THE IMPLEMENTATION OF SIX SIGMA PROCESS IMPROVEMENT IN A SMALL FLEXIBLE ENTERPRISE WITH LIMITED RESOURCES

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ABSTRACT

A small manufacturer in Cape Town with 60 employees successfully supplies low volume, specialized socks to its South African customers through fast delivery and high quality. Although the quality delivered to the customer is mostly very good, due to extensive visual inspection before the customer shipment, the processes within the company can be improved.

The Six Sigma process improvement methodology is often used in large corporations to improve complex processes, whereby trained experts titled as Six Sigma belts support the implementation. It is yet unknown if this system can be effectively implemented in a small, responsive enterprise with a low average level of education and extensive resource constraints.

The real-world implementation of the Six Sigma Methodology will show the strengths and weaknesses of the method within a SME and an environment as described. Depending on the process identified and the time needed for improvement, metrics will be measured to validate the effects of the Six Sigma implementation. In addition to this the feedback of Industry experts will be used to confirm the legitimacy of the results.
INTRODUCTION TO SIX SIGMA

The practical implementation according to [1] and [2] and the analysis of the results gained thereby, will form the focal point of the abstract.

In this chapter a short description of the Six Sigma Methodology will serve as the introduction.

1.1 Origin

Six Sigma was formed by Motorola in the early 1980’s with the intention of improving product reliability tenfold over a five year period. By 1988, the methodology had proved so successful that the company was awarded the Malcom Baldrige National Quality Award. Following this tribute, Motorola (Bob Galvin) decided to share Six Sigma with other companies in the world and it was rapidly adopted by other large manufacturers; most famously General Electric CEO Jack Welsh [3][4].

1.2 Definition

The content of Six Sigma varies within the different schools worldwide, as does the definition. A few examples in the literature are quoted in the following:

‘The Six Methodology is a structured tool with techniques of quality management. It is an effectiveness approach that uses mathematic techniques to understand, measure, and reduce process variation. The core function is process improvement by striving for perfection’ [5].

Originally the statistical definition included that a process could shift 1.5 sigma without detection. Therefore, a 1.5 sigma drift margin was built into the standard definition. If a Six Sigma process shifts 1.5 sigma units from the process mean to left or right, the process would be 99.97% defect free, having 3.4 defects per million opportunities (See Figure 1) [6].

![Figure 1 - Process shift of 1.5 Sigma units](image)

1.3 Goal

The goal of Six Sigma is to minimize the number of defects that will cost more to correct in the long term than it would to prevent them from the start. Defects are not only limited to measurable errors, but are defined as anything that stops the process from running at a high quality from the perspective of the customer. These factors are regarded to be critical to quality (CTQ). A large amount of CTQ defects will lead to lost customers and reduced profitability [7][8].

1.4 Metrics

Six Sigma primarily uses three metrics to measure the effectiveness of a given process. These are:
Defects per million opportunities (DPMO’s): Number of CTQ factors that are defective per million opportunities. When measuring, this value is extrapolated by sampling and it is not necessary that one million measurements be completed.

Error free yield (EFY): EFY is the percentage of a process that is free of defects.

Sigma Level (σ): σ is the Greek lowercase symbol for Sigma. The higher the sigma value, the lower the number of defects. This relation is described in Figure 2.

Provided one of these metrics is known, the others can be determined.

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**Figure 2 - Sigma Level & Error-Free Yield**

1.5 Six Sigma Process

*The steps of the DMAIC roadmap can be generally described as follows:*

‘Define a project’s purpose and scope, especially the output’s CTQ factors;

Measure by creating a performance baseline against which data evidencing errors can be compared, both leading to a more precise refining of the problem statement;

Analyse root causes quantified by actual data;

Improve performance by implementing procedures to eliminate the root causes of errors;

Control the process by evaluating performance both before and after attempting improvement; initiating a monitoring system to reduce future errors; and documenting results, recommendations and lessons learned’ [7]

Within these phases the tools as described by [2] as well as those described by [1], will be used where possible at Sockit Manufacturing and described in detail.
2 PRELIMINARY EXPLORING

Before the practical implementation of the Six Sigma approach could be started, a basic understanding of the processes at Sockit had to be acquired. This was critical as the Six Sigma Methodology would be implemented without prior work experience in quality management or the textile industry and ideally the ‘belt’ implementing the methodology should be an employee with experience in the given company.[9]

To partially acquire this experience and trust the of the employees two weeks were spent creating a software supporting the label creation in the factory and linear programming was used to understand where the profit is made at Sockit better. A value stream map and an organogram shown in Figure 3 were created too.

Figure 3 - Organogram
3 DEFINE

A better understanding of Sockit Manufacturing as a company had been acquired. The aforementioned also assisted in building a relationship with the employees and their trust. Therefore the implementation of the Six Sigma Methodology could now begin by starting with the first Phase of the DMAIC process: Define.

3.1 Project Charter

The Project Charter is the first tool of the Define phase according to [1][2].

It was finalised at Sockit Manufacturing as shown below (Table 1) after all the steps of the Define Phase were completed. Prior to this point no clear overview of the failure modes was known and the specific process problems to be solved were unclear.

At Sockit Manufacturing the project team consisted of all the key personnel per department. The CEO was selected as the champion and the author would fill the role of the belt.

![Table 1- Project Charter](image)

<table>
<thead>
<tr>
<th>Project Charter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Description</strong></td>
</tr>
<tr>
<td><strong>Project Nr.</strong></td>
</tr>
<tr>
<td><strong>Company</strong></td>
</tr>
<tr>
<td><strong>Department</strong></td>
</tr>
<tr>
<td><strong>Awarding Authority/ Champion</strong></td>
</tr>
<tr>
<td><strong>Process Owner</strong></td>
</tr>
<tr>
<td><strong>Start</strong></td>
</tr>
<tr>
<td><strong>End</strong></td>
</tr>
</tbody>
</table>

**Business Situation**

**Product / Process**

Knitting Process

**Problem Description**

The Uptime in the knitting department is too low.

**Situation the company is in.**

Sockit is less responsive and efficient due to too low uptime.

**Problem and Project Goal**

The Problem Definition at the Project Kick-Off

Accurate data is not available yet. It is visible that the Knitting machines are often standing still for half a day due to unplanned maintenance. They are also standing for shorter intervals.

**Project Goal**

Decrease the downtime which still has to be measured in order to be more specific.

**Problem Definition at the Project Kick-Off**

Accurate data is not available yet. It is visible that the Knitting machines are often standing still for half a day due to unplanned maintenance. They are also standing for shorter intervals.

**Project Benefits**

**Direct Cost Saving**

Missed deliveries, high inventory, direct maintenance cost (parts, labour etc.), additional equipment cost, training, administration

**Indirect Cost Saving**

Yarn storage cost, logistics, administration

**Direct Additional Revenue**

Increased sales

**Indirect Additional Revenue**

- Faster delivery

**Advantages that do not influence the Revenue**

Problem definition for future process improvements documented in the Define Phase.

**Advantage for the External Customer**

Faster delivery

**Project Focus and Framework**

**Project Focus**

Knitting Process

**Internal Metrics**

Load, Unload, Rework, Inspection, planned process maintenance, unplanned process failure

**Excluded from Project**

Downtime on the toe closing and forming machines is not relevant for this project.

**Roles and Milestones**

**Project Manager**

Markus Papsch 100%

**Team Members**

Mark 10%

Abe 10%

Shiftleaders 10%

**Support Required**

Which resources are needed? E.g. Hardware, Software, Material, Equipment, Support of Experts

Knitting machine data read outs, Konrad von Leipzig and Eugen Dohm

**Milestones**

Completion Date Define 28.09.12

Completion Date Measure 17.10.12

Completion Date Analyse 24.10.12

Completion Date Improve 31.10.12

Completion Date Control Open

**Comments**
3.2 Stakeholder Analysis Matrix

The Stakeholder Analysis Matrix (Table 2)[2] indicates the importance and attitude of the stakeholders towards the Six Sigma Project. Herein the current attitude of the stakeholders and the required attitude for the project to be successful are indicated. The usual discrepancy at this point leads to the Strategy to Influence the Stakeholders (Table 3)[2].

Table 2 - Stakeholder Analysis Matrix

<table>
<thead>
<tr>
<th>Nr.</th>
<th>Stakeholder</th>
<th>Classification</th>
<th>Importance</th>
<th>Attitude towards the project</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Internal / external</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>CEO Eugen</td>
<td>Internal</td>
<td>6</td>
<td>opposing strongly</td>
<td>G/X</td>
</tr>
<tr>
<td>2</td>
<td>Knitting Department Lead Mark</td>
<td>Internal</td>
<td>5</td>
<td>opposing slightly</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Maintenance Abe</td>
<td>Internal</td>
<td>4</td>
<td>opposing strongly</td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>Shiftleader Raphael</td>
<td>Internal</td>
<td>3</td>
<td>opposing strongly</td>
<td>X</td>
</tr>
<tr>
<td>5</td>
<td>Shiftleader</td>
<td>Internal</td>
<td>2</td>
<td>opposing slightly</td>
<td>X</td>
</tr>
<tr>
<td>6</td>
<td>Shiftleader</td>
<td>Internal</td>
<td>2</td>
<td>opposing slightly</td>
<td>X</td>
</tr>
<tr>
<td>7</td>
<td>Shiftleader</td>
<td>Internal</td>
<td>2</td>
<td>opposing slightly</td>
<td>X</td>
</tr>
<tr>
<td>8</td>
<td>Raw Material purchasing line</td>
<td>Internal</td>
<td>1</td>
<td>opposing strongly</td>
<td>X</td>
</tr>
<tr>
<td>9</td>
<td>Maintenance Replacement Matrix</td>
<td>Internal</td>
<td>1</td>
<td>opposing strongly</td>
<td>X</td>
</tr>
</tbody>
</table>

In the strategy to influence the stakeholders, the effects of the Six Sigma Methodology that will influence the stakeholders positively are mentioned (Table 3). These simple points proved to be very effective as soon as they were consciously used to influence the stakeholders. The support gained from the stakeholders became stronger, and in addition to this influenced them to motivate their colleges to support the project too.

Table 3 - Strategy to Influence Stakeholders

<table>
<thead>
<tr>
<th>Nr.</th>
<th>Stakeholder</th>
<th>Classification</th>
<th>Importance</th>
<th>Expectation / Worries</th>
<th>Leverage</th>
<th>Strategy to Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Knitting Department Lead Mark</td>
<td>Internal</td>
<td>4</td>
<td>iron-work less frustration</td>
<td>Markus</td>
<td>less control over department by measuring</td>
</tr>
<tr>
<td>2</td>
<td>Maintenance Abe</td>
<td>Internal</td>
<td>4</td>
<td>iron-work competence is measured</td>
<td>Markus</td>
<td>improve maintenance twice weekly in future if lack thereof is proven</td>
</tr>
<tr>
<td>3</td>
<td>Shiftleader Raphael</td>
<td>Internal</td>
<td>4</td>
<td>iron-work competence is measured</td>
<td>Markus</td>
<td>improve working conditions by monitoring and analyzing</td>
</tr>
<tr>
<td>4</td>
<td>Shiftleader</td>
<td>Internal</td>
<td>4</td>
<td>iron-work competence is measured</td>
<td>Markus</td>
<td>improve working conditions by monitoring and analyzing</td>
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<tr>
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</tr>
</tbody>
</table>

3.3 SIPOC Map

The SIPOC-Map (Supplier, Input, Process, Output, Customers) (Table 4) is an identification-and communication tool. The identification of the departments involved in the processes, and the definition of the supplier-customer relationships over the process-inputs and -outputs is achieved.

The SIPOC would serve as a communication tool in the Define Step [1] and ensure a uniform understanding of the process.
3.4 Brainstorming

Although the use of brainstorming to determine problems within the process is not discussed in the book by ‘[2]’ it is implemented at Sockit as defined by [1]’. This can be explained, as the practical example of [2] was implemented at an established company, with a higher average skill level and where current problem areas were clearer.

At Sockit Manufacturing there were concerns with regards to implementing the Murphy’s analysis, as the staff members might be afraid to speak about issues in their department in front of their colleagues. Quite a few feared losing their jobs if they mentioned any problems. For this reason the employees were interviewed on an individual basis, so their comments could be questioned directly. Hereby it would be more difficult for the person to withhold his opinion and the discussion could also be guided towards the problem source more. Additionally, worries about the consequences of the problem analysis could be discussed individually. By only interviewing one staff member at a time it also had minimal impact on operations and was in line with the target to be minimum resource intensive.

After interviews with the most experienced staff members were completed a first attempt was made to sort the answers into the problem categories [1]. At this stage it was still very difficult to prioritise and correctly allocate the problems to root causes. The issues were numerous and seemed chaotically spread over process steps in the different departments.

Therefore an attempt to use the Murphy’s Analysis was made nonetheless, as it serves to structure the root causes of the failure modes and should help to identify further failure modes.

3.5 Murphy’s Analysis

To summarise how a Murphy’s Analysis is usually completed, it is described with the following steps [1].

1) Show SIPOC map and define the goal of the process:
2) It is brainstormed how the process can fail and each failure mode is written on an individual sticky note.
3) For each failure mode identify why the failure mode occurs.

As there was not enough time to group all the failure modes according to their exact root cause during the one and a half hour brainstorming session with the staff members, the final grouping was completed with the CEO (Figure 4). He had a good overview of the processes as he was involved in solving the operational problems on a daily basis. Whilst going through every sticky note for approximately one hour, it became clear that he was aware of most of the problems. Nonetheless, the feedback from the employees by means of the whiteboard allowed him to see where the staff was confused and in some cases where the intentions of the staff were aligned with his own, but still not executed due to lack of communication. At the same time the voice of the customer, which is defined as that of the CEO in 3.6, could be integrated into the problem definition phase very early.

![Figure 4 - Failure Modes of CEO added and sorted according to affinity](image)

3.6 Voice of the Customer

The customer at Sockit Manufacturing was defined as the CEO and not the organisations to which Sockit delivers for the following reasons:

1) The internal problems were obvious enough. Contact to the external customer was not needed for first improvements
2) The risk of creating new expectations needed to be prevented, especially as the result of the Six Sigma project at Sockit Manufacturing was uncertain.
3) The Six Sigma Methodology was implemented successfully at Roeko Kaffeegenuss GmbH [2], without direct contact to the customers outside the company.

3.7 Knitting Department VOC-2-CTQ-Matrix

In the Voice of the Customer to Critical to Quality Analysis (VOC-2-CTQ) the CTQ’s show the properties of the process that influence how the customer sees the quality of the process. It was possible to define the problem categories [1]. These are defined as the key issues in accordance to [2].

The problems to be improved were narrowed down to those in the knitting department, as most of the errors occurring here influence all the downstream processes in the factory. From the twenty-five problem categories the following three (Figure 5) were selected as the Key Issues in the knitting department.

<table>
<thead>
<tr>
<th>What did the customer say?</th>
<th>Who is the customer? Is he internal or external?</th>
<th>How did you get this information?</th>
<th>Critical to...?</th>
<th>What is the key issue?</th>
<th>What is the requirement in a measurable form?</th>
<th>In which SI-unit is the requirement measured?</th>
<th>What is the target value?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Errors in knitting, rejects on change over</td>
<td>CEO</td>
<td>CEO</td>
<td>Quality</td>
<td>Process defects too high</td>
<td>Rolled Throughput Yield (RTY) or First Time Right</td>
<td>Defects, Accuracy, Scrap, Rework Issues</td>
<td>%</td>
</tr>
<tr>
<td>The knitting machines are standing still too often</td>
<td>CEO</td>
<td>CEO</td>
<td>Business</td>
<td>Knitting machine uptime too low</td>
<td>Value Adding Uptime</td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Theft, half used bobbins, unused yarn types</td>
<td>CEO</td>
<td>CEO</td>
<td>Business</td>
<td>Process wastefliss is too high</td>
<td>Raw Material Losses</td>
<td>∑inputs(kg) - ∑Outputs(kg)</td>
<td>%</td>
</tr>
</tbody>
</table>

Figure 5 - VOC-2-CTQ Matrix

3.7.1 % Uptime of Process is too low in the Knitting Department

From the three Key Issues that were found, the problem category “% Uptime too low” was selected as the core issue for the Six Sigma Analysis at Sockit Manufacturing for the following reason:

It was unclear, why many of the machines were standing for longer periods in regular intervals. It was assumed that this was mainly due to too much unplanned maintenance, but this could not be proven.

This point will automatically be considered when looking at the downtime, as it will lead to the definition of one of the following problem categories with a high likelihood [1].

- Load, unload, setup- or change-over time is too long
- Re-work time or inspection time is too high
- Too much unplanned maintenance
- Planned maintenance takes too long
- Scheduled workforce breaks

4 MEASURE

The problem category was defined so the Measure phase could begin. The first step to solve this process problem is to complete a Measurement System Analysis. As no data was being taken at this time, a measurement system had to be set up. The best option would have been to purchase a software system from the knitting machine supplier which could automatically log the downtime on a central computer. As it was too expensive an alternative manual measuring system had to be found.
4.1 Manual Measurement of Downtime
For this purpose a downtime sheet was created.

4.1.1 Downtime Sheet
The shift leaders were asked to log the type of downtime with start- and end-time. The types of downtime were defined as follows: Loading Yarn, Unloading Yarn, Rework, Inspection of Machine, Planned Maintenance, Unplanned Maintenance, Break Downs, Scheduled Breaks, and Scheduled-Process-Downtime of any form, Change-over time and Setup time. It was important to communicate to the staff that whenever the machine stood still, it was defined as downtime.

4.2 MSA Downtime
As there was no variable data but just attribute data, a classical MSA showing the influence of the measuring device (repeatability), the variance caused by the operator (reproducibility) and the variation caused by the part adding up to the total variation, could not be shown.

4.2.1 Validation
To validate the attribute data logged by the shift leaders, a second method in parallel had to be implemented [1]. Therefore, a second sheet was created to monitor the Rate of Production on the machines. On this sheet, Time of Day, Nr of Socks and Cycle Time should be logged in regular intervals.

After a first test-run where the author measured the production speed to control the logged downtime, the following results were gained. For each drop in production, the cause was found in the downtime sheet and is noted below the graph as shown in Figure 6 for the machines 11-K.

![Figure 6 - Rate of Production Machine 11 - L](image)

09:00:  Machine 13 had a mechanical error that caused the pattern on the sock to be faulty. Unplanned maintenance was needed to repair the error.

14:00:  A new sock type is produced on machine L
4.2.2 Validation Result

After the first measurements were completed it became visible that the different kinds of downtime had to be measured over a minimum of one week to draw valid conclusions.

During this phase it was also noticed that the operators were able to change the sock-count on the machines manually. However this did not have an influence on the validation, as the theoretically possible sock count could be compared to the amount that should be produced with the cycle time that was logged from the machines. After logging and doing the calculation, a method had been found to monitor the production performance by hand.

After discussing the diagrams the department head agreed to this method measuring.

4.2.3 Measuring by the Fixers

After a few weeks, it became apparent that the method to monitor the downtime was not being completed accurately by the fixers. They were well aware that they were measuring their own performance and that it would require effort to write down all the data. Even after repeated explanation the data was still not logged accurately. At this point, it became clear that the manual logging of data might be possible over the short-term under very tight supervision, but was not a long term solution.

4.2.4 Automatic Measurement of Downtime

As mentioned previously, the machine supplier did offer software that would enable a central computer, connected to the machines to monitor the downtime. The cost of this system was too high and would only be considered for purchase when the benefit it would have for Sockit and its 43 machines could be proven.

Therefore, the measurement data could not be validated and the problem category “Uptime of process too low” could not be further analysed for the machines with the current measuring method.

4.2.5 Advantages resulting from the Measurement Method

Although the measured data was not accurate enough for the Six Sigma Improvement Methodology, it became clear that the continued logging of downtime and production volume improved the process.

Before this time, there had been very little measurement tools in place for this process, which made the supervising function of the shift leaders more difficult. Even if the data was not valid and accurate enough for the Six Sigma analysis, it did help to show the major errors that did occur on the machines. The fixers that had to log the sock-count were informed at 3h intervals, which machines were standing still. Therefore they could take counter measures earlier.

As the production workers were now being visibly monitored, the head of the knitting department noticed a definite increase in productivity too.

Unfortunately, as this could not be measured at this time, it could not be proven.

4.3 Measuring Downtime on new machines only

Although a measuring system was not in place to measure the downtime for all the machines, a few of the latest machines on the floor were able to automatically log the last 70 failures. The type and duration of the failure could be measured. The task of writing down every value that the machine logged over the last two to three days was a big effort and would not be viable over the long term. Nonetheless one set of the latest data was enough to make the next attempt to continue with the DMAIC process on the latest machines.
4.4 Measurement System Analysis Downtime on New Machines

4.4.1 Validity

A perfect Attribute Measurement System would classify every entity of downtime correctly. Unfortunately this is not the case for the failure statistic. For example if the machine is paused or switched off manually, this is not logged, as it is not a failure. Another problem with the failure statistic is that the same error message can mean several different things. For example Broken Yarn H Sensor N. x indicates that there is no yarn passing a specific sensor. This could be caused by low quality yarn tearing or the unavoidable situation of when the bobbin runs out of yarn.

The Ishikawa Diagram which will be discussed later would create further clarity on the number of causes for each error type logged by the knitting machine.

4.4.2 Reliability

The automatic logging system is reliable according to the machine specifications.

5 CONTINUING WITH THE AVAILABLE DATA

As the last 70 values spanned over different times on the different machines, only the data over 24 hours was used, because all machines covered this period. By repeated copying of the data from the machines into an Excel sheet, further data could have been acquired, but this was not done due to lack of time.

It was unfortunate that only the downtime on the newest machines was logged. These would most likely have the least technical problems and therefore create a distorted picture of the real situation.

Nonetheless, with the knowledge that more extensive data could be acquired in future, the Six Sigma process was continued. The current data was sufficient to draw conclusions for the newest machines and could serve as a training run for the repeated implementation of the Analyse, Improve and Control Phase on other data in future.

6 ANALYSE

6.1 Baseline Capability Study

The baseline for the downtime with the different causes logged by the knitting machine for a 24 hour period is:

<table>
<thead>
<tr>
<th>Failure Type</th>
<th>Effect (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broken yarn H sensor N.x</td>
<td>373</td>
</tr>
<tr>
<td>Stop elastic 2</td>
<td>133</td>
</tr>
<tr>
<td>End bobbin scaffolding</td>
<td>26</td>
</tr>
<tr>
<td>Stop heel and toe take up</td>
<td>25</td>
</tr>
<tr>
<td>Yarn not cut H sensor N.x</td>
<td>18</td>
</tr>
<tr>
<td>Phase displacement encoder sinker cap posit. Motor</td>
<td>12</td>
</tr>
<tr>
<td>Stop Dial jacks enter 1</td>
<td>9</td>
</tr>
<tr>
<td>Stop yarn creel</td>
<td>9</td>
</tr>
<tr>
<td>Other</td>
<td>37.4</td>
</tr>
</tbody>
</table>

Table 5 - Baseline Capability: Downtime within 24h

As mentioned previously the machine does not log the times when it is switched off, which will typically be done during setup or after a break-down. Therefore this output is not complete.
6.2 Process Variables Map
The Process Variables Map is a graphical representation of the process that should be analysed. It is important to find the inputs (x's) influencing the output metrics (y's) that are important for the customer.

6.3 Pareto Chart
The Pareto Chart can be applied at any point in the project and helps to focus the attention on key areas when there are large amounts of data. With its help, the main downtime causes of the Baseline Capability (Table 5) were graphically displayed for further analysis.

6.4 Ishikawa Diagram
To identify the influencing factors for these main failures the Ishikawa Diagram was used in two separate discussions with the head of the knitting department and the maintenance technician. A diagram was created for each of the first five most common failures detected by the automatic logging system of the new machines. For example Figure 7 - Broken Yarn Sensor.

![Figure 7 - Broken: Yarn H Sensor Nx](image)

7 TEAM SUPPORT
At this point the implementation of Six Sigma with the team had to be aborted, as the time period of two months which had been dedicated to the project at the factory, had been completed.

8 CONCLUSION
8.1 Six Sigma Effects
The methodology definitely helped to identify some of the core problems experienced at Sockit Manufacturing (3.7 Knitting Department VOC-2-CTQ-Matrix).

8.1.1 Implementation in Sequence
During the implementation it was noticed, that the Six Sigma tools were intuitively understood and also helped to identify issues and gather ideas from the employees in a
constructive manner. Even as an outsider to the company it was possible to gain a good overview rapidly, by implementing the steps of the methodology in the correct sequence. If these quality tools had been picked and chosen without the methodology, they would not have supported each other as effectively. Lastly there was no experience required to implement the tools at the right moment in the improvement process.

8.1.2 Dangers

Care had to be taken when documenting the opinions of the staff. In many interviews problems were brought up that would shift the blame to other departments. Many of them would also not mention the problems in their own department, as they were worried that their performance would be judged to their disadvantage. Convincing the staff that the Six Sigma Process would be good for them and the company, was essential.

8.1.3 Knitting Process

For the knitting process specifically, the manual measurement of the downtime could be performed by a green belt [10], to improve the reliability of the results. Although the Hawthorne effect would play a role here, this would not change the major causes of the downtime, which would be expected to be technical issues. Additionally, the duration of the measurements could be increased to one or two weeks, improving the validity of the results even further. The belt would also be able to log the data on the laptop directly, making the data analysis more efficient.

After acquiring the results, the team members could be included in the Analyse, Improve and Control Phase. By doing so, a drastic improvement in the results would be expected, as the knowledge of the person close to the process could be utilised.

8.1.4 Innovation Management Capability Improvement

By continuing the implementation of the Six Sigma Methodology permanently, the innovation management capability of Sockit Manufacturing could be improved at a cost, which should be continuously monitored. The company would move from a level 2: ‘Know they need to change, but not how or where to get resources’ to a level 3 organisation ‘Know they need to change and have some ability to generate and absorb technology’.

8.2 Research Question

Can Six Sigma be used to improve the processes of Sockit Manufacturing with limited resources?

The following comments were made by the head of the knitting department:

- Lower downtime periods are being achieved as the fixers are more aware of the issues due to logging the production rate of each machine in three hour intervals.
- Improved concentration of the operators as their performance is measured by the new downtime sheet and the production rate sheet.
- The awareness of problems in the knitting department by the head of the knitting department has increased, due to the documentation of downtime and production rate.

For these reasons the downtime sheet and production rate sheet are still in use after the Six Sigma project was completed.

When discussing the results of the Pareto Chart with the head of the knitting department and the maintenance technician, these were confirmed to be major causes for the downtime across all the machines.
Feedback from the industry experts confirms that the Six Sigma approach helped to identify some of the core problems within the knitting department, even without having had substantial experience within the company. However, due to the time constraints, the Six Sigma Improvement project could not be completed in its entirety and the full advantage therefore not measured.

9 REFERENCES


