IMPLEMENTATION OF SIX SIGMA METHODOLOGY IN SPRINGS MANUFACTURING INDUSTRY TO REDUCE PRODUCTION AND QUALITY COSTS

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Abstract : In my project work mainly concentrate on how six sigma methodology will be implement in spring manufacturing industry. To implement the six sigma mainly concentrate as the changing of layouts and tools, improving the process, improving the work environment, motivating and giving the continuous training to the people. Finally critical successful factors for six sigma project implemented in spring manufacturing industry will be discuss.

I. INTRODUCTION

Before we study the subject of Six Sigma in any depth, we need to define the term. Perhaps unusually, Six Sigma has 3 distinct elements to its definition:

- ***A Measure***: A statistical definition of how far a process deviates from perfection.
- ***A Target***: 3.4 defects per million opportunities.
- ***A Philosophy***: A long term business strategy focused on the reduction of cost through the reduction of variability in products and processes.

Accordingly, it is defined in a variety of ways by several authors, but for the purposes of these notes the definition from Pande et al (2000) focused on the more comprehensive philosophy of Six Sigma will be used:

"A comprehensive and flexible system for achieving, sustaining and maximising business success. Six Sigma is uniquely driven by close understanding of customer needs, disciplined use of facts, data, and statistical analysis, and diligent attention to managing, improving, and reinventing business processes."

Six Sigma can be defined in a number of ways:

• As a **measure** of quality within an organisational process

• As a highly disciplined **process** for accelerated improvement that helps organisation focus on providing near-perfect products and services

• As an **enabler** or vehicle for cultural change, influencing how organisations understand their customer and themselves

• A measure of quality within an organisational process. The term sigma (s) is taken from a letter in the Greek alphabet and is used in statistics as a measure of how far a given process deviates from perfection (variation).

FEATURES OF SIX SIGMA

- Six Sigma's aim is to eliminate waste and inefficiency, thereby increasing customer satisfaction by delivering what the customer is expecting.
- Six Sigma follows a structured methodology, and has defined roles for the participants.
- Six Sigma is a data driven methodology, and requires accurate data collection for the processes being analyzed.

- Six Sigma is about putting results on Financial Statements.
- Six Sigma is a business-driven, multi-dimensional structured approach for:
    1. Improving Processes
    2. Lowering Defects
    3. Reducing process variability
    4. Reducing costs
    5. Increasing customer satisfaction
    6. Increased profits

The word *Sigma* is a statistical term that measures how far a given process deviates from perfection. The central idea behind Six Sigma: If you can measure how many "defects" you have in a process, you can systematically figure out how to eliminate them and get as close to "zero defects" as possible and specifically it means a failure rate of 3.4 parts per million or 99.9997% perfect.

KEY ELEMENTS

There are three key elements of Six Sigma Process Improvement:

- Customers
- Processes
- Employees

II. WHY SIX SIGMA

There can be few initiatives which have been trumpeted as loudly as Six Sigma; few where the claims have been so extravagant; and few which divide the quality community so completely. While this section does not, indeed cannot, propose to investigate fully the evidence supporting the self-declared results of major corporations it does attempt to clarify the level of expectation placed upon Six Sigma programmes. The sub-sections below address the potential answers to the question; 'Why Six Sigma?', and draws on the work of Henderson and Evans (2000) who investigated the GE experience in some detail.

III. IMPLEMENTATION OF SIX SIGMA

The six sigma is practically applied in M.G.M Springs Pvt. Ltd, Anantapur for the improvement of quality and production rate by reducing the ideal time, wastage, by changing the plant layout and installing the modern machinery as for the requirements.

METHODOLOGY APPLIED

Among the following two methods in six sigma DMAIC method is used it is as follows

DMAIC METHODOLOGY

DMAIC refers to a data-driven improvement cycle used for improving, optimizing and stabilizing business processes and designs. The DMAIC improvement cycle is the core tool used to drive Six Sigma projects. However, DMAIC is not exclusive to Six Sigma and can be used as the framework for other improvement applications.

DMAIC is the problem-solving methodology behind Lean Six Sigma. It consists of five Phases: Define, Measure, Analyze, Improve and Control. It is pronounced "duh-may-ik".

This methodology consists of the following five steps.

Define --> **M**easure --> **A**nalyze --> **I**mprove --> **C**ontrol

Define: In MGM Metallic's, the springs are manufactured in two stages that is primary operation and secondary operation before implementation of SIX SIGMA. The primary operations are all completed by the machines and the secondary operations are all completed by manually. When do like that, products are not good in cross sections and dimensional accuracy. Due these reasons number of products are to be going to rejected by the quality engineers.

Measure: The main problem is that, the springs ends are not bending properly by the workers and require more time and more number of workers to complete the secondary operations on the springs. Result of which more springs are rejected do to diameter of the closing end is not proper and finishing is not.

Analyze: Based on the processes on the products and procedures to complete the products are all analyzed and problems are also identified. To solve the problems SIX SIGMA is implemented and based on it machineries and processing layout and some modifications are done to improve the productivity with good quality with less wastage of time and materials.

Improve: Based on the above problems the better solutions are optimised and opportunities to implement those things are analyzed. For the better improvement, plant layout ,process layout and advanced machineries have to be change and based on those things we will rectify the problems and will produce the better springs without any defects.

Control: Finally the problems are identified with better solutions, this nothing but implementation of SIX SIGMA. By the implementation of SIX SIGMA, the process layout, plant layouts are changed based on requirements. The advanced machines are established which will work automatically and will reduces the manpower and produce the springs without defects with in a less time.

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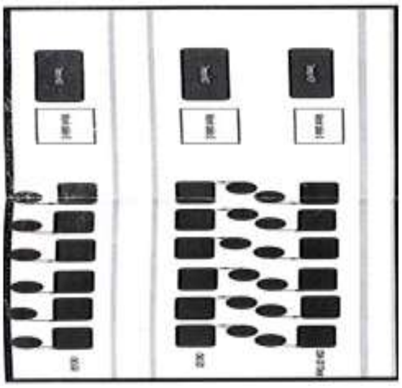
Before implementing six sigma the working process is completed by the machine but it is not completely finished product. To complete the product again 3 members are to work for final finishing the product. By six sigma, on semi finished product secondary operation is carried out by the machine itself by the modification of machinery also. These are all as follows.

Difference between two springs without secondary operation and with secondary operation

PLANT LAYOUT MODIFICATIONS

Before implementation of six sigma

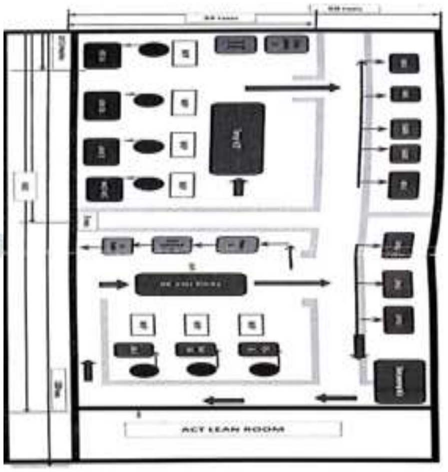
Before implementation of six sigma the plant layout is not to free for products to move in the plant. The products are to wait while in the processing time to get the process on the machines. The machines are set in a line wise not in the process wise, the products are move in a zigzag way to get their required operations on it. It will disturb the other products while in reaching the other machines for other operations.



Plant Layout Before SIX SIGMA

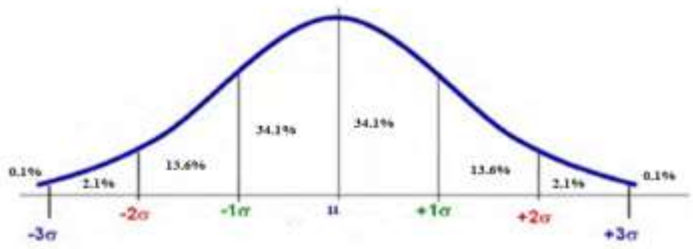
After implementation of six sigma

After implementation of six sigma, the flow of materials is very smooth. The machines are arranged in such a way that, the products will move simultaneously after each operation completion on the machine to the other machine based on the operation has to perform on it. The machines are flexible for product layout and which are arranged based on the process layout of the products. After implementation of SIX SIGMA new machinery is assembled for the better working process to complete within a time with preferred accuracy in dimensions. The set of all machineries are arranged for the betterment of smooth flow of working process in the plant. Arranged machineries are automated which will complete the work automatically without involvement of human being. It will reduces the labor cost, and the efficiency of the plant depends upon the plant layout, generated plant layout is such that, the efficiency of the plant is increased with in a less time.



Plant Layout After SIX SIGMA

STANDARD DEVIATION AND MEAN



Standard Deviation and Mean

- One standard deviation from the mean accounts for 68.26% of the set.
- Two standard deviation from the mean account for 95.46%.
- Three standard deviations from the mean account or 99.73%.

IV. FORMULA USED

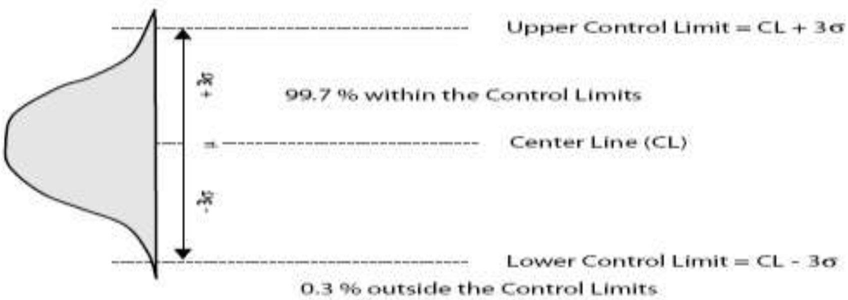
Control chart

Also called: statistical process control
The control chart is a graph used to study how a process changes over time. Data are plotted in time order. A control chart always has a central line for the average, an upper line for the upper control limit and a lower line for the lower control limit. These lines are determined from historical data. By comparing current data to these lines, you can draw conclusions about whether the process variation is consistent (in control) or is unpredictable (out of control, affected by special causes of variation).

Control charts for variable data are used in pairs. The top chart monitors the average, or the centering of the distribution of data from the process. The bottom chart monitors the range, or the width of the distribution. If your data were shots in target practice, the average is where the shots are clustering, and the range is how tightly they are clustered. Control charts for attribute data are used singly.

When to Use a Control Chart

- When controlling ongoing processes by finding and correcting problems as they occur.
- When predicting the expected range of outcomes from a process.
- When determining whether a process is stable (in statistical control).
- When analyzing patterns of process variation from special causes (non-routine events) or common causes (built into the process).
- When determining whether your quality improvement project should aim to prevent specific problems or to make fundamental changes to the process.



Control Chart

COMMON TYPES OF CHARTS

The types of charts are often classified according to the type of quality characteristic that they are supposed to monitor: there are quality control charts for *variables* and control charts for *attributes*. Specifically, the following charts are commonly constructed for controlling variables:

1. Variable Charts
2. Attribute Charts

- **X- Bar**

$$\bar{X} = \frac{\sum (X_1 \ldots X_n)}{n}$$ n is the number of observations, n=5

$$\bar{\bar{X}} = \frac{\sum (\bar{X}_1 \ldots \bar{X}_k)}{k}$$ k is the number of subgroups, k=25

- **Range**

$$Range = X_{max} - X_{min}$$

$$\bar{R} = \frac{\sum (R_1 \ldots R_k)}{k}$$

- Upper control limit:

$$UCL_x = \bar{\bar{X}} + A_2 * \bar{R}$$

- Lower control limit:

$$LCL_x = \bar{\bar{X}} - A_2 * \bar{R}$$

- Standard Deviation (σ) = $\bar{R} / d_2$ Where $d_2 = 2.326$ for n=5
- C_P = UCL-LCL / 6S

- **C_{PK} =** Min UCL - $\bar{\bar{X}}$ / 3S or $\bar{\bar{X}}$ - LCL / 3S

CAPABILITY INDICES

C_{PK} and P_{PK} are capability indices; they compare process variation to the specification.

C_{PK} (Process Capability) - Adjustment of c_p for effective of non-centred distribution.

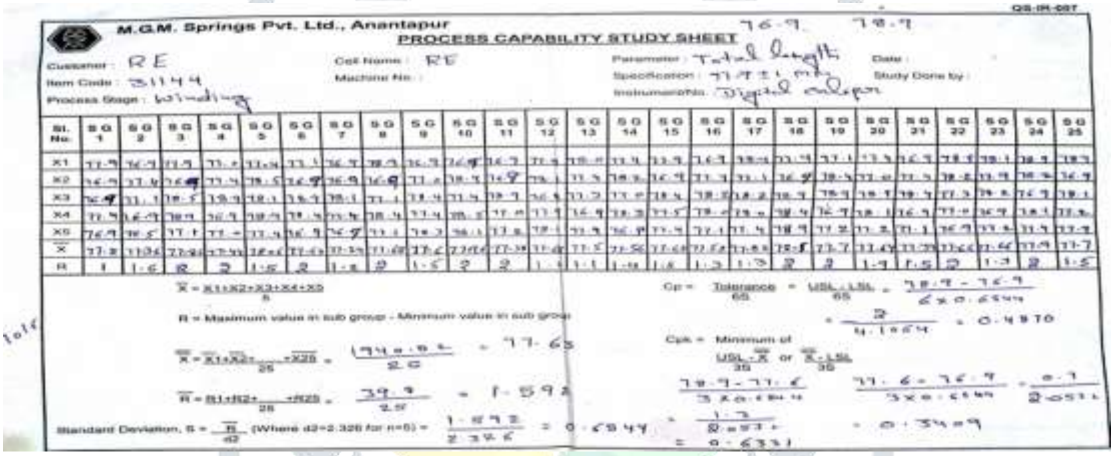
P_P (Process Performance) – The six sigma range off process total variation

P_{PK} (Process performance index) – Adjustment of P_P for effect of non- centred distribution

C_{PK} indicates what the process is capable of performing with respect to the specification 1.67.

P_{PK} indicates how the process has actually performed with respect to specification.

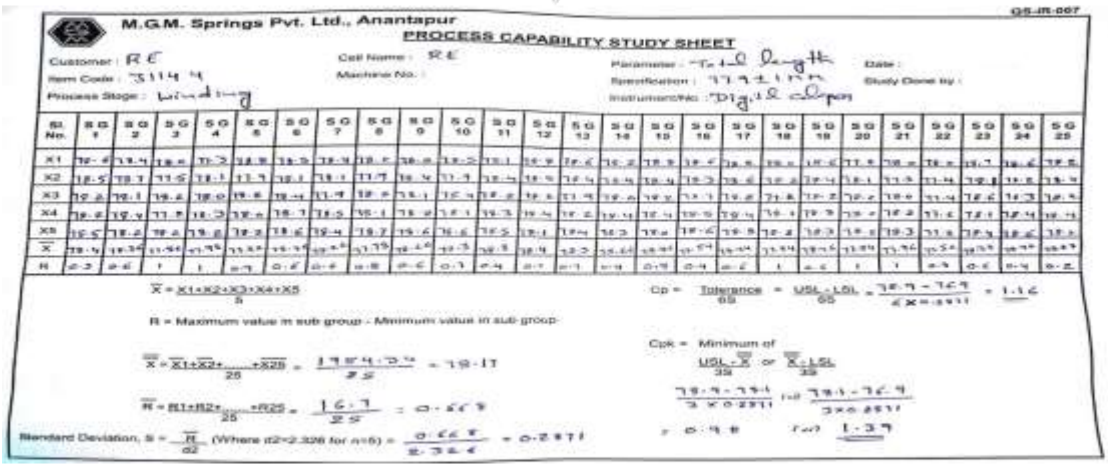
Before Capability Indices



Process Capability Sheet Before SIX SIGMA

Before SIX SIGMA, in MGM plant I can find out to change the tool, without going to secondary operation. In every machine I am collected 150 number of finished springs and then calculate the C_P and C_{PK} values. If the C_{PK} value is less than the 1.33 the process is capable. From the machine, I am collect more number of springs and calculate the C_{PK} , its become less than after the secondary operation, means that process is not capable.

After Capability Indices



Process Capability Sheet After SIX SIGMA

In MGM plant, I can find out to change the manufacturing tool, without doing secondary operation. At every machine I can collect 125 number of springs and then calculate the C_P and C_{PK} values. If C_{PK} value is greater than 1.33 the process is capable. If the C_{PK} value is less than the 1.33 then the process is not capable.

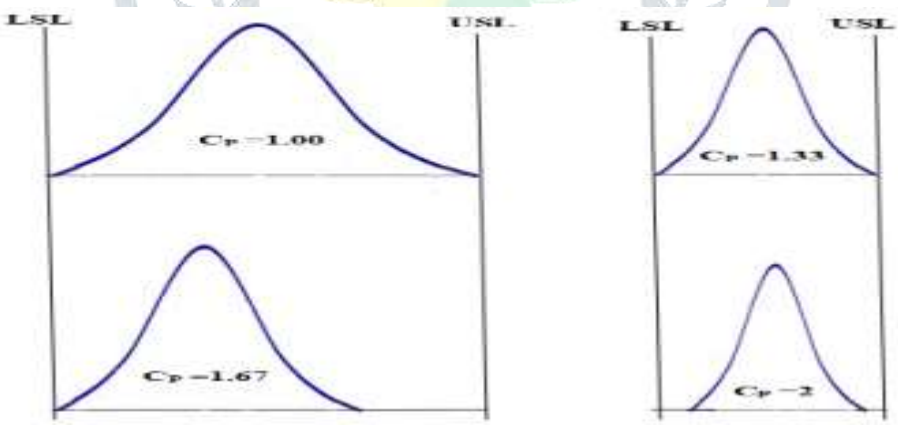
From the machines of the springs, I collected 125 numbers of springs and ten measure the values of the spring then calculate the C_{PK} values. After finishing the primary operations, the workers perform the secondary operations. At that time again I collect 125 springs and then calculate C_{PK} values. While doing the secondary operations the C_{PK} value is less which compare with the primary operations. At which, the secondary operations are by the workers more number of variations are occurred in the springs ross sections at the ends. By eliminating the secondary operations the C_{PK} value is grater than the 1.33, the labour cost is eliminated, time is less, more the customer satisfaction and less time to delivery.

PROCESS CAPABILITY (C_P)

The six sigma range of a process's inherent variation

process Capability

PROCESS CAPABILITY FOR VARYING PROCESS WIDTHS



Process Capability for Varying Process Widths

IMPORTENCE OF TOOLS USED

Tools Used Before SIX SIGMA

Before SIX SIGMA the products are not produces at a time in a single process in a single machine itself. For this the semi finished products has to be worked out by the extra labour in the semi finished machines, by this machines the products are completed manually. But it is time taking process and it will consume more time and more workers a has to work for to complete the single product it will leads more the product cost. Due to all the above reasons the productivity is low.

Tools Used Before SIX SIGMA

Tools Used After SIX SIGMA

After implementation of SIX SIGMA, the plant layout, process layout and also machineries also modified based on the requirement. The tools or machineries used are the automated machines which will produce the finished products or springs without any secondary operations. The updated machines will complete the operations on the product itself and it will give out finished products.

Tools Used After SIX SIGMA

This machine complete the all other operations not only on the single product at a time 8 products will be produced it will increase the productivity with a good dimensional accuracy and finish without damage and with in a less time.

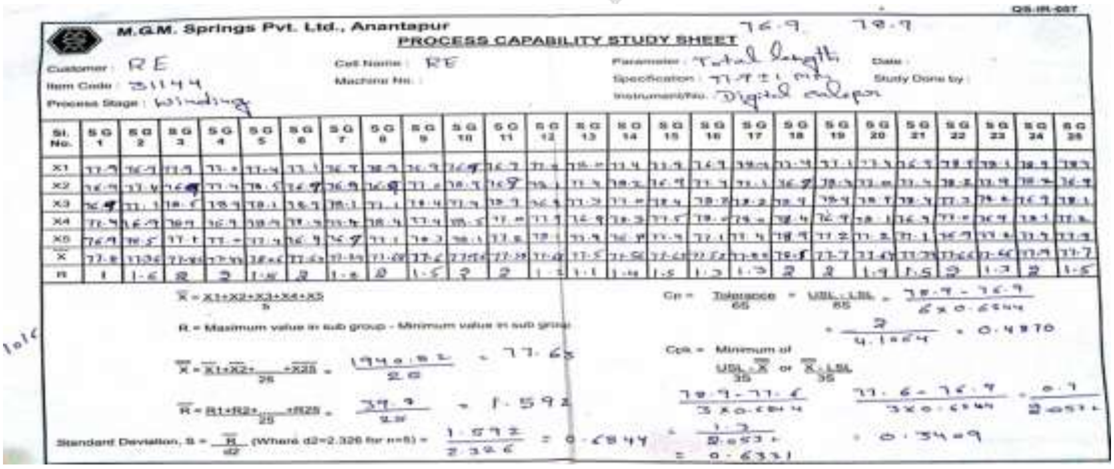
Secondary operations means, spring winding will be completed is same in both, but finally the spring end will be open in the old machineries it will be completed by the other tool by the other workers.

V. RESULTS

- **C_{PK} is 1.67 i.e 60% of tolerance= 1(Full tool) / 0.6(60% tool) =1.67**

Maintained between 9.4 - 10.60

PPM = 6 (6 Defectives out of 1000000 pieces produced)

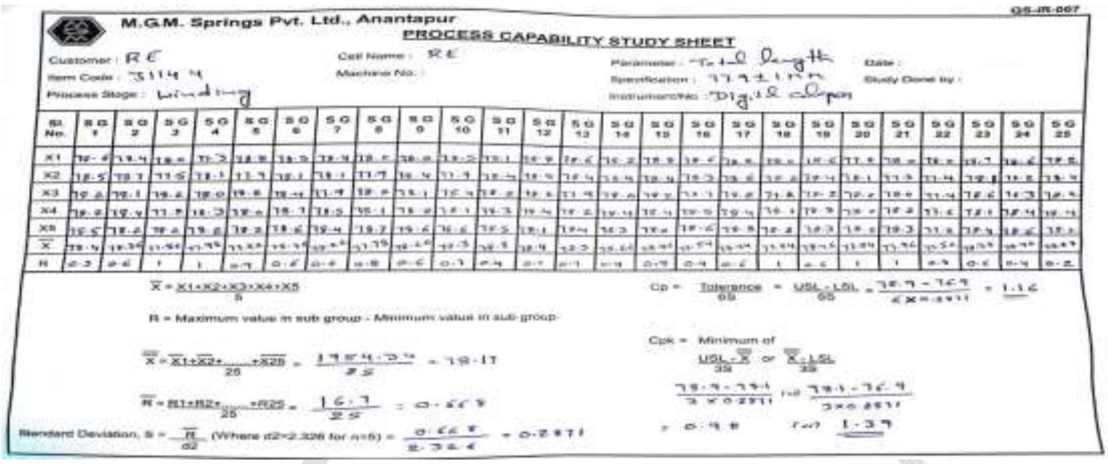


Process Capability Sheet with C_{PK} =0.6331

- **C_{PK} is 1.33 i.e 75% of tolerance = 1(Full tool) / 0.75 (75% tool) =1.33**

Maintained between 9.25 – 10.75

PPM = 63 (63 Defectives out of 1000000 pieces produced)



Process Capability Sheet with C_{PK} =01.39

- **C_{PK} is 1.00 i.e 100% of tolerance = 1(Full tool) / 1(Full tool) =1**

Maintained between 9.0 – 11.0

PPM = 2700 (2700 Defectives out of 1000000 pieces produced)

- **C_{PK} is less than 1.00 i.e beyond the of tolerance limit = 1(Full tool) / 1.2 (120% tool) = 0.80**

Maintained out of specifications

PPM = >2700 (>2700 defectives out of 1000000 pieces produced)

If the dimension is more or less by 0.2 mm C_{PK} will be less than 0.8 and 100% sorting is essential.

VI. CONCLUSION

In this, the conclusion of applying six sigma in M.G.M Metallic’s will be given. Continuing to improve the sigma level by reducing the range of workers and defects in springs will be part of the Future work and some reflections on the project also be described. 6.1 Conclusions First we can conclude that the applying six sigma in M.G.M Metallic’s had a positive effect and improved the test performance (in terms of finishing testing on time) and increased delivery quality. After investigating the current process and performance in the M.G.M Metallic’s, a DMAIC model was defined in order to reduce the Differ–Days leading to an improvement on time delivery. Based upon the analysis of the data from measurements of the process in 2017, the root cause (and sub causes) was found. This leads to a number of proposals for improvements. A number of effective improvement proposals were identified and then implemented. Additional processes were added, and a knowledge based setup and training program was executed. These proposals were evaluated based on their subsequent control during test activities in the first quarter of 2017. An analysis of these improvements showed that the project’s goal was fulfilled. Details of these further improvements are outside the scope of this thesis. \

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