REDUCTION OF STRAY WIRE RBFA INCIDENT AT WIRE BOND

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ABSTRACT

Stray wire is a type of defect call out wherein unwanted wires are present on the units. This defect is very critical that can possibly cause test fail, and possibility of customer complain.

Onsemi is encountering Increases in RBFA (Reject Bin Failure Analysis) occurrences due to stray from 2021 to 2022. Recurring event of RBFA (Reject Bin Failure Analysis) due to stray wire is a serious hold lots contributor and lot cycle time killer at test, since lot are needed to 100% xray and retest causing material cost and lot aging.

This paper discusses all the process improvement involving the causes of stray wire, process improvement included thorough processing mapping, validation, simulation and uses different statistical tools to conclude and understand the behavior of the process.

This paper further explain how Stray wire was reduced using different statistical method on the analysis and several improvements in the process such as the implementation of the **POKA-YOKE** solution to prevent the operator to perform dummy bond on the active region, procedural improvement to prevent stray wire and tool maintenance improvement.

1. 0 INTRODUCTION

Wire Bonding process is one of the most critical processes of assembly it is where the wires are interconnected on the lead frame. Before wire bonding starts proper Tool set up are needed to ensure smooth wire bonding, this included setting up your wires and indirect material like capillary. After the material tool set up completed it now where the wire threading comes wherein the operator/technician needed to thread the wire in the capillary before start bonding, the threading part of wire bonding process are the most critical and one of the contributors of stray wire. Wire threading are needed every Tool set up and Machine error.

After the wire bond process the device will now be inspected and if reject was seen during inspection the inspector will cute the wire, this is where potential causes of stray wire also induce. If stray wire was not detected at wire bonding process it will fail at final test as OS fail. This OS fail defect will now be analyze during RBFA (Reject Bin Failure Analysis) and if it's proven to be induced due to stray wire proper disposition will be done.

1.2 Stray Wire Occurrence

A Stray Wire A type of defect call out wherein unwanted wires are present on the units. Stray wire are rejects wire that propelled to the other die/ unit that contaminate the units during wire bond process. Refer to Figure 1. For the sample photo of Stray wire defect.

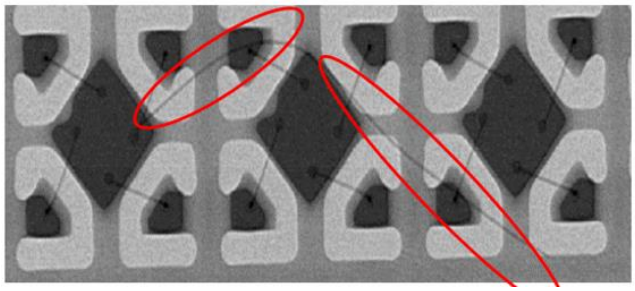

Figure 1. Stray wire defect Photo.

2. 0 REVIEW OF RELATED WORK

This Study did not used any reference form a previous study; thus, this section is Not Applicable for the study.

3.0 METHODOLOGY

This project used the DMAIC problem solving methodology to fully understand and reduce the cases of RBFA fail due to Stray wire. DMAIC is an acronym for Define, Measure, Analyze, Improve, and Control. is used by a project team that is attempting to improve an existing process. DMAIC provides structure because each phase of the process contains

tasks and tools that will lead the team to find an eventual solution.

3.1 Define

The first phase of DMAIC was used to help to properly determine the improvement opportunity in detailed outline that describes the statement of the problem, project scope, team composition, initial historical baseline data and business goal by better understanding the impact of Stray wire defect reduction in wire bond process. By doing an improvement to reduce this re-occurring issue, we will see an increase in improvement on scrap savings, reduction of hold lots and improvement in lot cycle time and EFAR prevention.

3.2 Measure

The Measure phase was used to validate the correctness of the baseline data that were identified in the define phase.
It was used to revisit the entire wire bond process and verify the critical steps relevant to stray wire defects. Attribute MSA is used on the MSA study to validate the consistency and effectiveness of the inspector in detecting the stray wire.

3.3 Analyze

Under this phase, the team performed process map to improve efficiency, listing the probable root causes, and identifying important factors/inputs (KPIV) that greatly impact the output using statistical tools like hypothesis testing. Fish Bone Diagram analysis and Cause-and-Effect matrix was used to validate the potential sources of the Stray wire defect at wire bond. KPIV validation was also performed to identified all possible root causes.

3.4 Improve

Under this phase were Solution development and selection happens. The team discussed and identified Corrective and Preventive Actions (CAPA) that can be implemented in the line each of the validated KPIVs that are valid. **POKA-YOKE** solution was identified as part of the CAPA also included procedural preventive actions. Monitoring of CAPA effectiveness was also incorporated on this phase after the implementation of all CAPAs.

3.5 Control

This Phase help ensure that the gains realized are locked up, this phase was used to document and standardize the CAPAs implemented. All pertinent details of this project were documented on all work instruction and specs, all Root causes corrective actions are incorporated in FMEA (Failure Mode and Effect Analysis).

Fan out was also carried out on all related platforms.
Finally, the annualized hard cost savings arising from the reduction of RBFA Incident due to stray wire was computed and validated by Finance.

4.0 RESULTS AND DISCUSSION

4.1 Define

Onsemi Wire bond is encountering Increases in RBFA (Reject Bin Failure Analysis) occurrences due to stray from October 2021 to March 2022.

Recurring event of RBFA due to stray wire is a serious hold lots contributor and risk for customer return if this project will not be supported, By doing an improvement to reduce this re-occurring issue, we will see an increase in improvement on scrap savings, reduction of hold lots and improvement in lot cycle time and EFAR prevention.

This project aims to reduce the RFBA occurrence due to stray wire at wire bond that can improve the quality, productivity and cost that support our corporate strategy which is Road to ZERO defect.

Figure 2. shows that RBFA cases are increasing from October 2021 to March 2022.

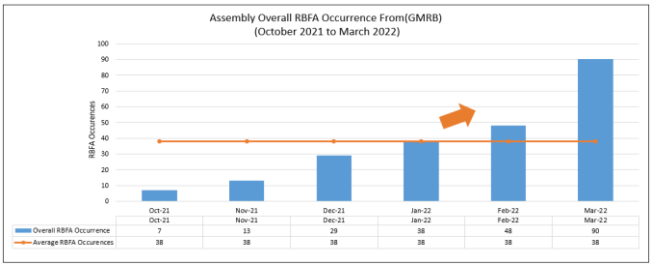

Figure 2. Increasing trend of Hold lots is observed starting from October 2021 to March 2022.

Based on 2021 overall RBFA hold shown in Figure 3. 5% of total RBFA hold is contributed by Stray Wire defect.
Focused on 4th top reject for this project since top 1 to 3 rejects already have LSS/QII projects.

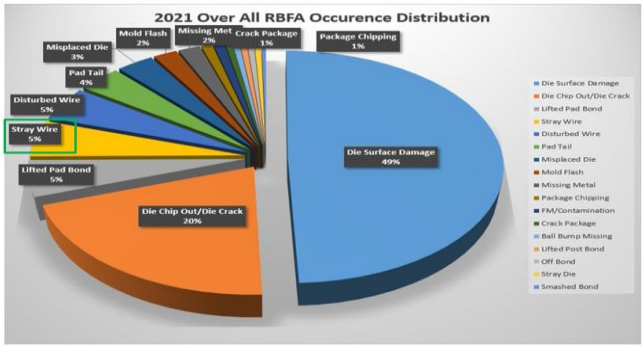

Figure 3. Top RBFA Defect Distribution report. Graph shows that stray wire contributes 5% of the RBFA Incident.

As shown in Figure 4. The average recorded cases of RBFA due to stray wire is 3 cases per month from Oct'21 to Mar'22. The DMAIC team was created in order to address this recurring issues and concern.

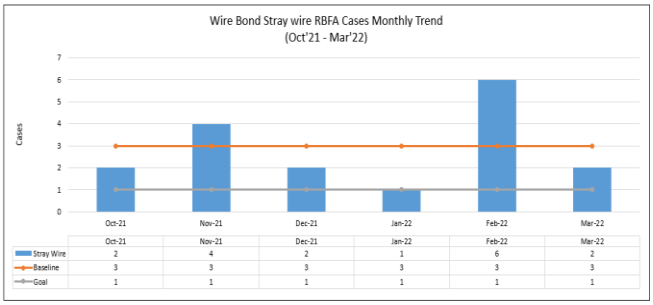

Figure 4. Wire bond RBFA cases due to stray wire monthly trend shows average of 3 cases per month.

4.2 Measure

Before digging deeper into the causes of problem, it is imperative that we understand the process and the metrics that will be useful for measuring the success of this project. The Attributes MSA study passed. The inspectors are effective and consistent in detection of Stray wire. With the given data integrity ruled out, that the RBFA incident due to stray wire of 3 cases per month from Oct 2021- Mar 2022 is proven true and correct as shown in Figure 5.

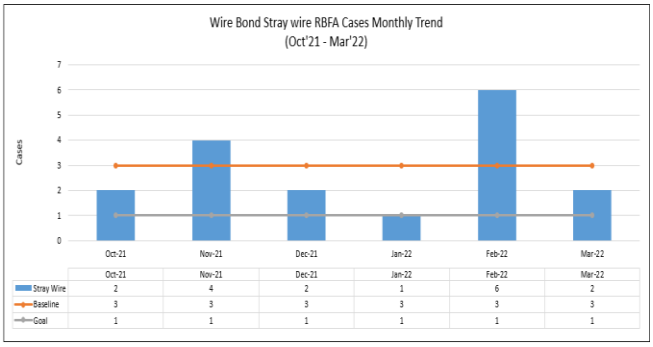

Figure 5. RBFA due to stray wire monthly trend. Graph shows average of 3 cases per month based on October 2021 – March 2022 data.

4.3 Analyze

The process steps where Stray wire can occur are during wire bonding and wire bond inspection. These are the main focus of the project as shown in Figure 6.

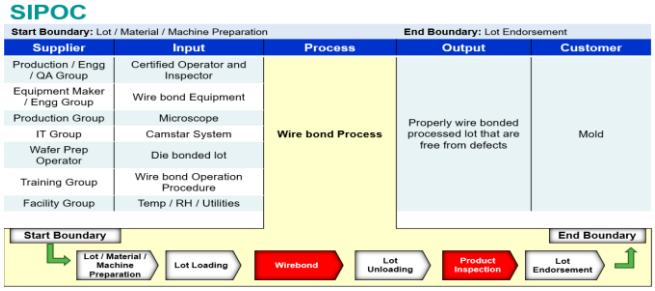

Figure 6. SIPOC- Supplier Input Process Output Customer at wire bond process.

Cause and effect analysis was used to study the detailed process of wire bond process form Lot/Material preparation to Post bond inspection. As can be seen in Appendix A. Several steps were identified wherein those Step highlighted in Red are identified where the Stray wire is originating.

Fish bone diagram were also used as seen in Appendix B and Appendix C to identify other potential root causes of Stray Wire.

Using the Cause-and-effect analysis matrix the team identified a total of 105 Key Process Input Variables (KPIVs). After our thorough analysis and processing mapping using similarities and grouping the KPIVs are narrow to 7 KPIVs. Refer to Table 1 for the short listed KPIVs.

Each of this KPIVs are validated using simulation, line validation and different statistical tool to determine if the KPIVs identified are valid or not and per summary on Table 1, all the identified KPIVs are valid.

Table 1 Shortlisted KPIV

KPIV#	KPIV	Hyphothesis	Remarks
1	No Dummy Lead frame available during bondtest	No available dummy leadframe can contaminate the good units during set up and bond test. Excess wire will contaminated the adjacent good units during bond test and set up	VALID
2	Poor Cutter condition	Poor cutter condition will induce stray wire during inspection	VALID
3	No cover installed on the machine	Machine With out pre and post heat cover is prone to stray wire wire, when wire drop on the bonding station during threading , stray wire can contaminate the good units if pre and post heat cover is not available	VALID
4	Open scrapped bin during wire disposal	Open scrapped bin can cuase stray wire to contaminate the units, excess wire can possiblye propelled on the good units when scrapped bin left open left open during threading process	VALID
5	Machine not capable for auto dummy bond outside bonding area	when machine don't have capability to perform auto bond, the operator will decide where to do auto bond, causing stray wire when operator did not remove the excess wire during auto bond.	VALID
6	No Cleaning Tool for the bond test area	Uncleaned bond test area can cuase stray wire, when excess wire/scrap wire is present on the work holder cleaning should be done.	VALID
7	No Good Tweezer Condition	Tweezer condition is contributed on the stray wire occurrence if tweezer condition is not maintain stray wire will contaminate the units during threading	VALID

The detailed result for the 7 valid KPIVs are shown in the next sections.

4.3.1 KPIV 1: No Dummy Lead Frame Available During Bond test.

To verify the hypothesis, we conduct historical data of Hold lots and EFAR from the period November 2021 to March 2022 validate that no available dummy to be used during for set-up/repair/change capillary and Bond test data gathering. No dummy units resulted in using good units resulting stray wire that resulted to RBFA Stray wire occurrences thus this KPIV is Valid. Refer to Figure 7. for the simulation.

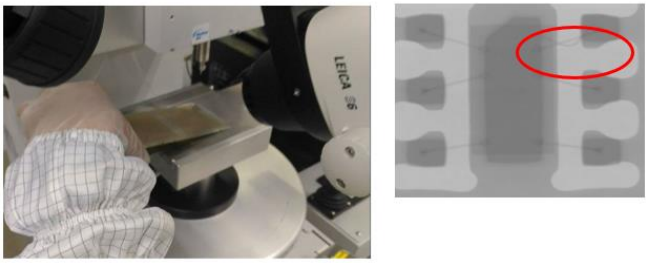

Figure 7. KPIV 1 Simulation result.

4.3.2 KPIV 2: Poor Cutter Condition

To validate the Hypothesis, we conduct simulation to used poor cutter blade/wrong cutting mode condition resulting to stray wire and used non parametric test to compare the performance of poor cutter blade versus good cutter blade. Validation results shows in Figure 8. that the Poor cutter condition is significantly different to good cutter condition. Thus, Poor cutter condition is a Valid KPIV.

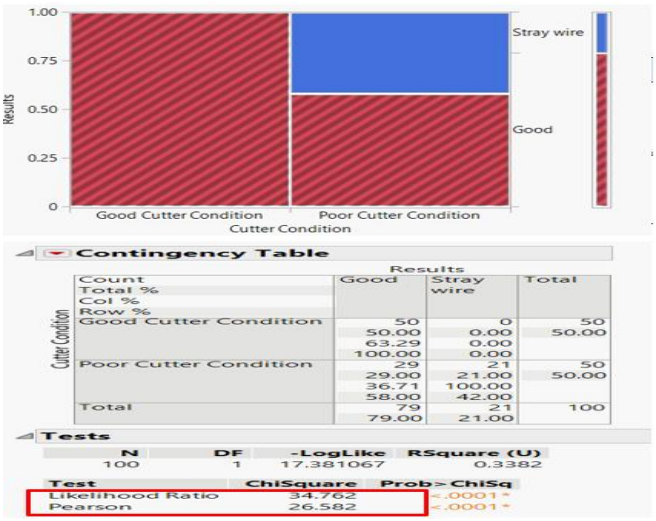

Figure 8. KPIV 2 Nonparametric test comparing Poor cutter condition and good cutter condition.

4.3.3 KPIV 3: No Cover Install on the Machine

To verify the hypothesis, we conduct validation on the line and perform simulation and as per validation results shown in Figure 9. pre and post heat without cover is prone to stray wire. During threading process possibility of wire to drop on the pre and post heat is very high contaminating the good units if cover is not available, thus this KPIV is Valid.

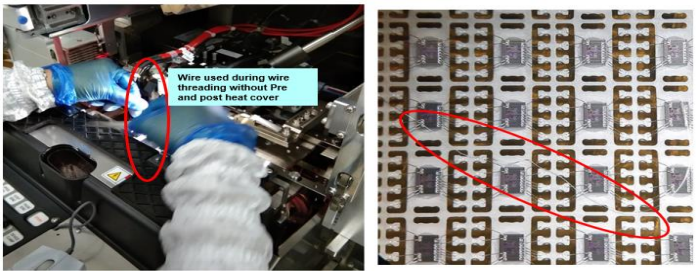

Figure 9. KPIV 3 Wire threading simulation with out the pre and post heat cover of the machine.

4.3.4 KPIV 4: Open Scrap Bin During Wire Disposal

To validate the Hypothesis, we conduct Simulation as shown in Figure 10. to perform wire threading with scrapped bin open and based on the validation results open scrap bin has a high potential contributor of stray wire when left open during wire threading process, thus this KPIV is Valid.

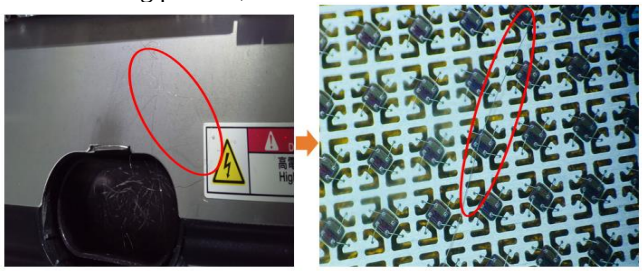

Figure 10. KPIV 4 Wire threading simulation with scrap bin open.

4.3.5 KPIV 5: Machine not capable for auto dummy bond outside bonding area

To validate the Hypothesis, we conduct simulation to perform dummy bond near the active region and without removing the excess wire during threading. Validation results shows that when the machine is not capable to do auto dummy bond operator can decide where to do dummy bond causing stray wire when not remove as shown in Figure 11. thus, this KPIV is Valid.

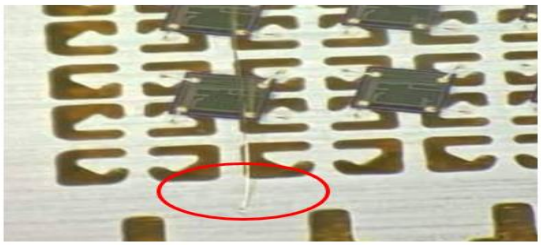

Figure 11. KPIV 5 Dummy bond simulation on the active region

4.3.6 Other VALID KPIVs

Following the similar approach on the validation and simulation on the rest of the KPIVs, it was validated that KPIV numbers 6, and 7were all valid and contributed to Stray wire.

4.4 Improve

After an extensive team brainstorming, alternative solutions were identified for each of the 7 valid root cause of stray wire. A total of 11 were identified to be implemented on the process two (2) of this action are Corrective action No human dependent in nature. Refer to Table 2 for the List of CAPA implemented.

Table 2 Implemented CAPAs

KP IV#	KPIV	CAPA
1	**No Dummy Lead frame available during bondtest**	Enhance dummy library management. work instruction
2	**Poor Cutter condition**	Install microscope with monitor
		Enhance inspection procedure to include validation of reject and adjacent units after wire-cutting of rejects
		Control Generate Cutter blade control and maintenance
3	**No cover installed on the machine**	Install Pre and Post heat cover
4	**Open scrapped bin during wire disposal**	Implement Scrapped bin with vacuum
5	**Machine not capable for auto dummy bond outside bonding area**	Implement bond off plate for wire threading for auto dummy bond
6	**No Cleaning Tool for the bond test area**	Provide Vacuum on the bond test area for cleaning
7	**No Good Tweezer Condition**	Implement black color on provide good contrast to check wire still on the tweezers
		Implement Checklist for the monitoring of Tweezer condition every shift.(SV to own the check list)

With all the CAPAs implemented, the trend chart was revisited and compare the before and after project performance as per results Upon implementation of 11 CAPA, The Goal of 1 RBFA occurrence per month was achieved for July 2023 TD. As shown on Figure 12. We are now seeing an opportunity for the Elimination of stray after the Fanout of auto dummy bond, this is our **POKA-YOKE** solution to eliminate the manual intervention of man during threading.

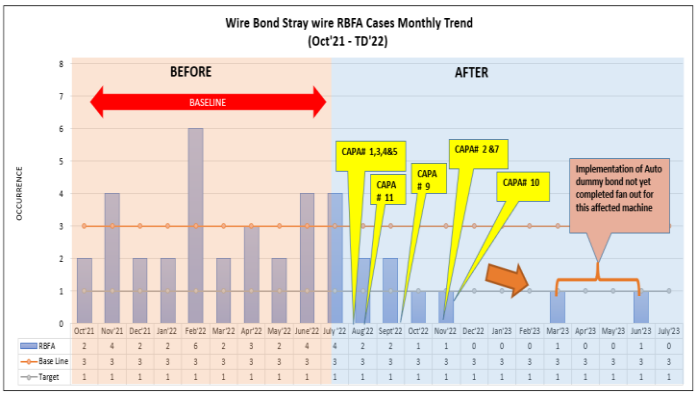

Figure 12. Before and After trend of stray wire after the implementation of CAPAs.

4.5 Control

All pertinent Work instruction and specs are updated and revised including FMEA to reflect all the Root cause and Corrective actions implemented on the line. Training on all line personnel also completed for them to align on all the CAPAs implemented.

The Annual cost saving of the project validated by finance is at $285, the Tangible benefit is not that high but the opportunity for customer satisfaction is very must important.

5.0 CONCLUSION

The previous section showed that Stray wire is significantly reduces and the opportunity of Elimination is possible, the identified 11 corrective actions are effective in reducing stray wire, the Fan out of the auto dummy bond as part of the **POKA-YOKE** solution is the best CAPA that can Eliminate the intervention of man during threading that causing the high percentage of stray wire occurrence.

6.0 RECOMMENDATIONS

Majority of the action are Preventive action with human dependent, need more automation project/**POKA-YOKE** Solution to prevent or lessen the human dependent action.

7.0 ACKNOWLEDGMENT

The author wishes to thank onsemi leaders for sponsoring the project.

Victor Generosa- QFN Assembly Manager
Arnel Hulipas- Process Engineer Section Head
Joanne Franco- Supervisor
Louie Dizon- LSS Mentor

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

Majhed Quismundo is a B.S. Electronics Communication Engineering graduate of Saint Louis University Baguio 2013 with more than 8 years of experience in Wire bonding process.

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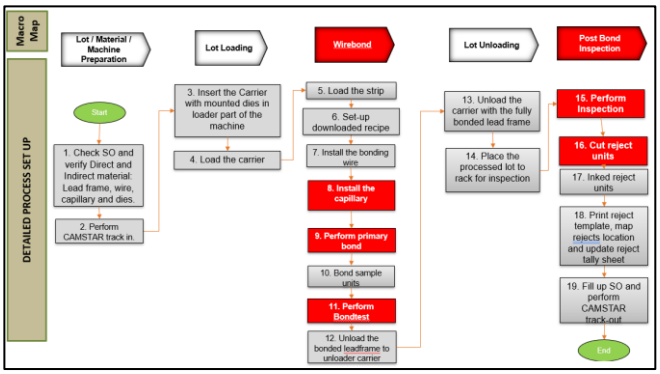
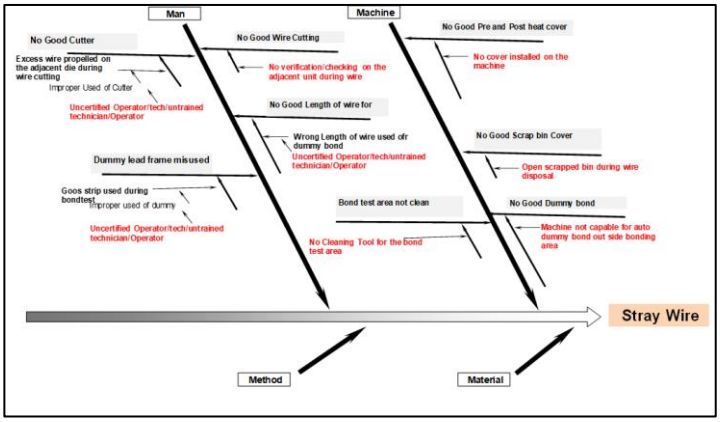
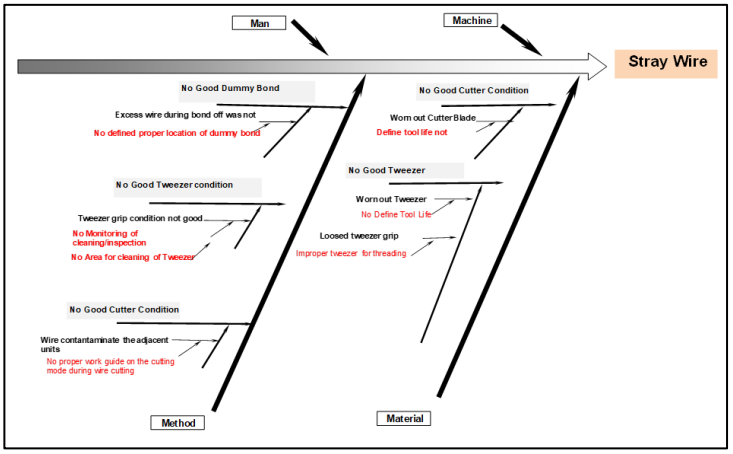
10.0 APPENDIX



Appendix A - Process Mapping of Wire bonding Process.



Appendix B – Fishbone diagram of stray wire under Man and Machine.



Appendix C – Fishbone diagram of stray wire under Method and Materia