Reduction of Defects at Company XYZ, with the Utilization of Six Sigma Methodologies

by

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Abstract

The objective of this paper is to demonstrate the use of Six Sigma Methodologies in order to reduce the level of defects at company XYZ. Moreover, the purpose of the study was to review the current film coating operation at XYZ in order to determine the sources of the high number of defects in the final product. Six Sigma DMAIC methodologies were used to find the root cause of the high number of defects that would enable implementation of corrective action. These actions then would result in the reduction of the number of customer complaints. The data collection process and methods are described with the common Six Sigma Methodologies: Define, Measure, Analyze, Improve and Control.

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Chapter I: Introduction

XYZ is an innovative company that produces thousands of products at various plant locations around the globe. One of the many products manufactured at XYZ, are Film Products used in Liquid Crystal Displays (LCDs).

Film Products are manufactured with the use of multiple internal and external raw materials and are sold to various customers and markets. For example, XYZ’s products are found in LCD televisions, LCD computer monitors, cell phone displays, and other handheld displays as well as in displays of automobiles. An important property in the manufacturing of the film products is final film visual quality. The film quality can be improved by reducing the amount of visual defects present in the film. Recently the Film Division has received an increase number of complaints due to an increase number of visual detected defects. Further classification on the type of rejected defects needed to be established and analyzed in order to find root cause and corrective action for the increase of complaints.

Statement of the Problem

An increase of the number of customer complaints related to defects in Film Products lead the XYZ Company to an increase amount of refunds to their customers.

Purpose of the Study

In order to reduce the amount of complaints, the customer rejected defects were first organized by type. Secondly, defects were prioritized by the highest defect occurrence. Using this method, the root cause behind the most common customer complaints was investigated and a proposal to implement corrective action was established.

Assumptions of the Study

1. All rejected defects are either created at the process or are in the incoming raw material. They are not created during shipment nor at customers.

2. There are no new failing defects; all are known types of defects.

3. Complaints are only from customers.

Limitations of the Study

This study is limited to reducing customer complaints for one specific product. A recommendation to decrease customer complaints is given, but may or may not be implemented.

Chapter II: Literature Review

The literature review will include four areas: (1) definition and types of optical films, (2) general defect definition and types of defects found in films, (3) human and automated inspection of defects, and (4) defect reduction using Six Sigma Methods. All four topics are essential and enrich readers' knowledge of the problem statement and the business area.

Optical Films Definition and Types

There are many optical film products offered in the market, such as: Anti-Reflective Films, Display Protection Films, Light Control Films, Multifunctional Films, Prism Films, and Reflective Polarizer Films for any electronic display applications (Optical Films, 2008). Anti-Reflective Films decrease reflection and increase contrast in flat panel displays and touch screens. Display Protection Films are designed to protect the display surface and are optically clear. Light Control Films are privacy films that use micro-louvers to hide displayed information and are used as contrast enhancement filters. Multifunctional Films provide equivalent brightness of two separate films and they also increase the brightness in LCD panels. Finally, Reflective Polarizer Films increase the brightness in the LCD panels by recycling light form the polarizer in the LCD (Optical Films, 2008).

Optical Films are enhancement films that increase the brightness in LCD panels (Optical Films, 2008). The films increase the brightness by utilizing structure to focus the existing light created by the backlight in the display. Depending on the film used in the display, the brightness can be up to 120%. This increase can be translated into power savings for the LCD users (Optical Films, 2008).

Furthermore, there are many types of film products such as: thin films, thick films, rounded films, wave films and turning films (Optical Films, 2008). Thin films are second generation enhancement films that can provide about 60% of brightness (Optical Films, 2008). These films are able to recycle light into the backlight and direct the light through the LCD to the viewer. A single sheet of film in a display provides about 60% increase of brightness. However, two sheets of film crossed in a LCD can provide up to 120% increase of brightness. Single sheets are used in LCD panel structures of monitors and televisions, while double sheets are used in notebook computers.

Thick films are also a second generation of enhancement films that use a different structure to provide brightness of 59% in a single sheet application (Optical Films, 2008). Two sheets crossed at 90 degree angle can be also used in LCD to increase the brightness to up to 111%. Single sheets are mostly used in LCD panels for monitors and televisions and crossed sheets are usually used in notebooks.

Defect Definition and Types of Defects in Films

Increase of defects in films can jeopardize the brightness performance of the LCD panels. (Optical Films, 2008) A defect in the film is an anomaly that visually appears in the product and can compromises the percentage of brightness in the LCD. There are different types of defects found in the film that vary in shape, size, intensity, and density. Moreover, the defects in the film are classified into two categories: macro-defects and micro-defects (Lu & Tsai, 2004). Macro-defects are anomalies, such as film unevenness, film banding, stains in the film, voids, etc. These defects are large; they appear to have high intensity and are easily detected by human visual inspection. On the other hand, micro-defects such as: point defects, particles, and scratches are very small defects that appear to have low intensity and are more difficult to detect with human visual inspection.

Furthermore, when film sheets are assembled in LCD panels the detected defects are further categorized in three types of defects: visual apparent defects, electricity induced defects and non-uniform display defects (Jiang, Liu & Wang, 2005). Display makers define visual appearance defects as strange particles, white spots, black spots, scratches, rubbing strings, fibers, and bubbles. The macro and micro defects are considered visual apparent defects. The second type of defect, the electricity induced defects, are described as continues lines, S shape lines, G shape lines, and dot or black spot defects. The third type of defect; the non-uniform display defects, are defined as an area in which the color or gray area is different then the rest of the panel.

Human and Automated Inspection of Defects

Human visual inspection and automated inspection are the most commonly used methods for film defect detection. However, human visual inspection is less reliable then automated inspection. Moreover, in the knowledge-based automatic defect classification article, the authors' state that human inspectors classify defects correctly 55% to 70% of the time compared to automated inspection accuracy of greater then 90%. (Clerico, Darwin, Kinikoglu & Liu, 2005).

However, trained and experienced human inspectors may show 80% or higher level of defect detection in materials. The downside to human inspection is that is more time consuming than automated inspection (Clerico et al., 2005). For instance, during the inspection of films, automated inspection can inspect 30 yards a minute while a human inspector will inspect one yard in 20 to 30 minutes.

Due to the less effective manual human inspection, the LCD panel makers have developed an automated computer based defect detection system for micro-defects such as scratches, particles, and point defects in panel surfaces (Brunner, Herbst & Schmid, 2001). This LCD automatic detection system is called the Electron-beam (E-beam) system. The E-beam system is able to detect defects in the LCD panels by sensing pixel voltages by actively driving through the beam. The pixels are collected into a vector and then they are characterized as good and bad pixels. The pixel characterization is done by the automated system and defects are characterized depending on intensity and density of the pixels.

Defect Reduction using Six Sigma Methods

Six Sigma is a methodology that is commonly used in organizations, such as General Electric and Motorola in order to reduce waste and cost and increase customer satisfaction (Thawani, 2004). Motorola defined Six Sigma as "a disciplined method of using extremely rigorous data gathering and statistical analysis to pinpoint sources of errors and ways of eliminating them" (Caulcutt, 2001, p.303). Bill Smith, a Motorola employee, developed the Six Sigma approach in 1970s to reduce defects and increase quality on products with the ultimate goal of reducing the likelihood of providing customer with defective parts (Kanji, 2008). Later, Motorola deployed Six Sigma in 1980s and since then, Six Sigma is used as a high performance, data driven method for improving quality by removing defects and causes that are important to customers. As a result of the Six Sigma deployment, Motorola had documented over $17 billion in savings, and they are continuously focusing efforts on improvements. Furthermore, the Six Sigma Methodology has moved from the USA to Europe and recently starting to impact Asian countries.

Six Sigma organizations recognize projects according to customer requirements (Kanji, 2008). They use the common Six Sigma methodology steps: Define, Measure, Analyze, Improve, and Control (DMAIC) to determine the direction of the Six Sigma project. Several tasks must be completed in each of the DMAIC steps.

The Define step of the Six Sigma Methodology identifies and evaluates projects for improvements and selects the team involved (Motorola University, 1994). It is the most important step of the project because it determines the customer's requirements, the objectives that need to be evaluated, it documents the team charter, project plan, process maps, and it evaluates the just do-it opportunities. Moreover, in the Define step, the Project Champion identifies the cross functional team that needs to be working on the project.

The Measure step collects the data on the type of defects, reviews customer requirements and determines key processes, product standards, and settings (Motorola University 1994). During this step the team uses numerous quality tools to determine the specific parts of the process. The team also verifies the accuracy and the precision for the measurement system, process capability, stability, and quality. The measurement phase team documents the Process Map and develops a Cause and Effect Matrix to help identify the critical inputs that need to be evaluated.

The Analyze step analyzes the data collected in the Measure phase by using quality charts, such as Pareto charts, histograms, and statistical hypothesis testing to narrow down the cause of defects (Motorola University, 1994). This is the most critical part of the DMAIC process. The steps in this phase should reduce the number of variables that need to be investigated or improved by the team. Also, the team uses a Multi-Vari Study in order to recognize any noise variables in the process.

The Improve step designs and performs experiments in order to find the root cause of the defects and the relationship to the process (Motorola University, 1994). During this step, the team should have identified suspect variables and developed a plan for improvements. Experimentation is the back bone to this phase in order to determine and prove out the root cause of the problem.

Finally, the Control Plan step implements and monitors the improvements (Motorola University, 1994). The team reviews the changes implemented and outlines future process audit plans. The Project Champion then hands over the control plan to the process owner and starts to track the financial benefits from the project.

Summary

In conclusion, there are various types of films that are used in LCD panels. Moreover, there are different types of defects in films that can be classified in two main categories of interest, micro-defects and macro-defects. Film defects can be detected with human inspection or automated inspection. Well developed automated inspection systems are more accurate, reliable and less time consuming then human inspection. Finally, Six Sigma Methodologies will be used in this study in order to reduce complaint levels and improve quality.

Chapter III: Methodology

The purpose of the study was to review the current film coating operation at XYZ in order to determine the sources of the high number of defects in the final product. The study used the Six Sigma DMAIC methodology to find the root cause of the high number of defects and would enable implements of corrective action that should result in the reduction of the number of customer complaints. The data collection process and methods are described with the common Six Sigma Methodologies: Define, Measure, Analyze, Improve and Control.

Define

The study started with defining the problem and outlining the objectives/goals and benefits gained after completion. Furthermore, the define phase determined not just the benefits to the company, but also the benefits of the customer. After outlining the objectives the best suited team was assigned to work on accomplishing those objectives. The core team consisted of a team lead, process owner, quality engineer, quality technician and process engineer. Once the team members were selected, the team was able to meet and discuss the project plan forward. The team needed to decide the production process and product that will be evaluated and measured.

The Company's complaint database has been collecting and tracking all of the customer complaints from various customers. The team will retrieve all the complaints from the complaint database and determine which product family and products had the highest number complaints in the past months and then concentrate on that product or product family. Moreover the team also needed to decide what process and product variables and measurement units to use in the evaluations. With the variables measured, the team will be able to review the current performance and establish an improvement plan and minimize the problem.

Measure

During the measurement phase activity, the team will retrieve, review, and analyze current visual inspection data on the product or product family that had the highest number of complaints. This data will show the level of the defect detected per every sample inspected over time. The data retrieved will show the team if there are any patterns in the data or sudden changes that may indicate potential problems with the measurements that are being used.

The team will conduct Measurement System Analysis and use Attribute Study to determine the repeatability and reproducibility of the test method used. Moreover, the team will also conduct capability study on the method used and determine the stability of the method. After the measurement step is completed, the team will select a specific process or piece of equipment that will be evaluated in order to reduce or eliminate the top defect.

Analyze

In the analyze phase the team will review the data that has been collected in the measurement phase and perform cause-and-effects analysis to determine what process changes or variables have the highest effects on the top defect. The team will be able to list the potential effects and rate each effect with respect to defect occurrence and severity.

Improve

From the effects analysis the team will be able to choose process variable that would have the highest impact on the defects and conduct Design of Experiments (DOE) on the process in order to see the effect on the level of the defect. For instance, the team might decide to increase in line speed and see how that change would affect the level of defect visually detected after the change. The potential variable changes, operational limits and specifications will be reviewed and documented for further testing.

In the improve phase, the team will select the process variable that had the greatest impact on defect reduction and perform verification runs for that variable. During verification the team will analyze the data collected and check if any of the changes negatively affect the final products. When the team successfully finishes, they will develop a plan for implementing the change. After the implementation is complete the team will review visual inspection data to assure that an improvement was made. The team might also decide to send samples to customers with the improvements in order to confirm that the defects levels are minimized or eliminated.

Control

After the implementation is completed the team will establish controls and procedures to ensure that the changes are followed. Some changes may be as simples as increase the frequency in cleaning the process line. For this type of change the operating procedure would need to be updated. Also control specification procedures will need to be updated if any of the operating procedures will be different. Each change will be also documented with a new revision of documents that will require certain management approval in order to be updated.

Chapter IV: Results

This chapter shows the defect reduction analysis and results outcome from the Six Sigma Team at Company XYZ. The team applied the DMAIC methodology in order to resolve the problem and each of the steps used in the process by the team are described in this chapter.

Define

During the define phase of the project, the team reviewed all the customer complaints from the past months. The table below shows all the complaints categorized by the type of defects rejected and the count or number of complaints per type of a defect rejected.

Table 1

Customers Complaints due to Defects

Description of Defect Type	Number of Complaints
Rejected due to downweb banding	20
Rejected due to scratches	8
Rejected due to dents	8
Rejected due to impressions	5
Rejected due to stains	3
Rejected due to contamination	1

A Pareto chart was generated by using the data in the table above. By looking at the Pareto chart in Figure 1 it shows that the defect responsible for highest number of complaints was downweb banding. The data shows that 44% of the total number of complaints was due to downweb banding. The rest of the defects such as scratches, dents, impressions and stains were shown at lower percentage, lower then 20%, and were not considered as the major contributor of complaints to the company. Since, downweb banding was the greatest contributor on the Pareto chart; the team focused on this defect in order to resolve the problem.

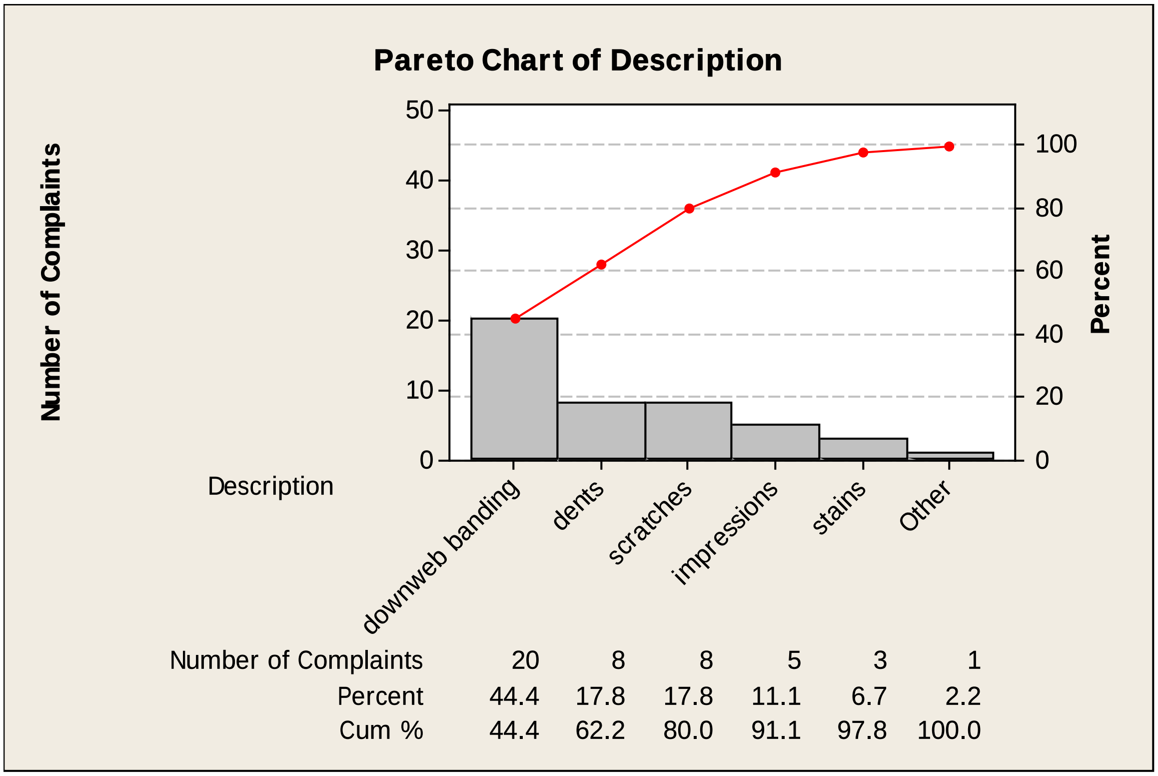

Figure 1. Pareto Chart of Customer Complaints due to Defects

Measure

The best way to measure the downweb banding is by visual inspection of the finish product on a light box. The entitlement would be no downweb banding visible in the product at final product inspection. However, per customer specifications, low levels of banding are considered acceptable and a Process Acceptance Visual Standard has been established with the customer and is used during inspection as the maximum acceptable level of downweb banding in the finish product.

Measurement Systems Analysis (MSA) was conducted in order to determine if the current visual inspection test method for downweb banding was adequate. For the analysis, thirty random samples were selected from different manufacturing lots with some slightly below and some above the Customer Visual Acceptance Standard and they were rated on a five-point scale (1, 2, 3, 4, 5). Three operators were chosen to perform the analysis.

Since it is a visual test method an Attribute Study was assembled. An attribute analysis either accepts or rejects a part after comparison to the standard. Each of the fifteen samples were randomly selected and measured twice by each operator. The results from the MSA are shown in Table 2 & Figure 2 through the Attribute Agreement Assessment.

Table 2

Results of Attribute Study for Visual Inspection Test Method

Attribute Agreement Analysis for Rating

Each Appraiser vs Standard

Assessment Agreement

Appraiser	# Inspected	# Matched	Percent	95 % CI
Op1	30	15	50.00	(31.30, 68.70)
Op1 rep	30	20	66.67	(47.19, 82.71)
Op2	30	27	90.00	(73.47, 97.89)
Op2 rep	30	24	80.00	(61.43, 92.29)
Op3	30	24	80.00	(61.43, 92.29)
Op3 rep	30	20	66.67	(47.19, 82.71)

Matched: Appraiser's assessment across trials agrees with the known standard.

Between Appraisers

Assessment Agreement

# Inspected	# Matched	Percent	95 % CI
30	7	23.33	(9.93, 42.28)

Matched: All appraisers' assessments agree with each other.

All Appraisers vs Standard

Assessment Agreement

# Inspected	# Matched	Percent	95 % CI
30	7	23.33	(9.93, 42.28)

Matched: All appraisers' assessments agree with the known standard.

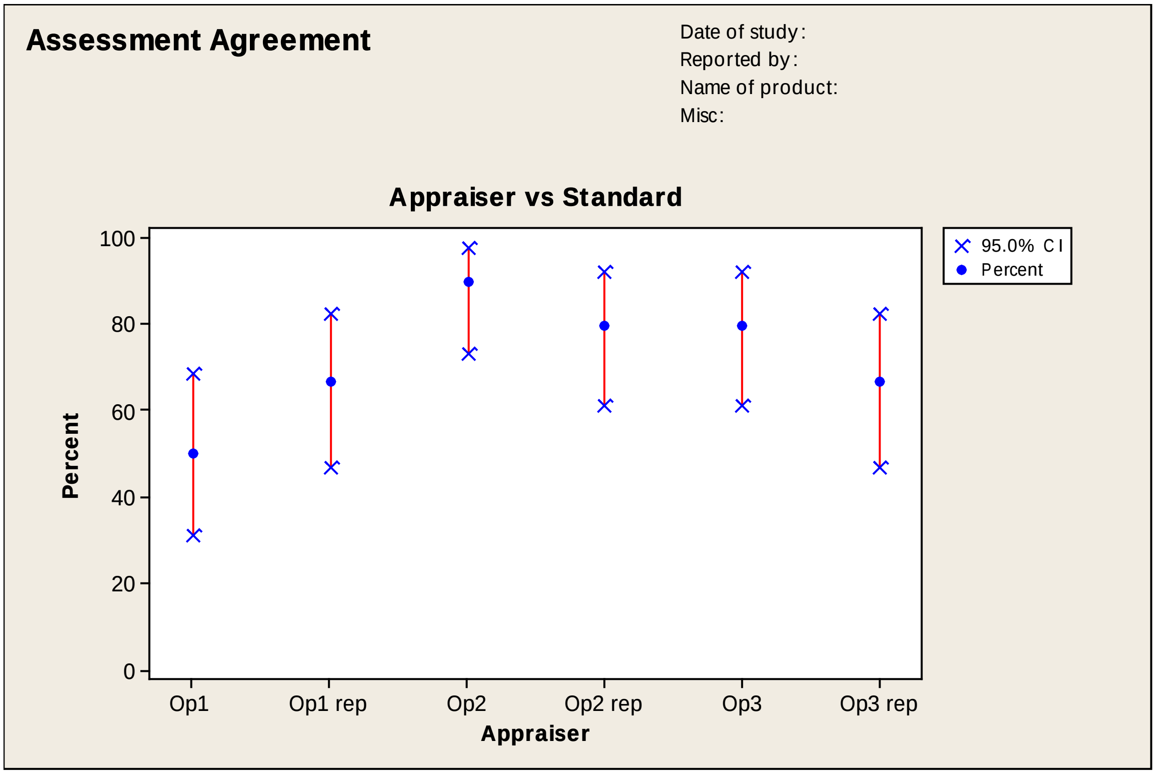

Figure 2. Attribute MSA

The results from the attribute method analysis show that the visual inspection test method is a reliable measurement system for accurate measurement of downweb banding in finish product. All of the measurements in the analysis agree and the study is accepted.

Moreover, in order to determine if the current process was running within customer specifications a process capability was performed. Samples were collected from the manufacturing process and were visually inspected. The data from the visual inspection was recorded and analyzed. Figure 3 below shows the process capability study.

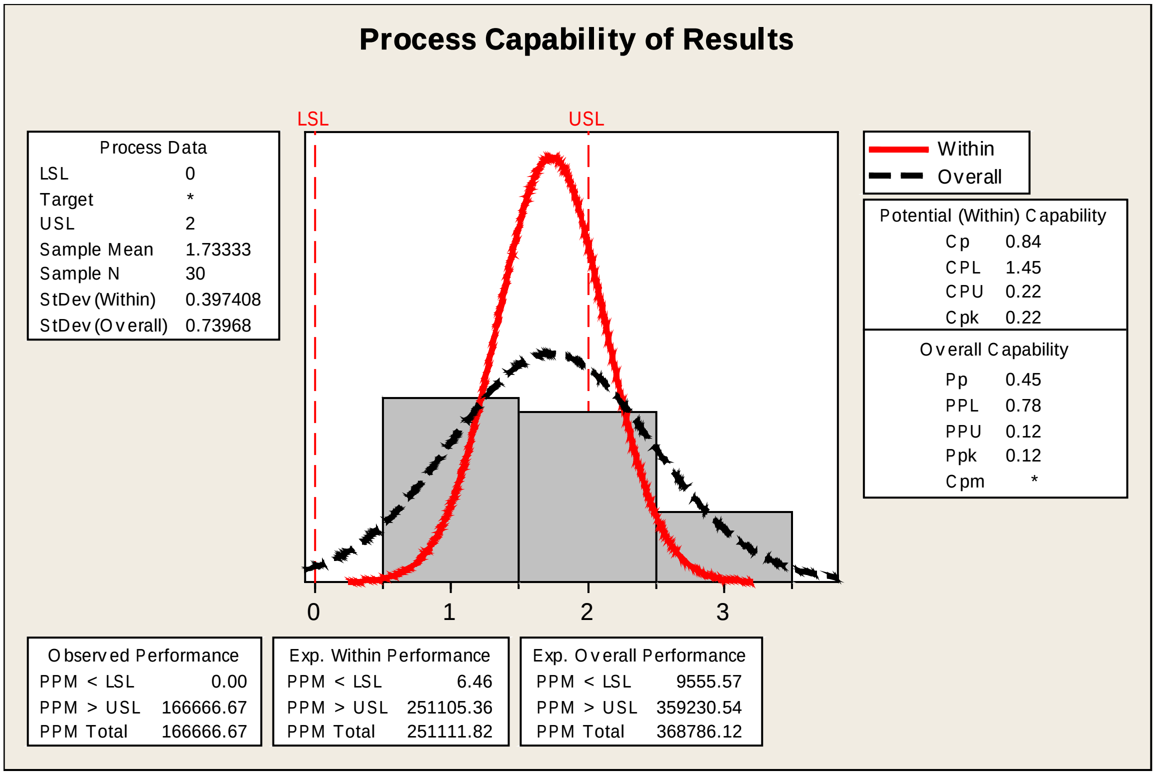

Figure 3. Process Capability Study

The results from the process capability showed that the process was running at the higher end of the process upper specification limit. The Cpk value is 0.22 which is much lower the 1.33 indicating that the process needs improvement and is not capable of producing within process specifications.

Analyze

In order to improve the downweb banding in finish product, the Six Sigma team started to investigate the process for potential failure modes. The team started with developing a process map of the current coating process in order to indentify in scope inputs and outputs of the process that can affect downweb banding in the final product. The process map is shown in Figure 4 below.

Raw Materials	Process	Key Output Variables	Input Variables	Input Types
		Visual Surface Quality	Film Caliper	controlled
		Functional Test Quality	Defects in input film	controlled
			Core	controlled
			Pallets/Pkg Supplies	controlled
Input Film			Environment	uncontrolled
			RM Specification	controlled
		Roll form defects	Material Handler	uncontrolled
		Surface Defects	Process Standard	controlled
		Wearing Parts	Idler Condition & Surface	controlled
			Line Speed	controlled
			Tension	controlled
			Steering	controlled
			Hoist Operation	controlled
	Unwind		Environment	controlled
			Process Technicians	uncontrolled
		Heaters	Defects	uncontrolled
		Coating adhearing	Temp	controlled
		Coating properties	Flow rate	controlled
Input coating solution			Filters	uncontrolled
			Filter Change Procedure	controlled
			RM Specification	controlled
		Coating	Coating Setup	controlled
		Defects	Tension	controlled
		Scratches	Idler Condition & Surface	controlled
		Coating Width	Process Standard	controlled
		Wearing Parts	Line Speed	controlled
		Coating Appearance	Environment	controlled
	Coating		Process Technicians	uncontrolled
		Defects	Environment	controlled
		Scratches	Idler Condition & Surface	controlled
		Wearing Parts	Process Standard	controlled
			Line Speed	controlled
			Process Technicians	uncontrolled
	Web Cleaning			
		Coating adhearing	Idler Condition & Surface	controlled
		Caliper	Process Standard	controlled
		Flatness	Line Speed	controlled
		Defects	Air Temp	controlled
		Scratches	Air Flow	controlled
	Oven	Wearing Parts	Process Technicians	uncontrolled
		Flatness	Core	controlled
		Defects	Winding Tension	controlled
		Visual Surface Quality	Process Standard	controlled
		Scratches	Idler Condition & Surface	controlled
	Winder	Wearing Parts	Process Technicians	controlled
		Defect Detection	Sample	uncontrolled
		Defect Judgment	Inspection Table	uncontrolled
		Caliper Measurement	Caliper Tester	controlled
	Inspection	Curl Measurement	Flatness Tester	controlled
		Data Entry into Database	Procedures & Specifications	controlled
		Yield Estimation	Operator	uncontrolled
		Undamaged Rolls	Rolls	controlled
			Material Handlers	uncontrolled
		Inventory	Packaging Procedure	controlled
		Properly Labeled Product	Bags	uncontrolled
			Boxes	uncontrolled
			Labels	controlled
	Packaging, Storing, & Shipping		Palletizing	controlled
			Truck	uncontrolled
			Shipping Method - ship vs. plane	controlled
			Environment - packing & storing	semi-controlled
			Environment - shipping	uncontrolled
			Time - storage & shipping	uncontrolled
			Orders	controlled
			Warehouse Storage Location	uncontrolled

Figure 4. Process Map

From the process map, the team did a brainstorm session in order to indentify possible effects that can cause downweb banding in the process. Figure 5 below shows a cause and-effect diagram of all the possible root causes for downweb banding. The root causes for downweb banding were classified into six major categories: machine, manpower, material, measurement, method and environment.

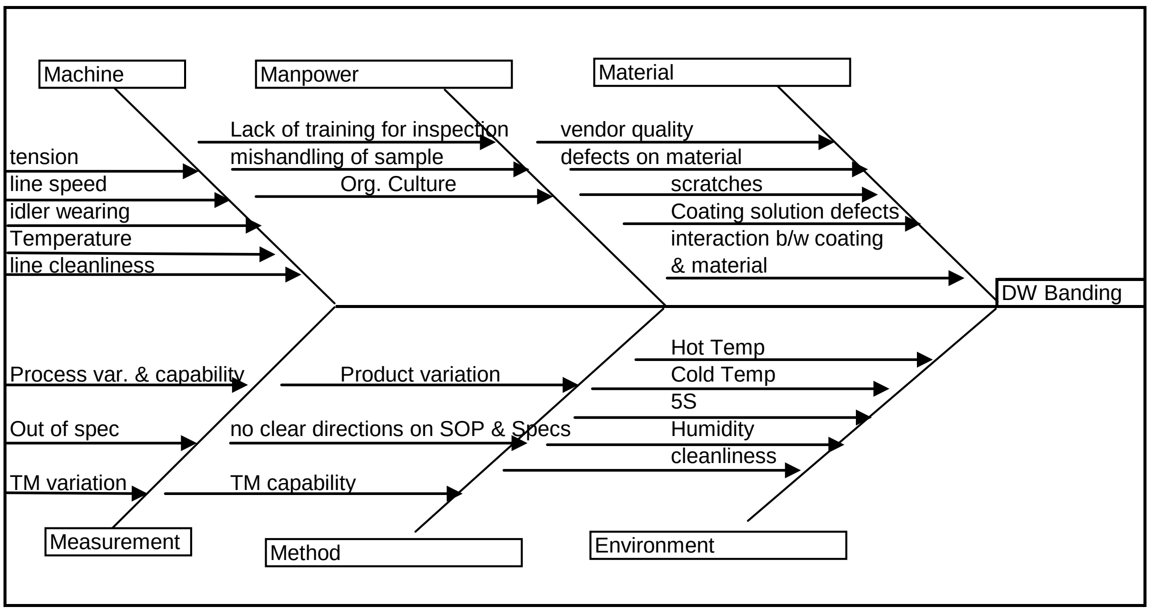

Figure 5. Cause-and-Effect Diagram

In the machine category, temperature can greatly influence downweb banding in the final product. On addition to temperature, line tensions were also considered as main variables that could effect downweb banding.

In the manpower category, the problem can be in the operator's lack of training for inspection as well as variation between new and experienced operators. For instance new operators might visually judge the level of downweb banding as passing level, while a more experienced operator could judge the same level as a failing level. This could result in test method variation. By looking at the measurement category, all the effects here were eliminated in the measurement system analysis in the measurement phase of this project.

From the method category, the problem can be in the specifications or the Maximum Product Acceptance Standard. Since it is a visual test, the Product Acceptance Standard, could be out of date, meaning the customer criteria over the years could change and their acceptance standard could be different then today.

Under the material category, the input material could be the root cause of downweb banding. The incoming input material can have high intensity downweb banding before they are processed through the coating process.

Finally the environmental conditions can enhance downweb banding after the material is coated and the product sits idle for a long period of time in a roll form. Hot and cold weather conditions could induce downweb banding.

Improve

After the cause-and-effect investigation, the team made a decision to focus on the machine category and work on process parameters in order to reduce the downweb banding in the final product. For the improvement plan, based on suggestions from the process engineer and historical data, the team decided to conduct a Design of Experiments (DOE) around two process variables, the line temperature and the line tensions. From the DOE the team would determine the optimal process setting for temperature and tensions that would reduce the downweb banding in the final product. Based on past runs, the team decided, the levels for each process factor, the temperature factor and the tension factor. The Table 3 below shows the factors and the corresponding levels of the factors.

Table 3

Factors and Process Levels for the Design

Factors	Low Level	High Level
Oven Temperatures	X	Y
Roll # 4 Tensions	a	b

Based on the two factors that the team decided to investigate, the DOE was developed as a simple two factors, two-level full factorial design. Minitab was used to construct the DOE. Table 4 below shows the Full Factorial Design from Minitab.

Table 4

Full Factorial Design from Minitab

Full Factorial Design

```
Factors:  2   Base Design:         2, 4
Runs:     5   Replicates:             1
Blocks:   1   Center pts (total):     1


All terms are free from aliasing.
```

Further, with the use of Minitab, the DOE matrix was generate to aid the team to record the response levels during the experiment. The DOE was run in standard order on the coating line and three samples were taken from each condition. The team waited about 20 minutes between each setting to ensure that the changed parameters were stabilized, before the sample material was produced. Each sample collected per condition was compared to the Acceptance Standard and the levels on downweb banding were recorded for each condition.

After the DOE was conducted, the team inputted all the response data for each condition in the design matrix and analyzed the data using Minitab. Table 5 shows the results of the analysis.

Table 5

Minitab Results of the DOE Analysis

Estimated Effects and Coefficients for Level (coded units)

Term	Effect	Coef	SE Coef	T	P
Constant		2.2041	0.1075	20.50	0.000
Roll 4 Tension	1.8219	0.9110	0.1418	6.42	0.000
Oven Temperature	2.0940	1.0470	0.1588	6.59	0.000
Roll 4 Tension* Oven	1.1950	0.5975	0.2094	2.85	0.008

The P values of the analysis in Figure 9 are all less then 0.05 indicating that both factors, oven temperature and line tensions settings are statistically significant. The Minitab analysis also generates the Pareto chart with the decision line for the significant variable. Figure 6 below shows the Pareto chart, which also confirms that temperature and tensions are both significant variable that effect downweb banding. The Pareto chart also shows that the interaction between the two main factors is also statistically significant.

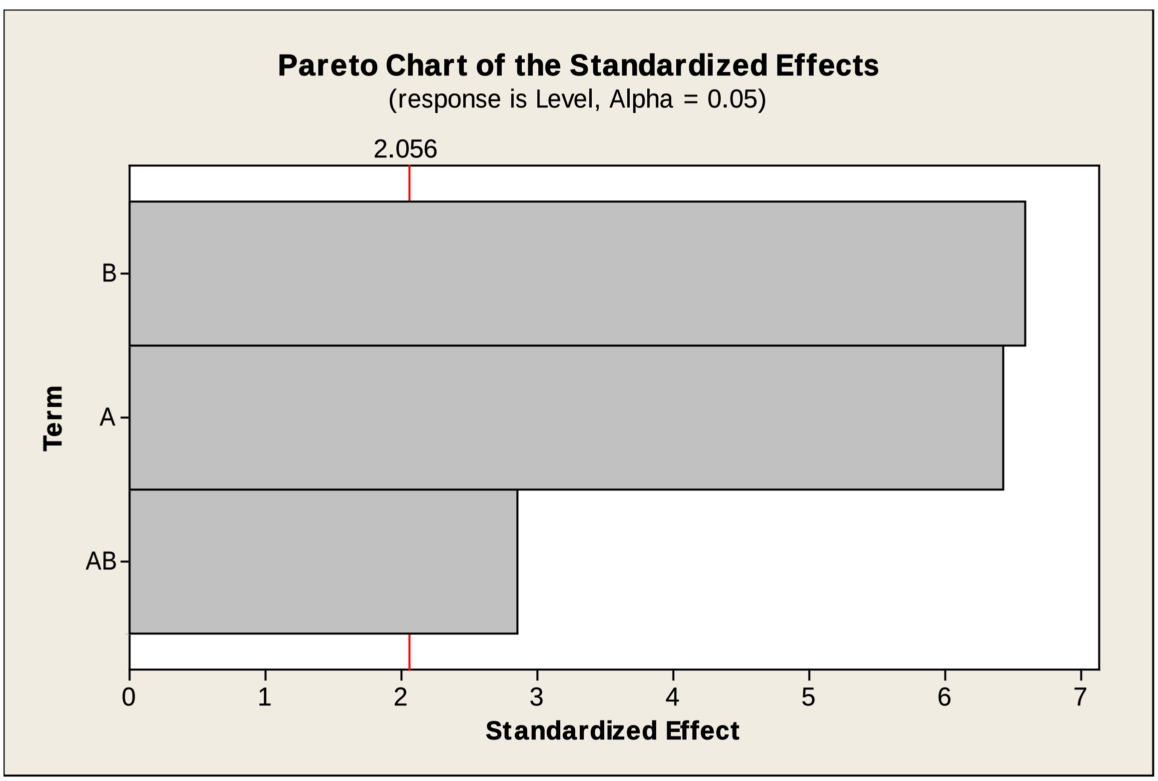

Figure 6. Pareto Chart of Effects

Further analysis was done by the team in Minitab by using the Main effects plot. Figure 7 shows the main effects plot which shows the relationship between each variable and the center point. The main effects plot shows that lower tensions and lower oven temperatures reduce the downweb banding level.

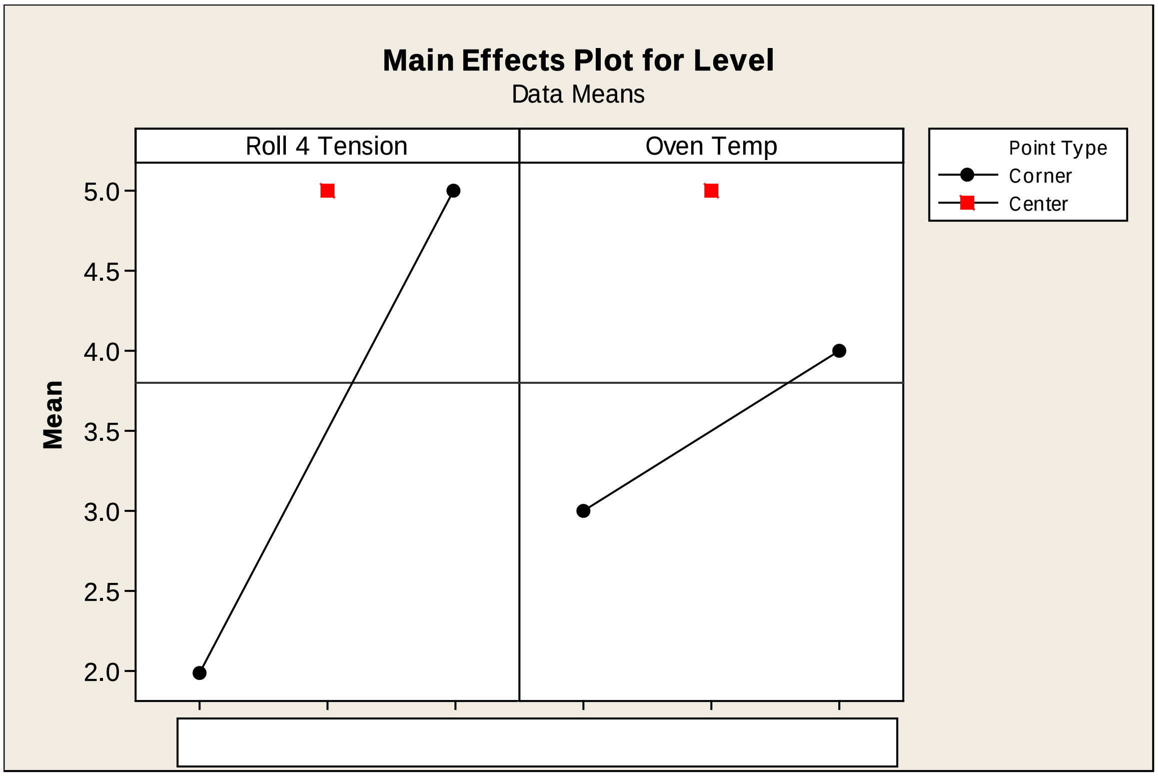

Figure 7. Main Effects Plot

Based on the DOE analysis, the process settings on the line during production for temperature should be changed in order to reduce the downweb banding in the final product.

Finally in order for the team to verify that the results from the DOE would work in standard production settings, decision was made to conduct verification runs with the new settings. For the verification run, the new settings were dialed in the line and after the conditions were stabilized thirty samples were collected and visually judged for downweb banding by comparing each sample to the Acceptance Standard. The average level of the thirty samples measured, was level 1 which indicated that the new settings improved the downweb banding.

Control

After the verification of the new settings, the team implemented a control plan in order to ensure that the new settings will be used for future production runs.

1. Process settings standards were changed to implement the new process settings for the oven temperature and tensions.
2. Process control charts for tension and temperature were implemented for operators to monitor during production runs.
3. Downweb banding control chart was implemented to monitor the levels of the downweb banding of each product inspected during production.

Chapter Summary

In order to reduce the downweb banding problem at the company, the DIMAC methodology was used by the team. For each phase of the DIMAC project, different six sigma tools were used by the team to aid the investigation. In the define phase the team Pareto chart analysis to look at historical data and determine the type of defect responsible for the highest number of complaints. Furthermore, in the measurement phase the team used the Attribute Study tool to conduct MSA on the test method. In the analyze phase, process mapping and cause and effect tools were used to determine the main variables to study in the improvement phase. Finally, in order to determine the main effects that reduced downweb banding, the team conducted a DOE and used Minitab DOE analysis tool to determine the new process settings for temperature and tension and reduce downweb banding. Therefore, with the use of Six Sigma Methodologies the team was able to reduce the level of downweb banding in the final product and reduce the overall number of complaints for XYZ.

Chapter V: Discussion

The Film Division of XYZ recently received an increase number of complaints due to an increase number of visual detected defects. In order to find root cause and corrective action for the increase of number of complaints, XYZ needed to conduct quality study and analysis.

The purpose of the study was to reduce the amount of complaints received by the customers by using Six Sigma Methodology. In order to reduce the amount of complaints, a Six Sigma team was assembled to lead the initiative. The first approach of the Six Sigma team was to collect historical data of complaint records and determine the defect that contributed to the highest number of complaints. After the number one defect, downweb banding, was recognized, the team used multiple Six Sigma tools and the DMAIC (Define, Measure, Analyze, Improve and Control) Methodology to reduce the level of downweb banding in the final product and hence reduce the overall number of customer complaints. The team conducted Measurement System Analysis to determine the repeatability and reproducibility of the visual test method used to measure downweb banding in the final product. Moreover, the team assembled cause-and-effect diagram to establish the main variable the effect downweb banding. Further the team used Design of Experiments (DOE) in order to indentify the optimal settings of the main variables and reduce downweb banding in the final product.

Limitations

This study would only consist the reasoning behind the increase of the number of customer complaints and would propose a suggestion on a way to decrease the number of complaints. This study might not include the implementation of the proposed plan. This study was only specific to one product manufactured at XYZ.

Conclusions

In order to reduce the number of complaints at XYZ, the Six Sigma DMAIC Methodology approach was followed. By looking at each individual phases of the project and the relationship between each phase, one would conclude that it is critical to follow each step of the DMAIC methods in order to successfully complete the investigation. Skipping a step or not completing one, would lead in inadequate results and prolongation of the project.

Recommendations and Future Studies

One recommendation to the XYZ is to monitor total number of complaints per month. On addition to monitoring the number of complaints, the company should record savings generated from the reduction of number of complaints. Further the company should implement control charting for process and product variables to have better understanding of the manufacturing process and generate ideas for continues improve. Future studies should be done on other film products made at the company to evaluate effectiveness of the findings. In addition, incorporating raw materials variability into the Design of Experiments should be a priority for future studies. Finally the Six Sigma tools used in this study can be also used on any other future quality studies that other companies might encounter.

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