Quality Circle in Practice: A Case Study at Tecumseh Products Company

Dr. Ravi Shankar Kalva[1], V.Srinivasu[2]
[1]Professor, Department of Business Management, J B. Institute of Engineering & Technology, Yenkapally (V), Moinabad (M), RR District, TELANGANA, 500 075, INDIA
[2]Sr. Manager Operations, Tecumseh Products Company, Balanagar Township, Hyderabad, TELANGANA, 500 037, INDIA

Abstract: This paper deals with the Quality Circle Case study carried out at Tecumseh Product Company Compressor Manufacturing division. The company has been sending Kit Assembly to their customer Tupelo. The customer assembles stator on Kit by tightening the 4 bolts with the help of Nut runner and some of the bolts were broken while assembling at customer end. The kit is rejected as a tapping defect and cost is debited to supplier plant. It was observed that the customer end PPM which was more than the target from AW Kit Assembly line. Victory Tecumseh quality circle working in this area took up this problem for study. A systematic application of quality control tools was used to find out the solution for the problem identified. The problem was analyzed and found the root causes as spring loaded tap adaptor travel incomplete depth and Chips getting trapped in stator holes due to Manual air jet cleaning of stator holes. Manual air cleaning of stator hole chips leading to missing & solidification of chips in the tapping holes. Based on the analysis the team suggested different solutions and develop a fixture to remove Chips from crank case fixing holes and providing sensor at machine spindles the problem could be overcome. Based on the suggested Developing solutions for the Root Causes the team adopted a concept of feeding air jet into crank case blind hole 3/4 depth and blow high pressure air through convergent nozzle by which the scrap blows out from the gap around jet. The suggested Solution has been implemented and the tangible and in tangible benefits have been encouraging.

Key Words: Customer end PPM, Kit, Quality Circle, Quality Control tools

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INTRODUCTION

The organization which uses traditional system to manage cannot stand in today's competitive environment as the traditional management tool is not effective in providing new solution to the new problems. So, we must implement new technique for the improvement of organization. One such tool is Quality circle. Quality Circle is basically defined as a volunteer group composed of members who meet to talk about workplace and service improvements and make presentations to their management with their ideas (Prasanna and Desai, 1998). [1]

Quality circle is a management tool which is implemented in many organizations to improve effectiveness of equipment in an organization. Quality circle is a tool which gives several benefits like organizational performance improvement, product quality improvement and improvement in the relationship within the organization which motivate workers and improve team work among them.

There have been different interpretations of the concept of quality circles in various organizations in India and abroad. However, the most commonly accepted definitions in keeping with the essence of the philosophy as it originated in Japan are: "Quality Circle is a small group of employees in the same work-area or doing a similar type of work who voluntarily meet regularly for about an hour every week to identify, analyse and resolve work-related problems, leading to improvement in their total performance, and enrichment of their work life" (Udupa 1986). [2]

"Quality circles are a formal, institutionalized mechanism for productive and participative problem-solving interaction among employees" (Lozano & Thompson (1980). [3]

Steps for Problem Solving

Step 1: Identification of problems
Step 2: Selection of problem
Step 3: Define the problem
Step 4: Analysis of the problem
Step 5: Identification of causes
Step 6: Finding out root causes
Step 7: Data analysis
Step 8: Developing solution
Step 9: Probable résistance
Step 10: Trial implementation

Step 11: Regular implementation
Step 12: Follow up/ review.

Step 1: Identification of problems
Following problems were taken from department problem bank identified by Department Quality Control Circle.

Table 1: Department Problem Bank

SNo	Defect
1	Crank Case OBB Pad Hole out
2	Crank Case Thrust Face N/C
3	Crank Case Cylinder Bore Porosity
4	Crank Case Bad Casting - Fixture
5	Crank case Cylinder Face Fix Hole Shift
6	Crank Case Spring Hole No Tap
7	Piston perpendicular Out
8	Piston outer diameter under size
9	Con rod Crank Bore N/C
10	Piston Pin Bore Over Size
11	Piston OD Ovality
12	Piston Groove Chamfer O/S
13	Con rod Centre Distance Out
14	Con rod Dents & Damages
15	Crank Case Stator Leg Broken
16	Short kit high Customer end PPM
17	Crank Case Centre Distance Out
18	Piston Deck Height U/S
19	Crank Case Stator Pad Blow Holes
20	Crank Case Obb Pad N/C
21	Crank Case Cylinder Bore Not clean
22	Crank Case Hub and OD Blow Holes N/C
23	Crank Case Stator Pad Hole chamfer under size
24	Piston Oil Hole Out
25	Con rod Pin Bore Damage
26	Crank Shaft Pin Not Clean
27	Crank Shaft Pin Día under size
28	Crank Shaft Over Bend
29	Piston centrality out
30	Piston Deck Height over size
31	Crank case rust
32	crank case obb fixing hole pcd out
33	Kit deck height variations
34	Valve Plate leak
35	Crank Case Cylinder Face N/C
36	Crank Case Spring Hole Out
37	Con rod Pin Bore Lines
38	Crank Bore Ovality
39	Crank Shaft Pin Ovality
40	Crank Shaft Pin Día over size
41	Crank Shaft Journal Diameter under size
42	Crank Shaft Journal Over size
43	Piston OD damages
44	Crank Shaft Thrust Face Concentricity out
45	Crank Case 17 Degree Slot Spindle play
46	Con Rod and Piston Jam in Assembly
47	Piston pin Outer diameter damage
48	IPRV brazing leak
49	D M A leak
50	Fixture Loose

51	Deck Height U/S

Step 2: Selection of problem

The quality circle team has selected the Problem through Ranking Criteria. These 51 problems listed are grouped into three categories viz., "A", "B" and "C" analysis. Where in "A" category - the problems which can be solved by self (team) are 23, "B" category - the problems require help of others (experts / others) are 18 and the problems require involvement of Management are categorized as "C" category are 10. The Team has shortlisted 12 problems in "A" category - the problems which can be solved by team.

Table 2: **S**election of the Problem

S. No	P	I	U	F	TS
1	Crank Case Spring Hole No Tap	8	5	1	14
2	Piston outer diameter under Size	5	5	5	15
3	Piston Pin Bore Over Size	5	5	4	14
4	Con rod centre Distance Out	8	8	5	21
5	More Short Kit Customer end PPM	10	8	8	26
6	Crank Case Spring Hole Out	6	4	5	15
7	Crank Shaft Journal Diameter under size	8	5	4	17
8	Piston OD Damages	8	5	5	18
9	Crank Case Cylinder Bore Not clean	8	5	2	15
10	Crank Case Stator Pad Hole chamfer under size	5	4	4	13
11	Crank Shaft Pin Día under size	4	5	4	13
12	Kit deck height variations	3	4	6	13

P – Problem; I -Important; U - Urgency; F – Feasibility
TS – Total Score

Step 3: Define the problem

The Team has selected AW Kit Assembly line as customer end PPM is more than our target. Rejection & Scrap Cost are the Global as well as internal target for this year. Hence our team took up this problem for Solution. The objective of selecting the problem is to reduce rework and rejections, and improve productivity.

The company has been Sending Kit Assembly to our Customer Tupelo. They assemble stator on Kit by tighten the 4 blots with the help of Nut runner and observed that some of the blots broken while assembly. Then the Kit is rejected as taping defect and Cost is debited to our plant**.** The Effects on External Customer are Increase Customer Line Rejection, Delay in Customer Orders and Increase Scrap Cost.

Figure 1: Short Kit

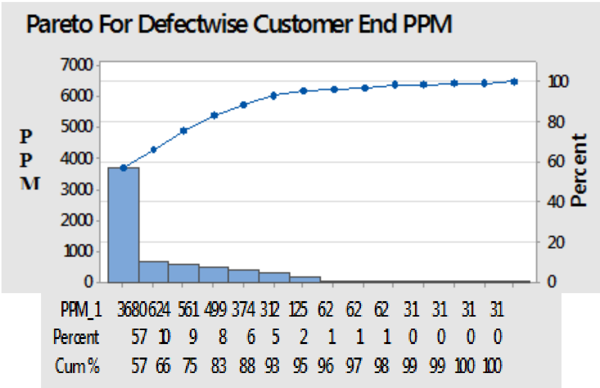

Figure 2: Pareto Analysis

Inference: Total Customer Line Rejection YTD Aug' 2016 is 6830PPM in that 3984 is Stator tapping Defect PPM which is Contributing to 58.3% of overall PPM

Step 4: Analysis of the problem: The team has analysed where tapping defect is occurring by studying the process of manufacturing the kit

4.1. Problem Analysis through "4 W & 1 H"

a. What is the problem?
b. Stator pad tapping hole defect
c. Where is the problem? :
d. At Crank Case Stator side machining
e. When the Problem does occur?
f. While stator pads tapping
g. Who are affected by the Problem?
h. Our internal customer
i. How to solve the problem?
j. By analyzing the Causes and developing the Solutions

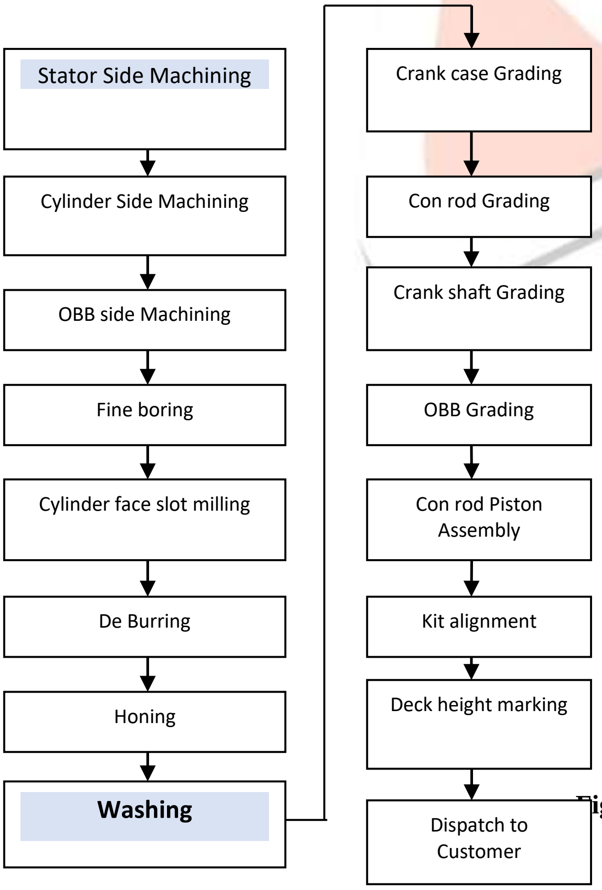

Figure 3: Process flow chart

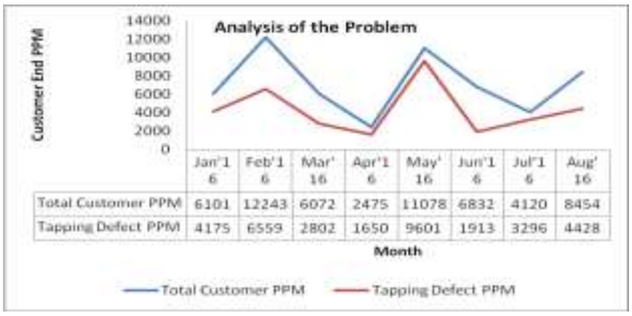

Figure 4: Analysis of the Problem

Total Customer Line Rejection YTD Aug' 2016 is 6830PPM in that 3984 PPM is Tapping Defect

Step 5: Identification of causes

Brain storming: the team after brainstorming has identified 13 causes as listed in Table 3.

Table 3: Finding in Brainstorming

1	Taps Wear out
2	Taps edge break In between the operation
3	Chips Accumulation in stator holes
4	Stator pad drill wear out
5	Stator bolts thread damages
6	Half thread of stator holes
7	Stator Pad Drill Depth Less
8	Stator Pad Hole Position out
9	Drill Angle, Major Día under size
10	Improper cleaning of stator fixing holes at Machining
11	Material hardness
12	Tool change frequency of drill & Tap
13	Operator skill at machining lines

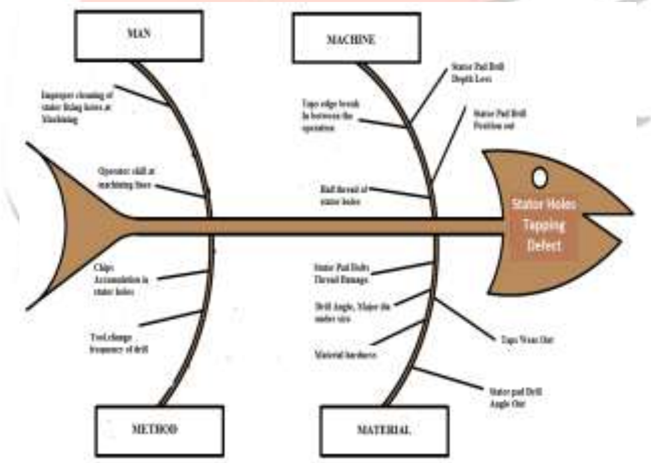

Figure 5: Ishikawa Diagram

Step 6: Finding out root causes

The root cause analysis was conducted taking into consideration the possible cause, validation, result and identified whether it is a significant cause on not with reference to Man, Machine, Method and material the analysis is tabulated below;

Table 4: Possible Causes

Possible Cause	Validation	Result	Significant Cause YES/ NO
MAN			
Operator skill at Machining lines	All operators engaged at machining lines are qualified	OK	

	as per skill requirement		Insignificant
Improper cleaning of stator fixing holes at washing	Observed chips in stator holes after cleaning, Further analysis needed	NOT OK	Significant
MACHINE			
Taps edge break In between the operation	Edge break checking mechanism available at machine	OK	Insignificant
Stator Pad Drill Depth Less	Verified Drill length at Gemba and found ok	OK	Insignificant
Stator Pad Hole Position out	Verified at Gemba with help of attribute gauge and found ok	OK	Insignificant
Half tap during operation	Verified at Gemba and found some pieces with half tap	NOT OK	Significant
MATERIAL			
Taps Wear out	Verified Taps and found ok. Tool changeover frequency being followed	OK	Insignificant
Stator pad drill wear out	Verified and found ok	OK	Insignificant
Stator bolts thread damages	Verified and found ok	OK	Insignificant
Drill Angle, Major Diameter under size	Verified at Gemba found ok	OK	Insignificant
Material hardness	Verified material hardness and found as per material specification	OK	Insignificant
METHOD			
Chips Accumulation in stator holes	Observed chips in stator pad holes	NOT OK	Significant
Tool change frequency of drill & Tap	Tool change frequency is in place.	OK	Insignificant

Investigation and data collection at shop floor and it is observed that there exist 13 possible causes and in which THREE (3) causes are vital.

Step 7: Data analysis

The team after investigating the root causes and attempt has been made to consider Probable Cause Verification through 3W & 1H

Probable cause Verification through 3W & 1H

Cause - 1

1. **WHAT** – Half Hole tapping during Tapping operation
2. **HOW** – Verification of crankcases for half hole tapping post operation
3. **WHO** – Team
4. **WHEN** – 08 Dec'16
5. **Remarks**: Verified and observed some Crank Cases half hole tapping after operation

Cause - 2

1. **WHAT** – Chips Accumulation in stator holes
2. **HOW** – Verification of crank cases after stator pad hole tapping operation
3. **WHO** – Team
4. **WHEN** –10 Dec'16
5. **Remarks** - Found chips in fixing holes

Cause - 3

1. **WHAT** – Improper Scrap cleaning of stator fixing holes at final Washing
2. **HOW** – Verified cleaning process
3. **WHO** – Team
4. **WHEN** –14 Dec'16
5. **Remarks** - Observed chips after washing

We have checked 10days Production 100% all 4 Holes Tapping after Tapping Operation and from the data it is observed that Half Hole tapping during Tapping operation is one of the cause for stator pad tapping hole defect.

Table 5: Results of inspection of 1200 No's

Sl No	Positions				CHIP YES/NO	Sl No	Positions				CHIP YES/NO	Sl No	Positions				CHIP YES/NO	Sl No	Positions				CHIP YES/NO
	1	2	3	4			1	2	3	4			1	2	3	4			1	2	3	4	
1	√	√	√	√	NO	26	√	√	√	√	NO	51	√	√	√	√	NO	76	√	√	√	√	NO
2	√	√	√	√	NO	27	√	√	√	√	NO	52	√	√	√	√	NO	77	√	√	√	√	NO
3	√	√	√	√	NO	28	√	√	√	√	NO	53	√	√	√	√	NO	78	√	√	√	√	NO
4	√	√	√	√	NO	29	√	√	√	√	NO	54	√	√	√	√	NO	79	√	√	√	√	NO
5	√	√	√	√	NO	30	√	√	√	√	NO	55	√	√	√	√	NO	80	√	√	√	√	NO
6	√	√	√	√	NO	31	√	√	√	√	NO	56	√	√	√	√	NO	81	√	√	√	√	NO
7	√	√	√	√	NO	32	√	√	√	√	NO	57	√	√	√	√	NO	82	√	√	√	√	NO
8	√	√	√	√	NO	33	√	√	√	√	NO	58	√	√	√	√	NO	83	√	√	√	√	NO
9	√	√	√	X	YES	34	√	√	√	√	NO	59	√	√	√	√	NO	84	√	√	√	√	NO
10	√	√	√	√	NO	35	√	√	√	√	NO	60	√	√	√	√	NO	85	√	√	√	√	NO
11	√	√	√	√	NO	36	√	X	√	√	YES	61	√	√	√	√	NO	86	√	√	√	√	NO
12	√	√	√	√	NO	37	√	√	√	√	NO	62	√	√	√	√	NO	87	√	√	√	√	NO
13	√	√	√	√	NO	38	√	√	√	√	NO	63	√	√	√	√	NO	88	√	√	√	√	NO
14	√	√	√	√	NO	39	√	√	√	√	NO	64	√	√	√	√	NO	89	√	√	√	√	NO
15	√	√	√	√	NO	40	√	√	√	√	NO	65	√	√	√	√	NO	90	√	√	√	√	NO
16	√	√	√	√	NO	41	√	√	√	√	NO	66	√	√	√	√	NO	91	√	√	√	√	NO
17	√	√	√	√	NO	42	√	√	√	√	NO	67	√	√	√	√	NO	92	√	√	√	√	NO
18	√	√	√	√	NO	43	√	√	√	√	NO	68	√	√	√	√	NO	93	X	√	√	√	YES
19	√	√	√	√	NO	44	√	√	√	√	NO	69	√	√	√	√	NO	94	√	√	√	√	NO
20	√	√	√	√	NO	45	√	√	√	√	NO	70	√	√	√	√	NO	95	√	√	√	√	NO
21	√	√	√	√	NO	46	√	√	√	√	NO	71	√	√	√	√	NO	96	√	√	√	√	NO
22	√	√	√	√	NO	47	√	√	√	√	NO	72	√	√	√	√	NO	97	√	√	√	√	NO
23	√	√	√	√	NO	48	√	√	√	√	NO	73	√	√	√	√	NO	98	√	√	√	√	NO
24	√	√	√	√	NO	49	√	√	√	√	NO	74	√	√	√	√	NO	99	√	√	√	√	NO
25	√	√	√	√	NO	50	√	√	√	√	NO	75	√	√	√	√	NO	100	√	√	√	√	NO

From the data, it is observed that chips accumulation being observed in fixing holes after manual air cleaning

Table 6: Production Vs Stator Hole Half Tap

Day	Production	Stator Hole Half Tap
1	950	
2	900	
3	850	**1 No**
4	800	
5	1050	
6	900	**2 Nos**
7	1000	
8	930	
9	910	
10	750	

We Have Checked 200 No's after Final Washing

Table 7: Results of inspection of 200 No's

Sl No	Positions				CHIP YES/NO	Sl No	Positions				CHIP YES/NO	Sl No	Positions				CHIP YES/NO	Sl No	Positions				CHIP YES/NO
	1	2	3	4			1	2	3	4			1	2	3	4			1	2	3	4	
1	√	√	√	√	NO	26	√	√	√	√	NO	51	√	√	√	√	NO	76	√	√	√	√	NO
2	√	√	√	√	NO	27	√	√	√	√	NO	52	√	√	√	√	NO	77	√	√	√	√	NO
3	√	√	√	√	NO	28	√	√	√	√	NO	53	√	√	√	√	NO	78	√	√	√	√	NO
4	√	√	√	√	NO	29	√	√	√	√	NO	54	√	√	√	√	NO	79	√	√	√	√	NO
5	√	√	√	√	NO	30	√	√	√	√	NO	55	√	√	√	√	NO	80	√	√	√	√	NO
6	√	√	√	√	NO	31	√	√	√	√	NO	56	√	√	√	√	NO	81	√	√	√	√	NO
7	√	√	√	√	NO	32	√	√	√	√	NO	57	√	√	√	√	NO	82	√	√	√	√	NO
8	√	√	√	√	NO	33	√	√	√	√	NO	58	√	√	√	√	NO	83	√	√	√	√	NO
9	√	√	√	√	NO	34	√	√	√	√	NO	59	√	√	√	√	NO	84	√	√	√	√	NO
10	√	√	√	√	NO	35	√	√	√	√	NO	60	√	√	√	√	NO	85	√	X	√	√	Yes
11	√	√	√	√	NO	36	√	√	√	√	NO	61	√	√	√	√	NO	86	√	√	√	√	NO
12	√	√	√	√	NO	37	√	√	√	√	NO	62	√	√	√	√	NO	87	√	√	√	√	NO
13	√	√	√	√	NO	38	√	√	√	√	NO	63	√	√	√	√	NO	88	√	√	√	√	NO
14	√	√	√	√	NO	39	√	√	√	√	NO	64	√	√	√	√	NO	89	√	√	√	√	NO
15	√	√	√	√	NO	40	√	√	√	√	NO	65	√	√	√	√	NO	90	√	√	√	√	NO
16	√	√	√	√	NO	41	√	X	√	√	YES	66	√	√	√	√	NO	91	√	√	√	√	NO
17	√	√	√	√	NO	42	√	√	√	√	NO	67	√	√	√	√	NO	92	√	√	√	√	NO
18	√	√	√	√	NO	43	√	√	√	√	NO	68	√	√	√	√	NO	93	√	√	√	√	NO
19	√	√	√	√	NO	44	√	√	√	√	NO	69	√	√	√	√	NO	94	√	√	√	√	NO
20	√	√	√	√	NO	45	√	√	√	√	NO	70	√	√	√	√	NO	95	√	√	√	√	NO
21	√	√	√	√	NO	46	√	√	√	√	NO	71	X	√	√	√	YES	96	√	√	√	√	NO
22	√	√	√	√	NO	47	√	√	√	√	NO	72	√	√	√	√	NO	97	√	√	√	√	NO
23	√	√	√	√	NO	48	√	√	√	√	NO	73	√	√	√	√	NO	98	√	√	√	√	NO
24	√	√	√	√	NO	49	√	√	√	√	NO	74	√	√	√	√	NO	99	√	√	√	√	NO
25	√	√	√	√	NO	50	√	√	√	√	NO	75	√	√	√	√	NO	100	√	√	√	√	NO

Inference:
From the data, it is observed that solidified chips are being observed in fixing holes after Final Washing

The Team did the Why-Why Analysis to find out the Root Causes
Cause 1

Half tap during operation – a). Due to short travel of Tap b). Retrieval of tap intermittently before travelling its complete length and c). Due to spring loaded tap adaptor.

Root Cause: Spring loaded tap adaptor travel incomplete depth
Counter Measure: Provide Mechanism to ensure full depth of travel

<u>**Cause 2**</u>

- **Chip accumulation in stator holes –** a). Chips getting trapped in stator holes; b). Air cleaning of chips and c). Manual Air Cleaning
  Root Cause: Manual air jet cleaning of stator holes
  Counter Measure: Provide a mechanism to remove chips effectively from fixing holes.

- <u>**Cause 3**</u>
- **Chip Left After Washing of stator pad holes –** a). Chip Left after Washing of stator pad holes; b). Getting Chip Solidified; c). Missing or Improper Cleaning of Some Holes at Tapping Operation and d). Manual air cleaning of stator pad.
  Root Cause: Manual air cleaning of stator hole chips leading to missing & solidification of chips.
  Counter Measure: Provide a mechanism to remove chips immediately from fixing holes after tapping operation.

Step 8: Developing solution

Table 8: 3W & 1H for Developing the Solution

S. No	What	How	Who	When
1	**:** Provide mechanism to remove chips from fixing holes effectively	By developing a fixture to remove Chips From crank case fixing holes	Team	10th Jan'17
2	Provide Mechanism to Ensure Full depth of Tapping	By providing sensor at machine spindles	Team	16th Jan'17

1. Made one Sample jet in Tool Room
2. Conducted Trials on Crank case by Manual Feeding of jet

Design Options for finding an optimal solution
Concept:
Feed air jet into crank case blind hole 3/4 depth and blow high pressure air through convergent nozzle. The scrap blows out from the gap around jet as per the above concept.
We have fixed the Sensors to ensure full depth of spindle travel and ensure Tapping depth on trial and error Method and Observed 4 days Production, Found OK.

Figure 5: Developing a new fixture

Table 9: Options to develop the solution

Suggestions for developing the solution	Stator pad Hole Diameter	Nozzle OD	Nozzle ID	Nozzle Wall Thickness	Clearance Between Nozzle & Taping Hole	Accepted/ Rejected
Option - 1	5.5mm	5mm	3mm	1mm	0.25mm	Rejected
Option - 2	5.5mm	3mm	2mm	0.5mm	1.25mm	Rejected

Option - 3	5.5mm	4mm	2mm	1mm	0.75mm	Accepted

Result: 4mm diameter Nozzle Used to clean the scrap and found cleaning is effective

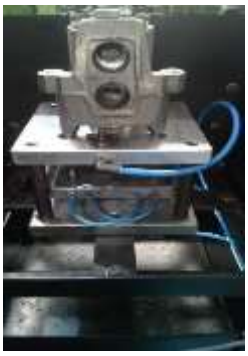

Figure 6: a new fixture

Step 9: Probable resistance
An awareness program is conducted for all the operators, who were working in Line and explained them about the solution and asked them to express their views for trial implementation

Step 10: Trial implementation
With help from MED & Approval from local management Trial implementation of solution on 30th Jan 2017

Step 11: Regular implementation
Designed and manufactured Cleaning Fixture suitable for Crank case both Regular & J Models

Table 10: 4W & 2H for Regular Implementation

S. No	What	How	Who	When	*Why*	*How*
1	Provide Air Cleaning Fixture	At Machine	Team	24thFeb '17	To avoid chips accumulation in stator holes	Design and manufactured Cleaning Fixture suitable for Crank case both Regular & J Models
2	Provide Sensor mechanism	At Machine	Team	16th Feb'17	To eliminate half tap rejection	By providing a sensor for all 4 Spindles

Figure 7: Before study Before Improvement

Figure 8: After Improvement

Results after implementation of the Providing Air Cleaning Fixture and Sensor mechanism the Tapping defect is 400 PPM and Overall Customer End line is 1200PPM

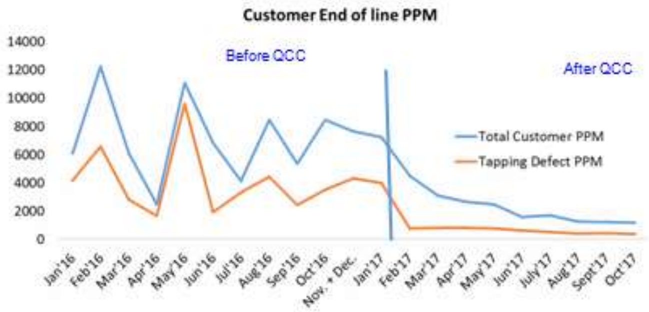

Figure 9: Customer end PPM comparision chart before and after QCC improvement

Step 12: Follow up/ review

Tangible Benefits

Total AW Kit Debits Received from Tupelo YTD Aug'16	168
Cost Debit per Kit	$80.00
YTD Aug' 2016 Total Nos Rejected due to Tapping	98
Cost Debited on account of Tapping Defects	$7,840.00
YTD June'17 Rejected on Account of Tapping defects	24
YTD June 2017 Cost Debited on Account of Tapping defects	$1,920.00
Proposed 2017 Cost Debited on Account of Tapping defects	$3,840.00
Saving on Account of Tapping Defects	$4,000.00
Cost Savings on account of End of line PPM Reduction	₹ 2,30,000.00
Cost Saving in INR	₹ 4,94,000.00

In-Tangible Benefits

The intangible benefits upon successful implementation of suggestions by quality circle team are team working and Knowledge Sharing, Improved the Analytical Skills, Job satisfaction, improved housekeeping and Team spirit enhanced

Conclusion

The problem was analyzed and found the root causes as spring loaded tap adaptor travel incomplete depth, Chips getting trapped in stator holes due to Manual air jet cleaning of stator holes and Manual air cleaning of stator hole chips leading to missing & solidification of chips, based on the analysis the team suggestion was to develop a fixture to remove Chips From crank case fixing holes and providing sensor at machine spindles the problem could be overcome. Based on the suggestion the team adopted a concept of Feeding air jet into crank case blind hole 3/4 depth and blow high pressure air through convergent nozzle by which the scrap blows out from the gap around jet. The suggestion has been implemented. Results after implementation of the Providing Air Cleaning Fixture and Sensor mechanism the Tapping defect is 400 PPM and Overall Customer End line is 1200PPM.

References

[1]. Prasanna N.K.K and Desai Tushar N. (2011), Quality Circle implementation for maintenance management in petrochemical industry, Journal of Engineering Research and Studies
[2]. Udpa S.R. (1986): "Quality Circles, Progress through Participation", McGraw-Hill Publishing Company Limited, New Delhi.

[3]. Lozano R. and Philip C. Thompson (1980): "QC Implementation in the Space Shuttle External Tank Program at the Michoud Marietta Corporation", 1980, ASQC 34th Annual Technical Conference Transactions.