REDUCTION OF OVER REJECTION AT 5 SIDES VISION OF TEST & TAPE MACHINES

Jiannina Zocor B. Manalo

Test Process Engineering
Onsemi, Tarlac, Luisita Industrial Park, SEPZ, San Miguel, Tarlac City
Jiannina.Manalo@onsemi.com

ABSTRACT

Yield is one key factor in determining company's success in terms of production. Good yield most of the time often tell us that we are a cost-effective and competitive company. However, due to the complexity of producing a single unit, several factors affect the output and final yield.

Cosmetic defect is one of the yield killers and scrap cost contributor. Detection of valid cosmetic defect is acceptable since it protects the company from future customer claims, but over rejecting in contrary, pulls down the yield, increases the scrap cost and delays the delivery due to slower output.
5Sides vision over rejection is a phenomenon occurring wherein an already tested defect-free known good unit (KGU) is being rejected during 5sides vision inspection on test and taping process.

This technical paper intends to reduce the over rejection of units during 5Sides Vision inspection in terms of PPM level on specified machine model.

DMAIC approach was utilized to systematically understand the problem. Probable root causes vital to the occurrence of 5sides over rejection were exposed and validated leading in determining improvement actions in reducing the PPM level of 5Sides over rejection. The result of these actions showed a significant reduction on PPM level.

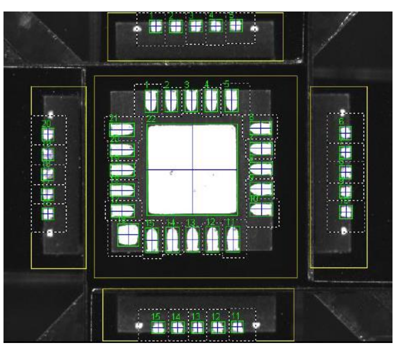


Fig 1 Tested and defect-free known good unit under 5Sides Vision Inspection

1. 0 INTRODUCTION

1.1 Historical Background

An alarming situation was experienced on the span of nine consecutive months, from January to September of 2020, when QFN Mechanical Finish (MEF) yield was not consistently met as shown on Fig 2. With this problem, Operations group and Engineering group observed an increased in defect count during and after each lot processing, unwanted machine downtimes and a slower output after test and tape, thus also affecting the cycle time of post processes after test & tape. This impacted the entire site not only because of low yield but also due to high scrap cost accumulation. Thus, the need to study and stop this situation began.

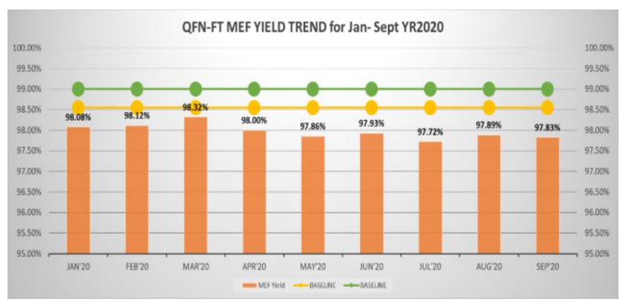


Fig 2 QFN Final Test MEF Yield Trend (Low Yield).
Target yield = 99.0%, Baseline = 98.50%. Both target were not met consecutively.

1.1.1 5 Side Over rejection

In every integrated Test&tape machine, there are three (3) vision inspections included, the Marking&package inspection, Pad/sides inspection and the Taped units inspection. Each electrically known good unit undergo Pad/sides inspection, and rejection on this part is significant since unit already undergone electrical test. Over rejection on a single unit is shown in Fig 3.

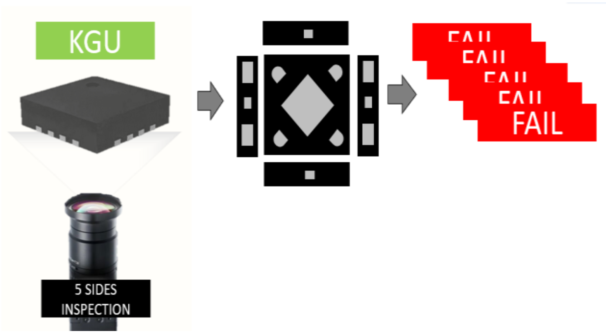


Fig 3 Illustration of 5Sides vision over rejection showing repetitive inspection conducted on a KGU with a consistent Fail judgement.

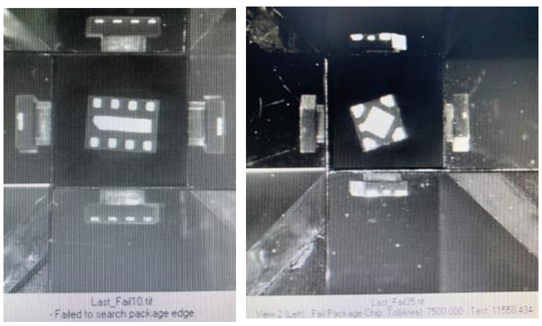


Fig 4 Actual KGU that were rejected under 5Side Vision inspection.

2. 0 REVIEW OF RELATED WORK

Not applicable.

3.0 METHODOLOGY

3.1 Define Phase

Based on reject bin analysis, Lead defect/5Sides reject was top 4 on the major yield loss contributors.

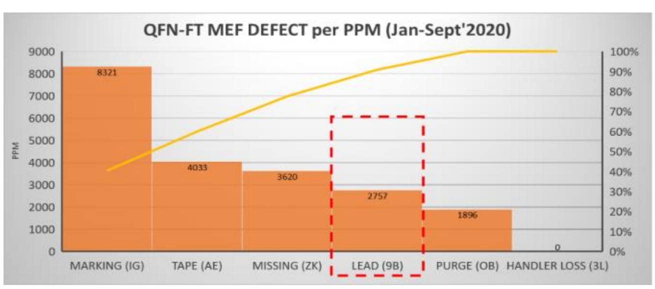


Fig 5 QFN FT MEF Defect per PPM

There are 13 specific reject type under 5Sides defect, and Side Package is the top among other as shown in Fig 6. This will be the focus of the project.

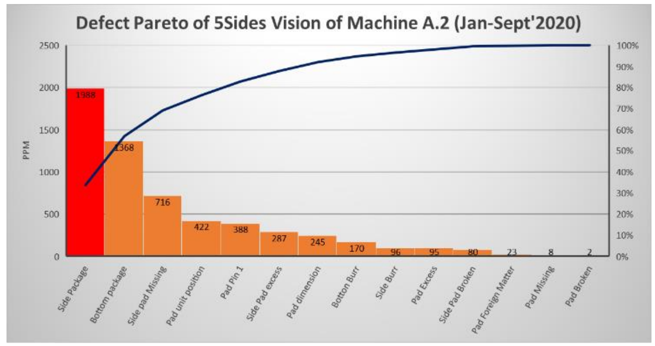


Fig 6 5Sides reject, Side Package fail is the top.

The project targets to reduce the defect PPM to 70% (596 PPM) from its baseline of 1988 PPM.

3.2 Measure Phase

3.2.1 Process and Process Step Analysis

The SIPOC and Top chart shown the three (3) sub-process critical to the occurrence of 5Sides Over rejection.

3.2.2 Machine A.2 MSA

MSA was performed on the Pilot machine, Machine A.2 along with Machine A.4 and Machine A.6, on which these machines have the same version of Vision inspection system. Overall MSA result passed confirming that the measurement system is consistent and effective in detecting Side package defect.

KPOV (Output or Response Variable)	MSA Method	Criteria	Actual Result	Remarks
Side Package Fail	Consistency	≥ 90%	MC A.2: → 96.6667% MC A.4: → 100% MC A.6: → 96.6667%	Passed
	Effectiveness (Individual)	≥ 95%	MC A.2:→ 98.8889% MC A.4: → 100% MC A.6: → 98.8889%	Passed
	Effectiveness (Overall)	≥ 95%	Overall: → 99.2593%	Passed
	Missed Rate	0%	MC A.2: → 0.0% MC A.4: → 0.0% MC A.6: → 0.0%	Passed
	False Alarm Rate	≤ 5%	MC A.2: → 1.67% MC A.4: → 0.0% MC A.6: → 1.67%	Passed

Table 1 Overall MSA result of Automatic Vision inspection machine.

3.3 Analyze Phase

3.3.1 Fishbone Diagram, Cause and Effect Analysis & Matrix

Forty-eight (48) probable rootcauses related to the occurrence of 5Sides over rejection were identified and listed through Fishbone diagram and Cause and Effect Analysis Matrix. After scoring, prioritization, grouping and validation, four (4) major root causes was known valid. (1) Clogged pickup head

(2) Un-even Light source/light source alignment (3) Uneven camera focus (zoom in/out)/Camera Mis-aligned Faulty Camera (hardware) (4) Dirty 5D mirror

3.3.2 Potential root cause 1: Clogged Pick Up Head

PUH (Pick up head) is the arm of an integrated machine that picks up each unit and transport it to each part of the machine sequentially until test and tape sequence is finished. A Clogged pickup head condition during lot processing results to a misaligned unit due to insufficient and ineffective suction to unit in place. The clogging occurs when there is dirt accumulation inside the Pick up head. Any misaligned unit during vision inspection is automatically declared as reject. Thus over rejection occurs.

3.3.2.1 Verification

Through actual machine checking and performing ON/OFF test, it was confirmed that clogged pick up head resulted to over rejection of units on 5Sides inspection.

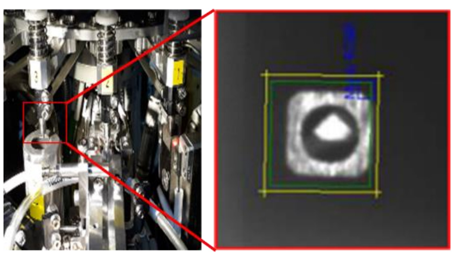


Fig 7 Bottom view of a clogged pick up head with dirt blocking the vacuum from the machine that holds up the unit.

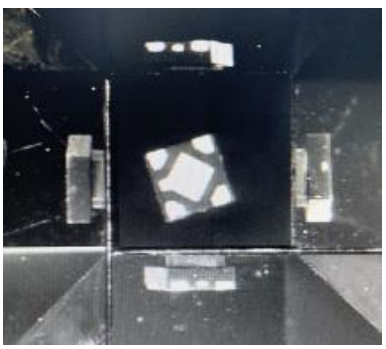
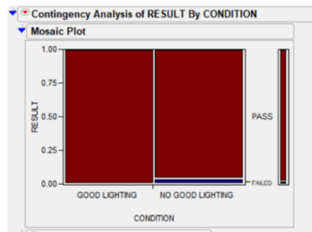


Fig 9 Misaligned unit during 5Sides vision inspection held by a clogged pick up head.

3.3.3 Potential root cause 2: Uneven Light source/light source alignment

Light setting plays a vital role in any automatic vision inspection. No good light setting results to over rejection since appearance of unit subjected to inspection is affected, thus impacting vision judgement.

3.3.3.1 Validation on No good and good light setting through Chi-Square Test Hypothesis testing



Tests

Source	DF	-LogLike	RSquare (U)
Model	1	2.813408	0.1435
Error	198	16.794415	
C. Total	199	19.607823	
N	200		

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	5.627	0.0177*
Pearson	4.082	0.0434*

Contingency Table

CONDITION / Count, Total %, Col %, Row %	RESULT: FAILED	PASS	
GOOD LIGHTING	0 0.00 0.00 0.00	100 50.00 51.02 100.00	100 50.00
NO GOOD LIGHTING	4 2.00 100.00 4.00	96 48.00 48.98 96.00	100 50.00
	4 2.00	196 98.00	200

Fig 10 Hypothesis Testing using Chi-square test shows that there was a significant difference on vision judgement during No good lighting and good lighting.

Also, there were three (3) to four (4) light sources utilized when inspecting a unit but values set per light source was mainly dependent on human. From the pilot machine, light sources were Channel 8 (CH8), Channel 9 (CH9), Channel 11 (CH11) and Light source 3 (LS3).

3.3.3.2 Validation on Light source settings of light sources through Parameter Characterization using DOE.

Durbin-Watson

Durbin-Watson	Number of Obs.	AutoCorrelation	Prob<DW
2.25	36	-0.1472	0.7658

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	7	75.000000	10.7143	21.6000
Error	28	13.888889	0.4960	Prob > F
C. Total	35	88.888889		<.0001*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
CH8(15,25)	1	1	12.500000	25.2000	<.0001*
CH9(15,25)	1	1	9.8608e-32	0.0000	1.0000
CH11(0,10)	1	1	12.500000	25.2000	<.0001*
LS3(0,10)	1	1	12.500000	25.2000	<.0001*
CH8*CH11	1	1	12.500000	25.2000	<.0001*
CH8*LS3	1	1	12.500000	25.2000	<.0001*
CH11*LS3	1	1	12.500000	25.2000	<.0001*

Fig 11 Based on the light source characterization, the 3 factors (CH8, CH11 and LS3) are significant to the occurrence of Over Rejection at 5sides Vision. CH9 was still taken into account due to its interaction.

3.3.4 Potential root cause 3: Uneven camera focus (zoom in/out)/ Camera Mis-aligned /Faulty Camera (hardware)

The physical condition (focus, alignment, functionality) of the camera performing the inspection was also critical to Vision system judgement since it serves as the "eye" of the machine.

3.3.4.1 Validation on Camera Physical Condition

Historically, low yield on 5Sides inspection encountered due to camera misalignment. By performing an ON/OFF Test, it was also proven that misalignment, uneven camera focus resulted to improper centering of unit ROI (region of inspection) vs FOV (field of view).

10-Jan-2020 10:06	DS	XFN_TST_ETS803	ETS88	SRM010	Z248	HANDLER REPAIR	HANDLER EQUIPMENT	on going repair 5 side d misalign and low yield
10-Jan-2020 11:49	DS	XFN_TST_ETS803	ETS88	SRM010	Z248	HANDLER REPAIR	HANDLER EQUIPMENT	problem misalign 5 side camera at vision_and fr jam at bowl *isolation tig screw and align the X&Y camera and perform vis at 5 sides and re teach t sides for monitoring__al bowl and adjust the air b before linear track for monitoring RTP

Fig12 Recorded low yield on 5Sides due to Camera misalignment

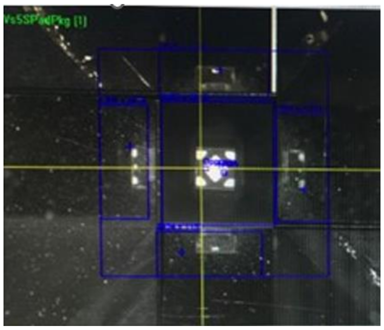


Fig 13 The appearance of unit under inspection with uncentered Region of inspection (ROI) vs Field of View (FOV)

3.3.5 Potential root cause 4: Dirty 5D mirror

Foreign materials appearing along with the unit during inspection results to fail judgement. This is due to some foreign materials appear as added leads/pads and some appears to be white defects on package. Thus another reason of over rejection.

3.3.5.1 Validation on Dirty 5D Mirror

Reviewing the historical machine record, frequent occurrence of 5Sides over rejection was noted due to dust particles observed during inspection. Also, during ON/OFF test, it was proven that dirty Prism or 5D mirror automatically results to a rejection. The activity on cleaning the 5D was also human dependent and should conducted periodically to prevent accumulation.

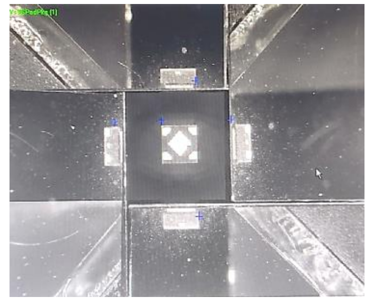


Fig 14 Dirty 5D mirror due to dust accumulation

Fig 16 Rejection on Top side of the device package due to the detected foreign material which are physically attached to the Prism and not to the unit being inspected

4.0 RESULTS AND DISCUSSION

4.1 Improve Phase

4.2 Clogged Pick Up Head: Activation of Automatic checking and cleaning of Pick up heads.

Machine automatically stops when Purge due cycle limit was reached prompting an error message shown in Fig 17. The lot processing will not resume unless cleaning of PUH was conducted. Also, this feature was already hardcoded and can not be disabled.

The implementation of the action was effective in eliminating clogged pickup heads resulting to 5Sides over rejection. No recorded case of low yield after action implementation.

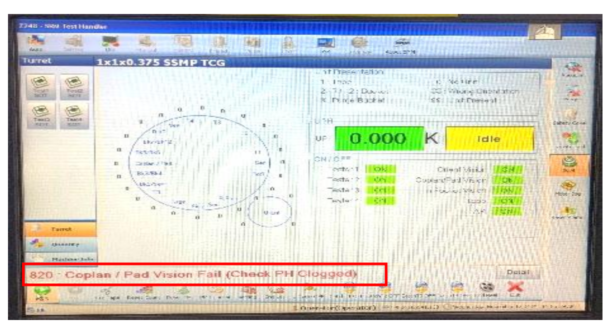


Fig 17 Actual machine alarm message during Pick up head purging and auto-cleaning.

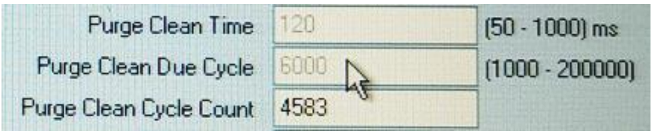
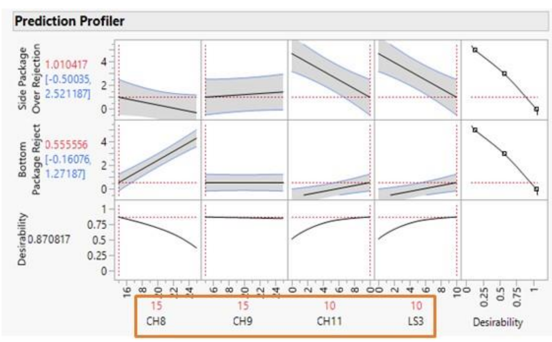


Fig 18 Shows the touchdown limit per Pick up head (Purge clean due cycle = 6000) set on Test and Tape machines.

4.3 Un-even Light source/light source alignment: Optimizing light setting and embedding in recipe

Recommended light setting for optimum 5Sides Vision inspection performance as shown in Fig after parameter characterization thru DOE was identified and reflected on recipe. Take note that in every lot number barcoding, the recipe will automatically be applied, and no human adjustment is needed on the setting.

The result of evaluation lots revealed that the set values for four (4) light sources, CH8 = 15, CH9 = 15, CH11=10 and LS3=10 were effective since the overall result of over rejection was 0 PPM.



Summary of Fit	
RSquare	0.84375
RSquare Adj	0.804688
Root Mean Square Error	0.704295
Mean of Response	0.555556
Observations (or Sum Wgts)	36

Fig 19 Optimized light setting for CH8, CH9, CH11 and LS3 saved on inspection recipe.

4.4 Uneven camera focus (zoom in/out)/ Camera Mis-aligned /Faulty Camera (hardware): Correcting ROI centering and limiting access to higher level account only.

The ROIs (region of inspection) was centered and secured as shown on Fig 20 thus eliminating over rejection due to improper centering. Access on this part of vision settings was also limited to engineering level only.

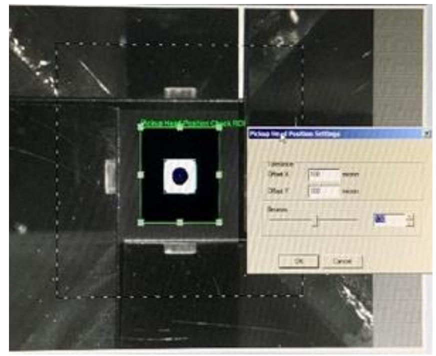


Fig 20 Properly centered pickup head vs device ROI vs FOV

4.5 Dirty 5D Mirror: Provision of cleaning frequency and tool.

Cotton swab shown on Fig 21 was identified as a proper cleaning tool of 5D mirror / prism. This activity was integrated as part of Standard operating procedure of FLA (First Level Analysis) group and performs 5D mirror cleaning and physical condition check once a week.

Action implemented prevented the over rejection caused by accumulated foreign materials on 5D mirror surface.

Fig 21 cotton swab for 5d mirror cleaning

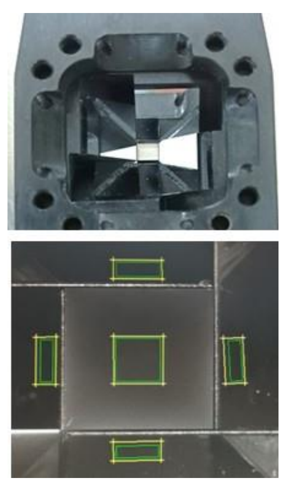


Fig 22 A dust-free 5D mirror and its appearance on vision.

4.6 Before and After Performance Comparison after Pilot run

Fig 23 shows the overall performance comparison of Machine A.2 in terms of 5Sides Overjection before and after the implementation of defined actions. The target of 70% reduction, equivalent to 596 PPM was achieved and after completing all the identified actions, it was further reduced to zero (0) PPM, thus almost eliminating the Side Package Over rejection on Machine A.2 for the pilot package.

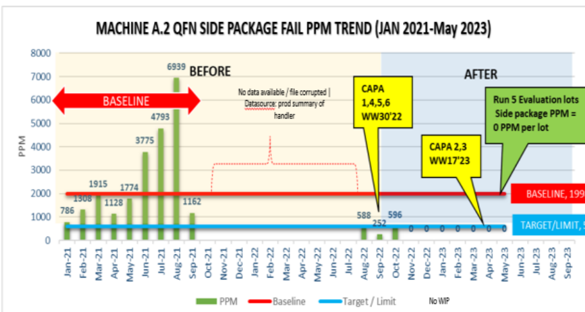


Fig 23 Performance of Machine A.2 in terms of Side Package Fail PPM, hitting the target of 70% reduction (596 PPM) and further achieving 0 PPM after completing all actions.

4.7 Control Phase

Procedural implemented actions were documented on 12MTA12989G. Standardized light settings were embedded on vision recipe. Set purge cycle limit for PUH cleaning and ROI centering were hardcoded on the machine.

5.0 CONCLUSION

Target of reducing 5Sides Vision Over rejection was achieved thru activation of PUH cleanliness, locking ROI centering, defining optimized light setting and embedding in recipe and periodic cleaning of 5D mirror with the aid of proper tool.

6.0 RECOMMENDATIONS

This paper, upon validation of impact, recommends to assess applicability of implemented actions to other machines and packages.

7.0 ACKNOWLEDGMENT

The paper author would like to acknowledge the following:

Sir Roy Rico, our Site Director and the Top Management for their strong drive and support on technical projects like this.

Sir Joel Medina, Sir Jay Lubao and Ma'am Al Rhea Estoque for their technical inputs and guidance to their engineers.

Sir Louie Dizon for his mentoring and leadership on this project, start to end.

And to the team members of this project who unselfishly extended their efforts and time.

8.0 REFERENCES

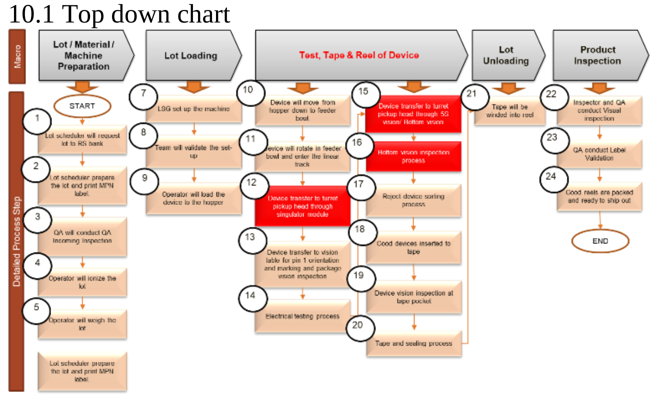
1. LSS Training Material- Lean Six Sigma Pocket Tool Book Michael L. George, David Rowlands, Mark Price and John Maxey

9.0 ABOUT THE AUTHORS

Jiannina Zocor B. Manalo is currently a Process Engineer under Final Test Department who has been with Onsemi for 7 years. She is a graduate of Electronics and Communications Engineering.

10.0 APPENDIX

10.1 Top down chart



10.2 Fishbone Diagram: