ENHANCING DIE CLEANING EFFICIENCY WITH AUTONOMOUS VACUUM TRIGGER IN TRIM & FORM MACHINES

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ABSTRACT

Unsatisfactory die cleaning may result to die parts breakage with long downtime impact and may produce quality related defects if not urgently observe and contain.

The invention aims to reduce productivity losses, cost avoidance due to die breakage and lessen the risk in producing product with quality related issues due to die contamination brought about by improper die cleaning.

This project will be utilizing the machine's vacuum cleaner to be triggered on automatically whenever the main safety door is opened. It will give full blast vacuum power generated by the machine's vacuum system ensuring debris and slugs remain inside die tool will be remove during idle mode and increase productivity wherein no need to pull out the die tool in times of die checking to prevent long downtime.

1. 0 INTRODUCTION

Previous practice in Trim and Form process is hand-held vacuum cleaner was being used in performing die cleaning which is time consuming in sourcing and waiting for vacuum cleaner availability and when performed unsatisfactory will result to catastrophic loosing thousands of dollars due to low product output, die breakage and worst customer claim due to quality related defects affecting factories KPI.

1.1 What is Trim and Form Process?

Trim and form is the process of separating the lead frame's leads from the lead frame strip. The Dambar that electrically isolates the leads is first removed during the operation is known as trim process. The leads are then inserted into tool, separate, and mechanically formed into the desired figure is known as form process (see Fig. 1).

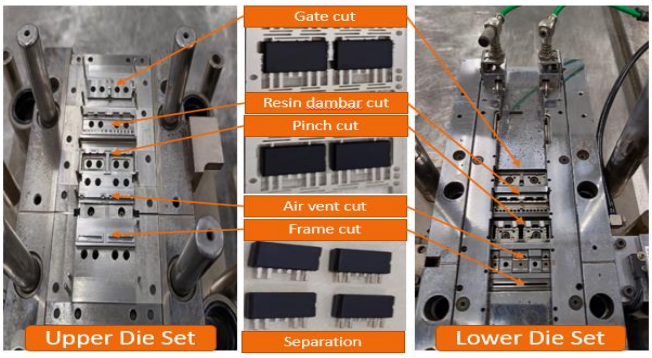


Fig. 1. Trim and Form Tool with Progressive Shots of Package Integrated Circuit. From attached on the lead frame strip to separated and formed to finished product.

1.2 Die cleaning at Trim and Form process, why is it very important?

Die cleaning is very important in Trim and Form because this log point is one contributor of dust and resin debris due to its cutting and trimming process. It is a combination of lead frame and mold compound debris where when not properly removed will result to various problems. Improper cleaning or without performing cleaning at all will result to catastrophe that will lose thousands of dollars due to low productivity output, die breakage and worst customer claim due to bent leads, stand-off and the like affecting factory's KPI (see Fig. 2).

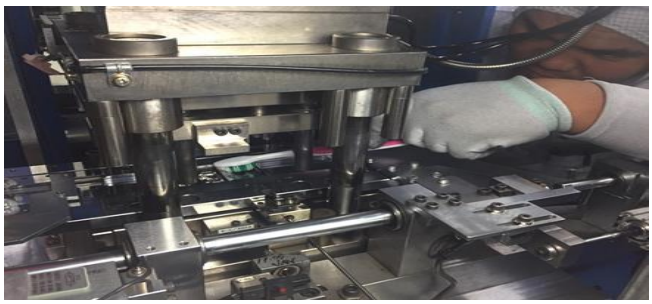


Fig. 2. Actual Presentation of Die Tool Cleaning Performed by Production Specialist.

2. 0 REVIEW OF RELATED WORK

"Not Applicable."

3.0 METHODOLOGY

3.1 Define Phase

Our project objective is to avoid productivity losses, cost avoidance due to die breakage and reduce quality related issues brought about by improper die cleaning resulted to die contamination.

Top long downtime contributor that affects machine productivity is the die contamination with cost involve once improper die cleaning was performed and possibly induce quality related defects if not contain immediately like bent leads, chipping, broken package or wounds.

3.2 Measure Phase

Data with regards to contamination trend shows surge, we have an average of 19 cases per year with 42% increase at 2023 vs 2022 data which is very alarming as this trend emphasizing a ticking time bomb with respect to time, cost & quality (see Fig. 3).

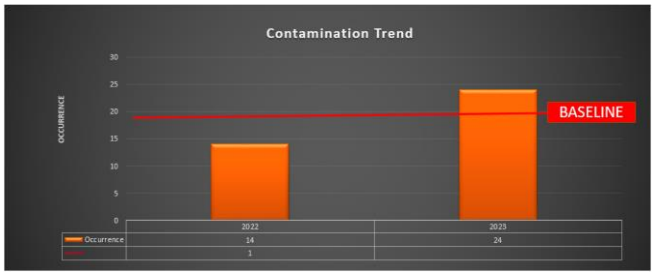


Fig. 3. Graphical Representation of Contamination Trend in terms of Occurrence as Baseline Data.

The graph shows die check/contamination as the top long downtime contributor for CC-7XX platform which was selected to improve by the team (see Fig. 4).

Fig. 4. Graphical Representation of Contamination Trend in terms of downtime as Baseline Data.

Potential damage cost when need to replace broken die parts brought about by contamination (see Table 1).

Table 1. Summary of Die Parts Costs per Parts.

PACKAGE TYPE	DIESET	PART NAME/CODE	PART DESCRIPTION	QUANTITY	ITEM COST
SIX5/5X/4X	T16X & T1X0	RESIN-DCD-0XX	RESIN AND DAMBAR CUTTING DIE 713-XXX	1	$334.00
		RESIN-DCP-0XX	RESIN AND DAMBAR CUTTING PUNCH 713-XXX	2	$316.13
		AIRVENT-CP-0XX	AIRVENT CUTTING PUNCH 713-XXX	1	$98.00
		AIRVENT-CP-00X	AIRVENT CUTTING PUNCH 713-XXX	1	$68.33
		LEAD-CP-XX0	LEAD CUTTING PUNCH 713-XXX	1	$64.02
		LEAD-CD-X0X	LEAD CUTTING DIE 713-XXX	2	$273
		FRAME-CD-XX5	FRAME CUTTING DIE 713-XXX	1	$246.15
		FRAME-CP-XX7	FRAME CUTTING PUNCH 713-5XX	1	$46
		FRAME-CP-XX8	FRAME CUTTING PUNCH 713-XX7	2	$46.09
		FRAME-CP-XX9	FRAME CUTTING PUNCH 713-X8X	2	$136.13
		GATE-CD-0X0	GATE CUTTING DIE 713-5XX	1	$481.15
		GATE-CP-0X1	GATE CUTTING PUNCH 713-5XX	1	$19.00
		GATE-CP-0X2	GATE CUTTING PUNCH 713-XXX	1	$23.06
		PINCH-CD-0XX	PINCH CUTTING DIE 713-XX6	1	$276.00
		PINCH-CP-0XX	PINCH CUTTING PUNCH 713-XX7	4	$62.00
		PINCH-AVCP-XX8	PINCH & AIRVENT CUTTING PUNCH 713-5XX	1	$83.00
		PINCH-AVCD-0XX	PINCH & AIRVENT CUTTING DIE 713-0XX	1	$541.00
				GRAND TOTAL	$3,113.06

3.3 Analyze Phase

One sample actual scenario of unsatisfactory die cleaning that resulted to produced product with quality issue, long downtime in tool repair and spent thousands of dollars in tool parts replacement. Total damage costs of die breakage incident above was $2, 329.59, material was made up of carbide metal (see Table 2-3).

Table 2. Why-Why Analysis of Contamination with Broken Package and Die Breakage.

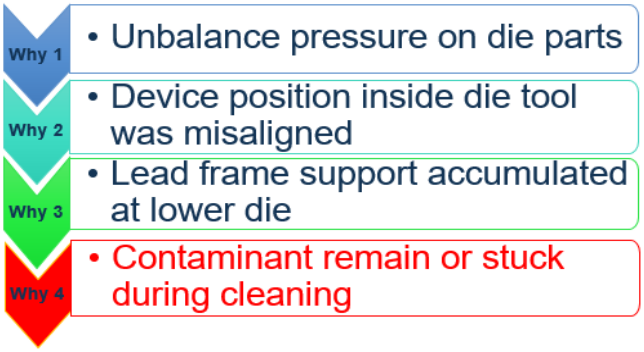


Table 3. Damage Costs of Above Problem Occurred.

Part	PCS	Cost
1. Resin and tie bar cut punch	4	934.4 USD
2. Punch Guide	1	472.63 USD
3. Resin and tie bar cut die A	2	669.56 USD
4.Resin and tie bar cut die B	1	253 USD
	Total	2,329.59 USD

The vacuum nozzle did not reach the narrow portion of Tool during cleaning resulted the resin contaminant to be stuck and not removed. When the lead frame inserted inside the tool, the resin contaminant was trimmed or cut together with the product IC leading to broken package and die breakage (see Fig. 5).

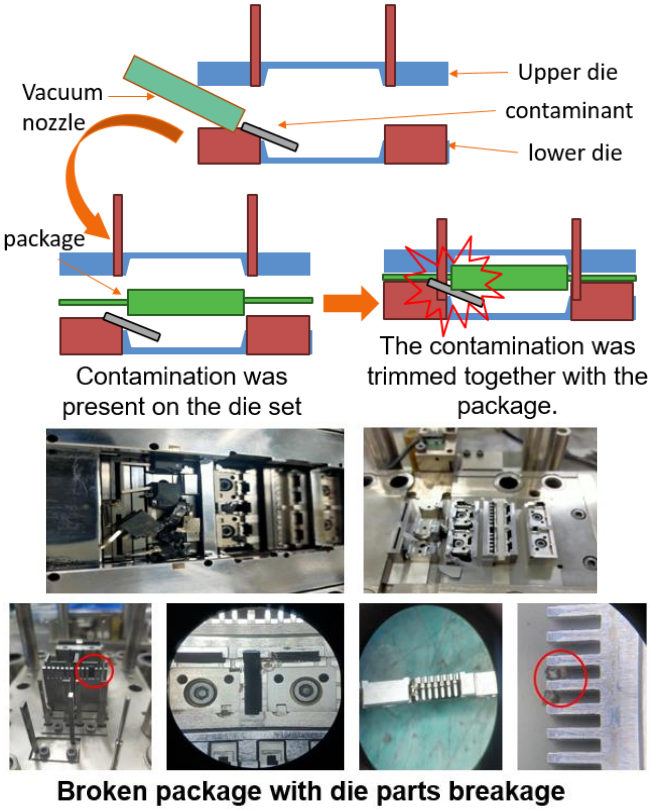


Fig. 5. Illustration on how the broken package and die breakage occurred.

3.3 Improve Phase

Upgraded vacuum system to stand-alone vacuum and Modified the current vacuum circuit to have it in use as offline vacuum cleaner to support manual die tool cleaning every after each lot.

Since all mechanism of machine shuts off when safety door was opened or error occur, need to modify its circuit design to enable the vacuum system to activate even any machine error prompted (see Fig. 6).

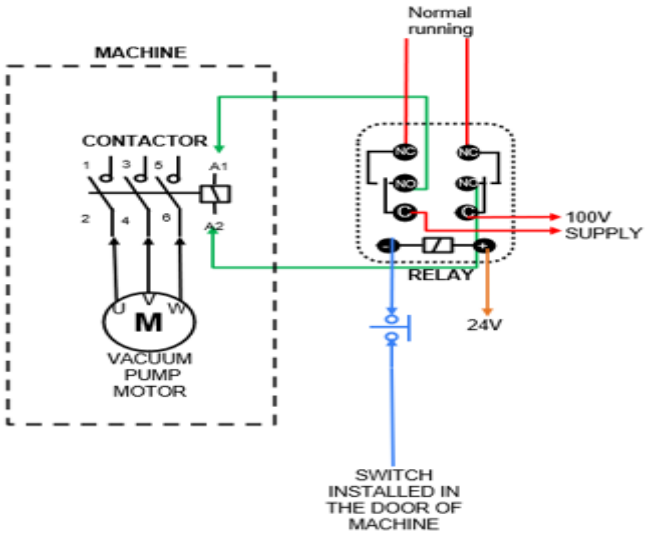


Fig. 6. Schematic Diagram of Redesigned Machine Circuit of Vacuum System.

When performing die cleaning, C (common) connector will be connected with NO (normally open) when door interlock switch was triggered providing 24v power supply to the SPDT relay or single pole double throw whereas interchanging the connector to control the motor contactor that will triggered ON the vacuum pump motor automatically during die cleaning and produces -7.0 kpa suction pressure under the die tool.

To return in normal state and auto running mode, just close the safety door then the relay is at rest C (common) connector is connected with NC (normally connected) allowing 100v power supply to flow normally as per controlled by the machine during machine operation (see Fig. 7).

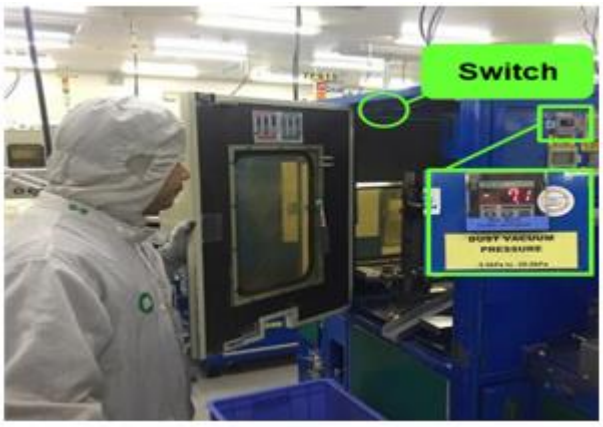
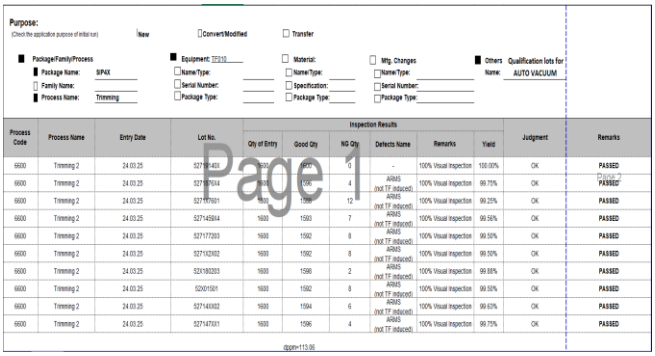


Fig. 7. Modified machine mechanism and how to perform its new function and use.

3.4 Control Phase

Conducted 10 lots qualification run subjected to 100% inspection resulted to pass with no any defect seen after modification of machine mechanism (see Table 4). Aligned die cleaning procedure of manufacturing operation to support the cleaning method using vacuum cleaner and restricted air blower gun (12MTA6XXX9E).

Table 4. Summary of 10 Lots Qualification.



4.0 RESULTS AND DISCUSSION

After implementation of project 1 contamination and die tool repair was decreased from average of 19 cases in year 2022 and 2023 down to 2.5 cases in year 2024 and 2025 year to date, 2 eliminated add on activity of operators in finding external vacuum cleaner whenever need to perform die cleaning, 3 removed the common reason of operator why they cannot perform their job satisfactory due to unavailability of vacuum cleaner, 4 increased productivity more than 2 hours stoppage down to 5 minutes, 5 cost avoidance of more or less $2,000 per Die tool parts breakage was prevented and reaches 6 months max tool life, 6 reduced the risk of producing products with quality related defects induced by contamination (see Fig. 8-9).

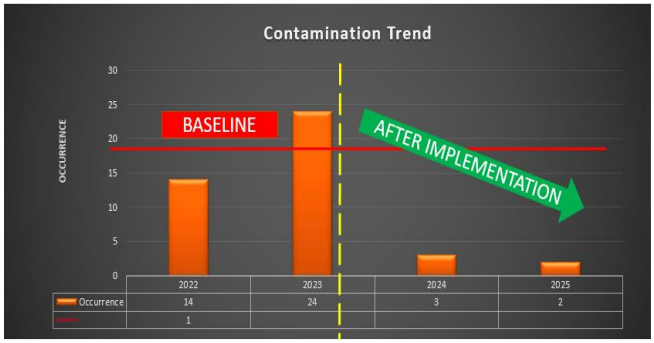


Fig. 8. Contamination Occurrence from the Baseline in Year 2022 and 2023 Compared to Year 2024 and 2025 after Implementation of Project has Significantly Decreased by 91.67%.

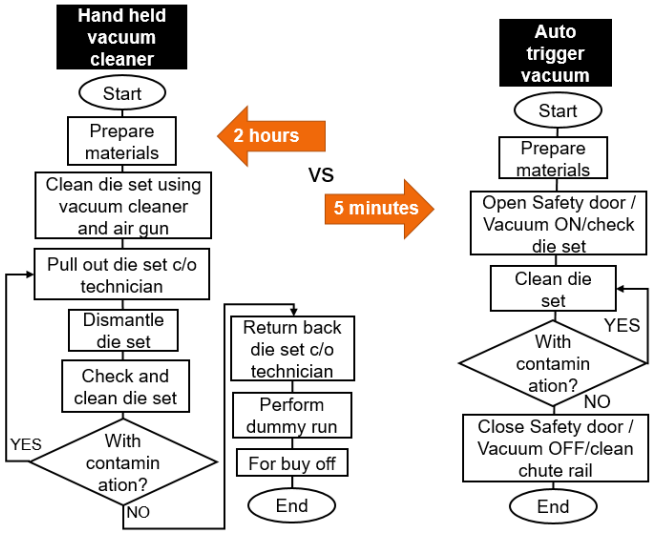


Fig. 9. Comparison of Downtime in Die Cleaning Using Hand-held Vacuum Cleaner versus in Auto Trigger Vacuum System significantly down by 95.83%.

5.0 CONCLUSION

Base on the machine performance after the implementation of the project auto trigger vacuum system, the number of occurrences of die contamination and die tool repair was decreased, therefore the productivity was improved and OEE increased. It has also huge impact in cost saving as die parts breakage and replacement was prevented.

6.0 RECOMMENDATIONS

As recommendation, work with Lean Six Sigma Green Belt committee to study deeper and check additional factor to eliminate resin flakes and excess resin on the side portion of the lead frame which is the major contributor of contamination.

7.0 ACKNOWLEDGMENT

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8.0 REFERENCES

"Not Applicable."

9.0 ABOUT THE AUTHORS

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10.0 APPENDIX

"Not Applicable."