DPMO	41250	9375
4	Sigma Level	3.3	4
5	Area Under Curve	0.68	0.6992
6	Cost Saving	……….	2.8 Lac.

5 CONCLUSIONS

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 Transmutation Gears after shaving.

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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