ENABLING CONTINUOUS IMPROVEMENT THROUGH POWER BI: POST-TEST YIELD ANALYTICS FOR SUSTAINABLE SEMICONDUCTOR MANUFACTURING IN THE AI AND INDUSTRY 4.0 ERA

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ABSTRACT

Post-test yield (PTY) dashboard was developed using Microsoft Power BI which provides real-time, data-driven insights through customized visualizations. End-users and stakeholders can efficiently monitor yield performance, identify key issues, and take prompt, effective actions. This paper showcases how the dashboard supports daily yield monitoring, continuous improvement initiatives, and the application of the Best Tool Matching (BTM) methodology.

With the implementation of this dashboard, report generation time is significantly reduced, and data analysis is accelerated. Results highlight how advanced data analytics and automation enhance operational efficiency, support ongoing yield improvement, and advance manufacturing excellence within the semiconductor industry.

1. 0 INTRODUCTION

Gross margin reflects a company's ability to retain a portion of its revenue [1], and one effective way to enhance gross margin is by increasing post-test yield (PTY). PTY represents the percentage of units that pass visual and mechanical inspection during the tape and reel process. Fewer defects translate to higher gross margins.

Accurate monitoring of PTY requires an analytical tool. In the absence of such a tool, engineers must rely on manual data extraction and computation, a process that typically takes around two hours per report. This manual approach not only consumes significant time but also increases the risk of errors and compromises data integrity.

Delays in reporting hinder timely analysis and obscure the identification of root causes—whether related to test processes, materials, assembly suppliers, package size, or lead count. Without a centralized PTY dashboard, teams may struggle to prioritize issues effectively, resulting in misaligned efforts and reduced productivity.

2. 0 REVIEW OF RELATED WORK

Power BI or Business Intelligence (PBI), a component of Microsoft Power Platform, is a data visualization tool capable of integrating with a wide range of data sources [2]. The team leveraged Power BI to develop an automated Post Test Yield (PTY) Dashboard.

Across the organization, various groups have adopted Power BI to create their own metrics monitoring dashboards. The key differentiator among these implementations lies in the methods used to collect and manipulate data, particularly through DAX (Data Analysis Expressions). DAX is a library of functions and operators that enables the creation of complex calculations and tailored visualizations to meet specific user requirements [3].

3.0 METHODOLOGY

3.1 Development of Post-Test Yield Dashboard

The team began by identifying the key requirements and data sources necessary for the dashboard, incorporating calculations and filters to support effective data analysis. All data sources were integrated into Power BI using the ADI Database and SharePoint. Development started with data modeling to ensure accuracy and integrity, followed by the creation of custom DAX calculations for critical metrics such as Yield (percentage), Defect Rate (defects per million, DPM), and Scrap Cost (dollars).

The resulting visualizations were designed to provide actionable insights: line and bar charts display trends in volume and post-test yield over time; stacked column charts illustrate the impact of defect rates on yield trends; pie and donut charts present the distribution of volume by package, handler type, or other user-selected parameters; stacked bar charts highlight the top contributors by DPM; and scatter plots are used for probability analysis and to compare best and worst tools using the Best Tool Matching (BTM) methodology.

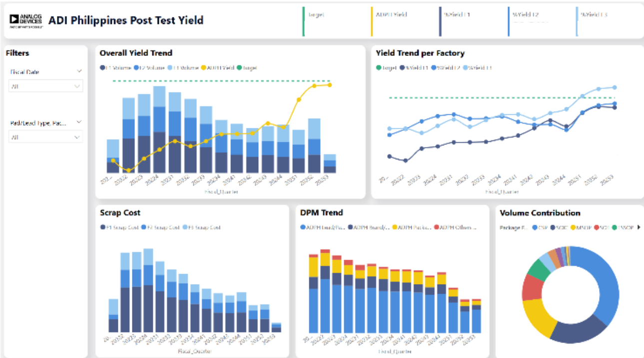


Figure 1. Sample page of Post-test yield dashboard

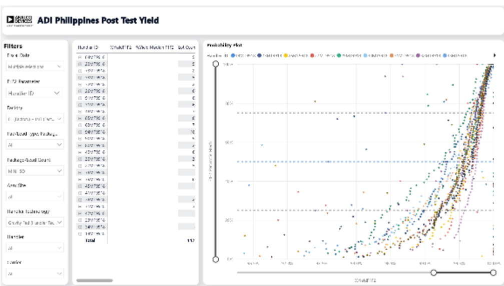


Figure 2. Sample probability plot

3.2 Application for Post-Test Yield Dashboard

3.2.1 Daily Yield Monitoring and Line Sustaining

3.2.1.1 Background:

The team detected a lot with low PTY due to lead standoff defect using the daily yield monitoring page in Power BI (Figure 3). This was immediately communicated to equipment and manufacturing representatives to investigate the machine.

Summary of Top Defects for F1 and F2

Fiscal Date	%Yield	lot_id	Handler_ID	Top Defect Name	Top Defect	T_rejects	Volume	Package	Factory
6/24/2025	5	BA44	371	Standoff				TSOT	
6/24/2025	9	BA44	353	Bent Leads				TSOT	
6/24/2025	9	BA44	13N	Pad Ball				LFCSP_SS	
6/24/2025	9	BB39	MC	Illegible Brand				MINI_SO	
6/24/2025	9	BA44	06N	Standoff				MINI_SO	
6/24/2025	9	BA44	07H	Standoff				SOIC_W	
6/24/2025	9	BA44	17N	Bent Leads				TSSOP_4.4_	
6/24/2025	9	BB38	MC	Standoff				MINI_SO	
6/24/2025	9	BB39	MC	Illegible Brand				MINI_SO	
6/24/2025	9	BA44	18N	Bent Leads				TSSOP_4.4_	
6/24/2025	9	BA44	286	Pad Ball				LQFN	
6/24/2025	9	BA44	90N	Standoff				MINI_SO	
Total									

Figure 3. Daily yield monitoring in Power BI

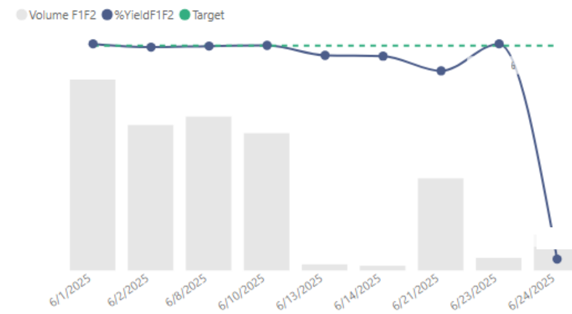


Figure 4. Daily Yield Trend of Affected Machine in PTY dashboard

3.2.1.2 Investigation:

The review was initiated starting with the historical PTY performance of the handler (Figure 4). It was observed that the handler deviated from its normal PTY performance. The current condition of the handler was inspected, and upon checking, a misaligned lead support was discovered on one of the contact sites (Figure 5a).

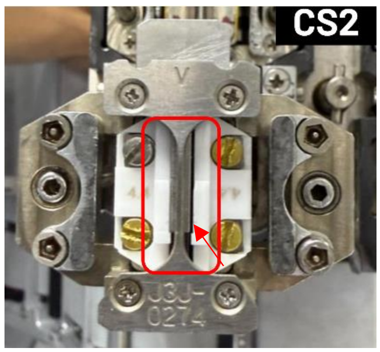


Figure 5a. Misaligned lead support (visible gap highlighted by a red arrow)

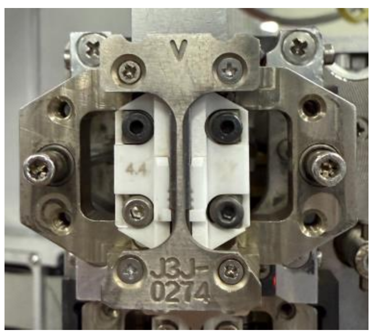


Figure 5b. A properly aligned lead support

Using the same handler condition, the team did a simulation run to reproduce the defect. After the simulation, it was confirmed that the misaligned lead support was the root cause since the defect was successfully replicated (Figure 6).

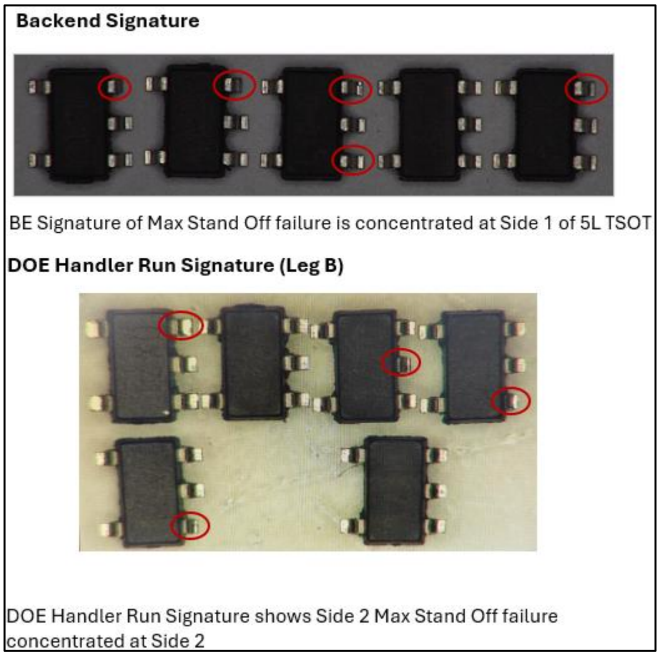


Figure 6. Tape and Reel (Backend) vs. Handler Simulation Lead defect

3.2.1.3 Action:

As part of the containment activities, misaligned lead support was promptly corrected. Subsequently, all similar machines were inspected to ensure compliance with alignment requirements. In parallel, a continuous improvement plan was developed to prevent recurrence and implement an error-proof solution.

3.2.1.4 Result:

Upon implementation of fixes on the affected machine, its performance gradually returned to the normal level (Figure 7).

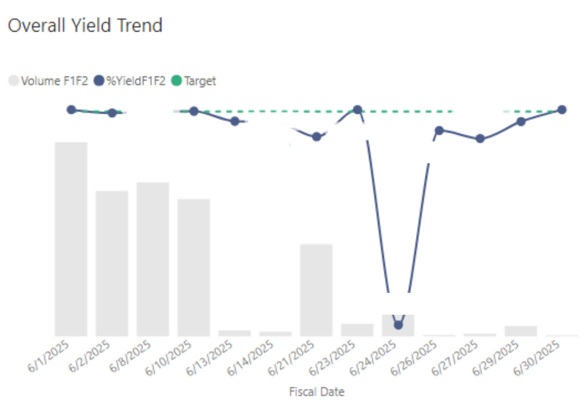


Figure 7. Daily Yield Trend of Affected Machine in PTY dashboard after implementation of fixes

3.2.1.5 Conclusion:

The PTY dashboard provides daily insights into the top lot IDs and setups with low PTY, enabling near real-time monitoring to prevent further impacts on subsequent lot IDs. Equipment and manufacturing area owners are promptly notified of issues, allowing them to take immediate, and targeted actions.

3.2.2 Continuous Improvement Projects

3.2.2.1 Background:

At Factory A, a downtrend in post-test yield was observed for SOIC N packages, primarily due to an increase in lead defects such as bent leads and standoff issues (Figure 9a and 9b). This project aimed to reverse the declining trend and restore SOIC N yield performance focusing on assembly site and machine type with the highest volume and defect rate contribution.

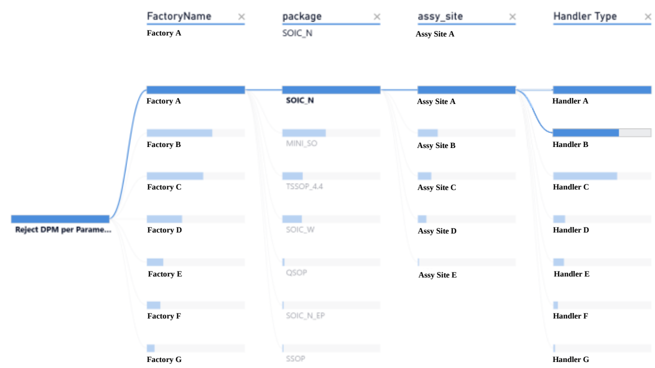


Figure 8. Tree Diagram of top DPM contribution

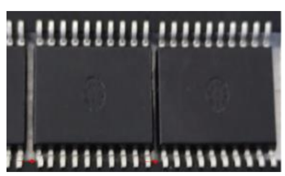


Figure 9a. Bent leads

Figure 9b. Standoff

3.2.2.2 Plan:

The team set a clear objective, which is to reduce lead defects by 2,000 DPM for SOIC N packages at Factory A which is equivalent to 0.20% PTY improvement. Root cause analysis, including process mapping, fishbone diagram (Figure 10), and root cause verification (Appendix A), identified several controllable factors: inconsistent handler settings, worn-out contact ledges (especially during lead count conversion), improper magazine-to-tube transfer, and wrong brake pin adjustment. Incoming material defects were also noted but considered uncontrollable within the test manufacturing scope.

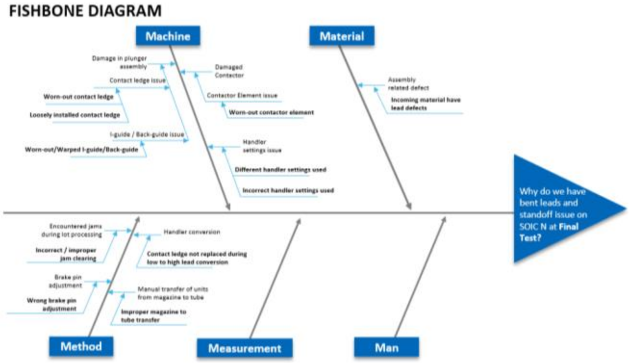


Figure 10. Fishbone Diagram on lead defects of SOIC N packages processed on Factory A

Table 1. Root Cause Ranking

Category	Probable Root Cause	Effect	Rank 1-Lowest 5-Highest
Machine	Different handler settings used	Different response per handler. Inconsistency in handling units during electrical testing and sorting. High probability to happen based on initial comparison made by the team on different handlers. Depending on the parameter, chances of lead defect could be high.	5
Method	Contact ledge not replaced during low to high lead conversion	During conversion, if contact ledge is already worn out, using the same contact ledge on a higher lead count setup could cause lead defects. High probability of happening since contact ledge for both low/high lead count package are the same. High chance to induce lead defects.	5
Machine	Worn out contact ledge	Frequent plunging of unit could cause for a worn out contact ledge. Over time, this would be deep enough that any misalignment during plunging could easily cause lead defect. High probability to happen. High chances of lead defect.	5
Method	Improper magazine to tube transfer	Mag-to-mag handlers (MT9308) has setup limitation when it comes to loading and unloading of units. Due to the nature of input and output process, units are manually transferred from tube to magazine and vice versa. Act of manual transfers could cause lead defect if misaligned. High probability to happen although lower frequency due to limited number of mag-to-mag handlers. Still a high chance of inducing lead defects.	3
Material	Incoming material have lead defects	If untested parts are already on the high or low side of measurement, paired with a scenario where shift in measurement would induce a valid lead defect. Medium probability of happening. IQA has random sampling to detect this prior start of testing. This would also need extensive collaboration with assy site engrs and is not controlled within test manufacturing resources.	1
Method	Wrong Brake pin adjustment	Low probability of happening since this is not typically adjusted every setup. Medium chance of inducing lead defect	1
Machine	Worn-out/Warped I-guide/Back-guide	Damaged I-guide/Backguide will cause for units to misaligned during plunging. The extra space brought by the warped I-guide will cause this mis alignment. Low probability of happening since this part is checked during handler PM. High chance to induce lead defect if I-guide and back guide is defective.	1

Based on the root cause ranking, the team will prioritize improvements targeting handler settings, worn contact ledges, and conversions from low to high lead count. The ranking methodology considered both the risk or severity associated with each root cause and the likelihood of occurrence.

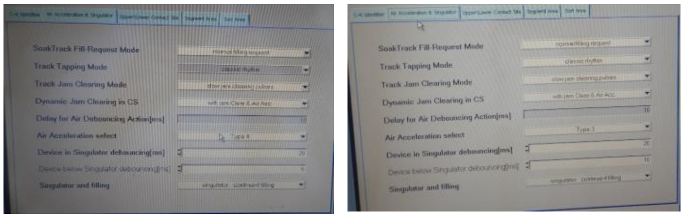
3.2.2.3 Do:

Table 2. Solutions Matrix

ALTERNATIVE SOLUTIONS		Root Cause vs Solution			Criteria				
		RC 1: Different handler settings	**RC 2:** Contact ledge replacement during lead conversion	**RC 3:** Wornout contact ledge	Impact on post yield / lead defect dpm	Feasibility	Time to Implement	Cost to Implement	**Score**
1	**Handler parameter standardization**	**5**	**1**	**1**	**5**	**5**	**5**	**5**	**27**
2	**Contact Ledge checking at start of setup**	**1**	**5**	**5**	**5**	**5**	**5**	**5**	**31**
3	New material for contact ledge	1	5	5	5	3	3	1	23
4	Semi-annual CL replacement	1	5	5	5	5	3	1	25
5	**Tool life cycle monitoring (separate team addressed this)**	**5**	**5**	**5**	**5**	**5**	**1**	**3**	**29**

Solutions focused on standardizing handler parameters (Figure 11) and establishing contact ledge inspections (Figure 12) as part of the setup checklist. Handler settings were reviewed and updated, with best practices disseminated across all handlers. Simulations and process documentation supported the changes, and comprehensive training was conducted for line maintenance and technicians. These actions were implemented between February and July 2024.

Before



After

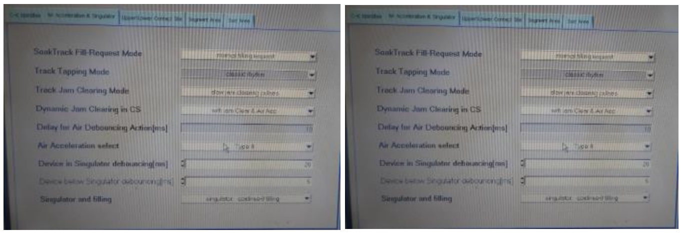


Figure 11. Changes in Handler Parameters

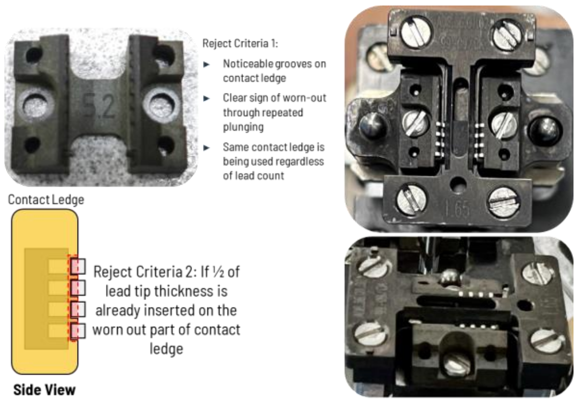


Figure 12. Contact Ledge Inspection

3.2.2.4 Check:

Bent leads DPM decreased from 4,700 to 2,900, while standoff DPM was reduced from 3,000 to 1,900 (Figure 13). This combined reduction of 2,100 DPM resulted in a 0.21% improvement in post-test yield, meeting the targeted yield increase (Figure 14). As a result, Factory A achieved its highest PTY performance in three years. Furthermore, the initiative yielded an estimated annualized scrap cost avoidance of $53,000. Performance was tracked weekly through the Power BI dashboard, with established feedback loops supporting ongoing continuous improvement.

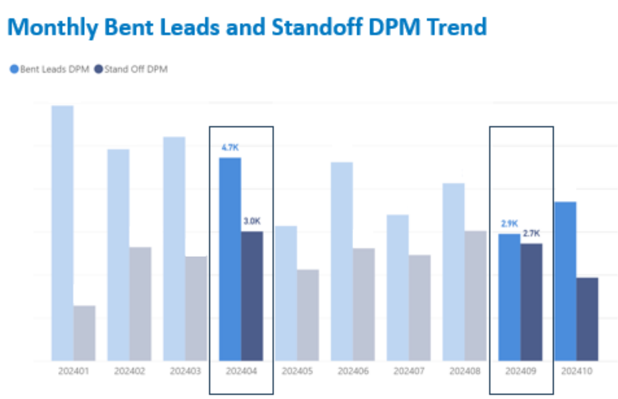


Figure 13. Monthly Bent Leads and Standoff Defect (DPM) Trend

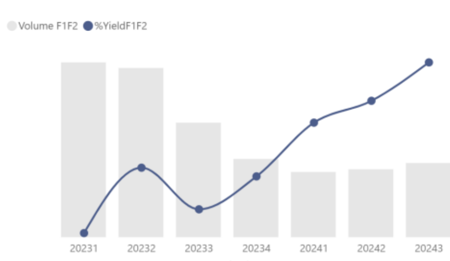


Figure 14. Quarterly Post-Test Yield Trend of SOIC N Package at Factory A

3.2.2.4 Act:

To sustain improvements, updated documentation in ADI library and training were fully rolled out in the third quarter of 2024. Ongoing monitoring ensures continued adherence to the new standards, and scalability assessments are underway to extend these solutions to other handlers and packages. Reflections highlighted the team's adaptability and creative problem-solving, especially under cost constraints. Succeeding plans include qualifying new contact ledge materials, introducing a magazine transfer jig, further standardizing parameters, and exploring additional process signals.

3.2.2.5 Conclusion:

Power BI enabled the Factory A team to systematically identify, address, and sustain improvements in post-test yield for SOIC N packages. Emphasizing agility, balance, and innovation, the project not only delivered measurable quality and cost benefits but also established a foundation for ongoing process excellence.

3.2.3 Best Tool Matching (BTM) Methodology

3.2.3.1 Background:

This project utilized the Best Tool Matching (BTM) methodology to drive post-test yield improvements for the SOIC N package, processed specifically on a specific handler type. Confounding variables were initially identified by isolating the top contributors to PTY. The dashboard enabled filtering of each variable, generating probability plots that compared the performance of all handler IDs (Figure 15).

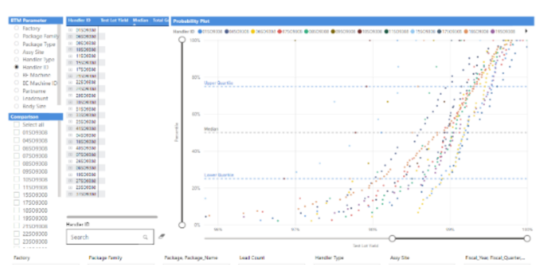


Figure 15. Probability Plot using Power BI

3.2.3.2 Plan:

The team established a clear, quantifiable objective which is to improve the post-test yield of the worst performing setup (Handler A) by the third quarter of 2024. Initial analysis involved gathering historical yield data and reviewing the probability plot to benchmark both the worst- and best-performing handlers. The analysis identified a matching opportunity (MO) of 0.36% for Handler A (Figure 16), representing the potential yield gain achievable by aligning process and equipment parameters with those of the best-performing tools.

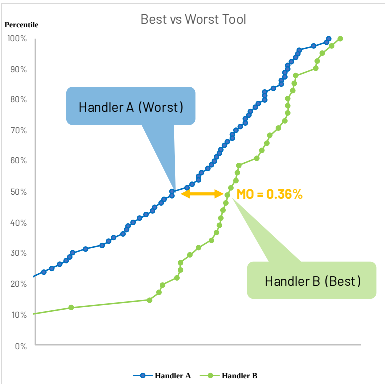


Figure 16. Probability plot comparison for worst- and best-performing tool

3.2.3.3 Actions:

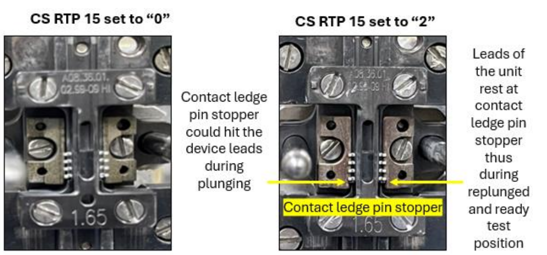


Figure 17. Comparison of handler settings for Contact Site Runtime Parameter 15 (CS RTP 15) between worst- and best-performing tool

The team focused on adjusting critical handler parameters that were found to differ between the worst and best tools (Figure 17). For Handler A, the key intervention was changing the plunger stroke parameter from 0 to 2 (Table 3), and standardizing output track and transition settings to minimize the risk of device leads being damaged during handling. All parameter updates were implemented in a controlled manner, with changes tracked and documented for each handler.

Table 3. Gap analysis and action taken on the worst-performing tool

Problem	Description	Worst Tool	Best Tool	Gap	Action
Difference in handler parameters	CS Runtime Parameter 15 - plunger stroke parameter	0	2	Parameter settings	Change parameter setting from 0 to 2

3.2.3.4 Results:

For Handler A, the worst tool's lead defect improved by 3,256DPM, with the median yield increasing by 0.33%. These results validated the effectiveness of parameter alignment and demonstrated that targeted process changes, guided by Power BI, could deliver significant quality gains.

3.2.3.5 Standardization:

The team moved to institutionalize these improvements. Documentation and standardization efforts were undertaken to ensure that optimized parameters were consistently applied across all handlers processing the relevant device types. Ongoing monitoring was assigned to key team members, with regular reviews scheduled to track the sustained impact on yield metrics. The team also began developing standard parameter sets for key metrics such as quality, yield, and Overall Equipment Effectiveness (OEE), supporting broader process control and knowledge sharing across the organization.

3.2.3.6 Conclusion:

On this project, utilizing Power BI in post-test analysis, combined with the Best Tool Matching (BTM) methodology, empowers teams to quickly identify and address handler-related issues through real-time data visualization and actionable insights. This integration streamlines root cause analysis, enhances decision-making, and drives continuous yield improvement. Ultimately, adopting PBI with BTM not only resolves current challenges but also builds a foundation for sustained process excellence and operational efficiency.

4.0 RESULTS AND DISCUSSION

With the deployment of the PTY dashboard, daily automated reports now provide users across the company with timely and actionable insights from comprehensive data visualizations. The time required to generate these reports has been reduced from nearly two hours using manual Excel and PowerPoint methods to just 15 minutes per report (Figure 18), allowing engineers to focus more on analysis and problem-solving.

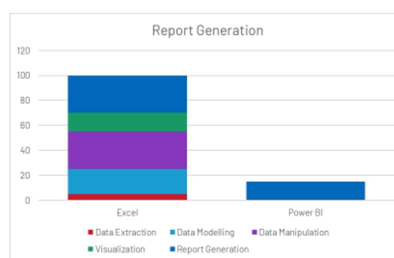


Figure 18. Report Generation Comparison between Excel and Power BI (measured in minutes)

Daily reporting accelerates the identification of top contributors to low yield events and enables immediate feedback to process owners. This rapid communication minimizes delays in root cause analysis and helps prevent further impacts on subsequent lots or equipment, supporting more consistent post-test yield performance.

The PTY dashboard's real-time monitoring empowers teams throughout the company to respond quickly and precisely to emerging issues. By leveraging Power BI, teams have systematically identified, addressed, and sustained improvements in post-test yield, strengthening the foundation for ongoing process optimization.

The integration of Power BI with the Best Tool Matching methodology streamlines root cause analysis and decision-making through real-time data visualization and targeted insights. As a result, the company has established a reliable system for continuous yield improvement and operational excellence—an important step as the industry evolves toward more advanced, data-driven manufacturing solutions.

To date, the implementation of all the solutions driven by post-test yield dashboard resulted in total cost savings of ~$1.80 million.

Finally, the post-test yield dashboard has become the company's official reference for the Factory Performance Award (FPA), directly linking data-driven results to team recognition and incentives.

5.0 CONCLUSION

The implementation of the PTY dashboard has transformed post-test yield monitoring and reporting, significantly reducing manual effort and enabling faster, data-driven decision-making. By integrating Power BI and the BTM methodology, teams can now promptly identify and address yield issues, fostering a culture of continuous improvement and operational excellence. The dashboard's adoption as the official reference for performance recognition further reinforces its value in aligning team efforts with organizational goals. As the company continues to advance its manufacturing solutions, the success of this initiative demonstrates the impact of leveraging digital tools to drive sustainable performance and maintain a competitive edge in the evolving semiconductor and electronics industry.

6.0 RECOMMENDATIONS

Power BI is a powerful tool that extends beyond post-test yield monitoring and can be applied to a wide range of metrics to drive sustainable improvements across the company. When developing dashboards, full automation should be prioritized to ensure long-term consistency and reliability in reporting. Data sources should be centralized and maintained within secure, cloud-based repositories.

Visualizations must remain clear and intuitive to support effective data interpretation by all users. It is essential to provide appropriate access to all relevant stakeholders to maximize the dashboard's impact. Finally, dashboards should be designed not only for monitoring but also as tools to prompt timely, data-driven actions that directly contribute to improving key performance indicators across the organization.

7.0 ACKNOWLEDGMENT

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9.0 ABOUT THE AUTHOR

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10.0 APPENDIX

Appendix A. Root Cause Verification

Category	Probable Root Causes	Method of Verification	Result of Verification	Team's Conclusion
Machine	Different handler settings used	Compare best performing handler to worst performing handler and check for differences in parameter	Observed difference of handler settings on output track to tube. Setting of the handler is causing the tapper to tap more frequently causing for tube to move creating a gap. Added air acceleration could induce lead defects. Plunger stroke parameter also causes units to misalign during handler jam inducing lead defect (See reference Figure 19)	**True Cause, Controllable**
Machine	Incorrect handler settings used	Check handler documentations	Handler settings of affected setups are still within limits	False Cause
Machine	Worn-out/Warped I-guide/Back-guide	Check integrity of plunger assembly of top handler contributors then simulate if lead defect will be encountered	Simulated a damaged I-guide and back-guide and run sample units in the handler. Observed lead defects after the simulation. (See before and after data) (See reference Figure 20)	**True Cause, Controllable**
Machine	Worn-out contactor element	Check low yielding lots at backend and see if there are any commonality in contactor technology used. Simulate worn out contactor element if it could induce lead defect.	No shift in measurement observed after the simulation. (See reference Figure 21)	False Cause
Machine	Worn out contact ledge	Collect worn-out contact ledge and simulate if defect will be encountered	Found lead defects after the simulation. Unit could be misaligned and settle improperly in the worn-out contact ledge during plunging. (See reference Figure 22)	**True Cause, Controllable**
Method	Wrong brake pin adjustment	Simulate wrong brake pin adjustment and run sample units	Found lead defect when break pin is beyond tolerance limit of 0.3mils to 0.5mils	**True Cause, Controllable**
Machine	Loosely installed contact ledge	Simulate a loosely installed contact ledge. (Loose screw and incomplete screw)	Shift in measurement observed but still insignificant to cause lead defect. (See reference Figure 23)	False Cause
Method	Incorrect / improper jam clearing	Survey line activities and check with equipment training	No anomalies found. Proper jam clearing still part of training of operators and technicians	False Cause

Appendix A. Root Cause Verification (cont.)

Category	Probable Root Causes	Method of Verification	Result of Verification	Team's Conclusion
Method	Improper magazine to tube transfer	Survey line activities and check with test training	Probable cause for lead defects if tube is misaligned during transferring. Force failure simulation performed to replicate scenario of misaligned tube. Lead defects would be induced in the transition from tube to magazine.	**True Cause, Controllable**
Material	Incoming material have lead defects	Check measurements of incoming/untested parts	Observed significant difference on different assy site measurements. Stand off has marginal failures but still within limits. This marginality could cause lead defect on certain scenarios where small shift on measurement could cause a valid lead defect. (See reference Figure 24)	**True Cause, Uncontrollable**
Method	Contact ledge not replaced during low to high lead conversion	Simulate a setup from 8L to 16L and use the same CL with damage (wornout)	Shift on lead measurements observed on 2 out of the 10 samples. Still within the POD requirements. Since the shift is drastic, this could cause a valid lead defect if the fresh material's measurement are on the high side of the limit. (See reference Figure 25)	**True Cause, Controllable**

Figure 19. Difference in handler settings affecting the units flow inside the handler

Figure 20a. Warped Back-guide (left) and I-guide (right)

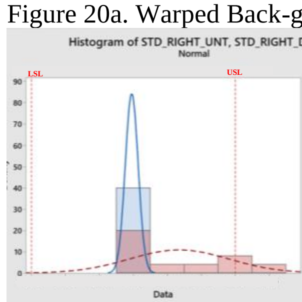

Figure 20b. Standoff Measurements before (blue) and after (red) the simulation for Warped I-guide and Back-guide

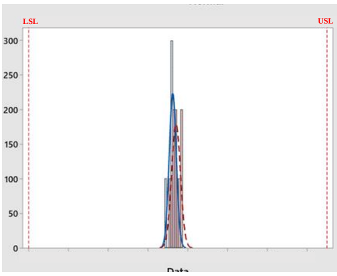

Figure 21. Standoff Measurements before (blue) and after (red) the simulation for Worn-out Contactor Element

Figure 22a. Worn-out Contact Ledge

Figure 22b. Standoff Measurements before (STD_RIGHT_UNT) and after (STD_RIGHT_DOE) the simulation for Worn-out Contact Ledge

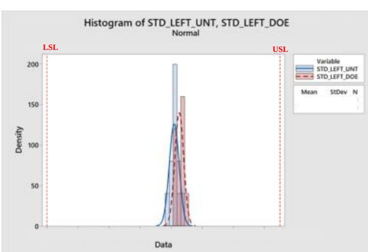

Figure 23. Standoff Measurements before (blue) and after (red) the simulation for Loosely Installed Contact Ledge

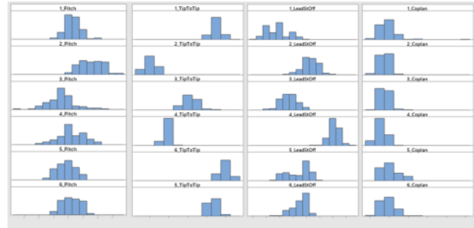

Figure 24. Comparison of Standoff Measurements from different incoming materials

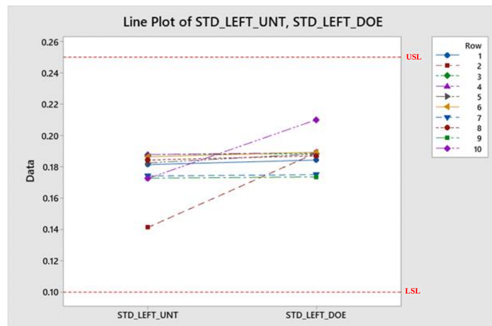

Figure 25. Standoff Measurements before (STD_LEFT_UNT) and after (STD_LEFT_DOE) the simulation for Worn-out Contact Ledge