REDUCTION OF OVER REJECTION AT MARKING, ORIENTATION, AND PACKAGE (MOP) VISION INSPECTION OF DEVICE X

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ABSTRACT

Testing of Integrated Circuit units ensures that only good units are shipped to customers. Good units are those which passed electrical tests and are free of cosmetic defects. During Marking, Orientation, and Package (MOP) inspection, units are subjected through Vision Inspection systems to ensure that they are free of any cosmetic defects.

MOP Over Rejection is a phenomenon occurring wherein the Vision Inspection system judges a defect-free known good unit (KGU) to be a reject. When a unit is detected as a reject, it would then be sorted to the reject bin and will not be subjected for electrical test anymore. Over Rejection is one of the yield killers and scrap cost contributor. This technical paper intends to reduce the over rejection of units during MOP Vision Inspection in terms of PPM level.

The DMAIC methodology was used in this study to systemically understand the problem. Probable root causes were determined and validated to arrive with the improvement actions vital to reduce the PPM level of Over Rejection during MOP inspection.

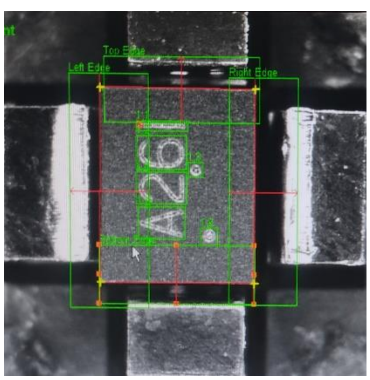

Fig.1. Known Good Unit under Marking, Orientation and Package (MOP) Vision Inspection.

1. 0 INTRODUCTION

1.1 Historical Background

Among all devices of a particular Business Unit (BU), Device X had the highest scrap cost contributing to 49.48% among all other devices for the year 2022. Digging a little deeper on the issue, an alarming situation was found out that the Mechanical Finish (MEF) Yield for Device X was not consistently met as shown on Figure 2. With this issue, the need to study and stop this situation began.

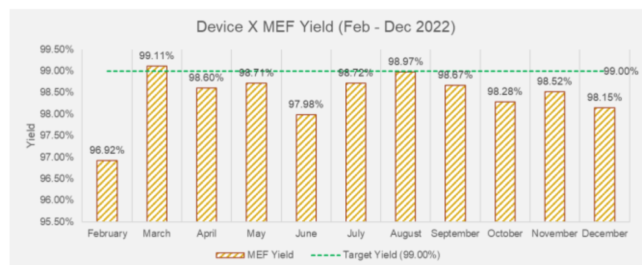

Fig.2. Device X MEF Yield Trend. Target Yield of 99% is not consistently achieved throughout the year 2022.

1.2 Marking, Orientation, and Package (MOP) Vision Inspection

Integrated Test&Tape machines have three (3) vision inspections. These includes the Marking, Orientation, and Package (MOP) inspection, Pad and Sides inspection, and Taped units inspection. During MOP inspection, the units are inspected by the vision system if it has proper marking, correct orientation, and if the package has any cosmetic defect. Units that passed MOP inspection will then proceed to Electrical testing, Pad and Sides inspection, and lastly to the Taped units inspection

Over Rejection at MOP inspection occurs when a unit without any defect is judged as a reject during inspection. Reduction of over rejection during MOP inspection can greatly impact yield and scrap cost, since potential good units are being scrapped.

2. 0 REVIEW OF RELATED WORK

Not Applicable.

3.0 METHODOLOGY

3.1 Define Phase

Based on the MEF reject bin analysis of Device X, the top yield loss contributor was rejects from MOP inspection (see Fig.3). From a defect baseline of 5178 PPM of MOP rejects, the study aims to reduce the defect rate by 50% (2589 PPM).

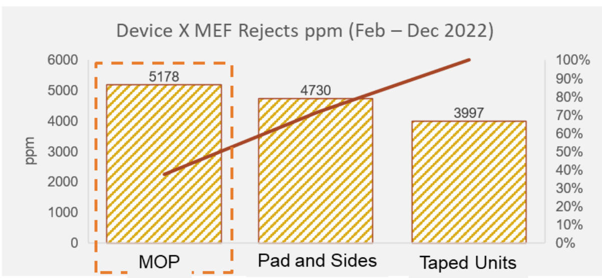

Fig.3. MEF reject bin distribution for Device X shows MOP inspection has the highest yield loss contribution.

3.2 Measure Phase

In the Measure Phase, Process Mapping and Measurement Systems Analysis (MSA) were used. These tools are used to fully understand relationships between inputs and outputs and to evaluate the reliability of measurement systems involved.

3.2.1 Process Map

A Top Down Chart (Fig.4) was used during the process mapping. By listing down the detailed process steps for every macro process, we are able identify the processes critical to the occurrence of MOP Over Rejection.

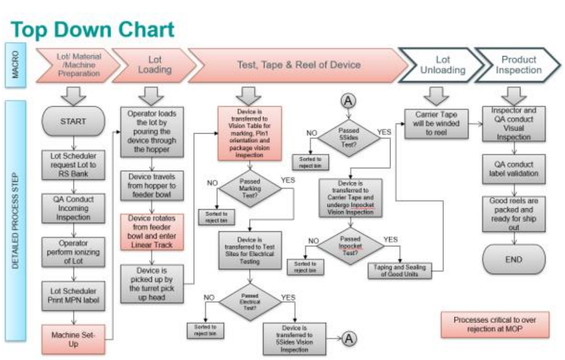

Fig.4. Top Down chart showing the detailed process mapping. Detailed process step highlighted in red are the processes critical to the occurrence of MOP Over Rejection.

3.2.2 Measurement Systems Analysis

MSA was performed on the pilot machine to verify the soundness of the MOP Vision Inspection system in detection of valid failures. Table 1 shows that the machine passed the MSA confirming that the measurement system is consistent and effective in the detection of valid MOP rejects.

Table 1. MSA Result of MOP Vision Inspection System

Output or Response Variable	**MSA Method**	**Criteria**	**Actual Result**	**Remarks**
MOP Vision Fail	Consistency	≥ 90%	100%	Pass
	Effectiveness (Individual)	≥ 95%	100%	Pass
	Effectiveness (Overall)	≥ 95%	100%	Pass
	Miss Rate (Under-Rejection)	0%	0%	Pass
	False Alarm Rate (Over-Rejection)	≤ 5%	0%	Pass

3.3 Analyze Phase

In the Analyze Phase, Key Process Input Variable (KPIV) are determined and validated. Validation of KPIVs is important because it confirms the true root cause of the problem.

3.3.1 Identification of potential root causes (KPIVs)

To identify the potential causes of over rejection during MOP inspection, different tools were used. From the Top Down Chart completed during process mapping, a SIPOC (Supplier, Input, Process, Output, Customer) analysis was done. Another tool used to identify potential root causes is the Fishbone diagram (see Appendix A). Initially, thirty-five (35) KPIVs were identified from the SIPOC and Fishbone Analysis.

A Prioritization Matrix such as the Cause & Effect (C&E) Matrix was used to filter the KPIVs to prioritize. After grouping and prioritization, from 35 KPIVs only eight (8) KPIVs were prioritized and proceeded validation.

3.3.2 Validation of prioritized KPIVs

Different validation tools were used for each KPIV prioritized. From the eight (8) prioritized KPIVs, only five (5) were proven to be valid and are then considered to be the true root causes of Over Rejection at MOP inspection. The validation of the five (5) KPIVs are outlined on the next sections.

3.3.2.1 Un-even camera alignment/ focus

The image captured by the MOP Vision Inspection camera is very significant during testing since it is what the vision system analyzes when detecting defects. Thus, the physical condition (focus, alignment, functionality) of the camera is considered critical.

Historically, there were reports that low yield issues were encountered due to blurred marking captured by the MOP inspection camera. Upon checking of actual units, no blurred marking was observed. The root cause of the blurred marking was found out to be due to uneven camera alignment/focus. Thus, validating our claim that Un-even camera alignment/ focus can cause Over rejection at MOP inspection.

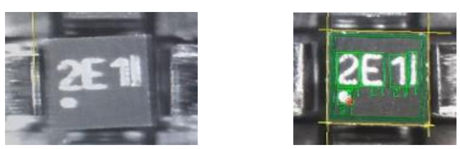

Fig.5. Blurred Marking (Over Rejection) was captured by MOP inspection camera (left). On the right is the image captured by MOP inspection camera during normal operation.

3.3.2.2 High speed rotation of Feeder Bowl

The orientation of the device is important during MOP inspection. It is vital that the marking is faced upward towards the camera for the Vision system to detect the marking. When the device is inverted, the vision system will not detect any marking and would consider the unit as reject.

The feeder bowl is where untested units are poured before it is picked up and placed on the MOP Vision Table for inspection. Before the device is picked up, it passes through the linear track, but it should already be on the correct position where the marking is facing upward (see Figure 6).

By using ON/OFF test, different speed rotation of feeder bowl was set during operation. Through this, it was validated that high speed rotation of feeder bowl can cause Over Rejection at MOP inspection.

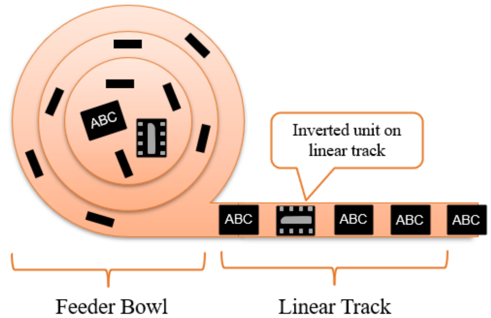

Fig.6. An inverted device on the linear track.

3.3.2.3 Unoptimized Feeder Bowl settings

Aside from the feeder bowl rotation parameter, the feeder bowl has other controls to ensure devices enter the linear track on its correct orientation. However, based on historical data there are occurrences of low yield due to inverted units detected that was caused by the feeder bowl controls turned off. Upon validation of the machine setup checklist, these items are not included on the check items. Thus, the need to correct this issue arise.

3.3.2.4 Unoptimized Vision Settings

Vision system parameters play a vital role during inspection. Unoptimized parameters result to unreliable data of judgement of good and no good units. Over rejection due to vision system failing to detect the package edge was experienced. To validate that vision settings are the root cause of the issue, Characterization DOE (Design of Experiment) was performed. Appendix B presents the data collected during DOE. KPIV that Unoptimized Vision Settings are found to be valid based on the different test from the DOE.

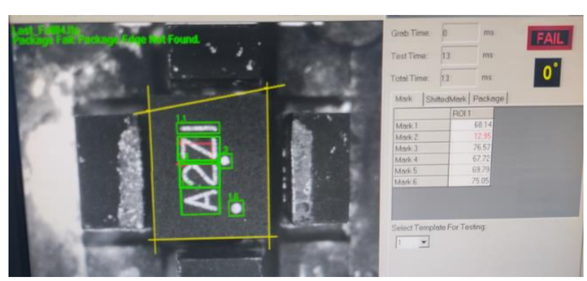

Fig.7. A known good unit (KGU) that failed MOP Vision Inspection. Failure was that the vision system failed to detect the package edges.

3.3.2.5 Deteriorated Vision Table

The vision table is where the device is placed while the MOP Vision camera captures its image to be tested. To validate the claim that a deteriorated vision table causes over rejection at

MOP inspection, hypothesis testing using Chi-Square test was performed.

The result of the Chi-Square test is presented on Figure 8. P Value is at <0.0001 meaning that there is a significant difference between Good vs Deteriorated Vision Table on occurrence of Over Rejection.

Fig. 8. Chi Square test resulted to a p-value of <0.0001 proving that Deteriorated Vision Table causes Over Rejection at MOP inspection

4.0 RESULTS AND DISCUSSION

4.1 Improve Phase

The Improve Phase presents the preventive or corrective actions targeted at the validated root causes.

4.1.1 Un-even camera alignment/ focus

To address the uneven camera alignment of MOP inspection camera, a 3D print of the MOP camera support was made. A sample illustration of the Before and After implementation is shown on Figure 9.

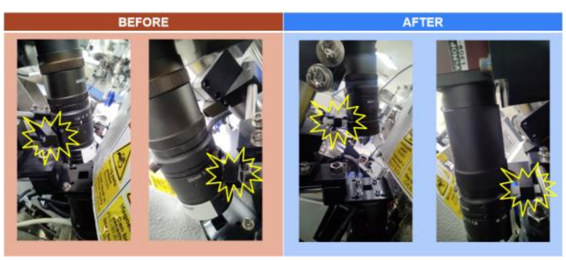

Fig. 9. Before (left photos) implantation of Corrective action, MOP camera supports are missing. After (right photos) shows marking camera with the 3D printed supports.

Another Corrective Action was implemented to address the uneven camera focus causing over rejection. This is to attach a seal on the MOP camera lens to avoid tampering/ adjustment during operation (see Fig.10).

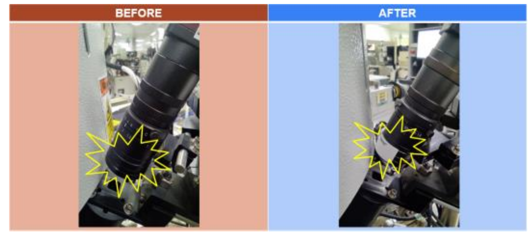

Fig.10. Seal is attached on MOP camera to prevent tampering/adjustment during operation.

4.1.2 High speed rotation of Feeder Bowl

The validated speed rotation of the feeder bowl for Device X was documented on the machine setup checklist. This is, to imply that Device X has a certain speed rotation to be followed compared to other devices processed on the machine.

4.1.3 Unoptimized Feeder Bowl settings

Similar action was made for the other feeder bowl settings. Feeder bowl setting for sensors and blowers were included to be checked for functionality on the machine setup checklist. This is to ensure that all parameters and controls are being utilized during machine operation.

4.1.4 Unoptimized Vision Settings

Optimization DOE was performed to determine the optimized Vision settings that will result to less/no Over Rejection. Figure 11 presents that at View 2 lighting of 255 and all sides package thresholding of 55 is the optimal vision setting for Device X.

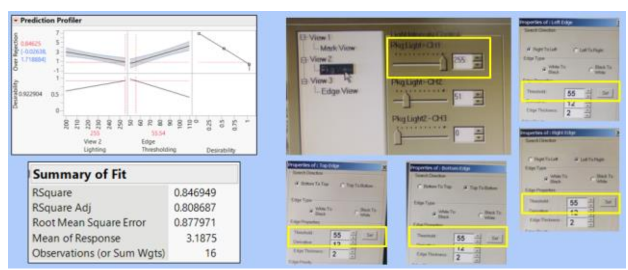

Fig. 11. View 2 lighting of 255 and all sides package thresholding of 55 is the optimal vision setting for Device X.

4.1.5 Deteriorated Vision Table

From the Chi-Square test conducted during validation, the corrective action was to replace the deteriorated vision table to a new one.

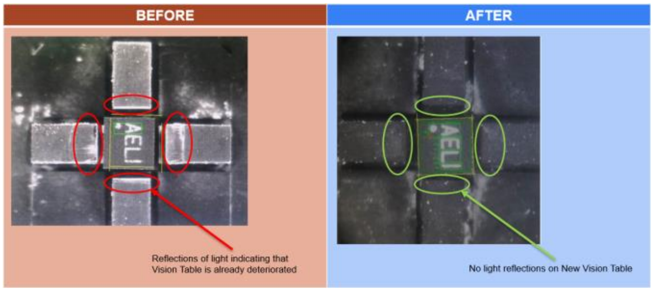

Fig. 12. On the left is the image captured with Deteriorated Vision Table where package edge was not correctly detected by vision system. While on the right is the one using a new vision table. The package edge is detected correctly.

4.2. Control Phase

To ensure that the completed actions are permanent standardization of the actions are all reflected on Work Instructions for Final Test. These actions were also aligned on PFMEA database and Control Plan document.

5.0 CONCLUSION

Upon completion of the study, Over Rejection at MOP Vision inspection was reduced from 5178 PPM baseline to an average of 1235 PPM 9 months after completion of the Analyze Phase.

6.0 RECOMMENDATIONS

The actions completed to Reduce the Over Rejection at MOP Vision of Device X may also be patterned to other devices or machines applicable.

7.0 ACKNOWLEDGMENT

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8.0 REFERENCES

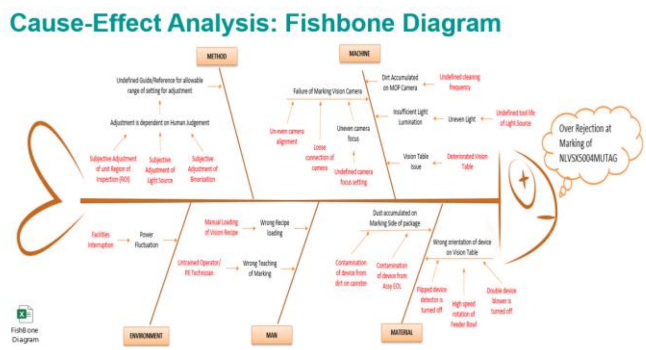
1. LSS Training Material- Lean Six Sigma Pocket Tool Book Michael L. George, David Rowlands, Mark Price and John Maxey

9.0 ABOUT THE AUTHORS

Einna Liz L. Tadeja is a licensed Chemical Engineer from Saint Louis University, Baguio City. She joined onsemi Tarlac 2 years ago as a Process Engineer for the Final Test department. At present, she is part of the assembly team as a Process Engineer for the Plating department.

10.0 APPENDIX

Appendix A – Fishbone Diagram



Appendix B – Characterization DOE of Vision Settings