INSTITUTO TECNOLOGICO Y DE ESTUDIOS SUPERIORES DE MONTERREY

UNIVERSIDAD VIRTUAL

TECNOLÓGICO DE MONTERREY®

BBF3 BEKIDO RATE 15% INCREASE

SIX SIGMA PROJECT

SIX SIGMA BLACK BELT CERTIFICATE

POR:

JOSE FLORES SALINAS

MONTERREY, N. L. MEXICO MAY, 2008

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BBF3 Bekido Rate 15% Increase

Six Sigma Project

Six Sigma Black Belt Certificate

José Flores Salinas 777686

May 2008. Monterrey, Nuevo León, México.

BBF3 Bekido Rate 15% Increase

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NAME. - GILBERTO GONZALEZ MUÑOZ

Signature:

BBF3 Bekido Rate 15% Increase

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SIX SIGMA PROJECT PRESENTED TO ITESM

THIS WORK IS A PARTIAL REQUISITE TO OBTAIN SIX SIGMA BLACK BELT CERTIFICATE

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Abstract

The following document was developed at Bridgestone Neumáticos de Monterrey. It describes the application of a Six Sigma methodology to increase the efficiency of the Bead Manufacturing Line # 3, from 36% to 50%. Following the 5 phases, Define, Measure, Analyze, Improve and Control, the project accomplishes its objective, achieving the 50% Bekido Rate (cycle time efficiency) on the Bead Manufacturing Line # 3.

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Chapter 1: Introduction

This project consists in the application of Six Sigma methodology to solve a real problem in an enterprise. The author works at Bridgestone Neumáticos de Monterrey, a manufacturing enterprise. He decided to implement the methodology to provide a solution that would impact the efficiency of the Bead Manufacturing Line #3, which represents a critical problem to Monterrey Plant tire production.

The objective of this project is to increase the Bekido Rate of Bead Manufacturing Line #3 from 35% to 50%. In order to achieve this goal we followed the Six Sigma methodology, which consists of five phases: Define, Measure, Analyze, Improve, and Control. Through these five phases we defined the scope of our project, measured the actual condition of the process, and analyzed what factors affect the process, implemented actions to minimize those factors, and finally, control actions we developed to maintain the gain obtained. This document is organized according to these five phases.

Chapter 2: Bibliographic Revision

You may have heard of Six Sigma, a process-focused strategy and methodology for business improvement. Companies such as General Electric, Honeywell, Motorola, DuPont, American Express, Ford, and many others, large and small, have been using it to improve business performances and realize millions of dollars in bottom-line savings (Snee & Hoerl, 2005).

Six Sigma is a strategic approach that works across all processes, all products, and all industries. Six Sigma focuses on improving process performance to enhance customer satisfaction and bottom-line results (Snee & Hoerl, 2005).

Six Sigma is about business improvement; it is not about culture change per se, although it will radically change culture. The strategy is to get the improvements, then create the infrastructure in the traditional sense of the word, although it results in improved quality. It is not about training, although training is used to build the skills needed to deploy it. Six Sigma is about breakthrough business improvement, not incremental improvement. Sig Sigma projects are defined to produce major improvements 30%, 40%, 50%, 60% and more in process performance in less than 4-6 months with a significant bottom-line impact (Snee & Hoerl, 2003).

Most material in a manufacturing process spends 95% of ... waiting for someone to add value to it or waiting in finished goods inventory... by reducing this lead time 80% manufacturing overhead and quality cost can be reduced by 20%, in addition to the benefits of proportional faster delivered and lower inventories (George, 2002).

The sigma level numbers often associated with Six Sigma represents the capability of a core business process, as measured in defects per million opportunities.

The "per million opportunities" aspect of the Six Sigma metric is critical because it allows you to compare the capability of widely different processes. The sigma metric makes sure that simpler processes, which have fewer steps and fewer chances for something to go wrong, aren't given an advantage over more complex processes (George, 2002).

The source of the defects is almost always linked to variation in some form: variation in materials, procedures, process conditions, etc. That's why the fundamental thesis of Six Sigma is that variation is evil because a high level of variation means customers will not get what they want (George, 2002).

Chapter 3: Methodology

3.1 DEFINE

PROJECT CHARTER

Element	Team Charter
1. Process:	Bead manufacturing line.
2. Project Description: what is the "Practical Problem"	On February 2008 the **bead manufacturing line #3 (BBF3)** has a 35% of Bekido Rate, where 100 % Bekido Rate represents the optimal designed cycle time. This represents a very low level of efficiency and the bottom line is that the machine cannot make the daily ticket of bead carts.
3. Objective:	Increase the Bekido Rate of the BBF3 from 35% to 50%.
4. Team members:	José Flores Project Leader Gilberto Gonzalez Electrical Engineer Manuel Mendoza Production Control/Financial Advisor Abraham Cantú Project Champion/Mechanical Engineer Manuel Miyamoto Production Advisor
5. Benefit to Internal Customers:	Provide the required amount of bead carts to the tire assembly line.
6. Schedule:	Project Start *01/28/2008* Measurement Completion *02/28/2008* Analysis Completion *03/08/2008* Improvement Completion *03/31/2008* Control Completion *04/04/2008* Safety Reviews *04/07/2008* Project Completion *04/12/2008*

Table 3.1-1. Project Charter

PROBLEM STATEMENT

On February 2008 the **bead manufacturing line #3 (BBF3)** has a 35% of Bekido Rate, where 100 % Bekido Rate represents the optimal designed cycle time. The actual level represents a very low level of efficiency and the bottom line is that the machine cannot make the daily ticket of bead Carts.

GOAL STATEMENT

Increase the Bekido Rate of the BBF3 from 35% to 50%.

TEAM MEMBERS

Name	Function
José Flores	Project Leader
Abraham Cantú	Project Champion/Mechanical Engineer
Gilberto Gonzalez	Electrical Engineer
Manuel Mendoza	Production Control /Financial Advisor
Manuel Miyamoto	Production Advisor

Table 3.1-2. Project Team Members

TIME LINE

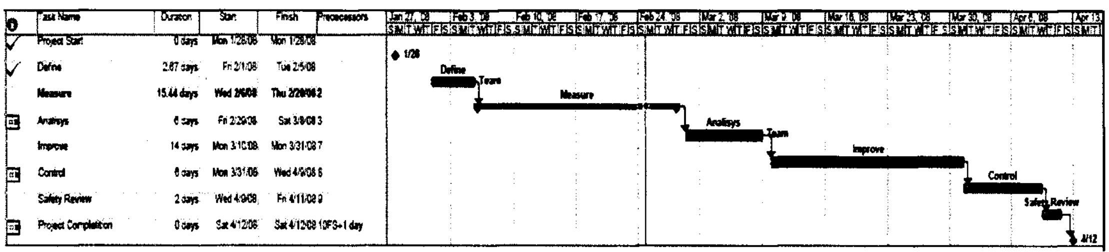

Figure 3.1-1. Project Gantt

ESTIMATED FINANCIAL BENEFITS

Every 10% of Bekido Rate represents 10 Carts of production. The goal of this project is to increase 15 % the Bekido Rate, that is 15 more bead Carts per day.

1 Cart = 32 Tires	15 Carts = 480 Tires
1 Tire = $60 USD	480 Tires = $28,800 USD
This project represents a potential income of $28,800 USD per day.	

Table 3.1-3. Project Estimated Financial Benefits

3.2: MEASURE

SIPOC: BBF3

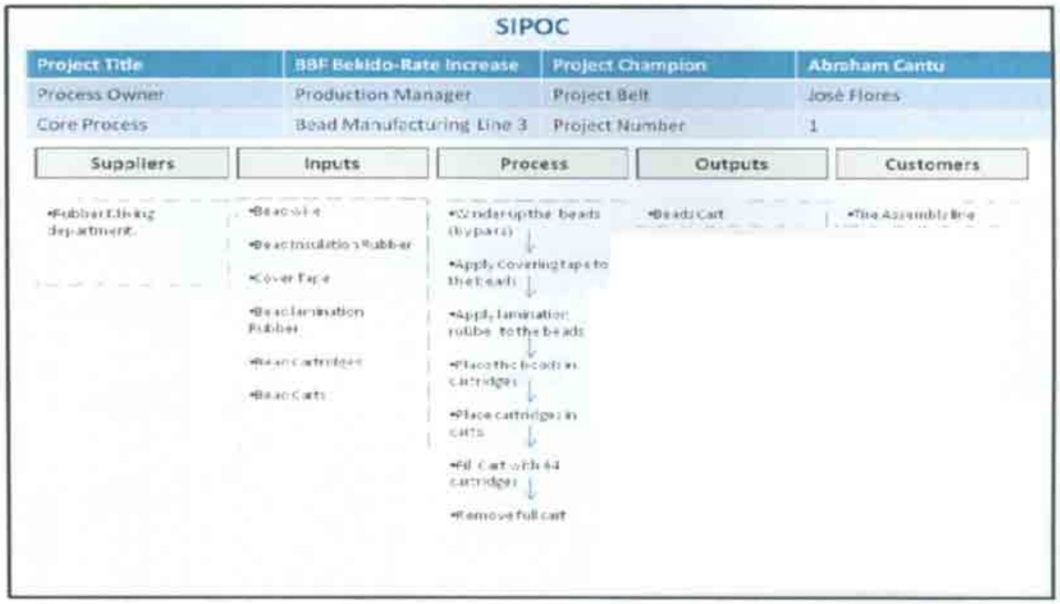

Figure 3.2-1. SIPOC of BBF3

HIGH LEVEL PROCESS MAP: BBF3

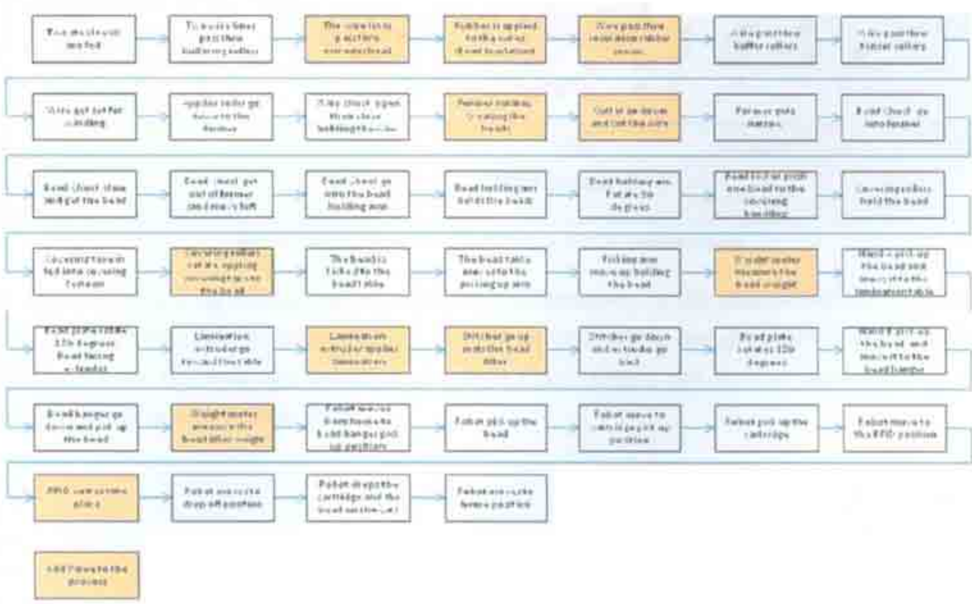

Figure 3.2-2. High Level Process Map of BBF3

The BBF3 collects the cycle time of every bead that it is manufactured. Beside the cycle time it also collects the alarms that occur on the machine. This information is continuously sent to a data logger server were it is stored on a data base. The CTQ metric for this project is the Bekido Rate. The first step is to measure it during some time.

The next figure shows the Bekido Rate scatter plot of all the carts manufactured on February 2008 in the BBF3.

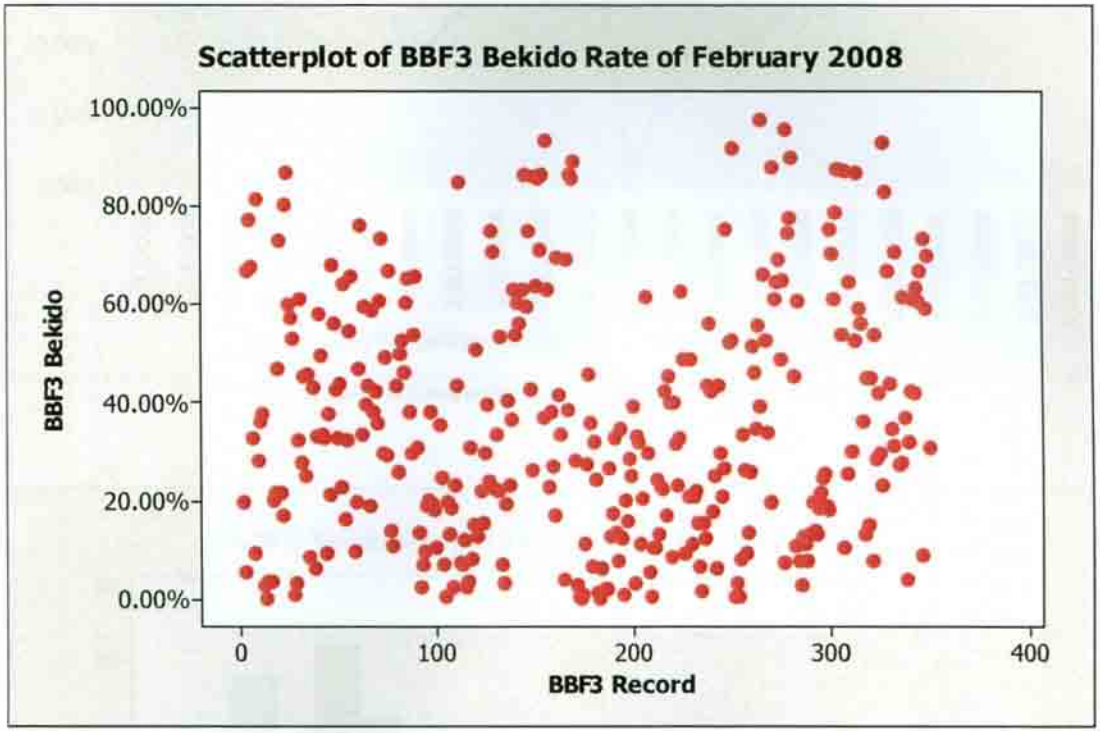

Figure 3.2-3. Scatterplot of BBF3 Bekido Rate of February 2008

This figure shows a significant variation in the performance of the machine from cart to cart. It was decided that the Bekido Rate records should be filtered, so we grouped the records by day and calculated the day average Bekido Rate. Next figure shows the Bekido Rate average by date vs. the target that is 50% Bekido Rate.

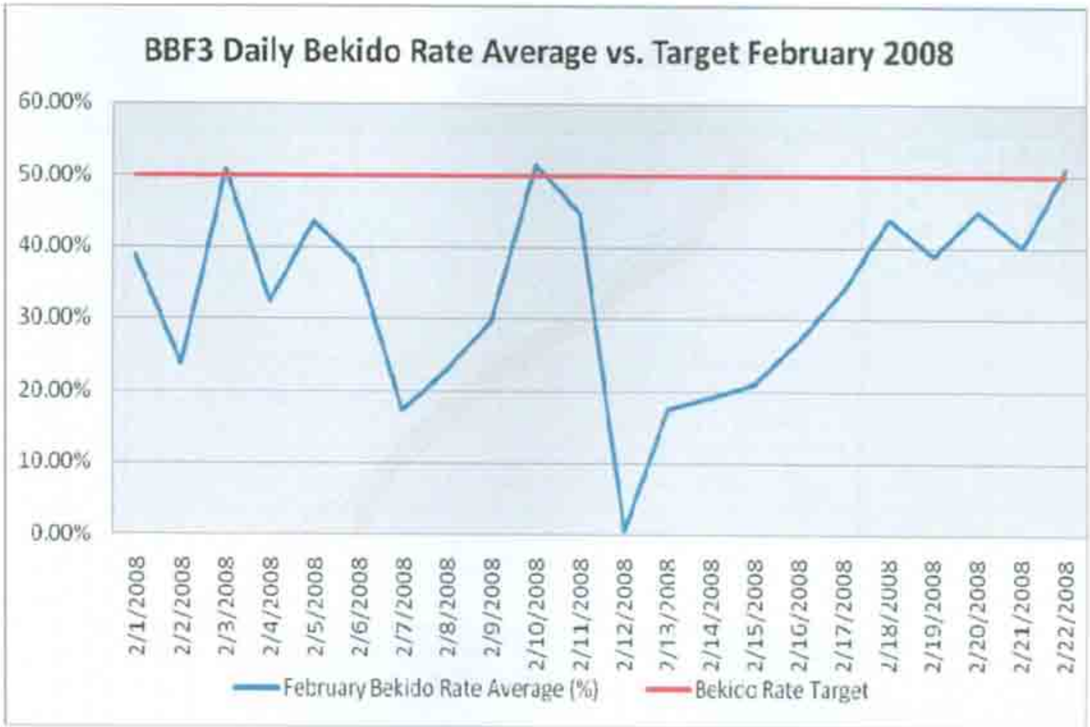

Figure 3.2-4. BBF3 Daily Bekido Rate Average vs. Target February 2008

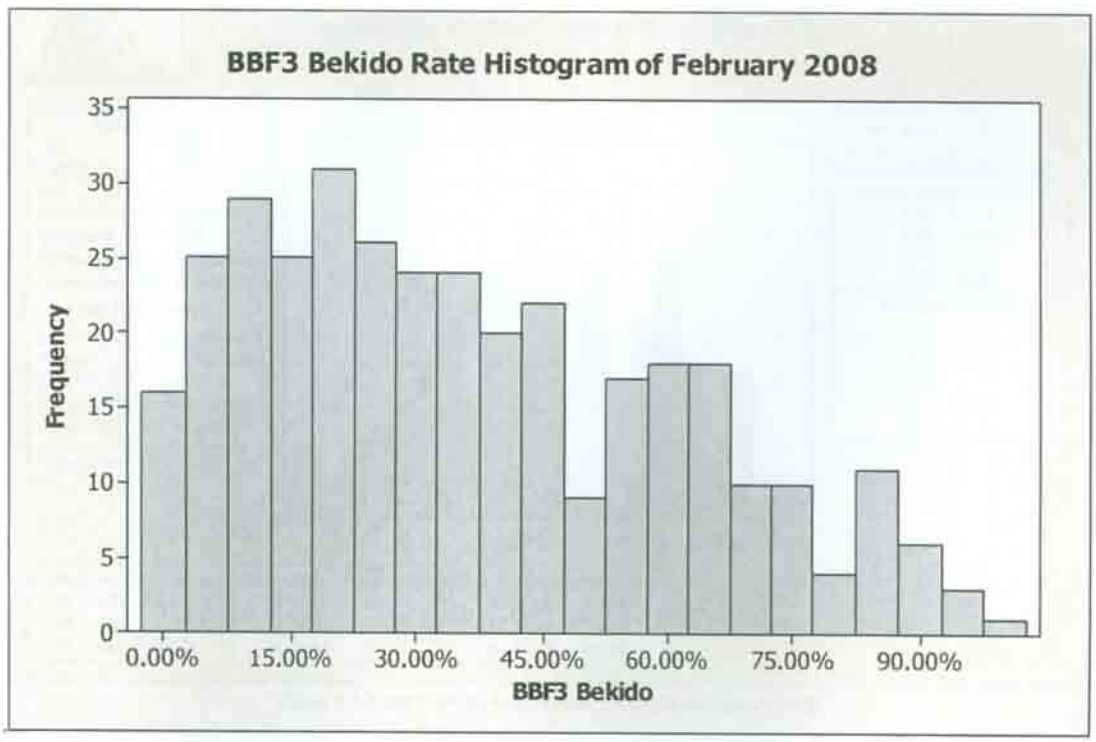

Figure 3.2-5. BBF3 Bekido Rate Histogram of February 2008

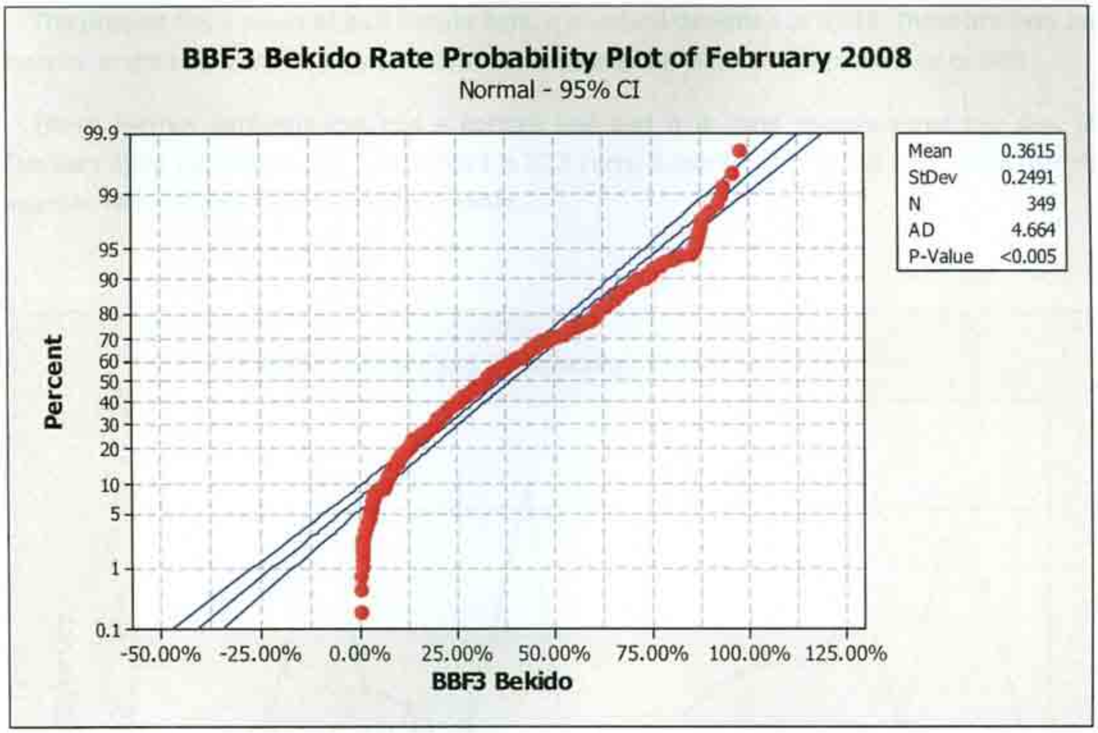

Figure 3.2-6. BBF3 Bekido Rate Probability Plot of February 2008

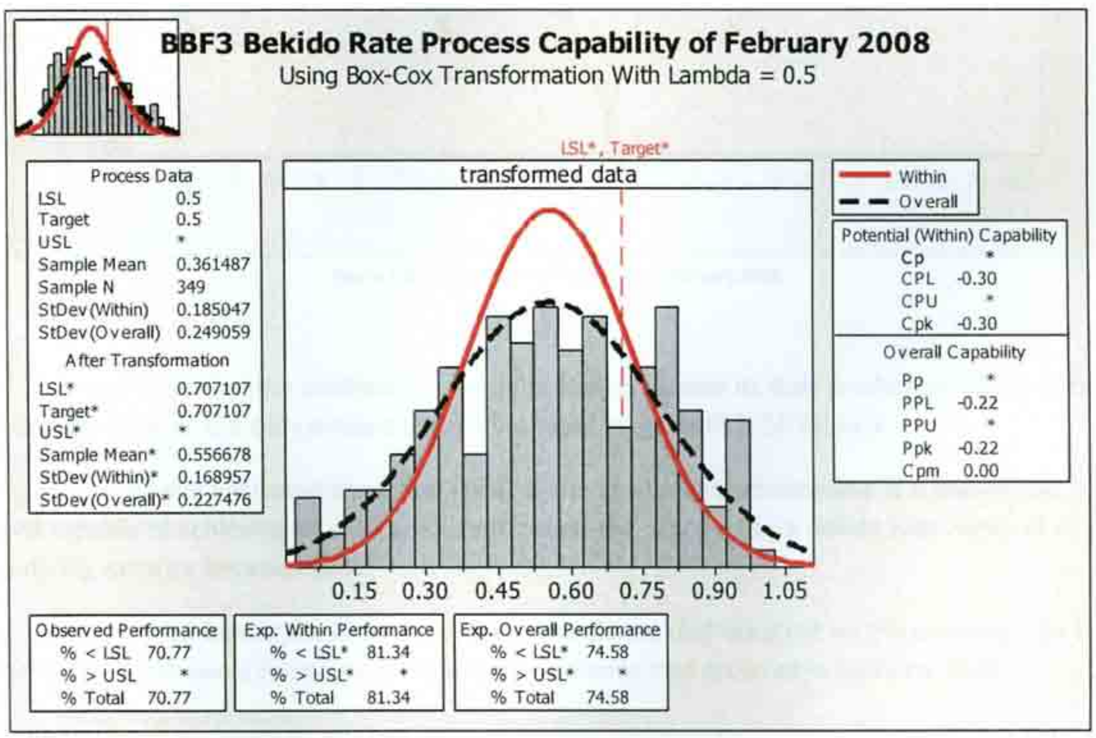

Figure 3.2-7. BBF3 Bekido Rate Process Capability of February 2008

The process has a mean of 36% Bekido Rate, a standard deviation of 0.249. These are very bad metrics. In the scope of this project consist of increasing the mean of the process up to 50%.

These metrics performances had a bottom line and it is carts manufactured per day. On February 2008 the daily ticket for the BBF3 is 27.3 carts, it can be seen in the next figure that the machine was not able to achieve that number.

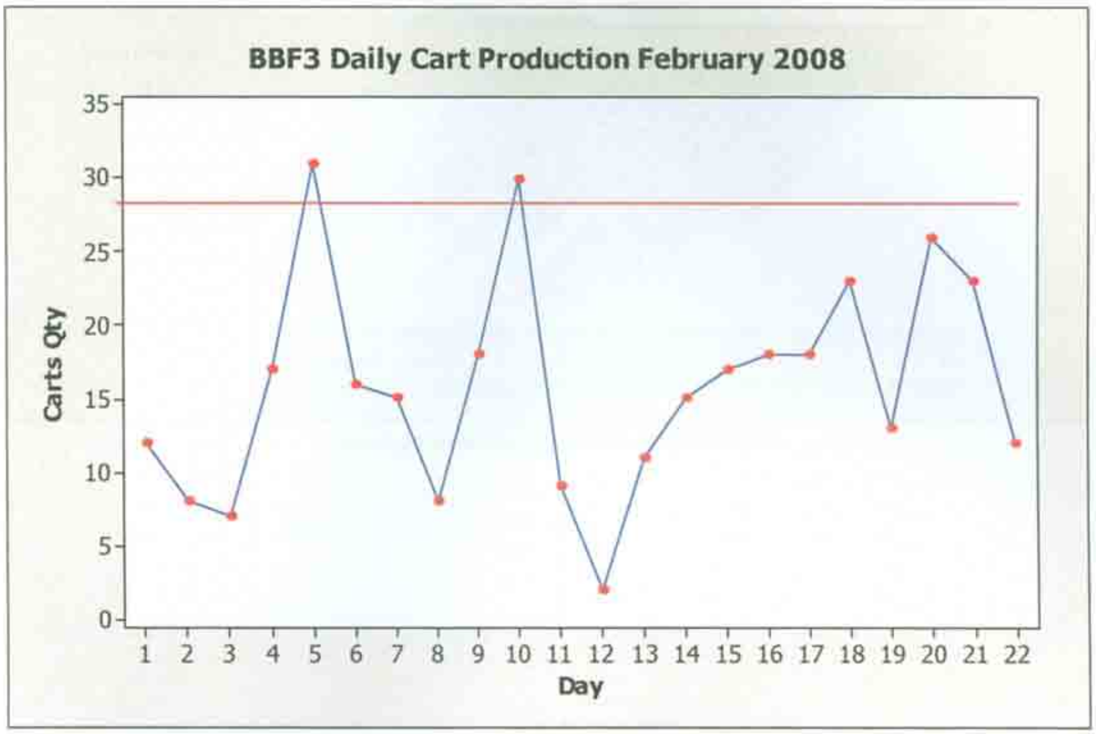

Figure 3.2-8. BBF3 Daily Cart Production February 2008

It is very clear that the machine has not been able to achieve its daily production ticket. At this time the mean of the daily amount of carts produced in the BBF3 is 15.86 carts.

So far we have measured the actual status of the bead manufacturing line. It is known that it is not capable of achieving its daily production ticket; the process has a Bekido Rate mean of 36 % with big variance between carts.

As mentioned before the BBF3 also records the alarms that occurred on the machine. On the next figure is shown a Pareto chart analysis of the alarms that occurred in February 2008.

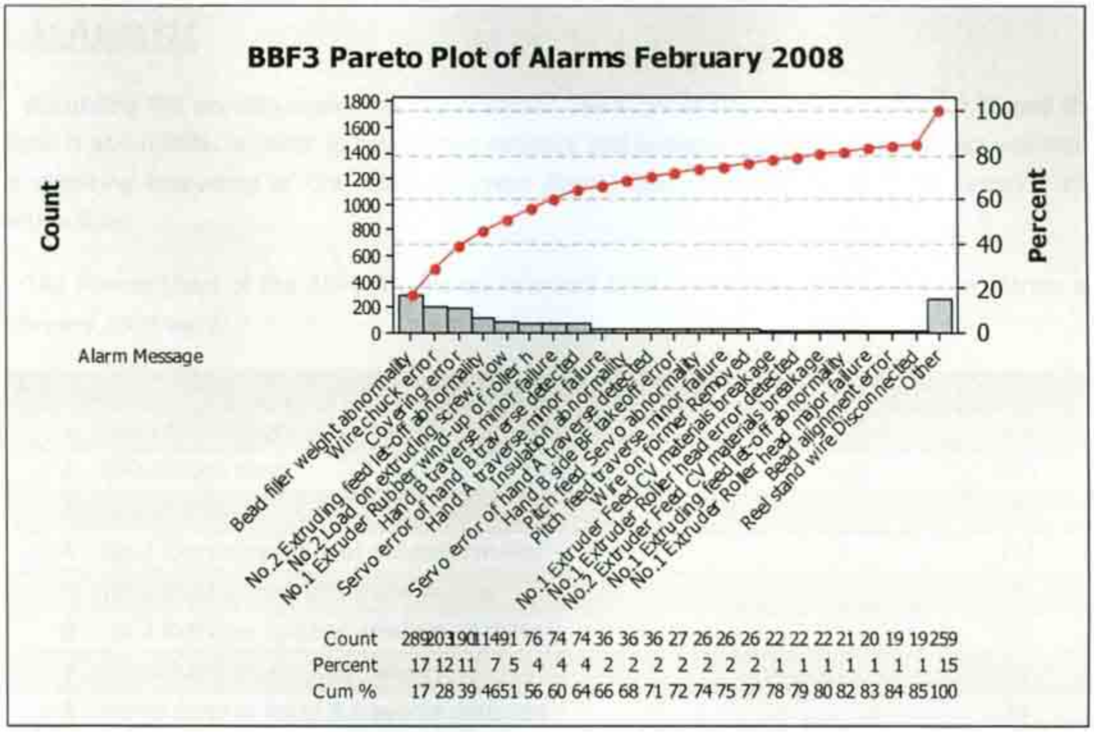

Figure 3.2-9. BBF3 Pareto Plot of Alarms **February** 2008

3.3: ANALYZE

According the process capability, the standard deviation of the process is about 0.25 and the mean is about 36%. In order to reduce the variance and increase the mean, this project will focus on reducing frequency of the most recurrent alarms that stop the process and decrease the Bekido Rate.

The Pareto chart of the **BBF3 Alarms on February 2008** shows that most recurrent alarms on February 2008 were:

Top	Alarm	Counts
1	Bead filler weight abnormality	289
2	Wire chuck error	203
3	Covering Error	190
4	No.2 Extruding feed let-off abnormality	114
5	No.2 Load on extruding screw: Low	91
6	No.1 Extruder Rubber wind-up of roller h	76
7	Hand B traverse minor failure	74
8	Servo error of hand B traverse detected	74

Table 3.3-1. BBF3 Top 8 Alarms February 2008

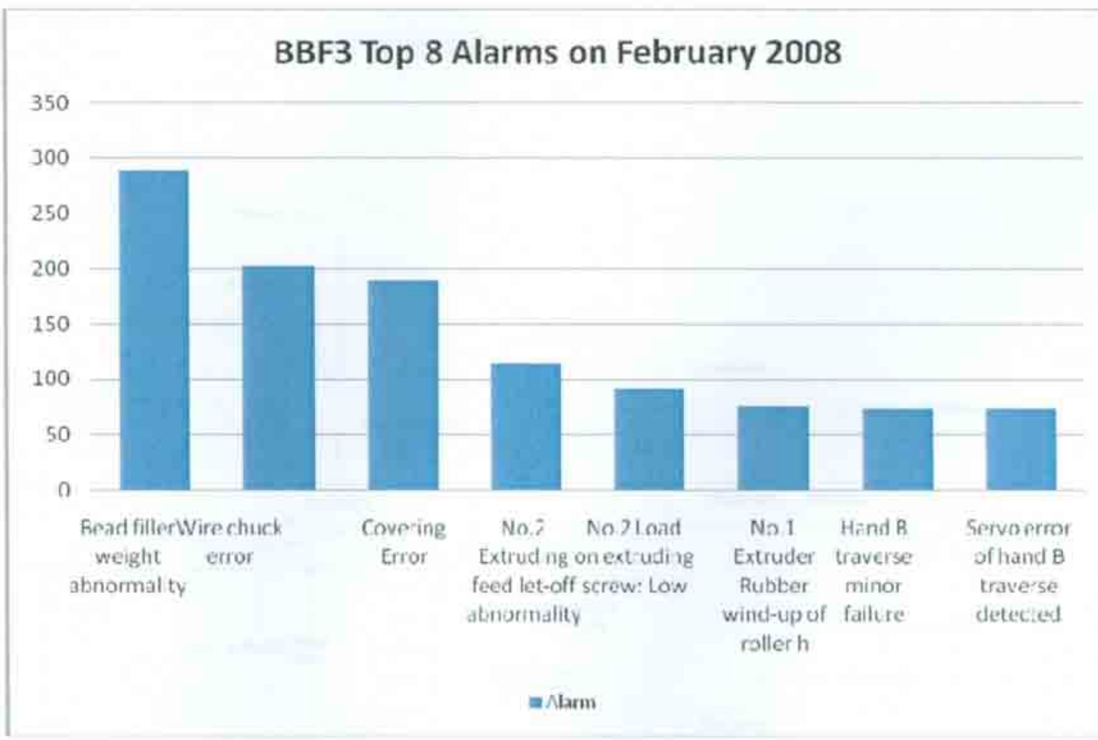

Figure 3.3-1. BBF3 Top 8 Alarms on February 2008

Cause and effect analysis of the Alarms

Bead filler weight abnormality

Bead filler weight abnormality						
1 = very low or none 2 = low or minor 3 = moderate or insignificant 4 = high 5 = very high or catastrophic						
No.	Causes	Jose Flores	Abraham Cantu	Gilberto Gonzalez	Operator	Total
1	Personnel Experience	2	2	3	3	**36**
2	Visual Checkups	1	2	1	1	2
3	Temperature Checkups	1	1	1	1	1
4	Material Lamination Compound Condition	3	2	1	1	6
5	Bead Weight OK	1	1	1	2	2
6	Weight Meter Calibration	3	2	5	3	**90**
7	Product Weight Parameters	1	1	1	1	1
8	Extruder Temperature of Screw	2	2	2	2	16
9	Extruder Temperature of Cylinder	2	1	2	2	8
10	Extruder Temperature of Roller Head	3	1	2	3	18
11	Bead Filler Take up Device Gripper Chuck	3	1	2	1	6
12	Weight Meter Stability Time	4	1	2	1	8
13	Weight Meter Accuracy	2	4	1	2	16
14	Hand B Pickup Position Damage Bead Filler	4	3	3	5	**180**

Table 3.3-2. BBF3 Bead Filler Weight Abnormality Causes Matrix

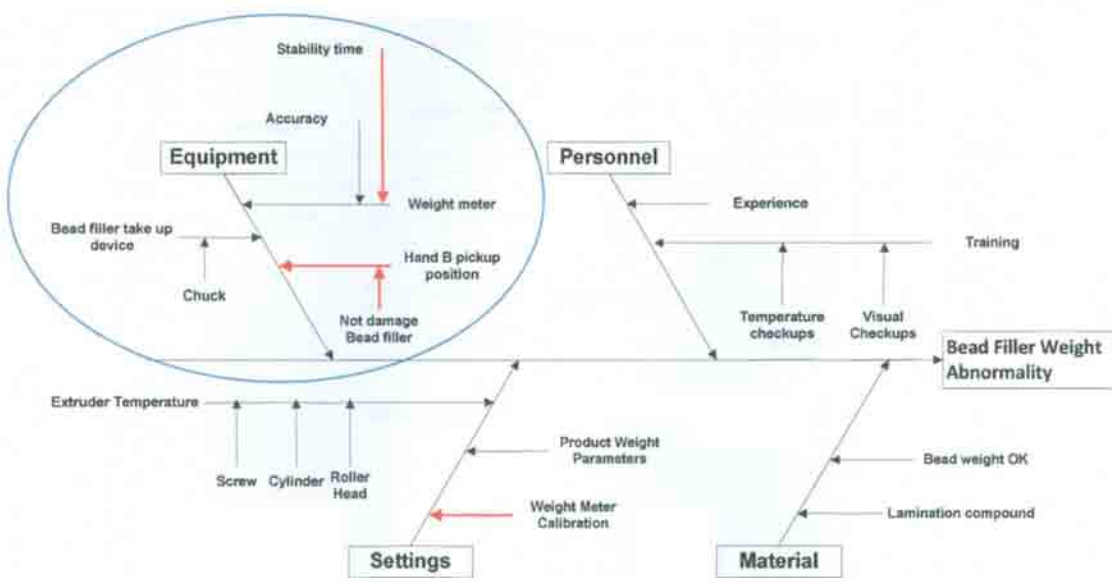

Figure 3.3-2. Bead Filler Weight Abnormality Cause and Effect Diagram

Wire chuck error

Wire Chuck Error						
1 = very low or none 2 = low or minor 3 = moderate or insignificant 4 = high 5 = very high or catastrophic						
No.	Causes	Jose Flores	Abraham Cantu	Gilberto Gonzalez	Operator	Total
1	Personnel Experience	1	1	1	1	1
2	Visual Checkups	2	1	1	1	2
3	Bead Wire Condition	1	1	1	1	1
4	Bead Wire Thickness	1	1	1	1	1
5	Insulation Compound Application OK	4	3	2	4	96
6	Insulation Compound Stickiness	2	1	1	2	4
7	MW Extruder Temperature	2	1	1	1	2
8	Wire Festoon Pressure	1	1	1	1	1
9	MW Former Alignment	1	2	2	3	12
10	Pitch Feeder Alignment	3	2	4	3	72
11	Magnets Alignment	2	3	3	3	54
12	Pitch Roller Alignment	4	4	3	2	96
13	Wire Chuck Tooling	1	1	1	1	1
14	Magnets Tooling	4	3	3	2	72
15	Pitch Roller Tooling	4	3	3	2	72

Table 3.3-3. BBF3 Wire Chuck Error Causes Matrix

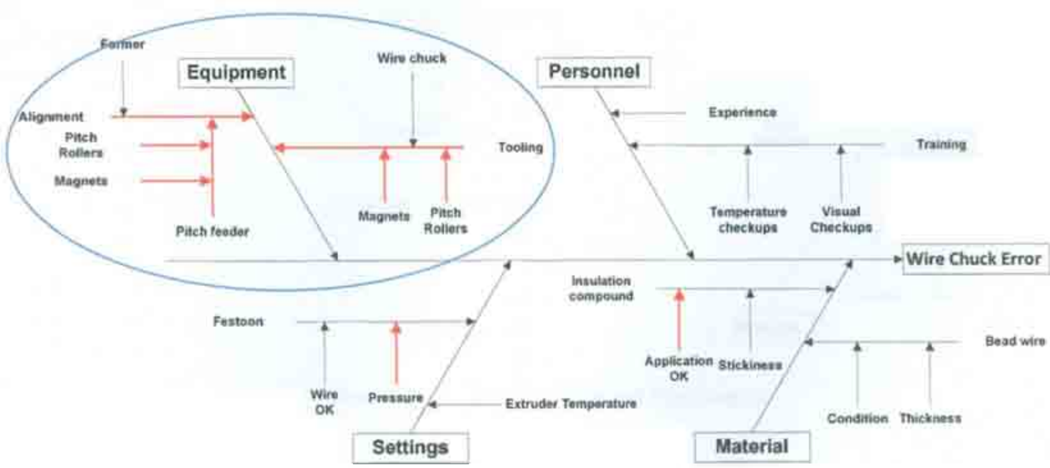

Figure 3.3-3. Wire Chuck Error Cause and Effect Diagram

Covering Error

Covering Error						
1 = very low or none 2 = low or minor 3 = moderate or insignificant 4 = high 5 = very high or catastrophic						
No.	Causes	Jose Flores	Abraham Cantu	Gilberto Gonzalez	Operator	Total
1	Personnel Experience	1	1	1	1	1
2	Personnel Visual Checkups	2	1	1	2	4
3	Covering Tape Condition	1	1	1	1	1
4	Covering Tape Size	1	1	1	1	1
5	Covering Tape Size Selected	1	1	1	1	1
6	Covering Tape Number of Turns	4	4	4	4	256
7	Winding Festoon Limits	4	3	4	4	192
8	Winding Number of Turns	4	4	4	4	256
9	Bead Position Up And Down Guide	1	3	1	1	3

Table 3.3-4. Covering Error Causes Matrix

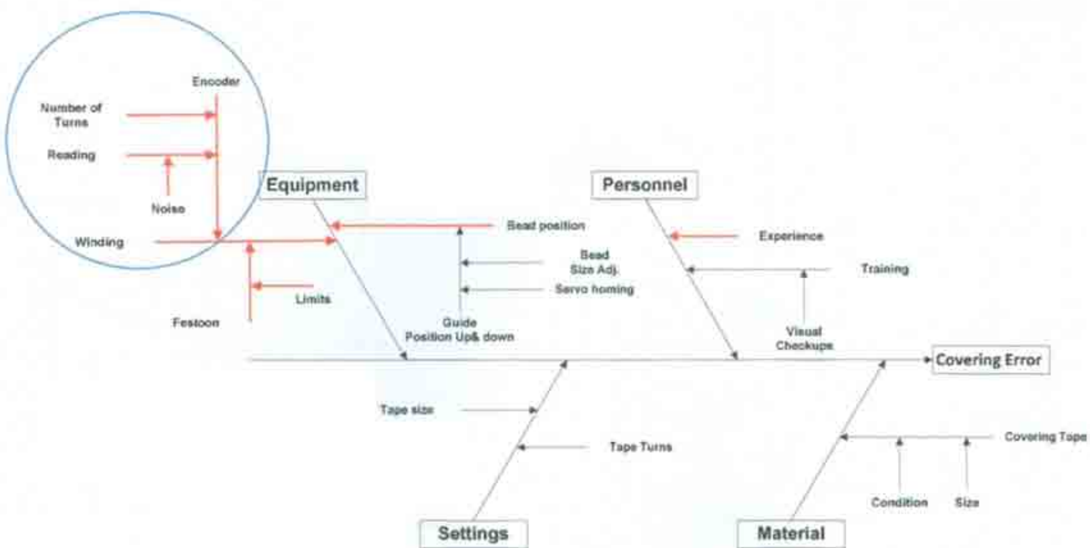

Figure 3.3-4. Covering Error Cause and Effect Diagram

No.2 Extruding feed let-off abnormality

No. 2 Extruding Feed Let-off Abnormality						
1 = very low or none 2 = low or minor 3 = moderate or insignificant 4 = high 5 = very high or catastrophic						
No.	Causes	Jose Flores	Abraham Cantu	Gilberto Gonzalez	Operator	Total
1	Personnel Experience	3	4	2	3	72
2	Personnel Visual Checkups	3	4	2	3	72
3	Lamination Compound Feed Cut	4	4	4	4	256
4	Lamination Compound Reel Winding	3	3	3	3	81
5	Lamination Extruder Pressure	1	2	1	1	2
6	Lamination Extruder Speed	1	1	1	1	1
7	Feed Conveyor Motor Speed	1	1	1	1	1
8	Feed Conveyor Applies to Much Friction to Material	4	3	4	3	144

Table 3.3-5. No.2 Extruding Feed Let-off Abnormality Causes Matrix

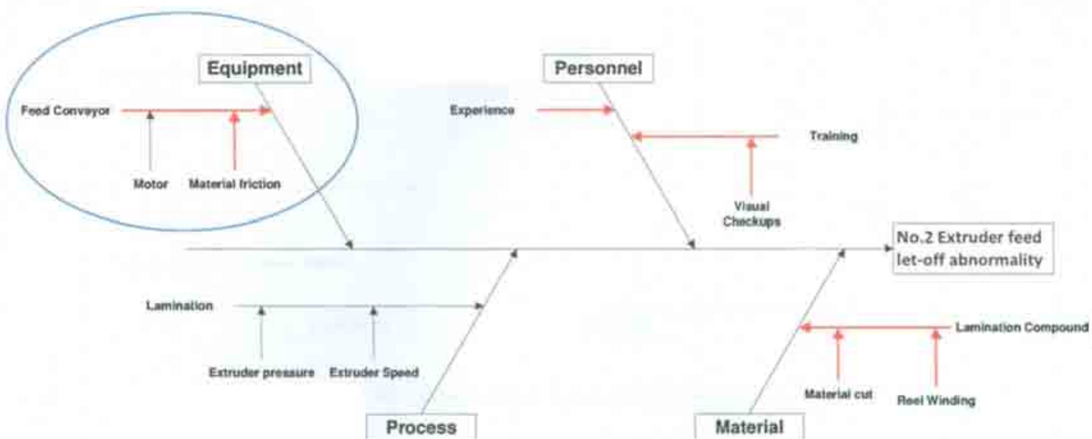

Figure 3.3-5. No. 2 Extruder Feed Let-off Abnormality Cause and Effect Diagram

No.2 Load on extruding screw: Low

No. 2 Load on Extruding Screw: Low						
1 = very low or none 2 = low or minor 3 = moderate or insignificant 4 = high 5 = very high or catastrophic						
No.	Causes	Jose Flores	Abraham Cantu	Gilberto Gonzalez	Operator	Total
1	No. 2 Extruding Feed Let-off Abnormality	5	5	5	5	625
2	Screw Pressure Sensor Malfunction	1	1	1	1	1
3	Screw Speed Malfunction	1	1	1	1	1

Table 3.3-6. No.2 Load on Extruder Screw Low Causes Matrix

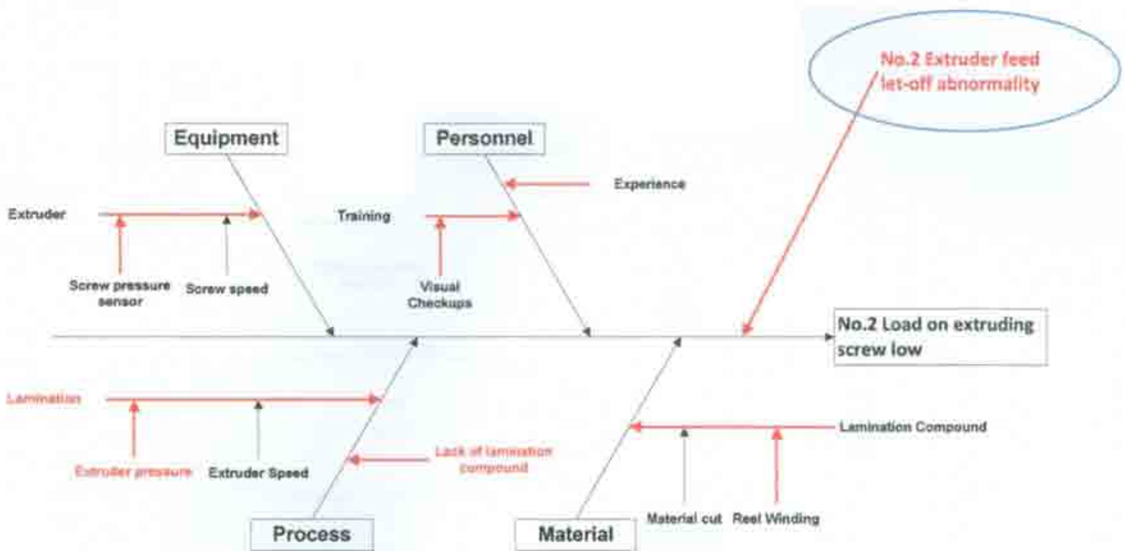

Figure 3.3-6. No.2 Load on Extruding Screw Low Cause and Effect Diagram

No.1 Extruder Rubber wind-up of roller h

No. 1 Extruder Rubber Wind-up of Roller H						
1 = very low or none 2 = low or minor 3 = moderate or insignificant 4 = high 5 = very high or catastrophic						
No.	Causes	Jose Flores	Abraham Cantu	Gilberto Gonzalez	Operator	Total
1	Personnel Experience	1	1	1	1	1
2	Personnel Visual Checkups	1	1	1	1	1
3	Lamination Compound Condition	1	1	1	1	1
4	Roller Head Motor Speed	2	3	3	2	36
5	Roller Head Rollers Temperature	3	4	4	3	144
6	Roller Head Motor Condition	2	2	2	2	16
7	Roller Head Gear Condition	4	4	4	4	256
8	Roller Condition	4	4	4	4	256

Table 3.3-7. No.1 Extruder Rubber Wind-up of Roller H Causes Matrix

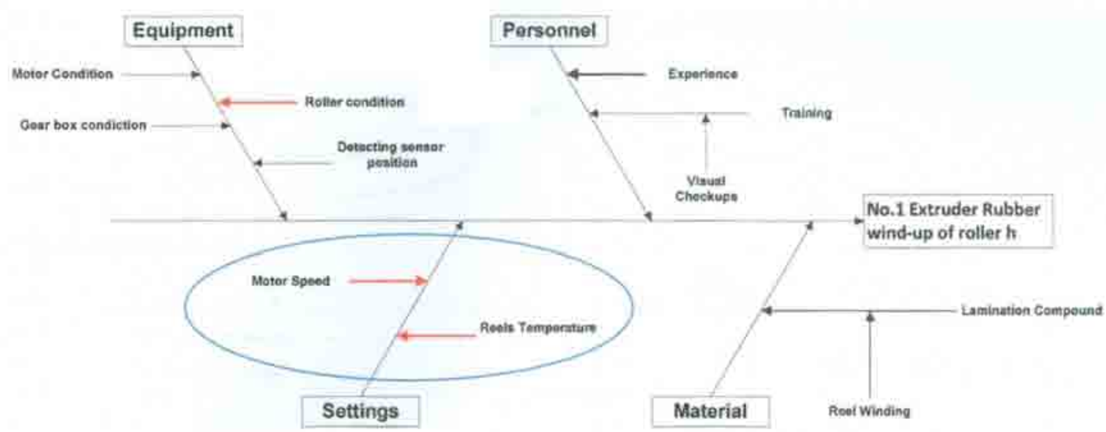

Figure 3.3-7. No.1 Extruder Rubber wind-up of roller h Cause and Effect Diagram

Hand B traverse minor failure

Hand B Traverse Minor Failure						
1 = very low or none 2 = low or minor 3 = moderate or insignificant 4 = high 5 = very high or catastrophic						
No.	Causes	Jose Flores	Abraham Cantu	Gilberto Gonzalez	Operator	Total
1	Personnel Experience	1	1	1	1	1
2	Personnel Visual Checkups	1	1	1	1	1
3	Servo Motor Maximum Torque	2	1	3	1	6
4	Servo Motor Acceleration Curves	1	1	1	1	1
5	Servo Motor Positioning Malfunction	3	1	1	1	3
6	Servo Motor Condition	1	1	1	1	1
7	Gear Box Condition	1	1	1	1	1
8	Mechanic Hindrance or Obstruction	3	2	3	4	72
9	Motor Band Tension too Low or High	2	2	1	1	4

Table 3.3-8. Hand B Traverse Minor Failure Causes Matrix

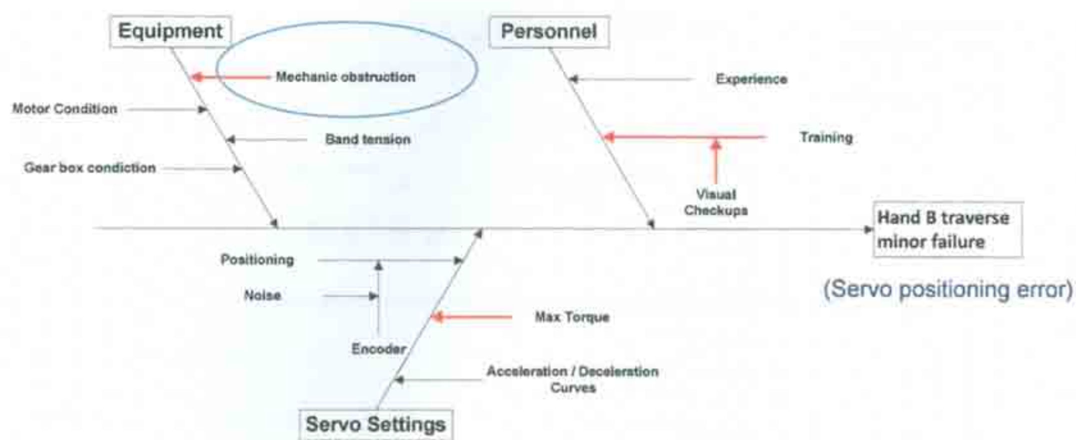

Figure 3.3-8. Hand B traverse minor failure Cause and Effect Diagram

Servo error of hand B traverse detected

Servo Error of Hand B Traverse Detected						
1 = very low or none 2 = low or minor 3 = moderate or insignificant 4 = high 5 = very high or catastrophic						
No.	Cause	Jose Flores	Abraham Cantu	Gilberto Gonzalez	Operator	Total
1	Hand B Traverse Minor Failure	5	5	5	5	625

Table 3.3-9. Servo Error Hand B Traverse Detected Causes Matrix

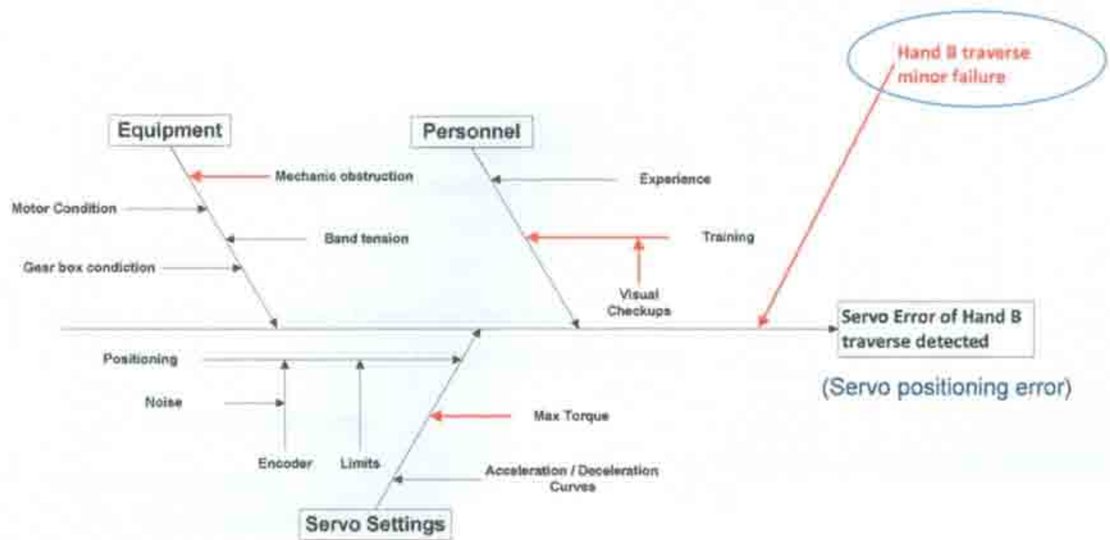

Figure 3.3-9. Servo Error Hand B traverse detected Cause and Effect Diagram

3.4: IMPROVE

Bead filler weight abnormality

Team consensus. Items found on the field

1. Hand B pickup position damage bead filler. (Cutting some rubber)
2. Weight meter not return to zero after measuring.

Countermeasures

1. Hand B re-homing.
2. Hand B chuck segments re-alignment.
3. Weight meter re-calibration.
4. Operator to visual inspect weight meter when this alarm occurs again. If it does not return to zero call maintenance to re-calibrate.

Wire chuck error

Team consensus. Items found on the field

1. Misalignment between former and pitch feeder.
2. Pitch rollers damage.

Countermeasures

1. Pitch feeder re-alignment according to former position.
    a. In/out servo motor.
2. Replace pitch rollers.
3. Re-alignment of pitch rollers.
4. Re-alignment of magnets.

Covering Error

Team consensus. Items found on the field

1. Number of turns applied to the bead is incorrect. (using the upper side tapes)

    a. Noise on power supply of the high speed counter of the encoder is making impossible to read the number of turns applied.

    b. The festoon upper limit is activated.

Countermeasures

1. Use a different 24 volt power supply for the high speed counter.

No.2 Extruding feed let-off abnormality & No.2 Load on extruding screw: Low

Team consensus. Items found on the field

1. The feed conveyor is making friction with the lamination compound when feeding the extruder # 2 hopper, breaking the compound.

2. If the compound is broken the extruder load decreases.

Countermeasures

1. Change the position of the feed conveyor aligning it to the extruder # 2 hopper reducing the friction of the lamination compound.

No.1 Extruder Rubber wind-up of roller h

Team consensus. Items found on the field

1. Speed of the reel rotation is very slow.

2. The condition of the roller head is not very good, we recommend replacing as soon as possible.

Countermeasures

1. Increase 20 % the speed of the motor.

Hand B traverse minor failure & Servo error of hand B traverse detected

Team consensus. Items found on the field

1. Hand B chucks segment touches the lamination plate guard, when the lamination plate rotates to the extruder side. This has been happening for a while because the guard of the lamination plate has a big scratch mark.
    a. This misaligns the hand B chuck segments. (Bead filler weight abnormality)
    b. This makes the torque of the servo motor to go high and fault the servo drive.

Countermeasures

1. Re-locate the guard of the lamination plate, avoiding the contact with the hand B.

Implementation finished on March 16. After the implementation we again measured the alarms occurred in the remaining time of the month of March, getting the next data.

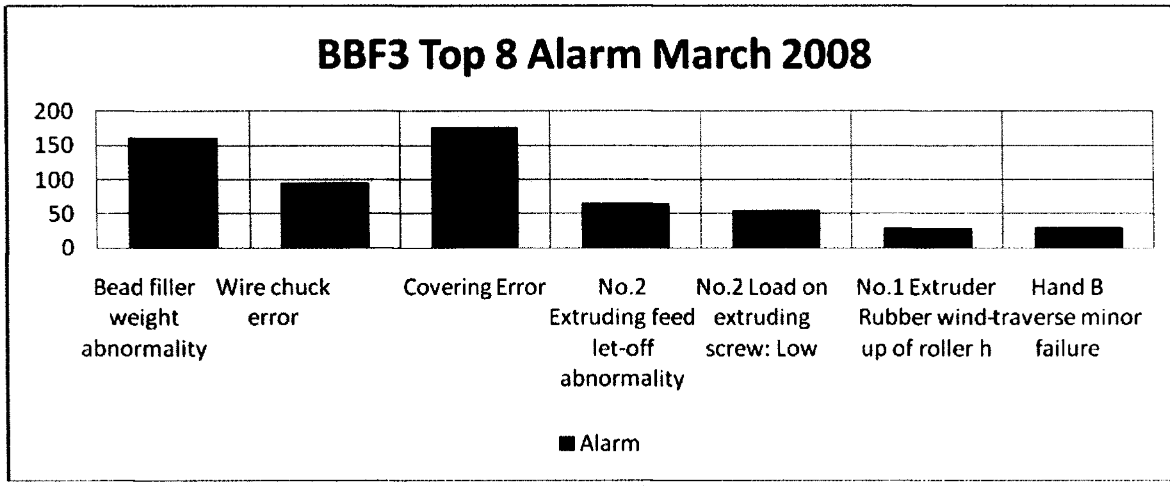

Figure 3.4-1. BBF3 Top 8 Alarm of March 2008

The data shows that the alarms seleced for this implementation did reduce after the implementation. Although the data collected only represests the alarms ocurred after the implementation, that is after March 16.

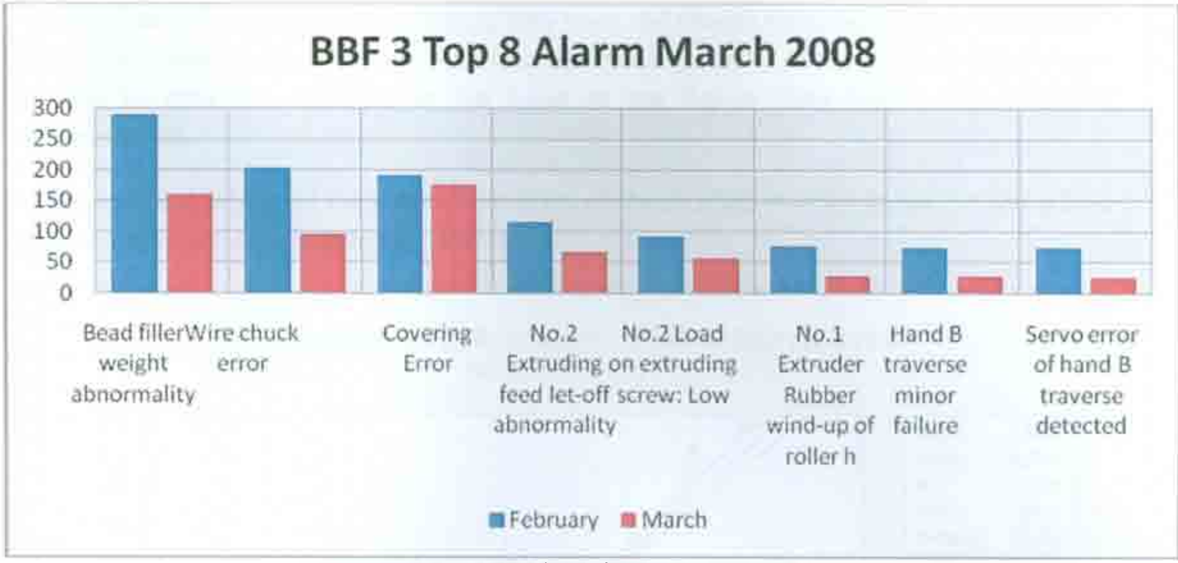

Figure 3.4-2. BBF3 Top 8 Alarm February vs. March 2008

So far, that the alarm frequency reduced from February to March. By reducing the alarm frequency it is intended to increase the Bekido Rate up to 50 %. Bekido Rate data of March 2008 was collected and filtered by day Bekido Rate average.

The next figure shows how the Bekido Rate by day average behavior in March before and after the implementation.

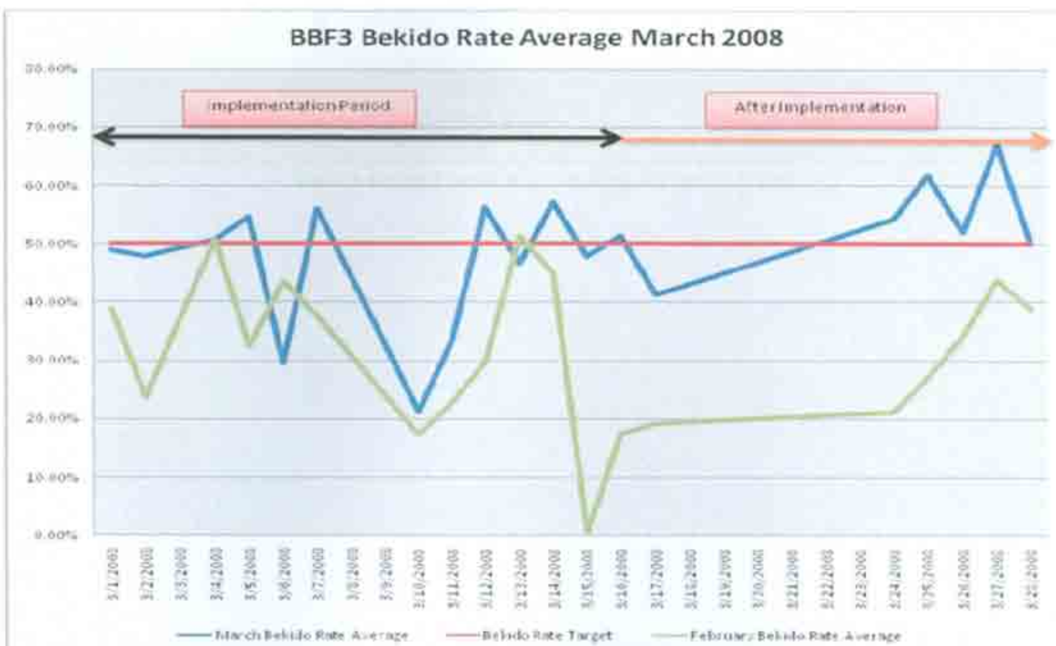

Figure 3.4-3. BBF3 Daily Bekido Rate Average of March 2008

As it can be seen in this figure the Bekido Rate trend did change from the month of Februaty to the month of March, the average did shift up the the target point of 50 % Bekido Rate. Is also importat to note the diference in the trend of the Bekido Rate before and after the implementation.

Now lets calclulate again the process capalbility of March 2008, in order to see if it was achive edor not the target: 50 % Bekido Rate average.

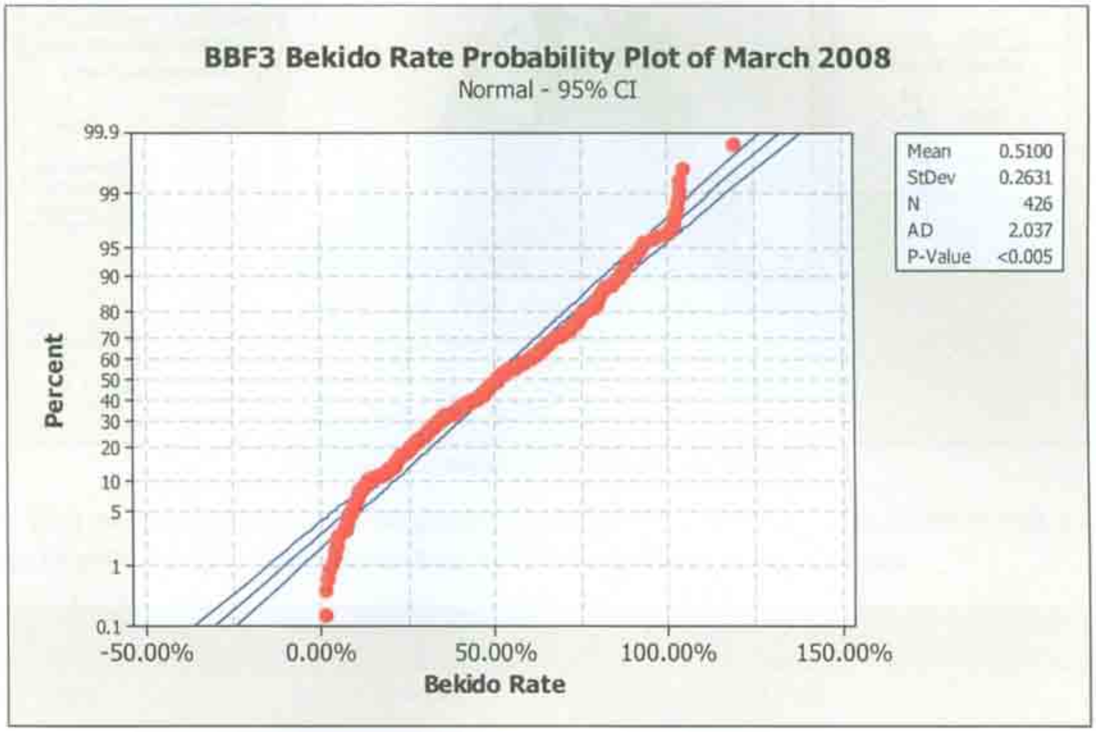

Figure 3.4-4. BBF3 Bekido Rate Probability Plot of March 2008

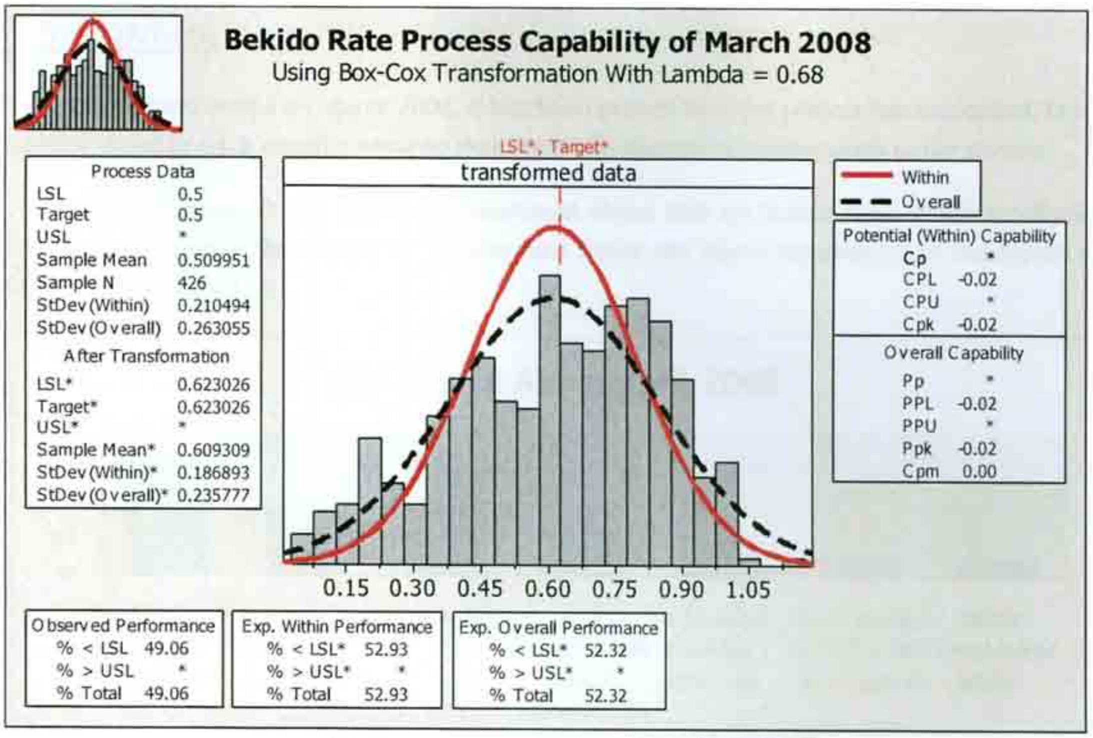

Figure 3.4-5. BBF3 Bekido Rate Process Capability of March 2008

With the information given by the process capability analysis of Bekido Rate in March 2008, it can be seen that the mean of Bekido Rate is 50.9% the standard deviation is. 263.

	February	March
Average	36.14%	50.99%
Std Dev.	.249	.263

Table 3.4-1. BBF3 Metrics Comparison February vs. March 2008

Based on this data it is agreed that the implementation did have an impact on the Bekido Rate sufficient enough to achieve the target of 50% Bekido Rate.

3.5: CONTROL

Improve phase ended on March 2008, it has been proved that this project has succeeded, but it must be maintained, it must be ensured that the implementation is maintained under control.

It has been shown that 8 alarms can represent about 15% on Bekido Rate, which is why we must closely monitor their behavior. On the next figure the alarm occurrences of the month of April 2008 are shown.

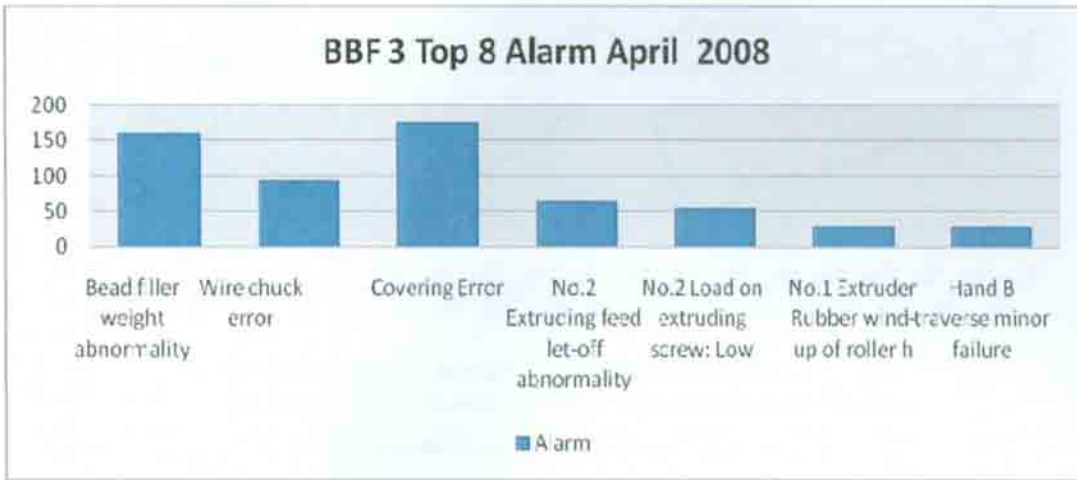

Figure 3.5-1. BBF3 Top 8 Alarm of April 2008

Now let's review the occurrences of the alarms from the beginning to the end of the project.

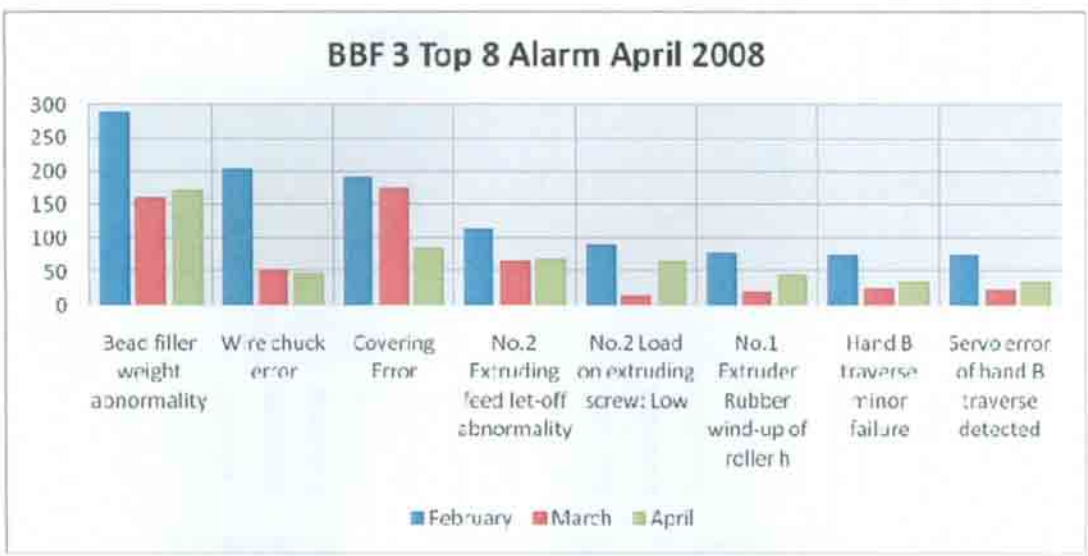

Figure 3.5-2. BBF3 Top 8 Alarm of February vs. March vs. April 2008

The last figure shows that the implementation did have an impact reducing the alarm occurrences on March and it continues the same way on April 2008.

Beside monitoring the occurrences of those 8 alarms we must monitor our main metric, the Bekido Rate. In the next figure we show the Bekido Rate obtained in April 2008.

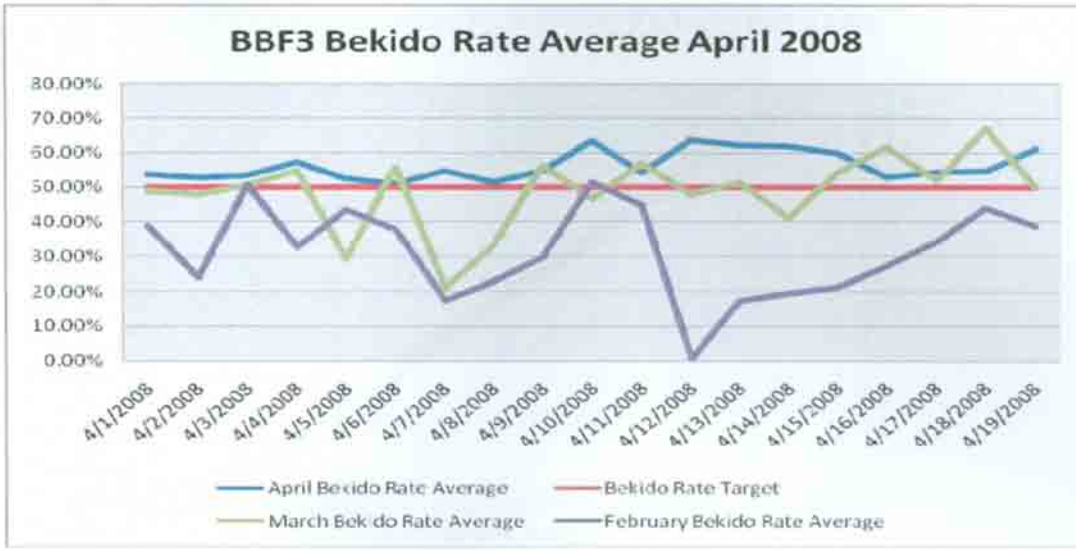

Figure 3.5-3. BBF3 Daily Bekido Rate Average of April 2008

This last figure shows that the Bekido Rate has been maintained above our target of 50%. Now lets review the progress of the Bekido Rate from the beginning of the project to the end.

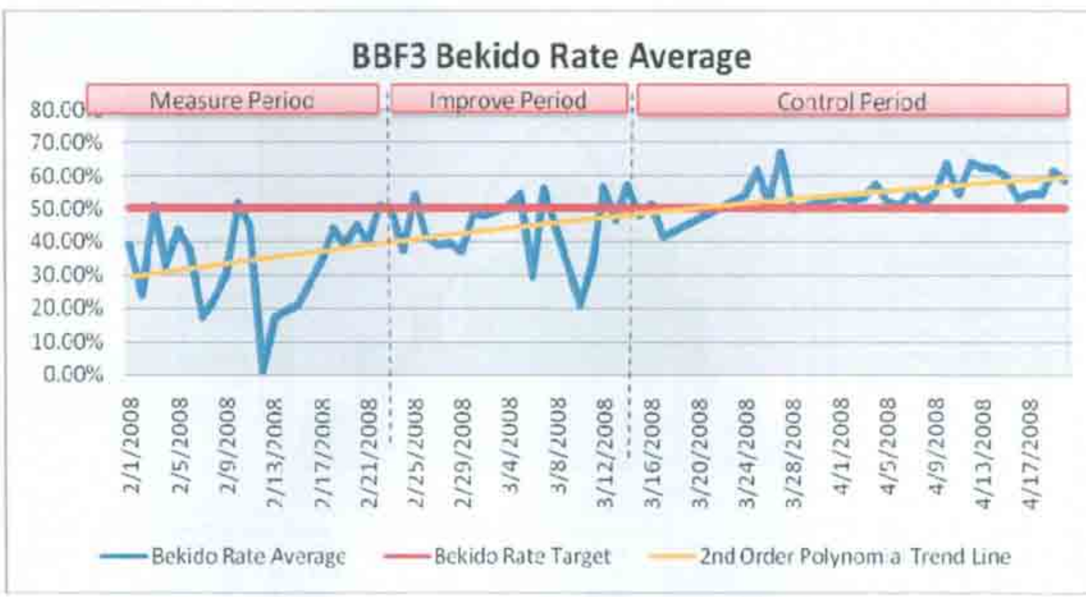

Figure 3.5-4. BBF3 Daily Bekido Rate Average from February to April 2008

On the previous figure a trend line was plotted that shows how our metric had behaved in the last two months and it also gives a little projection of the next periods, If the alarms are maintained under control. Once more let's review the process capability now on the month of April 2008.

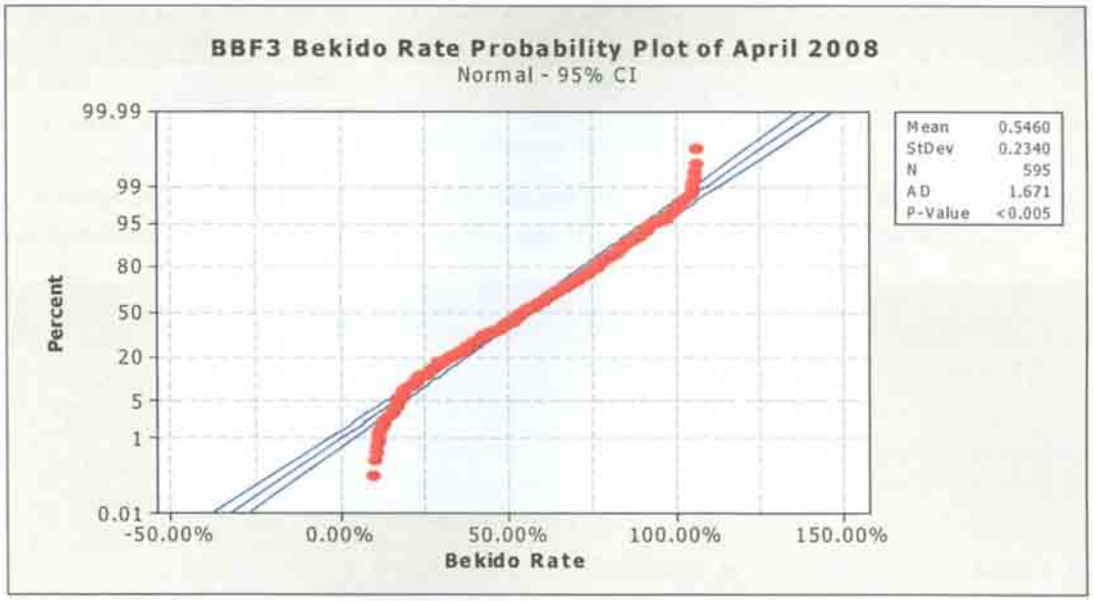

Figure 3.5-5. BBF3 Bekido Rate Probability Plot of April 2008

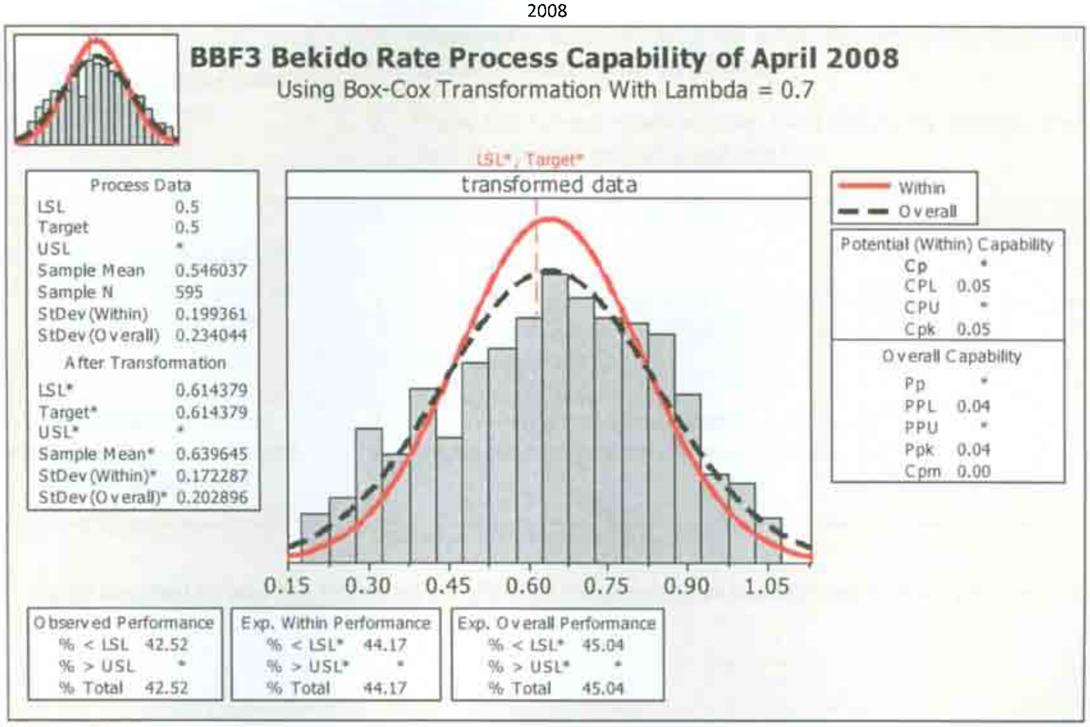

Figure 3.5-6. BBF3 Bekido Rate Process Capability of April 2008

With the information given by the process capability analysis of Bekido Rate in April 2008, it can be seen that the mean of Bekido Rate is now 54.6% the standard deviation is 0.234.

	February	March	April
Average	36.14%	50.99%	54.6%
Std Dev.	.249	.263	.234

Table 3.5-1. BBF3 Metrics Comparison February vs. March vs. April 2008

In order to control the alarm levels there actions must be taken to prevent their occurrences. It was decided to include the following activities into the operator's start of shift (SOS):

Alarm	Operator SOS Activities
Bead filler Weight Abnormality	1. Measure the temperature of the extruder after restarting from a stop period bigger than 20 minutes. 2. Verify the Weight Meter shows "0" when there is no bead filler at it. If it is not Zero, press the Zero Calibration button and verify that it turns to Zero. 3. Use 200 gr. calibrated block to verify the weight displayed is 200 gr. (± 2gr). If it is not ask maintenance to calibrate the Weight meter.
No.1 Extruder Rubber wind-up of roller h	1. Measure the temperature of the roller head after restarting from a stop period bigger than 20 minutes. 2. Probe the correct rotation roller head rollers, by rotating them, they should do it smoothly and balanced.
No.2 Extruding feed let-off abnormality & No.2 Load on extruding screw: Low	1. Verify that there is not rubber stuck in the rollers of the Feed Conveyor. 2. Probe the correct rotation of the rollers by spinning them by hand, they should rotate smoothly. If one or more do not, report to maintenance.
Hand B traverse minor failure & Servo error of hand B traverse detected	1. Visually verify that there is not an evident obstruction in the way of the Hand B traverse movement. If there is, report to maintenance.

Table 3.5-2. SOS Activities added April 2008

It was decided to add the following activities to the preventive maintenance (PM) routines:

Alarm	Maintenance PM Activities
Bead filler Weight Abnormality	1. Verify the Weight Meter shows "0" when there is no bead filler at it. If it is not Zero, press the Zero Calibration button and verify that it turns to Zero. 2. Use 200 gr. calibrated block to verify the weight displayed is 200 gr. (± 2gr). If it is not, proceed to calibrate the weight meter. 3. Bolt tightening of the take up device base. 4. Verify the homing of the Hand B device.
No.1 Extruder Rubber wind-up of roller h	1. Clean, lubricate and inspect the roller head gears and chain. If bad, replace. After replacing any parts of the roller head homing must be done and verified.
No.2 Extruding feed let-off abnormality & No.2 Load on extruding screw: Low	1. Verify that there is not rubber stuck in the rollers of the Feed Conveyor, if so, clean up and lubricate.
Hand B traverse minor failure & Servo error of hand B traverse detected	1. Bolt tightening of the guards around the way of the Hand B traverse; Lamination Plate A (A & B side) and Lamination plate B (A& B side)
Wire chuck error	1. Visually inspect the condition of the roller pitch, magnets and nylon roller. If bent, fix if possible or replace if needed. 2. Verify the alignment of the roller pitch, magnets, and nylon rollers again specification. If alignment is out specification proceed to re-homing.

Table 3.5-3. PM Activities added April 2008

It is believed that including these activities, into the production and maintenances routines, the alarm occurrences is going to be maintained under control, the bottom line is, that our metric, the Bekido Rate is going to be maintained in our target of 50%.

These activities were included in the FMEA analysis. In the FMEA it can be pondered which alarms have a bigger impact in our process, making it possible to prioritize them. The FMEA is shown in the next tables.

FAILURE MODE AND EFFECTS ANALYSIS (FMEA)

Process Name: BBF3
Prepared by: José Flores

FMEA Date: 04/30/08

Page 1/3

1 = very low or none 2 = low or minor 3 = moderate or insignificant 4 = high 5 = very high or catastrophic

Alarm Name	Potential Failure Mode	Potential Failure Effects	SEVERITY	Potential Causes	OCCURRENCE	Current Control	DETECTION	RPN	Actions Rec.	Resp.	Actions Taken	SEVERITY	OCCURRENCE	DETECTION	RPN
Bead filler weight abnormality	The product weight is out of tolerance	The weight of the bead filler is to low or to high making the product scrap	4	Extruder temp. out of spec	3	System Alarm	1	**12**	Include into the Op. Procedures: Measure the temp. of the extruder after restarting from a stop period	Operator					
			4	Bead filler take up device vibration	1	System Alarm	1	**4**	Include into the PM activities: Bolt tightening of the base	Maintenance					
Wire chuck error	The monowire cannot hold the bead wire	The bead cannot be made	4	The alignment of the tooling is not correct	2	System Alarm	1	**8**	Include into the PM activities: Inspect alignment of the tooling against design specs.	Maintenance					

Table 3.5-4. FMEA page 1/3 April 2008

FAILURE MODE AND EFFECTS ANALYSIS (FMEA)

Process Name: BBF3
Prepared by: José Flores

FMEA Date: 04/30/08

Page 2/3

1 = very low or none 2 = low or minor 3 = moderate or insignificant 4 = high 5 = very high or catastrophic

Alarm Name	Potential Failure Mode	Potential Failure Effects	SEVERITY	Potential Causes	OCCURRENCE	Current Control	DETECTION	RPN	Actions Rec.	Resp.	Actions Taken	SEVERITY	OCCURRENCE	DETECTION	RPN
Covering Error	The covering tape is not applied correctly	The bead is not cover with the proper amount of covering tape	4	There is electric noise in the encoder reading	1	System Alarm	1	4	Include into the PM activities: Inspect the quality of the encoder reading	Maintenance					
No.2 Extruding feed let-off abnormality & No.2 Load on extruding screw: Low	Rubber compound feed is broken	The extruder is not fed with rubber compound	3	Feed conveyor rollers rotation malfunction	1	System Alarm	3	9	Include into the SOS: Inspect the correct rotation of the conveyor rollers	Operator					
Hand B traverse minor failure & Servo error of hand B traverse detected	Hand B servo motor is faulted by and over torque alarm	The process is stopped due servo motor alarm	2	There is a mechanic hindrance in the hand B transverse movement	1	System Alarm	1	2	Include into the PM activities: Ensure the correct position of the guards around the hand B transverse movement	Maintenance					

Table 3.5-5. FMEA page 2/3 April 2008

FAILURE MODE AND EFFECTS ANALYSIS (FMEA)

Process Name: BBF3
Prepared by: José Flores

FMEA Date: 04/30/08

Page 3/3

1 = very low or none 2 = low or minor 3 = moderate or insignificant 4 = high 5 = very high or catastrophic

Alarm Name	Potential Failure Mode	Potential Failure Effects	SEVERITY	Potential Causes	OCCURRENCE	Current Control	DETECTION	RPN	Actions Rec.	Resp.	Actions Taken	SEVERITY	OCCURRENCE	DETECTION	RPN
No.1 Extruder Rubber wind-up of roller h	Rubber is stuck in the roller head.	Lamination is not applied correctly	5	Roller head rollers mechanisms is not correct	2	System Alarm	4	**40**	Include into the SOS: Inspect the correct rotation roller head rollers	Operator					
			5	Roller head rollers temperature is not correct	1	System Alarm	4	**20**	Include into the Op. Procedures: Measure the temp. of the roller head rollers after restarting from a stop period	Operator					
			5	Roller head rollers mechanisms is not correct	2	System Alarm	4	**40**	Include into the PM activities: Inspect the function of the roller head gears and chain; If bad replace	Maintenance					

Table 3.5-6. FMEA page 3/3 April 2008

Once these activities are included into the production and maintenance routines, the tables will be complemented.

Chapter 4: Results

The project increased the Bekido Rate of the Bead Manufacturing Line # 3, from 36% to 54.6%. These metrics indicate that the goal of the project was achieve. In order to prove these results it was decided to analyze the data obtained by statistic means.

The two-sample t-test is one of the most commonly used hypothesis tests in Six Sigma work. It will be applied to compare whether the average difference between two samples is really significant or if it is due to random chance instead. This test will help answer whether the average success rate is higher after the implementation of the project than before.

February 2008 Bekido Random Sample				
25.60%	32.60%	40.50%	69.30%	65.60%
37.00%	60.30%	77.40%	36.30%	77.50%
45.00%	29.50%	38.10%	35.40%	45.50%
7.50%	6.60%	61.70%	27.30%	3.20%
25.20%	32.20%	39.10%	43.40%	0.50%
6.20%	54.60%	29.20%	17.00%	31.80%
42.20%	40.00%	34.80%	29.60%	64.10%
10.30%	69.40%	21.50%	43.40%	15.30%
63.90%	9.50%	6.30%	33.40%	41.80%
59.60%	20.30%	8.70%	70.00%	36.00%

Table 4-1. BBF3 Bekido Rate Sample February 2008

April 2008 Bekido Random Sample				
28.40%	22.20%	52.90%	51.00%	76.50%
43.00%	54.50%	71.30%	74.10%	83.80%
47.70%	84.00%	91.40%	61.10%	24.90%
27.10%	49.10%	81.90%	84.80%	62.80%
51.80%	49.00%	52.60%	57.60%	48.40%
28.30%	29.40%	47.00%	60.40%	53.90%
54.30%	91.40%	33.40%	28.50%	89.90%
61.50%	51.30%	43.00%	105.20%	38.10%
74.60%	29.80%	60.70%	66.80%	51.50%
68.80%	53.70%	77.60%	65.10%	68.90%

Table 4-2. BBF3 Bekido Rate Sample April 2008

In order to perform this test both samples must be normally distributed.

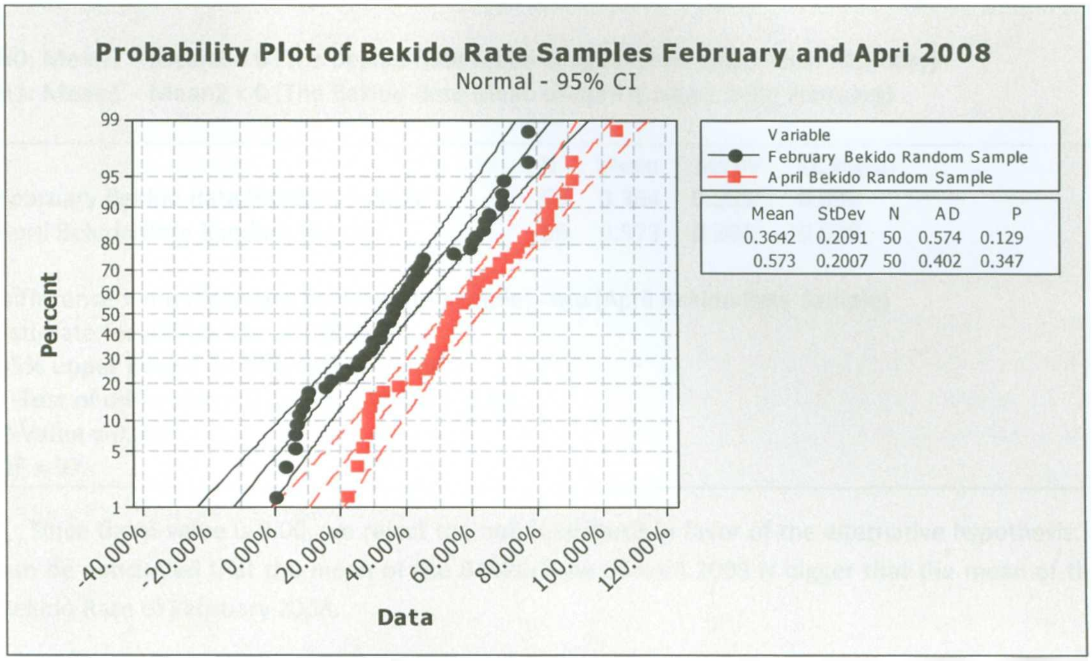

Figure 4-1. Probability Plot of Bekido Rate Samples of February and April 2008

Since both samples have a p-value above 0.05 (or 5 percent) it can be concluded that both samples are normally distributed.

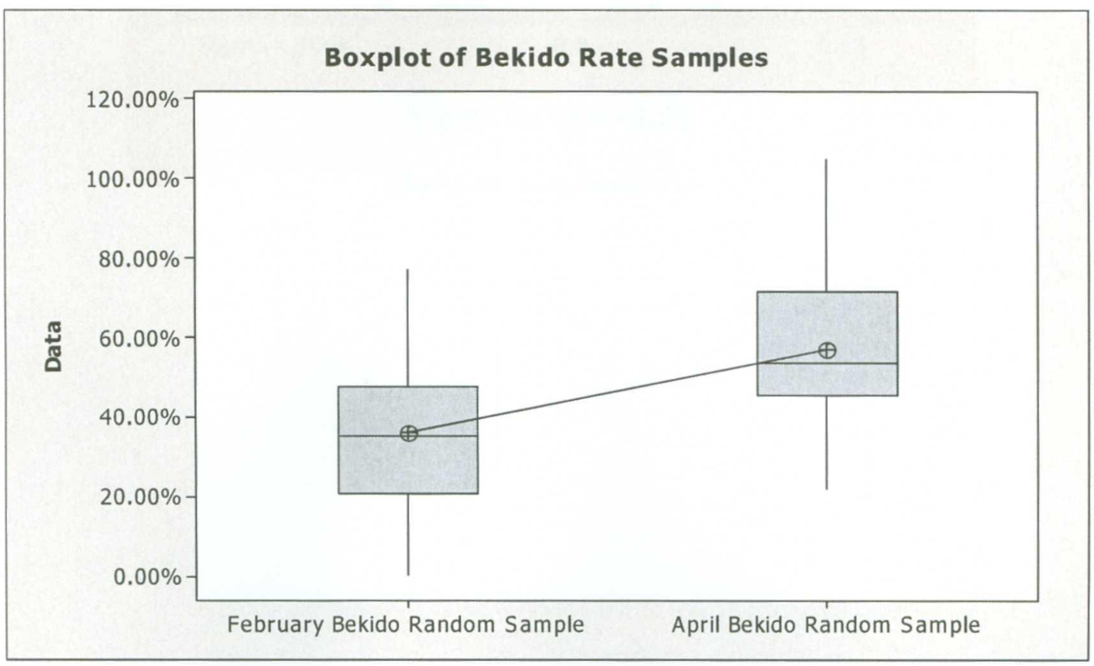

Figure 4-2. Probability Plot of Bekido Rate Samples of February and April 2008

Two-sample T Test for February Bekido Rate Random Sample vs. April Bekido Rate Random Sample.

H0: Mean1 – Mean2 = 0 (The Bekido Rate Mean of April is not bigger than February)
H1: Mean1 – Mean2 < 0 (The Bekido Rate Mean of April is bigger than February)

	N	Mean	StDev	SE Mean
February Bekido Rate Random Sample	50	0.364	0.209	0.030
April Bekido Rate Random Sample	50	0.573	0.201	0.028

Difference = mu (February Bekido Rate Sample) - mu (April Bekido Rate Sample)
Estimate for difference: -0.2088
95% upper bound for difference: -0.1407
T-Test of difference = 0 (vs. <): T-Value = -5.09
P-Value = 0.000
DF = 97

Since the p-value is 0.00, we reject the null hypothesis in favor of the alternative hypothesis. It can be concluded that the mean of the Bekido Rate of April 2008 is bigger that the mean of the Bekido Rate of February 2008.

This project was able to increase the sigma of the process. On the next table the increase on sigma before and after the project is shown.

	February	April
Sigma = 3Cpk	**-0.9**	**0.15**
	Sigma Delta = +1.05	

Table 4-3. BBF3 Bekido Rate Sigma Level

Chapter 5: Conclusion

Throughout this project Six Sigma methodology was applied to solve a practical situation in a manufacturing enterprise, Bridgestone Neumáticos de Monterrey. This methodology, which consists of five phases (Define, Measure, Analyze, Improve, Control), provided the necessary guidelines to approach a specific problem, offering the engineer all the crucial logical structure to solve it. Defining the objective and scope of the project, measuring and understanding actual conditions, analyzing critical factors that intervene in the process, implementing corrective actions to eliminate or minimize those factors, and developing contingency plans in order to maintain effectiveness of the implementations. Simple tools like cause-and-effect diagrams, histograms, run charts, control charts, Pareto plots and process capability plots, are greatly useful to define and understand the behavior of the process, find root causes of problems, think of logical solutions, and monitor the impact of those solutions.

This document was developed under Six Sigma methodology, the project obtained satisfactory results since it reached the goal proposed, proving that this methodology is an easy and practical tool for approaching and solving problems in a manufacturing environment.

Bibliography

Snee, R. and Hoerl R. (2005). *Six Sigma Beyond the Factory Floor.* New Jersey, USA: Pearson Prentice Hall.

Snee, R. and Hoerl R. (2003). *Leading Six Sigma.* New Jersery, USA: Financial Times Prentice Hall.

George, M. (2002). *Lean Six Sigma: Combining Six Sigma Quality with Lean Speed.* New York, USA: McGraw-Hill.

George, M., Rowlands, D., Price, M., and Maxey, J. (2005) *The Lean Six Sigma Pocket Tool book.* New York, USA: McGraw-Hill.

Vita

Education

B.S. Electronics and Communications
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Startup of automation systems.
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Startup and support to the Fori Automation line. Ford, Hermosillo, MX 05.
Support in the development and manufacture of press automations systems. Gudel, Michigan, USA 05.
Implementation, startup, training and support to the 2058 line. Magna, Kentucky, USA 05.
Implementation, startup, training and support to the 1500 Toyota line. Dana, Melbourne, AUS 06.
Startup of the line K6. Elring Klinger, Toluca, MX 06.