#### Case Study of INTEL: Double Stack Prevention Thru TRIZ Methodology

Author: Nagappan AnnamalaiCo-Author: Nadarajan Subramanian



### **TRIZ In INTEL**

Driven by manufacturing groups

- □ Fab/Sort Manufacturing
- Assembly/Test Manufacturing (ATM)
  - One of the area: Improve equipment performance
  - Boundary conditions for equipment solutions: Effective & low cost (small changes due to large equipment base



## **INTRODUCTION: TEST**

Class Test (CT) - measurement of assembled device performance. Products categorized by speed/power/performance.

Product testing is identified to specific type of equipment (tester/handler)

> CT consist of 3 sub modules; tester; handler; TIU (tester interface unit).

Presentation discusses a case study of how double stack prevention on a legacy handler being approached thru TRIZ methodology



Double Stack

## **OVERVIEW**

Quality is key in factor in any industries

Legacy tools does not have poka yoke futures. No prevention system.

> Available system are more on post occurrence detection.

The equipment will damage the device/product, leads to painful rescreening and scrapping





## **TRIZ FLOW**

- **4 Important Function Analysis**
- 1. Productive irreversible chg of object parameter
- 2. Providing temporary chg
- 3. Corrective chg parameter to eliminate unwanted char.
- 4. Harmful function that worsen the parameter



### **PROBLEM STATEMENT**

- High BDO on double stack (DS) jam clearance (alarm)
- Detection upon post incident
- Non value add time spent on screening and scrapping when there is an occurrence.
- No poka yoke system





**Double Stack** 

## **PROCESS ANALYSIS APPROACH**

Process Analysis (PA) – an analytical method used to analyze the manufacturing process, defining operation functions and propose a way to improve the system by improving/simplifying

PA helps to identify disadvantages connected (waste elimination) with numbers of unnecessary process steps or frequencies

Analyzing a process thoroughly has led towards enhancing a process through innovative solutions

Process improvement:

- a. change process parameter
- b. eliminate function where possible
- c. perform steps which shorten the tpt

#### PROCESS ANALYSIS & DIRECT OBSERVATION

Both are analytical method used to analyze the manufacturing process, and interpret current reality through result of process

Deep dive into detail process steps and look for opportunity through direct observation to improve (eliminate waste):

- trim redundant steps
- long hour activities, frequency etc
- identify disadvantages connected







### **Cause Effect Chain (CEC)**



CEC is important, prior generating solution on conceptual ideas

It review on each fundamental root cause (RC) which are then;

(1) Discarded if not plausible or

(2) Considered potential (RC) to original problem.

## **SOLUTION APPROACH**

Here are some LEAN approaches through direct observation applying TRIZ process analysis and innovation through Inventive Principle to develop ideas for systematic improvement and waste elimination.

- (1) Process Analysis + DO + CEC
- (2) Derive Engineering Contradiction
- (3) Review potential solution thru 40 Inventive Principles
- (4) Define Innovative Solution

			- A 4	
1 2 3 4 5 6 7 8 9 9 10 11 12 13 14 15 16 19 10 11 12 13 14 15 16 17 18 19 19 12 12 13 14 15 16 17 18 19 19 12 12 13 14 15 18 19 19 12 13 14 15 18 19 19 12 13 14 15 18 19 19 12 13 14 15 18 19 19 12 13 14 15 18 19 19 12 13 14 15 18 19 19 12 13 14 15 18 19 19 12 13 14 15 18 19 19 13 14 15 18 15 18	11 12 13	34 35	36 37 3	39
Meight of moning 15.8, 29, 29,2, 2,8, 8,10, 10, 00, 135, 28, 5,34, 6,29, 19,1, 35, 12, 6,2, 5,35, 10, 10, 3,26, 13, 28, 28, 12, 2	2, 27, 35,3	1, 2, 27, 29,	5 26 28 26	35.1
abjed 23.4 17. 40.28 15.78 18.7 56 14 19.9 27. 35.5 4.88 32 12. 56 34.19.33 14.35 55 18.11 1.27 27. 15. 12. 7	5. 28.1. 2.24	38,11 15.	8 30. 29, 18	24, 37
Neight of dationary 10, 1 1, 1, 55, 5, 55, 8, 10, 13, 15, 26, 28, 2, 2, 27, 28, 19, 18, 15, 18, 5, 8, 10, 11, 19, 6, 10, 18, 10, 1, 2, 19, 9	6, 28, 1, 6, 13	3, 2,27, 19	1, 18, 25, 2,	1, 24,
abject 28.35 34 14.2 19.35 28 10 19.1 10.27 19.6 19, 22.35 19, 19, 19, 19, 19, 19, 19, 19, 19, 19,	1, 9 1.32	38, 11 15, 1	9 36, 99 38, 3	9 15, 55
Legis of moving 8.15	15 1, 29, 15,	1, 28, 14,	1, 19, 35, 1, 1	34,4
emplot 25.30 17.4 4.75 8 10.4 15.51 (2.5 1.2 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5	17 29,	10 15,	26,24,26,24, 2	3 28,29
1411 1410 1410 141 141 141 141 141 141 1	15, 2,25	3 1,3	5 1,26 26	20,
2.17 U 7.11 9. 9 10 10 10 10 10 10 10 10 10 10 10 10 10	17.47 5.2. 18.1. 18.	15	14.1. 2.36 1	10.0
Interface in project 20,4 15, 7,4 30,4 30, 15, 12,4 (13,9) 40,14 6,3 16 22, 10,22 18, 17, 35,2 (0,26) 43,4 30,6 (2,9) 2, 22 33, 19	39 26.24 17.	B. 15,3	13 25.18 3	8 35
Ansold disear 30.2 26.7 10.8 10. and 1	l and ar a		1, 18, 2, 95,	30,
abjed 1, 1, 18 1, 29 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	40, 18 16, 4	16 15,1	8 36 30,18	15,
Vihaned nering 2.26, 1.7, 1.7, 29,4, 15, 6.35, 1.15, 28, 9,14, 6.35, 34, 2.15, at 35,6, 7,15, 36, 3, 34, 2, 6, 29, 14,1, 26, 25, 22, 17	2, 29, 1, 15,	10 15	e 14 1 28, 3	6 10.6
abject 23.4 4.5 4.17 38.34 55. 56.37 23.4 10.1 15.7 4 39. 10 33 13.8 13.16 39. 42 34.10 35.7 4.11 36.28 36.2 10.4	1,1 40 13,	10 13,1	26,1 26,4 3	2.34
Velame of dationary . 35, 19, 14 35, 8,	8 35	1	1.31 2,17,	35,
ebject 10, 12,14 37 55 38, 17,15 34,38 4 59, 16,33 16 10,15 39, 1	8	-	26	37,
Speed (2.5) 17, 25, 7, 25, 15, 85, 16, 11, 13, 16, 16, 17, 18, 16, 11, 18, 18, 18, 18, 18, 18, 18, 18, 18	24, 35, 32,	34,2, 15	10, 3, 36, 10	
1.3 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5	21 15.8, 28,	28,27 10,2	3 28.4, 17, 18	1.24
	18 27 3.10	11 17	35 27 2	2.0
14 15 W W1 10 16 40 W 10 16 16 W 10 16 16 W 10 16 16 W 10 16 16 16 16 16 16 16 16 16 16 16 16 16	31.1.91	r 11 17	19.1. 2.94	10.
Stress of pressare 36, 29, 11, 56 (14, 16) 15, 15, 10 (5, 2) (5, 2) (5, 2) (13, 2) (3, 0) (27) (9), 24, (5, 14) (25) (6, 3) (54, 14, 56) (3, 15) (3, 2) (7) (7) (7) (7) (7) (7) (7) (7) (7) (7	18 16 11	2 35	35 37 35	H H
K (0) [K, 24] [1, 4] [2, 2] [K, 3] [10] [3] [4, 2] [3, 2] [4, 2]	1.2. 2.	2.13. 1.1	16 15 15	17.
2,40 10, 34,5 14, 4,10 15,22 35 15, 10, 15, 11, 15, 11, 15, 11, 15, 12, 14, 16, 21, 10, 40 2,51	17,28 15,3	6 1 29	29.1, 13.39 3	36
SubDay of the 21, 26, 15, 27, 21, 28, 24, 33, 30, 25, 22, 21, 27, 5, 13, 35, 5, 12, 5, 14, 22, 14, 20, 14, 2, 24, 24, 24, 24, 24, 24, 24, 24, 24	15, 15 10 SZ,	2,55, 55	2, 35, 35, 1,	23,
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	n <sup> 24,19</sup> 95,9	e 10.16 St	22.36 22 3	25





## **Solution Approach**

#### **Engineering Contradiction**

IF the double stack detected THEN no quality issue BUT it will slow down the equipment process tpt

Wosening Feature	Weight of moving object	Weight of stationary object	Length of moving object	Longth of stationary object	Area of moving object	Area of stationary object	Volume of moving object	Volume of stationary object	Speed	Porce (Intensity)	Stress or pressure	Shape	Stability of the object's composition	Strength	Duration of action of moving object	Duration of action of stationary object	Temperature	Illumination intensity	Use of energy by moving object	Use of energy by stationary object	Power	Loss of Energy	Loss of Substance	Loss of Information	Loss of Time	Quantity of substance	Reliability	Measurement accuracy	Manufacturing precision	Object-affected harmful factors	Object-generated harmful factors	Ease of manufacture	Ease of operation	Ilaso of repair	Adaptability or vessatility	Device complexity	Difficulty of detecting and measuring	<b>Eldent of automation</b>	Productivity
	1	2	3	4	5	6	7	\$	,	9	11	12	13	14	15	16	17	18	19	39	21	22	23	24	25	э	27	3	29	30	31	32	33	34	35	з	37	35	39
Weight of moving			15.8		29,	-	29.2		2,8,	8,10	18,	10.	135	28,	5.34		6, 29,	19,1	蕉		12,	6.2	5,95	10,	18,	3,26,	13	28,	38	22	22,	27,	2.22	2.27,	29, 5,	26	28, 1	36.3	15.1
object	*		29.34		17.		40.38		15.38	18.57	56	14	19.39	27.	31, 35		4.38	22	12		36	34, 19	3.31	34, 35	35.	18.31	11.27	27.	35	21.	35.	38.1.	2.24	38.11	15.8	30.	29.	8.1	31.3
Weight of stationary				18, 1,		35,		5,35,		8,10,	13,	13	26,	28,2		2,27,	35,	19,		18,	15	孩	5.8	30,	11,	19,6,	10,	18	10.1.	2, 19,	35	3.1	6.13	2,27,	19,	1,18,	25,	2,28	1.2
object	1			29.35		31.		14.2		19,35	29.	10.	39.L	18.27		19.6	19.	2.5		19.	19.	19,	13.30	15,35	21.	18.35	38.8.	3.3	35,17	2.3	22.1.	9	1.32	38.11	15.29	36,39	38.	35	15,3
Length of moving	8, 15,			_	15,		7,17,	_	13,4,	17,	1,8,	1,8,	1,8,	8, 35,			11,	-	8, 35,		1.10	7,2,	4, 29,	1.14	15,2,	14.10	11,	28,	10,	1, 15,		1, 29,	15,	1, 28,	14,	1, 19,	35, L	17,	14,4
object	29.34		1		17.4		4.35		8	11.4	35	10.29	15.34	29.34	0		15,19	24	24		1, 33	55,39	23.10	1, 24	29	27,35	14,	32.4	38	17.24	17,15	17	29.	10	15.L	36.34	26.24	24.	38.2
Length of stationary		35,				17,7,		35,8,			1,14,	13	39,	15,		1, 10,	3, 35,					1.10	18,	24,	38,		15,	32,	2, 32,			15,	1.10		1.40	1.56	34		30,
object		38				10.40	Ľ.	2.14		25, 10	35	14.	\$7,35	14.		35	38, 18	20			14,8	0,20	3.	26.	29.14		29.28	38.3	10	1, 15		17.27	40	,	14-33	1,20	20		14.7
uva of moving object	2, 17, 29,4		14, 15,		•		7,14, 17,4		29, 30,4.	19, 30,	18, 15,	5,34, 29,4	11, 2, 13, 39	3, 15, 40, 14	6,3		2,15, 16	15, L	19,32		线机	15, 17,	1県 55.2	30, 26	26,4	29, 30,6,	29,9	24, 28,	2,32	22, 33,	17,2, 18,39	13,1, 36,24	15, 17,	訪訪	15,30	14, 1, 13	2,36, 35,18	14, 30,	10, 36,
Area of stationary		30,2,		26,7,						1, 18,	18,		1.10			2, 10,	35,					17,7,	18,	30.16	18,	2, 18,	힟,	26,	2, 29,	27, 2,	22, 1,	10.16	16.4	14	12.14	1, 18,	2,35,	20	30,
object	÷.	14, 18		9,39			· ·			35,36	15,		4.30			19,30	39,38		· ·		27,74	30	14.	30, 10	5.4	40.4	35,	3.	18,36	筑穷	48	40, 10	20,1	10	12,18	36	31, 18	10	15,
Volume of moving	2, 26,		1,7,		1,7,				29,4,	15,	6,35	1, 15,	28,	9, 14,	6,35,		З,	2, 13,			35, 6,	7,15,	36,	3 33	2,6,	29,	14, 1,	26,	25,	22,	17, 2,	29, 1,	15,	10	15.56	16.1	29,	35,	10,6
object	29,48	· ·	4,35		4.17			Ľ.	38.34	35,	36.37	29.4	10.1.	15,7	4		39,	10	30	· ·	13,18	13, 16	39,	4.44	31.11	30,7	48, 11	3.3	28.2	21,	40,1	40	13,		13,23	20,1	26.4	34	2.3
Volume of stationary		35,	18 18	35, 8,						2, 18,	54.92	7,2,	34,	9,14,		艿	35,6,				20.6		18,		35,	15.3	2,35,		М,	34,	30,	95				1.91	2, 17,		35,
object	÷.	10.	17, 14	2.14			· ·			$\mathfrak{V}$	24,33	35	38.	17,15		34,38	4				,70,9		筑		16,32	33,5	16		11,25	39,	18.	30				4.74	36		37,
Speed	2,28, 13,38		13, 14,8		29, 30, 34		7,29, 34		+	13, 38,	6.13, 策.朝	馬馬	28, 33.1.	8,3, 36.14	3,19, 35,5		28, 30,	18, 13, 19	8, 15, 35, 38		线筑	14, 30.	18, 13,	13, 26		10, 19,	11, 35,	進 定し	10, 38,	1,28, 55,23	2,24, 35,21	35, 13.8	92, 38,	34, 2, 38, 27	15, 10.26	10, 28.4	3,34, 27,16	10, 1	
Force (Intensity)	8,1, 57,18	18, 13.1.	17, 19.9.	28, 10	19, 10,15	1,18, %. T	15,9,	2,36, 18,57	13, 28,	•	18, 21,11	18, 35,	35, 10.21	易題	19,2		35, 10.21		19, 17, 10	1,16,	线纸	14, 15	8,35, 40,5		11, 37.36	14, 29,	3,95, 13,21	然	28, 29,	1.35, 紙 18	13,3, 36,34	15, 37,	1,28,	15,1,	15, 17,	26, 35,	36, 37,	2,9	3,28
Stess or pressure	11, 36,	13, 29,	35, 11.36	35,1, 14,16	10, 15,	18, 15,	6,35, 10	35, 24	6.35 36	36, 35,21	+	35.4. 15.10	35, 33,2	9,18,	19,3, 27		35, 99,		14,		10, 35.14	2,36, 25	11, 36.3.		37, 36.4	10, 14.36	10, 13,	6,28, 25	3,35	22,2,	2, 33, 27, 18	1,35,	11	2	35	19,1, 35	2,36	95, 2	10, 14,
Shape	8, 10, 29, 40	15,	29,	13,	5,34,		14,4,	7,2,	第.	35, 10	34, 15		151	30, 14	14,		22,	13, 15, 10	2,6,		4, 6, 2	14	35, 29.3		14,	36,22	18, 48, 16	28,	2. 19.48	22,1,	35,1	1,32,	32,	2, 13,	1,15,	16, 29.1	15,	15, 1 30	17,
Subilit of the	21.	25	13		2.11		3	1.1	11	11.	2.35	22.1.		12.9.	13	313	35.1	23		27.4	12	14.2	2.14			15				10	35		U.	2.95	<u>N</u>	2.%	35	1.8	23.
object's composition	55.2	38.1.	15.1	37	13	39	10.	38	15,	35.	40	18.4	+	15	27.	35.23	32	27,16	13, 19	29, 18	55	39.6	31.40		35,Z	32,35		13	18	24	41.	35, 19	35.30	10, 16	31.	22.36	22	35	35.

<ul> <li>Introduce recuback (referring back, cross-crecking) to improve a process of action.</li> </ul>
If feedback is already used, change its magnitude or influence.      S5. Parameter changes     Change an object's physical state (e.g. to a gas, liquid, or solid.)     Change the concentration or consistency.     Change the degree of flexibility.     Change the temperature.
<ul> <li>40. Composite materials</li> <li><u>Change from uniform to composite (multiple) materials.</u></li> </ul>
<ul> <li>3. Local quality         <ul> <li><u>Change an object's structure from uniform to non-uniform, change an external environment (or external influence)</u> from uniform to non-uniform.</li> <li><u>Make each part of an object function in conditions most suitable for its operation.</u></li> <li><u>Make each part of an object fulfill a different and useful function.</u></li> </ul> </li> </ul>

> 39 interactive TRIZ matrix

closest solution achieved thru Principle#23 (Feedback) & Principle#3 (Local Quality)

### **40 Inventive Principles**

Using TRIZ methodology – 40 Inventive Principle (solution)

- 1. Segmentation
- 2. Taking out / Extraction
- 3. Local Quality
- 4. Asymmetry
- 5. Merging / Combination
- 6. Universality
- 7. "Nested Doll"
- 8. Anti-weight / Counter-weight
- 9. Preliminary anti action / Prior counter-action
- 10. Preliminary action / Prior action
- 11. Beforehand cushioning / Prior cushioning
- 12. Equi-potentiality / Remove tension
- 13. 'The other way round'
- 14. Spheroidality-Curvature
- 15. Dynamics
- 16. Partial or excessive actions
- 17. Another dimension
- 18. Mechanical Vibration
- 19. Periodic action
- 20. Continuity of useful action

- 21. Skipping / Hurrying
- 22. 'Blessing in Disguise'
- 23. Feedback
- 24. Intermediary
- 25. Self- Service
- 26. Copying
- 27. Cheap / short Living
- 28. Mechanics substitution / Another sense
- 29. Pneumatics and hydraulics / Fluidity
- 30. Flexible shells and thin films / Thin & flexible
- 31. Porous Materials / Holes
- 32. Color changes
- 33. Homogeneity
- 34. Discarding and recovering
- 35. Parameter changes
- 36. Phase transitions
- 37. Thermal expansion / Relative change
- 38. Strong oxidants / Enriched atmosphere
- 39. Inert atmosphere / Calmed atmosphere
- 40. Composite materials / Composite structures

## **Solution Approach**

Principle#23: Feedback

Generate a feedback solution thru a sensor and loopback to the system (alarm) before issue occurrence (prevention).

Principle#3: Local Quality

Explore on system hardware to be able detect and prevent from occurrence. Vacuum suction cup as a present sensor.



#### **New Invention**

Generate a feedback solution using handler pick and place vacuum suction cup as present sensor and loopback to the system (generate alarm).

➢ If there is a missing unit from the suction cup, alarm generated (prevention) and system halt. Remove the physical unit (stuck) before being DS else the system not able to continue process (new script programmed)





# **Key Learning**

 DO & Analyzing a process thoroughly has led towards enhancing a process through innovative solutions



- Breakdown operation in depth, to ease on function and interaction details
- Always look into opportunity to reduce process steps by change frequency, waste elimination where possible
- Give way for creative thoughts



#### SUMMARY

- LEAN approach through TRIZ solution has helped through trimming by process analysis conceptual idea to look into innovative solution on double stack prevention
- The discovery of innovative solution led to ZERO quality issue thru DS issue and enabled a poka yoke system
- Methodologies relate to specific examples but the concepts are equally applicable to other industries.