# ELIMINATION OF BROKEN WIRE AT HEEL FOR SSOP PACKAGE

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## ABSTRACT

Manufacturing department is suffering on quality issue broken wire at heel.
Broken wire at heel (Fig. 1) is the top 2 highest abnormality occurrence. Expect downtime and quality issue along the way if this issue was not resolved. Worst it might cause customer feedback.

This project aims to eliminate the occurrence of broken wire at heel abnormality thus improvement of product quality, productivity and cost that support our corporate strategy which is Road to ZERO defect.

Using DMAIC approach to analyze the problem and formulate improvement actions on process parameters, material characteristics and wire bond machine set-up significantly help to achieve the goal “elimination of broken wire at heel”.

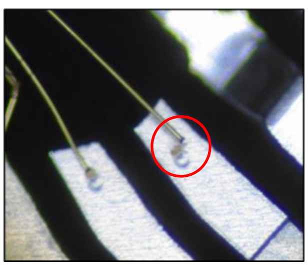


Fig. 1: Broken wire at heel. Encircled area is the disconnection of wire at heel area.

## 1. 0 INTRODUCTION

This paper will focus on the SSOP package, and its problem broken wire at heel defect.
SSOP package has an average of 1 abnormality occurrence of broken wire at heel per month. Any lot with broken wire at heel occurrence regardless of defect quantity will be hold and tagged as abnormal lot, analysis and corrective action/s required to release the lot.
Production is suffering because of such defect occurrence in the line causing non-value added activities such as x-ray inspection, cavity segregation and wire pull test for risk assessment of affected lot/s. Thus, it will prolong the cycle time of affected lot/s.

## 2. 0 REVIEW OF RELATED WORK

N/A

## 3.0 METHODOLOGY

### 3.1 Define Phase
What is important?

Broken wire at heel is a type of broken wire or cut wire defect wherein the disconnection is at stitch heel area (Fig 2).

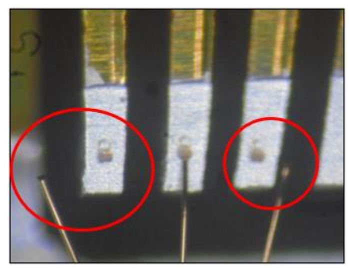
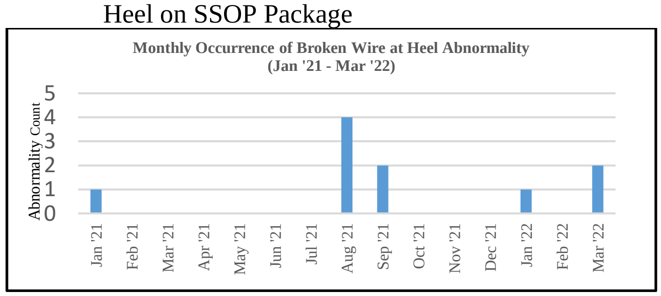


Fig. 2: Another sample of broken wire at heel. Encircled area is the disconnection of wire at heel area.

### 3.2 Measure Phase
How are we doing?

3.2.1 Monthly Trend Chart Occurrence of Broken Wire at Heel on SSOP Package




Broken wire at heel is a chronic issue at production having average of 1 abnormality occurrence per month.

### 3.3 Analyze Phase
What is Wrong?

From the SIPOC Macro Map generated (Fig. 3), it was identified that broken wire at heel can be generate on wire bond, lot unloading and product inspection processes.

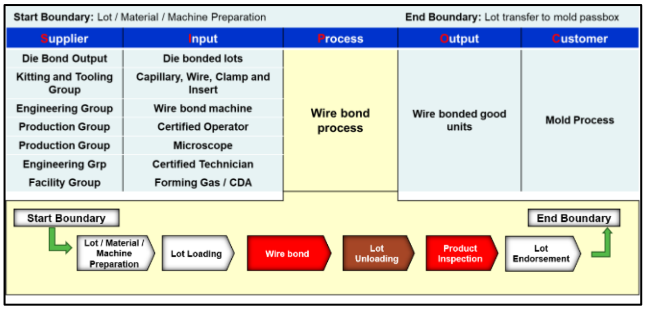



Fig. 3: SIPOC Macro Map Highlighting the focus processes of investigation.

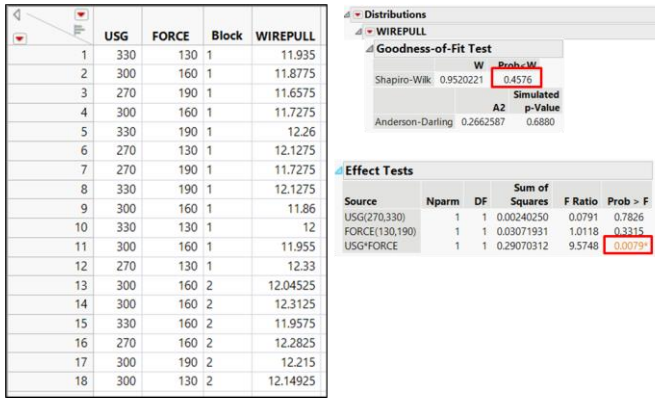
Other tools like Cause-and-effect matrix (C&E), fault tree analysis (FTA) and Detailed process map were utilized to dig down the major root causes that significantly producing broken wire at heel.

Table 1. Identified root causes

| Item # | Root Cause | Hypothesis | Validation |
|---|---|---|---|
| 1. | Excessive Force and USG parameter | It can produce heel crack | DOE and Hypothesis testing |
| 2. | Misalignment of Unloader Magazine to Feeder rail | Generates friction to stressed wire bonded units | Hypothesis testing. Compare mean to good set-up |
| 3. | Tight Feeder Width | Generates friction to stressed wire bonded units | Hypothesis testing. Compare mean to good set-up |

3.3.1 Excessive Force and USG parameter

Device A defined parameter limits – the Force and USG/ultrasonic power were subjected to design of experiment to check if has significant effect on broken wire at heel issue. By using 2x2 full factorial DOE and hypothesis testing, both the parameter has significant effect of broken wire at heel (refer to Fig 4).



| | USG | FORCE | Block | WIREPULL |
|---|---|---|---|---|
| 1 | 330 | 130 | 1 | 11.935 |
| 2 | 300 | 160 | 1 | 11.8775 |
| 3 | 270 | 190 | 1 | 11.6575 |
| 4 | 300 | 160 | 1 | 11.7275 |
| 5 | 330 | 190 | 1 | 12.26 |
| 6 | 270 | 130 | 1 | 12.1275 |
| 7 | 270 | 190 | 1 | 11.7275 |
| 8 | 330 | 190 | 1 | 12.1275 |
| 9 | 300 | 160 | 1 | 11.86 |
| 10 | 330 | 130 | 1 | 12 |
| 11 | 300 | 160 | 1 | 11.955 |
| 12 | 270 | 130 | 1 | 12.33 |
| 13 | 300 | 160 | 2 | 12.04525 |
| 14 | 300 | 160 | 2 | 12.3125 |
| 15 | 330 | 160 | 2 | 11.9575 |
| 16 | 270 | 160 | 2 | 12.2825 |
| 17 | 300 | 190 | 2 | 12.215 |
| 18 | 300 | 130 | 2 | 12.14925 |

Distributions
WIREPULL
Goodness-of-Fit Test

| | W | Prob<W |
|---|---|---|
| Shapiro-Wilk | 0.9520221 | 0.4576 |

| | A2 | Simulated p-Value |
|---|---|---|
| Anderson-Darling | 0.2662587 | 0.6880 |

Effect Tests

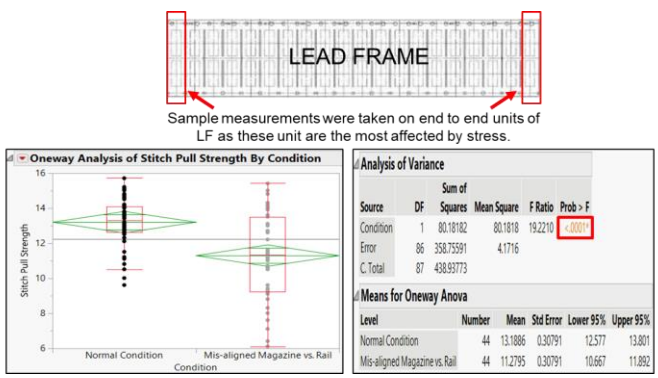
| Source | Nparm | DF | Sum of Squares | F Ratio | Prob > F |
|---|---|---|---|---|---|
| USG(270,330) | 1 | 1 | 0.00240250 | 0.0791 | 0.7826 |
| FORCE(130,190) | 1 | 1 | 0.03071931 | 1.0118 | 0.3315 |
| USG*FORCE | 1 | 1 | 0.29070312 | 9.5748 | 0.0079* |

Fig. 4: DOE results. Data normal distribution check. Effect Test.

3.3.2 Misalignment of Unloader Magazine to Feeder rail

At the concern production department, machine flexibility is being practiced preventing line down when specific machine is having a problem. But due to flexibility, machine set-up has been changed at most thrice a week. In effect machine mechanical set-up may vary from every change device. Misalignment of Unloader Magazine to Feeder rail is the effect.

By using hypothesis testing comparing the mean misaligned set-up to good set-up, the P-value result is less than 0.05 thus the misalign unloader magazine set-up is significant to broken wire at heel issue. Refer to fig 5 for testing results.




Analysis of Variance

| Source | DF | Sum of Squares | Mean Square | F Ratio | Prob > F |
|---|---|---|---|---|---|
| Condition | 1 | 80.18182 | 80.1818 | 19.2210 | <.0001* |
| Error | 86 | 358.75591 | 4.1716 | | |
| C. Total | 87 | 438.93773 | | | |

Means for Oneway Anova

| Level | Number | Mean | Std Error | Lower 95% | Upper 95% |
|---|---|---|---|---|---|
| Normal Condition | 44 | 13.1886 | 0.30791 | 12.577 | 13.801 |
| Mis-aligned Magazine vs. Rail | 44 | 11.2795 | 0.30791 | 10.667 | 11.892 |

Fig 5: 2 Sample t-test comparing mean of mis-aligned magazine set-up to good set-up. P-value less than 0.05.

3.3.3 Tight Feeder Width

One of the effects of machine flexibility is Tight feeder width set-up. Our technician may fail to properly check the correct feeder width setting when the same lead frame outer dimension is being processed. Unfortunately, even the lead frames are having the same outer dimension requirement, but it may differ on design, thickness, tolerances, and thermal expansion resulting to tight feeder rail width condition.

By using hypothesis testing comparing the mean of tight feeder width set-up to good set-up, the P-value result is less than 0.05 thus the tight feeder width set-up is significant to broken wire at heel issue. Refer to fig 6 for testing results.

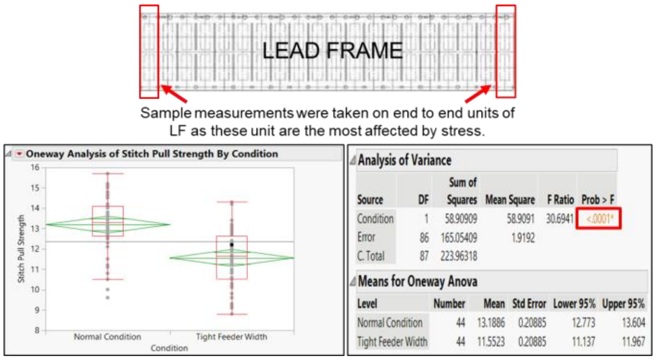
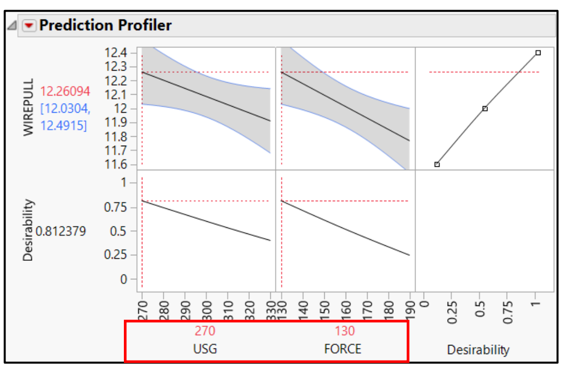



Fig 6: 2 Sample t-test comparing mean of tight feeder width set-up to good set-up. P-value less than 0.05.

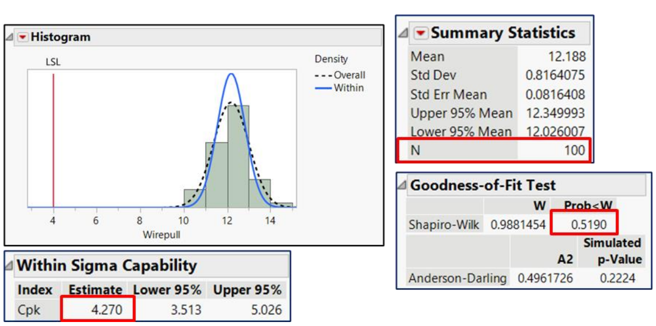
## 3.4 Improve Phase
## What needs to be done?

3.4.1 USG and Force Parameter Optimization

Current USG and Force limit was subjected to validation run using 100 samples to analyze prediction profiler and check for SPC.




Based on the prediction profiler the wire pull strength was degraded when force and USG parameter is getting higher. The team concluded to lessen the maximum parameter limit to lessen degradation of stitch bond ability.




Data are normally distributed and upon checking of Cpk the result is passing the min requirement of 1.67.

3.4.2 Consideration of thermal expansion during rail width setting

Every lead frame with different design is having different thermal expansion. This condition was not considered on previous method/controls established in the line. Action on paragraph 3.4.3 improves the sustainability of this action.

3.4.3 Standardization of Lead frame and Magazine recipe name

Standardization of lead frame and magazine recipe helps to lessen the variation on mechanical set-up when doing change device. Previously the control is – 1 recipe can be used by multiple lead frames/device that are differ in design. The proposed control is – 1 recipe is exclusive only for 1 lead frame/device only.

3.4.4 Documentation of defined actions to implement in the line.

OLD:

| ITEM | 2ND BOND | |
|---|---|---|
| NEO STEP | 1ST STEP | 2ND STEP |
| BOND TIME | 2 | 3 |
| BOND FORCE | 20-25 | 130 - 190 |
| US POWER | 0 | 270 - 330 |

NEW:

| ITEM | 2ND BOND | |
|---|---|---|
| NEO STEP | 1ST STEP | 2ND STEP |
| BOND TIME | 2 | 3 |
| BOND FORCE | 20-25 | 130 - 170 |
| US POWER | 0 | 270 - 310 |

Optimized parameter from DOE has been implemented and documented as reference in production line. The wire bonding recipe was also revised to lock the new limits.

**4.4.1** Return the lead frame to loader magazine and index it to first bond position (first column of the lead frame will be indexed to boding site of the machine).

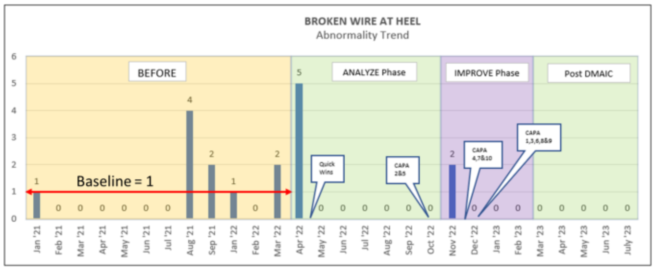
**4.4.2** Let the clamp and insert grip and heat the lead frame for 30 seconds. Unclamp the lead frame and repeat to gently slide the lead frame back and port to consider lead frame thermal expansion during feeder width setting. Adjust if necessary. Return the lead frame back to loader magazine once done.

Line specification or work instruction for machine set-up has been revised to include the heat up of lead frame when checking and setting feeder rail width.

| | |
|---|---|
| 53.1 | **Frame and Magazine Recipe Name** (should be the same on device LF name)<br>[For Ex. LF-M44Vx40D6-94-P Recipe name is **M44VX40D6**] |

Had revised the wire bond set-up buy-off form to include the correct recipe naming format for lead frame and magazine recipe.

3.4.5 Validation




Upon implementation of all CAPA, the abnormality trend was ZEROED-OUT for 8 consecutive months.

### 3.5 Control Phase
### How to maintain improvements?

All the pertinent documents to reflect defined actions were revised and updated. Dissemination and training to production personnel regarding new control has been completed. PFMEA already revised to include define corrective actions. Control plan has been checked and no revision needed.
System and production personnels were already equipped with the defined controls to prevent recurrence of broken wire all heel on SSOP package.

## 4.0 RESULTS AND DISCUSSION

The defined actions are significantly helps to attain and sustain the goal elimination of broken wire at heel for SSOP package. Implemented actions have no consequential effect or it will not create another production issues as validated upon implementation.

## 5.0 CONCLUSION

DMAIC approach is very effective resolving chronic production line issues as it will examine all possible root causes and provide effective preventive and detection actions.

## 6.0 RECOMMENDATIONS

It is recommended to utilized DMAIC approach to resolve top and chronic production issue and yield killers to help business growth.

## 7.0 ACKNOWLEDGMENT

I want to say thank you to my Project Champion Arnel Hulipas, Project Sponsor Victor Edgar Generosa and Mentor Louie Dizon. The completion of this project could not have been accomplished without your continued support and encouragement to me.

## 8.0 REFERENCES

LSS Training Material- Lean Six Sigma Pocket Tool Book. Michael L. George, David Rowlands, Mark Price and John Maxey

## 9.0 ABOUT THE AUTHORS

Renante Somera is currently a wire bond process engineer who has been with onsemi for 4 years and graduated a course of BSECE.