SOT227 PRE-FORM/FINAL FORM POKA-YOKE FOR TOOL PARTS BREAKAGE PREVENTION

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ABSTRACT

Trim and forming is the process where the cutting of leadframe tie bars and forming of leads are performed based on dimensions required on package outline drawing.

For cost effective and product robust process, Semi-conductor manufacturing usually purchase the manually operated machines/tools with multiple function that capable to produce the variety of products that only requires minor machine set up and conversions.

Processing of SOT227 in multiple machines or tools combining different functions such as tie bar cutting and multiple stages of lead forming are prone to mis-process that could lead to yield loss, product scrappage and tool parts breakage having process control and check items are known to be human dependent.

Process Engineering keeps on focusing the continuous improvement drive aim to provide the sophisticated process control to eliminate all potential factors leading to product gross rejection, lot scrappage, long machine downtime and disatisfaction of our customer.

Process Engineering initiate to provide the fool proof solution (Poka-yoke) on SOT227 manual Trim/Forming tool that could give signal and reference for operator. This is to pre identify the issue itself and total machine stoppage in the event of wrong product loading versus the machine set up on Trim and Forming machine.

1. 0 INTRODUCTION

SOT227 is one of the Discrete packages assembled in Fastech and considered as one of the major electronics component widely use in various applications particularly in commercial and automotive industry.

Trim and forming process of SOT227 is comprise of two (2) machines/tools. the first tool with function of Trim to cut the lead tie bar, 1st lead Form and 2nd lead Form while the succeeding lead form stages are accomplished by 2nd tool to perfrom the final lead form and spanking.

As part of process control, only qualified and dedicated operators are allowed to process and operate the machine/tools. In spite of this control, any mistake of unit loading position on machine will be processed that will lead to product scrappage and tool parts breakages.

Due to various occurrence of product or unit misloading and frequent tool parts breakages, Process Engineering has designed, installed/evaluated and qualified the fool proof solution that can immediately identify by operator the unit loading mistake with corresponding error indicator and machine stoppage in the event of wrong loading versus the set up requirements.

1.1) Problem description:

Occurrence of SOT227 Trim/Form unit mis-load leading to tool parts breakage resulting to product rejection, long downtime, high maintenance cost and productivity loss.

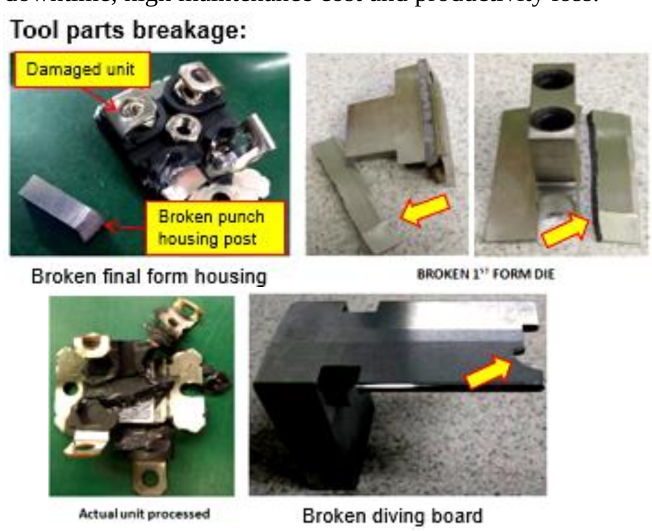


Figure 1-1 Tool parts breakages/product rejection

	SOT227 T/F tool parts breakage occurence				
Year	**2016**	**2017**	**2018**	**2019**	
Tool parts	Broken final form housing	Broken 1st cam pad (1)	Broken 1st cam pad (2)	Broken 1st cam pad (2)	Broken Pre-form die (2)
Root cause	Unit mis-loading	Unit mis-loading	Nut on diving board	Unit mis-loading	Unit mis-loading

The series of occurrence showed that the inplaced process controls are not guaranteed to prevent the unit mis-load issue. Process Engineering will have to formulate the effective solution that could effectively capture and prevent the occurrence of unit mis-load, so this technical paper will be focusing on full proof solution (Poka-Yoke) and realization of process improvement.

2. 0 REVIEW OF RELATED WORK

Not Applicable.

3.0 METHODOLOGY

3.0.1 Use the PDCA to execute the project.
3.0.2 Use fish bone diagram for rootcause analysis.
3.0.3 Generate the mechanical and electrical design concept and collaborate with external provider.
3.0.4 Fabrication and purchase of all needed materials
3.0.5 Evaluate, qualified and gather all needed data.
3.0.6 Perform the final qualification and documentations
3.0.7 Utilize by production

3.1 USE PDCA TO EXECUTE THE PROJECT

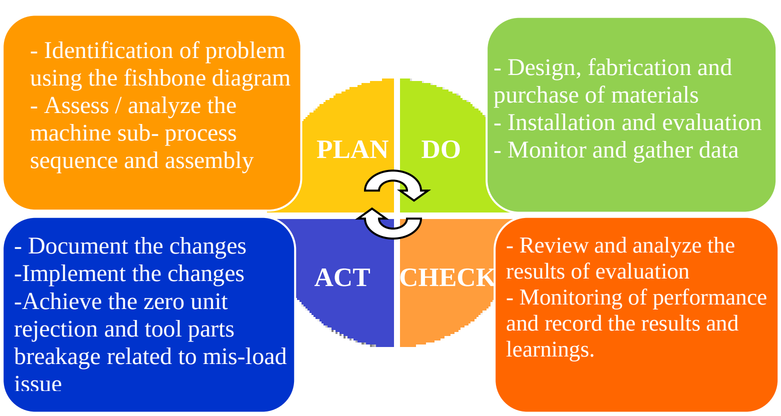


Figure 3-1 Fish bone diagram to identify and validate the potential factors.

3.2 FAILURE ANALYSIS:

3.2.1 USE OF FISHBONE DIAGRAM

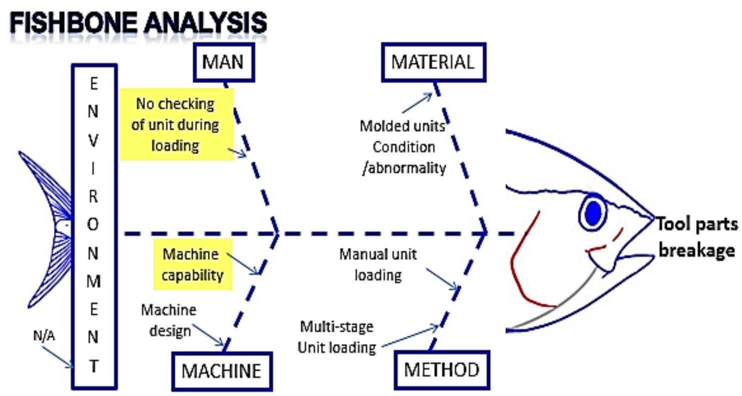


Figure 3-2 Fish bone diagram to identify and validate the potential factors.

Have identified factors related to MAN (No checking of unit) and MACHINE (machine capability).

3.2.2 Validation

	Potential Root cause	How Verified	Validated as root cause	
			Yes	No
1	No checking of unit during loading	Conducted investigation and interviewed of involved operator and verified lapses on actual checking of units during loading	✓	
2	Molded units condition abnormality	Team reviewed all related process documents and verified that all controls are in placed to trap unit condition abnormality		✓
3	Machine Capability	Operator failed to verify the unit loading abnormality and machine is not capable to detect.	✓	
4	Machine design	Machine was designed as required manual unit loading		✓
5	Manual loading	Machine design as manually operated		✓
6	Multi-stage unit loading	Machine design with multi-stage unit loading		✓

Figure 3-2 Potential rootcause validation

3.2 EXPERIMENTAL SECTION

3.2.1 Objective

-To evaluate / validate the effectiveness of full proof (Poka-Yoke) project of detecting or prevent from occurring the unit rejection and tool parts breakage on SOT227 Trim and Form Machine/tool.

-Eliminate unit scrappage/tool parts breakage:

-Eliminate long machine downtime related to parts long fabrication period.

-SOT227 Trim and Form robust process.

3.2.2 Equipment and Materials

-SOT227 T/F machine
-Dummy units
-Non-contact fiber optic sensor
-Sensor jig/bracket
-Relay bracket
-Electrical relay

4.0 RESULTS AND DISCUSSION

4.1 Poka-yoke design improvement

4.1.1 Design and installation of non-contact unit position fiber Optic sensor (1st tool)

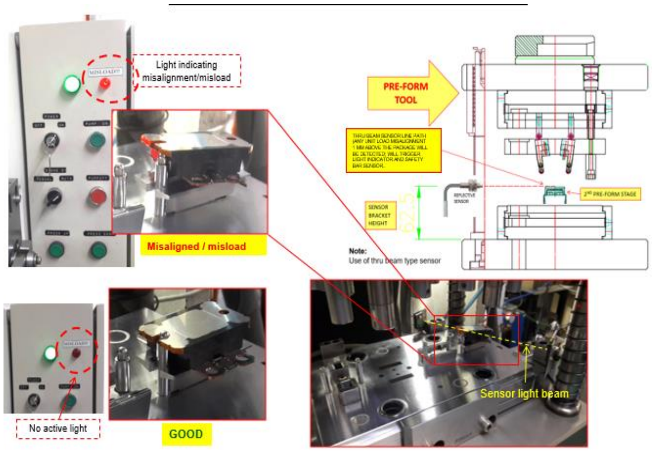


Figure 4-1 Bracket/jig, indicator and sensor lay-out illustration

1) Sensor bracket jig is designed as fiber optic holder with fixed position set up. The sensor will detect the type of unit loading beyond the defined position. Any unit mis-load will be detected and feedback the system to halt operation with corresponding error light indicator

4.1.2 Design and installation of non-contact unit position fiber Optic sensor (2nd tool)

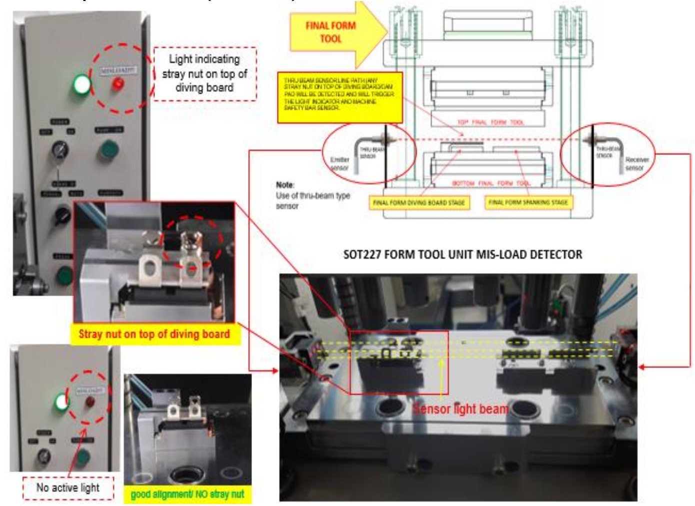


Figure 4-2 Bracket/jig, indicator and sensor lay-out illustration

2) Fiber opticsensor will detect both mis-aligned unit load and the presense of nut on top of diving board. Automatic halt of machine operation with red light indicator on front panel upon detection.

4.1.3 Electical Circuit diagram. (mis-aligned unit detector)

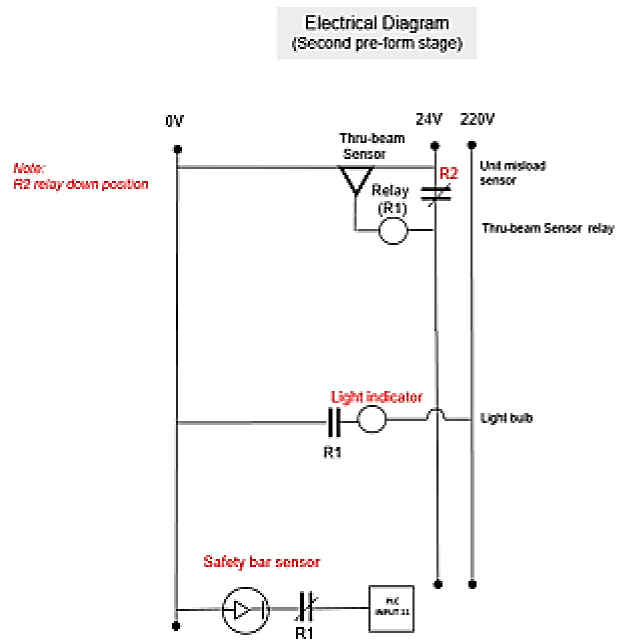


Figure 4-3 1st tool mis-aligned unit deterctor

4.1.4 Electical Circuit diagram. (Detection of mis-aligned unit and presense of nut on top of diving board)

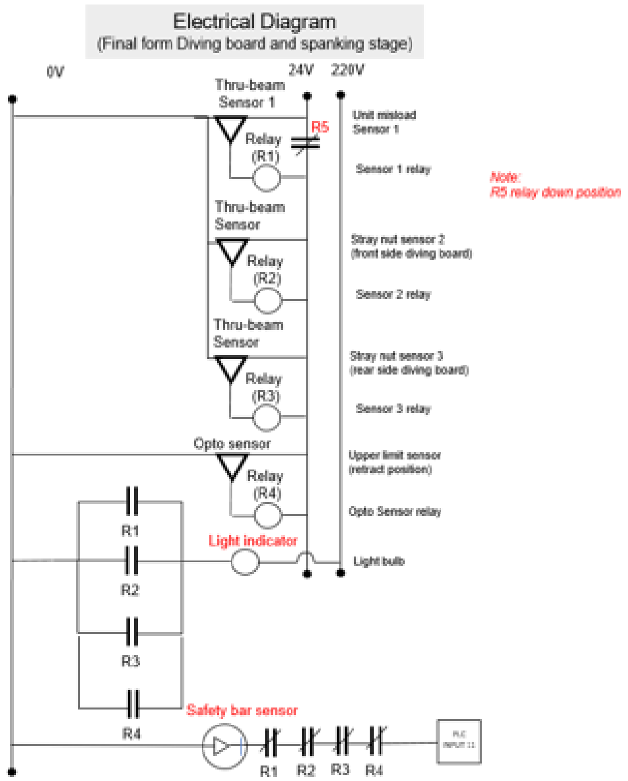
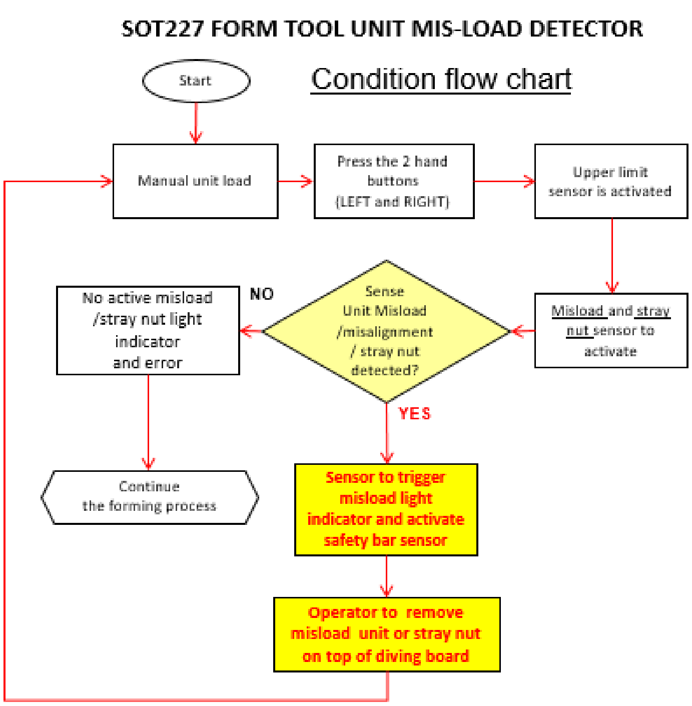


Figure 4-4 2nd tool active circuit diagram detecting mis-aligned unit and presense of nut.

4.1.5 Condition flow chart



4.2 SOT227 tool parts breakage occurrence data

Based on gathered data, NO occurrence of tool parts breakage after installation of Poka-Yoke project on year 2020 to present. Replacement occurred once reach the initially defined tool life.

TOOL PARTS	Last Date Replaced	PROCESSED QTY
1st cam pad	January 19,2020	1,045,979
1st cam holder/housing	November 08,2019	1,117,192
2nd form die	September 30,2020	729,559

Figure 4-6 Parts replacement history monitoring data:

4.3 SOT227 downtime and VAS delay improvement

Based on IE data, about 41.5K VAS is delayed due to the 9 days machine downtime on SOT227 TRIM/FORM process based on computation provided in reference to 2020 VAS. Note that the 9 days downtime can be recovered within the succeeding week because of large T/F capacity which is big enough to recover the 9 days downtime.

4.4 Project Materials list

Item	Description	Quantity	Cost
1	24V Electrical relay	6 pcs	US$59.40
2	Fiber optic sensor	7 sets.	US$570.50

4.3 SOT227 downtime and VAS delay improvement

COST SAVINGS COMPUTATION

DESCRIPTION	MACHINE	CUSTOMER	PACKAGE	VAS PER WEEK	TOTAL POSSIBLE SAVINGS	REMARKS
spare parts downtime	Trim/Form	MICROCHIP	SOT 227	$ 41, 500	$ 41, 500	possible VAS for the year if 9 days downtime is avoid (avoidance of VAS delay)

Note: IE computation

VAS per Week based on VAS Report

VAS per Week : $27,666.7
Divide by 6 : 6 Days per Week
VAS per Day : $4,611

Multiply by 9 Since 9 days possible avoid the DT per year

VAS Improved by : **$41,500 for the year**

Figure 4-7 VAS possible avoid downtime data:

4.3 SOT227 Trim and Form Repair/Downtime and Maintenance Improvement

TOOL PARTS DESCRIPTION	QTY	Unit Price	AMOUNT
1st cam pad (diving board)	(5)	$1300	$6500
2nd preform die	(2)	$467.5	$ 935
1st cam housing	(2)	$465	$ 930
TOTAL			$ 8,365

Elimination of form tool parts replacement/consumption = **$ 8 365**

TOOL PARTS DESCRIPTION	QTY	UNIT PRICE	TOTAL COST
1st cam pad (diving board)	5	$ 1,300.0	$ 6,500
2nd preform die	2	$ 467.5	$ 935
1st cam housing	2	$ 465.0	$ 930
	TOTAL COST FOR 4 YEARS		$ 8,365
COST PER REPLACEMENT :	$ 2,091		

TOOLS SAVINGS

DESCRIPTION	SET UP	FREQUENCY (TOOL LIFE)	COST PER REPLACEMENT	VOLUME PER YEAR (2022)	FREQUENCY PER CHANGE TOOL	COST PER YEAR	SAVINGS PER YEAR
TOOL REPLACEMENT	BEFORE	480,000	$ 2,091	728,858	1.52	$ 3,175	$ 1,790
	AFTER	1,100,000	$ 2,091		0.66	$ 1,386	

Note: Before Yearly Volume Average of 480k (Y2016-Y2019)

Figure 4-8 Repair and Maintenance data:

4.4 Project Investment and cost data:

-Sensors (thru-beam, opto) ***7 pcs ($ 81.50) = $ 570.5***
-Relay ***6 pcs ($ 9.9) = $ 59.4***

Total of ***$ 629.9***

ROI:

-(Project cost / cost savings) (1 year)

($629.9) /($ 49,865)
= 0.0126

Project cost / (cost savings/ year)
($629.9) /($ 1,790)
= **0.35 month/10 days**

5.0 CONCLUSION

-Project implementation achived the goal of eliminating tool parts breakages, improved the productivity, product quality and cost of maintenance for SOT227 TRIM and FORM processes.

6.0 RECOMMENDATIONS

Recommended to fan-out the same project concept to other DTFS machines encountering the same issue of tool parts breakages.

7.0 ACKNOWLEDGMENT

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8.0 REFERENCES

N/A

9.0 ABOUT THE AUTHORS

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10.0 APPENDIX

N/A