



# Indirect Material Cost Reduction by Eliminating Manual Derailing Process through Process Simplification

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## Authors' contributions

*This work was carried out in collaboration among all authors. Author CLDC designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author PCJr managed the analyses of the study. Author MP managed the literature searches. All authors read and approved the final manuscript.*

## Article Information

DOI: 10.9734/JERR/2021/v20i517305

### Editor(s):

(1) Dr. Heba Abdallah Mohamed Abdallah, National Research Centre, Egypt.

### Reviewers:

(1) Antun Stoić, University of Slavonski Brod, Croatia.

(2) Raveen Rathilall, Durban University of Technology, South Africa.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/66564>

Original Research Article

Received 19 January 2021

Accepted 22 March 2021

Published 03 April 2021

## ABSTRACT

This paper will discuss how to reduce (IDM) Indirect Material consumption for derailing process by eliminating the manual derailing method as part of cost saving project. It involves the removal of cutter blade used for derail. Cost improvement was one of organizational goals of the company for 2019. This drive can be supported by analyzing Indirect Material spending and process simplification at assembly plant. At assembly End-Of-Line processes, derail cutter blade was one of the top Indirect Material spending at singulation and there is an opportunity to reduce if not eliminated the cost consumption of derail cutter blades through process simplification. Increasing volume in Quad-Flat-No lead (QFN) packages and new banner products being develop by New Product Integration *NPI*, Q1'20 means increase in IDM consumption per process. The challenge is to drive a process simplification that will reduce IDM to save cost by start of Q2'20. DMAIC methodology was used to improve the process of derailing process.

**Keywords:** Derailing; singulation; derail cutter; cutter blades.

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## 1. INTRODUCTION

Since the introduction of QFN packages at Assembly Process, Derail station already serves as a prelude to Singulation process. Singulation blade wear at that time was also dependent from the cutting of siderail / end rail of leadframes and so we derived from using Manual Derail offline prior Singulation process [1-3]. This prolonged the blade life limit on lead frame base packages for sawing process.

Removing side rails of lead frames before package singulation improves the cutting life limit for the saw blade, thus, maximizing the blade life usage. Manual Derailing method is purely a skill dependent process for removing siderails. Only trained operators are allowed to perform the activity [4,5].

As shown in Fig. 1, A certified operator performs manual derailing using derail jig. Derail jig is a metal base platform designed with integrated

cutter blade that swivels and act as scissor to cut the protruded part of the lead frame. Fig. 5.

However, this method of derailing induced quality issues such as package crack and package scratch, since this process is purely manual, the quality of derailing is skill-dependent from the operators. Safety issue was a lot more concern as this manual process may potentially induce cut for the user if wrongly performed. Fig 3.

The company drive to support the business opportunity on IDM cost reduction led the team to initiate the process simplification for the end line processes. From singulation blades life extension to UV tape second sourcing, the team also come up to process simplification for derailing process [6,7]. The team also consider the QFN devices that undergone Manual derailing process wherein 16 rawlines from Advance and Instrip QFN packages need to undergone this process. Derail cutter blade was identified as the top IDM with highest cost consumption for derail station.



Fig. 1. Manual Derailing Process

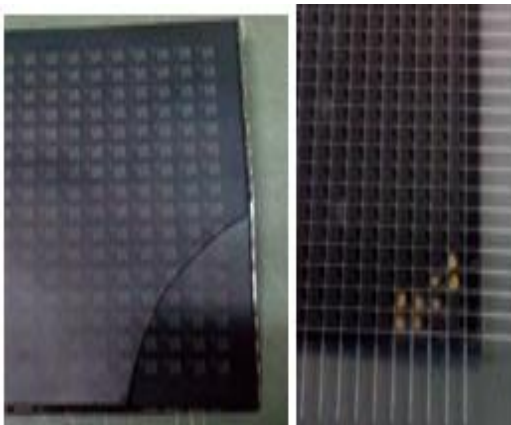


Fig. 2. Package crack



Fig. 3. Thumb was wrongly placed at cutting area of the jig

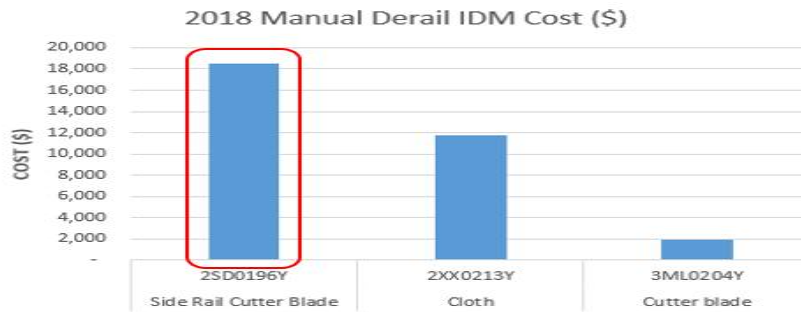


Fig. 4. Cost consumption at derail station

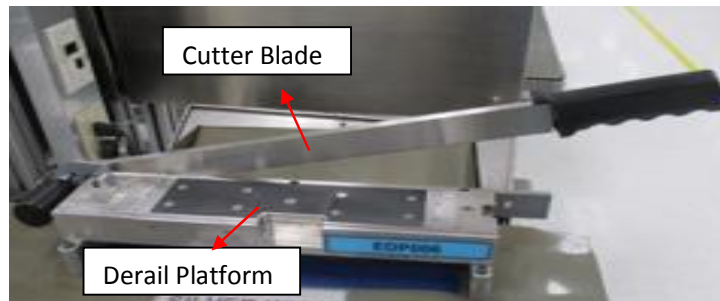


Fig. 5. Derail jig

Since there is an opportunity to use Singulation machine considering it's current volume saturation with only 70%, there is available machine for the derailing process to proceed to Auto Derailing instead of scrapping blades that reached limit. An opportunity to eliminate the IDM cost consumption of the cutter blade [8,9]. These blades has reached it's maximum blade life defined during the blade life study. See Fig. 6.

Industrial Engineer (IE) capacity study for Singulation machines shows 70% volume saturation which supports the idea for Auto Derailing process. 2 machines are available to cater the volume for auto derailing process. See Table. 1.

With all the major factors for the propose change favors the team concept on process simplification through auto derail process, the team proceed for the initial validation.

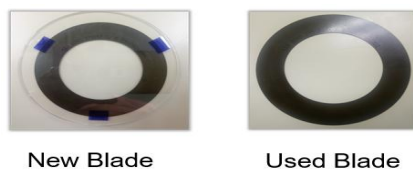


Fig. 6. 3" Diameter resin bond blade

## 2. REVIEW OF RELATED LITERATURE

The idea of DMAIC methodology helps an organization maximize production.

1. Define some very critical questions like the errors in the production process and how it affects the production operations.
2. Measure their current production systems. When everything is measured up, an organization is able to know what the rootcause of their production problem is and start looking for ways to solve it. Having a data collection plan is very useful when conducting this phase.
3. Analyze data gathered during the measurement phase about their production process. After analyzing the data, the organization is able to narrow down the cause of their production problems and figure out ways to maximize things.
4. Improvement phase is the stage where an organization tests, assess and implements all their ideas in terms of improving production.
5. Control phase is to make sure that they maintain all the improvement actions. The last stage of the continuous improvement process and it is all about strategies to maintain high level of production.

**Table 1. EAD695 machine capacity assessment**

|  | Feb'19_C | Mar'19_C | Apr'19_C | May'19_C | Jun'19_C | Jul'19_C | Aug'19_C | Sep'19_C | Oct'19_C | Nov'19_C | Dec'19_C | Jan'20_C |
|--|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| SLITTING REQ'T (EAD695)                        | 0.67     | 0.70     | 0.70     | 0.71     | 0.63     | 0.64     | 0.61     | 0.61     | 0.61     | 0.61     | 0.61     | 0.61     |
| SINGULATIO N REQ'T (EAD695)                    | 4.36     | 4.74     | 4.08     | 4.08     | 4.08     | 4.01     | 4.01     | 4.01     | 3.91     | 3.89     | 3.90     | 3.88     |
| USING CURRENT UTILIZATION TOTAL REQ'T (EAD695) | 5.04     | 5.44     | 4.78     | 4.79     | 4.71     | 4.64     | 4.62     | 4.62     | 4.52     | 4.50     | 4.51     | 4.48     |
| ON-HAND  | 8.00     | 8.00     | 8.00     | 8.00     | 8.00     | 8.00     | 8.00     | 8.00     | 8.00     | 8.00     | 8.00     | 8.00     |
| SATURATIO N REMARKS                            | 0.63     | 0.68     | 0.60     | 0.60     | 0.59     | 0.58     | 0.58     | 0.58     | 0.56     | 0.56     | 0.56     | 0.56     |
| CAN ACCOMMODATE SLITTING                       |          |          |          |          |          |          |          |          |          |          |          |          |
|  | Feb'19_C | Mar'19_C | Apr'19_C | May'19_C | Jun'19_C | Jul'19_C | Aug'19_C | Sep'19_C | Oct'19_C | Nov'19_C | Dec'19_C | Jan'20_C |
| SLITTING REQ'T (EAD695)                        | 0.67     | 0.70     | 0.70     | 0.71     | 0.63     | 0.64     | 0.61     | 0.61     | 0.61     | 0.61     | 0.61     | 0.61     |
| SINGULATIO N REQ'T (EAD695)                    | 4.80     | 5.21     | 4.48     | 4.48     | 4.49     | 4.41     | 4.41     | 4.41     | 4.30     | 4.28     | 4.29     | 4.26     |
| TOTAL REQ'T (EAD695)                           | 5.47     | 5.91     | 5.18     | 5.19     | 5.12     | 5.05     | 5.02     | 5.02     | 4.91     | 4.89     | 4.90     | 4.87     |
| ON-HAND  |          |          |          |          |          |          |          |          |          |          |          |          |

|   | Feb'19_C | Mar'19_C | Apr'19_C | May'19_C | Jun'19_C | Jul'19_C | Aug'19_C | Sep'19_C | Oct'19_C | Nov'19_C | Dec'19_C | Jan'20_C |
|---|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| SATURATION                              | 8.00     | 8.00     | 8.00     | 8.00     | 8.00     | 8.00     | 8.00     | 8.00     | 8.00     | 8.00     | 8.00     | 8.00     |
| DERAIL PROJECT TO PROCEED WITH SLITTING | 0.68     | 0.74     | 0.65     | 0.65     | 0.64     | 0.63     | 0.63     | 0.63     | 0.61     | 0.61     | 0.61     | 0.61     |

**Table 2. Selection process criteria**

| <b>Alternative Direction to Improve IDM Reduction At derail process (1--Highest Impact, 5--Lowest Impact)</b> |  |                   |                         |               |      |       |   |          |
|---|--|-------------------|-------------------------|---------------|------|-------|---|----------|
| No.   | Option   | Derail Cycle Time | Quality Issue Reduction | Safety (Risk) | Cost | Total | Remarks   | Decision |
| 1   | Cutter blade life extension                          | 3                 | 1                       | 1             | 2    | 7     | From the original supplier of cutter blade, the life was set to 12k strips per blade, but unfortunately the supplier company declared closure. From the new supplier, we can only reach 3k strips per blade. We can't extend any further. | No GO    |
| 2   | Alternative Supplier of cutter blade with lower cost | 3                 | 1                       | 1             | 2    | 7     | The current is already the alternative supplier since the original supplier already closed.   | No GO    |
| 3   | Auto derailing process using new blade               | 2                 | 4                       | 5             | 2    | 13    | Using new blade for auto derailing process will add cost for blade consumption.   | No GO    |
| 4   | Auto Derailing Process using used blade              | 2                 | 4                       | 5             | 5    | 16    | Considered action -- Auto derailing method at EAD695 machine using used blades that reached blade life limit.   | GO       |

**Table 3. Validation plan**

| <b>Validation Plan and Results</b> |                        |                     |               |                         |  |  |  |                         |             |              |              |                    |
|------------------------------------|------------------------|---------------------|---------------|-------------------------|--|--|--|-------------------------|-------------|--------------|--------------|--------------------|
| <b>Y (or mini Y)</b>               | <b>Unit of Measure</b> | <b>Y treated as</b> | <b>X</b>      | <b>True nature of X</b> | <b>Levels of X, if discrete or converted into discrete</b> | <b>Hypothesis Statement</b>                |  | <b>Statistical Test</b> | <b>Beta</b> | <b>Alpha</b> | <b>Delta</b> | <b>Sample Size</b> |
|                                    |                        |                     |               |                         |  | <b>Null Hypothesis</b>                     | <b>Alternative Hypothesis</b>              |                         |             |              |              |                    |
| Package Crack Metal Burrs          | PPM                    | Discrete            | Derail Method | Discrete                | Manual Auto  | $H_0: P_{\text{manual}} = P_{\text{Auto}}$ | $H_a: P_{\text{Auto}} < P_{\text{manual}}$ | 2 proportion test       | 0.1         | 0.05         | 0.0001       | 43200              |
| Package Chipout                    | PPM                    | Discrete            | Derail Method | Discrete                | Manual Auto  | $H_0: P_{\text{manual}} = P_{\text{Auto}}$ | $H_a: P_{\text{Auto}} < P_{\text{manual}}$ | 2 proportion test       | 0.1         | 0.05         | 0.0000       | 95179              |
| Package Scratch                    | PPM                    | Discrete            | Derail Method | Discrete                | Manual Auto  | $H_0: P_{\text{manual}} = P_{\text{Auto}}$ | $H_a: P_{\text{Auto}} < P_{\text{manual}}$ | 2 proportion test       | 0.1         | 0.05         | 0.0000       | 95179              |



**Fig. 7. EAD695 package sawing machine**

This DMAIC tool refers to a data-driven improvement cycle used for improving, optimizing and stabilizing business processes and designs. The DMAIC improvement cycle is the core tool used to drive six sigma projects.

A recent study of implementation of Six Sigma at Continental Mabor, a tire manufacturing company located in Famalicao, Portugal, provides a step-by-step look at putting Six Sigma's DMAIC methodology in place. The company focused on improvements in the rubber extrusion process, particularly the mixing, preparation and construction department. The mixing department receives raw materials that are used in the preparation department on seven extrusion lines which focus on thread and sidewall extrusion. The amount of material generated in the process – which is later reused for other purposes. is one of the indicators of the company on how efficient the operation is running. The focus is to limit the amount of extra material generated during the thread and sidewall extrusion process, called "work off". They save thousands using Six Sigma's DMAIC Methodology. A tire manufacturing company has provided an excellent study in implementing Six Sigma and how it can impact business performance. Six Sigma already has proven its value in the automobile industry.

### **3. METHODOLOGY**

In this study, DMAIC methodology was used to eliminate the manual derailing method and to improve quality by reducing package crack and

package scratch PPM from 50PPM to 0 PPM and total cost annualized savings of 36K USD by eliminating the use of cutter blades.

#### **3.1 Define Phase**

Fig. 8 Shows the top spending IDM for the Singulation sub process, Derail Station. With cutter blade cost of 512\$/pc and a total of 6 pcs. A minimum of 6 pieces of derail blade withdrawal every month and a total of 16 devices from Advance and Instrip packages.

#### **3.2 Measure Phase**

The critical process at End of Line identified on this project was the Derail Process. See Fig. 9.

Through Selection Process Criteria shown in Table 2 Alternative direction to improve IDM spending at derail process was categorized via quality issue, safety and cost. Auto Derailing process was identified with the highest score considering all categories mentioned for the selection. See Table 2.

Safety risk involved when performing manual derailing process, it has the potential to cut the operator if the hand is not properly placed on the safety position during cutting as shown in Fig 10.

Used blade from package singulation that reached blade life limit was identified to use for the Auto Derailing process. With a maximum blade exposure of 3.9mm (used blade). See Fig. 11 for used blade.

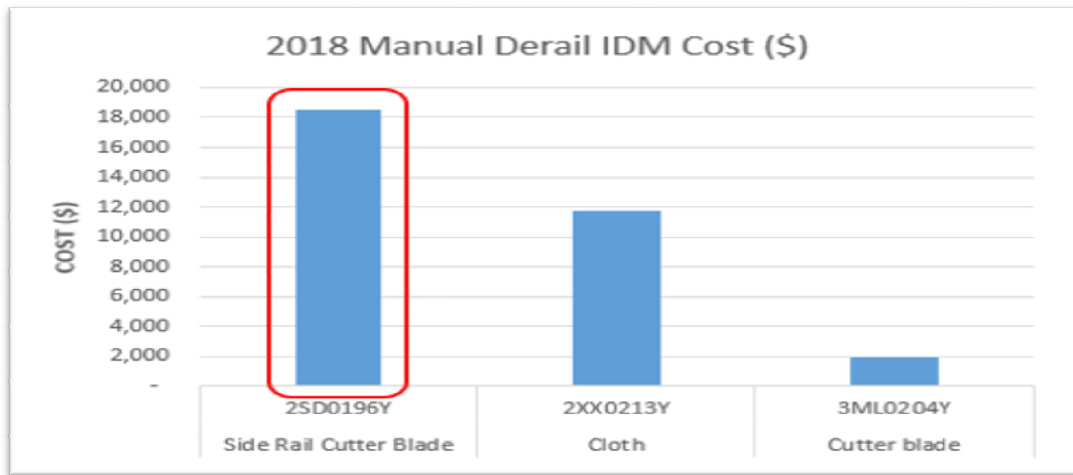


Fig. 8. Graphical presentation of derail process

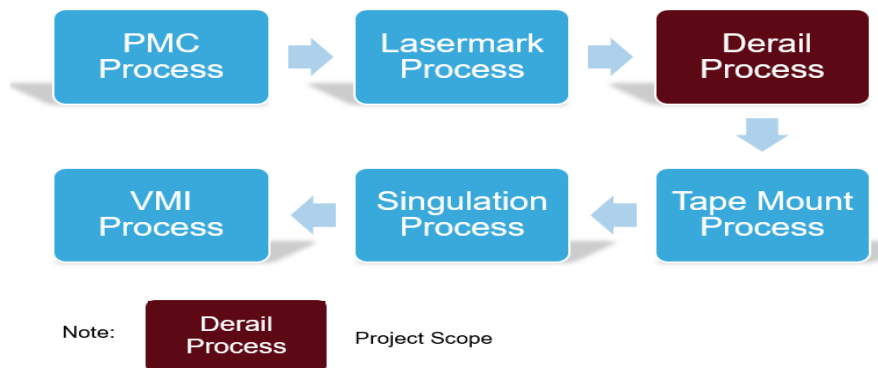


Fig. 9. End of line process map



Fig.10 Safety risk Involved for manual derail



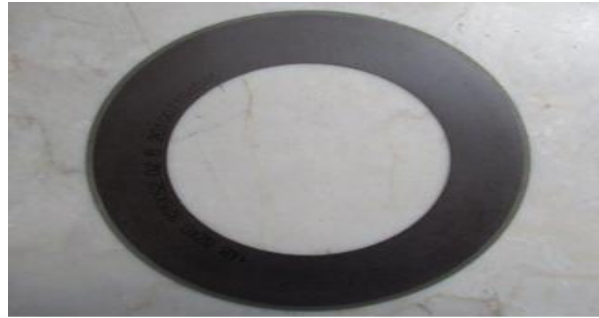


Fig. 11. Used blade

## Statistical Testing – Metal Burrs

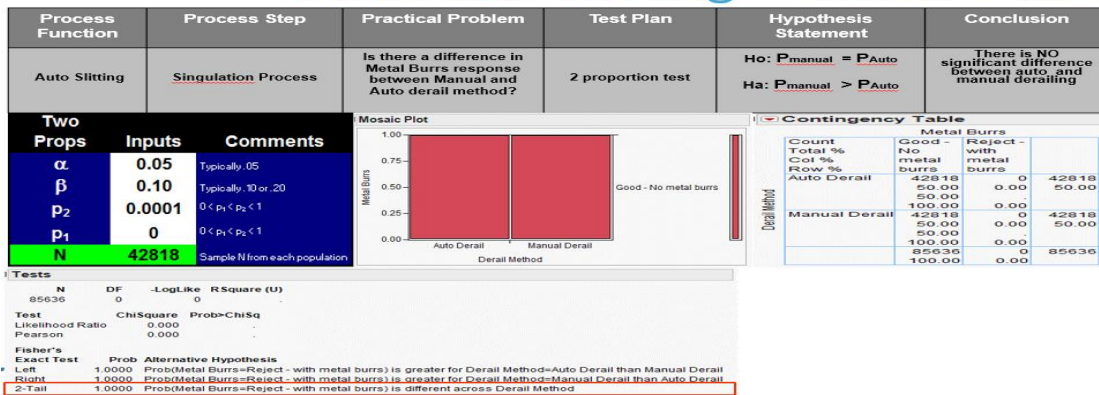


Fig. 12. 2 Proportion test for metal burrs

### 3.3 Analyze Phase

A validation plan for the test was created to check the result comparison of characteristics between Manual Derail and Auto Derail Method. EAD machine was set-up accordingly considering Feed Speed and Spindle RPM parameters. Cutting Sequence program according to number of cuts required for QFN 2 maps packages. See Table 3 Validation Plan.

Validation results based from statistical testing shows that Metal Burrs has NO Significant difference between Manual and Auto Derail process. Statistical validation was used to compare characteristics response between the derailing method. Validation result for Auto derailing passed.

#### 3.3.1 Delamination test

Delamination test was also required to check and validate that there were NO issues on delam when using Auto Derailing Process. Scat result passed with no delamination issues on Die, Lead and Normal Delamination monitoring.

### 3.4 Implementation Phase

10x lots where processed and result passed all quality characteristics requirement. See Table 4.

### 3.5 Control Phase

After the implementation of the project, the team continue to monitor the derail performance for all QFN 2 maps packages.

#### 3.5.1 Blade life limit for extended used blades

Computation for blade life limit extension for derailing process. With the 3.9 mm blade exposure for the used blades, study shows that blade can still further extend to 100 m equivalent to 10lots of 10 strips per lot for QFN packages.

Blade Management System was also included to monitor the blade use for Auto Derail process. Used blades will be collected and will be verify and check by the Process Engineer. Wobble and damaged blades will not be accepted for derail use.

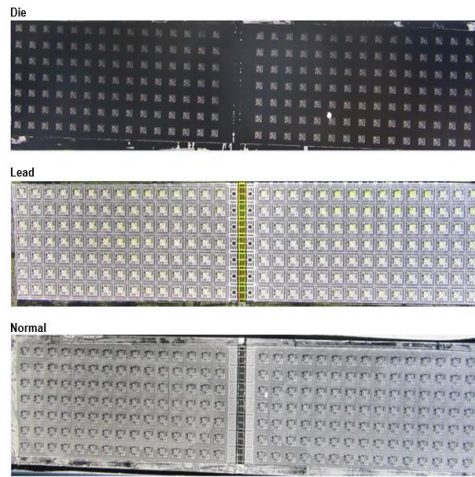


Fig. 13. QFN scot result

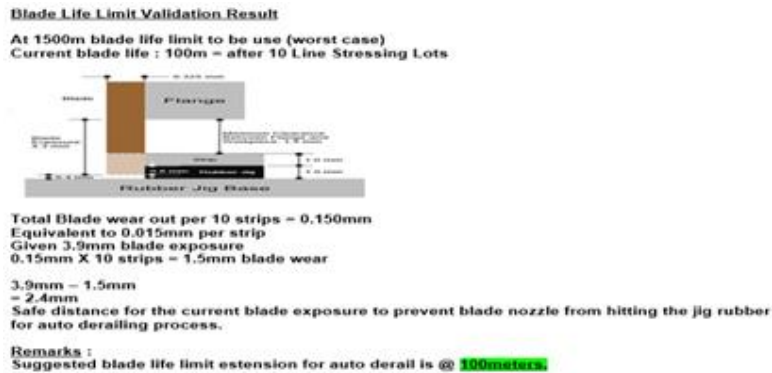


Fig. 14. Blade life limit validation result

Table 4. 10X Lots implementation result

**IMPLEMENTATION RESULT :  
MRB NO. P1C7-FW2-190829-0142**

| Qualification Characteristics Result for Auto derail ( 10 line stressing lots – 5x5 & 7x7 Repat ) |              |          |             |         |          |             |         |         |
|---|--------------|----------|-------------|---------|----------|-------------|---------|---------|
| Characteristic  | Ideal Target | POR Mean | POR Std Dev | POR Ppk | New Mean | New Std Dev | New Ppk | Remarks |
| Package Crack   | 0 PPM        | 150 PPM  | n/a         | n/a     | 0 PPM    | n/a         | n/a     | PASSED  |
| Railing Metal Burrs   | 50um         | n/a      | n/a         | n/a     | 40um     | n/a         | n/a     | PASSED  |
| Package Chipout   | 0 PPM        | 100 PPM  | n/a         | n/a     | 0 PPM    | n/a         | n/a     | PASSED  |
| Package Scratch   | 0 PPM        | 50 PPM   | n/a         | n/a     | 0 PPM    | n/a         | n/a     | PASSED  |
| Delamination  | 0 PPM        | 0 PPM    | n/a         | n/a     | 0 PPM    | n/a         | n/a     | PASSED  |

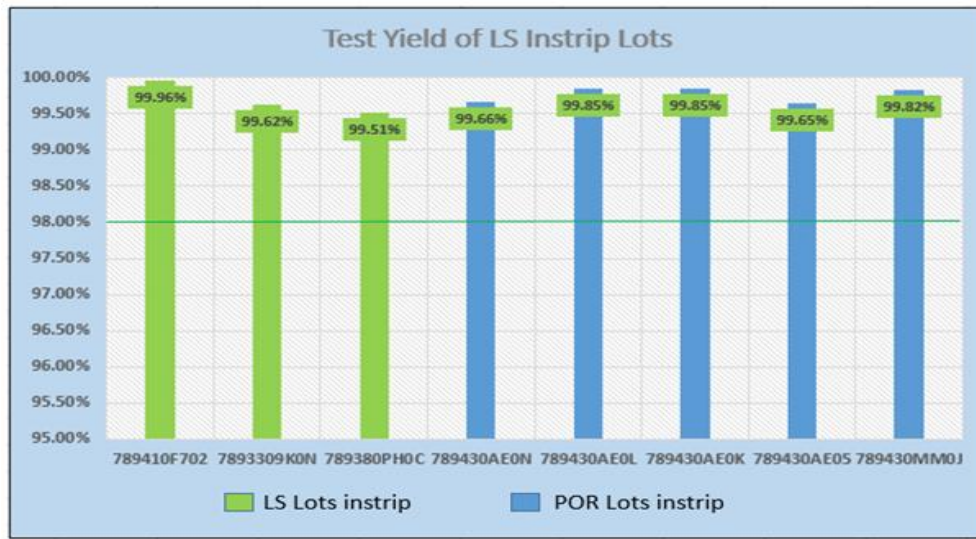


Fig. 15. Test Yield LS Instrip Lots

#### 4. RESULTS AND DISCUSSION

Actual results with 10x line stressing lots validated the effectiveness of Auto Derail process instrip test yield passed and all above 95% yield target. See Fig. 15.

#### 5. CONCLUSION

Automation of Manual derail for QFN Packages using DMAIC Methodology is an effective solution to address the quality issues and reducing the IDM cost for derail blade used for manual derailing. Other non-added value activities were removed and translated to a better quality, productivity and efficiency. Removal of manual derail and converting it to auto derailing is viable for the growing QFN package and technology.

#### 6. RECOMMENDATIONS

Based on the results of this study, it is recommended to proceed with Auto Derailing process For QFN packages using existing saw machines in production line.

#### DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products

as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

#### ACKNOWLEDGEMENT

The authors would like to thank ST-Calamba Management for the support in this study. Thanks also to ST-Calamba Operations for the validation/ line stressing execution.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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