Reduction of Machine Downtime and Repairs by Root Cause Analysis

Mr. Suresh P[1], Dr. Sham Prasad .M.S[2]
[1, 2] Department of Industrial and Production
[1, 2] National Institute of Engineering, Mysore, Karnataka

Abstract- *It is a present scenario that manufacturing industries are facing a greater competition in the market. So there is a need for continuous improvementin quality and productivity. If we can reduce the downtime or breakdowns of the machines then we can easily increase the availability of machines. The main objective of the project is to reduce the downtime and repairs of a machine and to increase the availability of a machine. The project is carried out on Maxpro H650 machine where all repeated breakdowns were analysed along with the other breakdowns. Also the reason for the breakdown has been analysed and the root causes of the breakdowns were identified by the RCA tools. The aim of project is to reduce the downtime of machine and towards increasing availability and MTBF of machine.*

Keywords- RCA (Root Cause Analysis), Availability, Downtime, Preventive measure, Breakdown, ATC (Automatic tool changer), PM (Preventive maintenance), Fish bone diagram and 5 why analysis.

I. INTRODUCTION

RCA is a tool to identify the basic factors which are responsible for the failure or breakdown event. If we are able to determine why an event or failure occurred then it will be easier to take corrective measures that prevent future failures. Based on the root cause of the failure we can easily implement preventive measure. In simple terms RCA is to determine what happened and how it happened (1). Root Cause Assessment (RCA) is the process of identifying causal factors using a structured approach with techniques designed to provide a focus for identifying and resolving problems. Root Cause is the fundamental breakdown or failure of a process which, when resolved, prevents a recurrence of the problem (2). RCA is a tool to identify not only what and how an event occurred, but also why it happened. To meet up the high changing market demands along with high quality at comparable prices, one shall have to identify quickly the root causes of quality related problems by reviewing an event, with the goals of determining what has happened, why it has happened and what can be done to reduce the likelihood of recurrence (3). In this paper an attempt has been made to reduce the downtime and repairs of the machine thereby increasing its availability and to ensure that the performance of the machine is satisfactory.

II.STEPS FOR SUCCESSFUL ROOT CAUSE ANALYSIS (RCA)

There are four steps to carry out successful Root Cause Analysis involving the following:

1. Collection of data
2. Charting the causes
3. Identifying the root causes
4. Preventive action

Root Cause Analysis (RCA) is an effective tool for trouble shooting breakdowns and to obtain effective solution. For successful implementation of RCA following seven points are necessary.

Seven points of RCA are:

- Note down the breakdown or failure.
- Define the breakdown or failure.
- Collect all data related to breakdown or failure and note down all the possible causes of breakdown or failure.
- To focus on all the aspects of breakdown or failure work as a team rather than individually.
- Identify the root causes of the breakdown or failure by RCA tools.
- Take immediate action for the breakdown or failure.
- Based on the root cause of the breakdown or failure, implement preventive measure.

III. ROOT CAUSE ANALYSIS TOOLS

a. Fish Bone Diagram (FBD) or Cause-and-Effect Diagram (CED)
b. Interrelationship Diagram (ID)
c. Current Reality Tree (CRT)
d. 5 Why Analysis
e. Multivariate Analysis
f. Brainstorming

IV. NEED FOR ROOT CAUSE ANALYSIS

A Root Cause Analysis will disclose:

- Why the incident, failure or breakdown occurred
- The future failures can be eliminated by:

- Giving changes to procedure
- Giving changes to type of operation
- Training the operators
- Giving changes to design
- Verification that new or rebuilt equipment is free of defects

V. PROBLEM IDENTIFICATION

There are 3 BFW's Maxpro machines in the carrier line, these machines completes about 70% of the carrier line operations. So if any one of the machine gets breakdown then there will be production line stoppage or bottleneck in the line which in turn responsible for company's production loss or company will fail to deliver the products to customers within the specified time.

In this study one Maxpro machine is taken for the RCA study. After collecting the previous year breakdown data it is observed that breakdowns such as tool change problem, spindle alarm and other reasons are responsible for the breakdown of the machine. In order to determine the root cause for the particular breakdown we have to make use of RCA tools such as 5-whys, fishbone diagram etc. After that we can implement the corrective action for the breakdown.

VI. ROOT CAUSE ANALYSIS

1) Data collection:

TABLE 1: MACHINE BREAKDOWN DETAILS OF BFW MAXPRO H650

Sl. No	Problem	Number of times breakdown
1	Tool changing problem	9
2	Spindle drive alarm	8
3	Pallet change problem	3
4	Problems related to ATC arm/door	3

For analysis purpose repeated Breakdowns are taken to carry out the RCA

2) Cause analysis:

2.1) Problem Statement: Tool Falling Problem

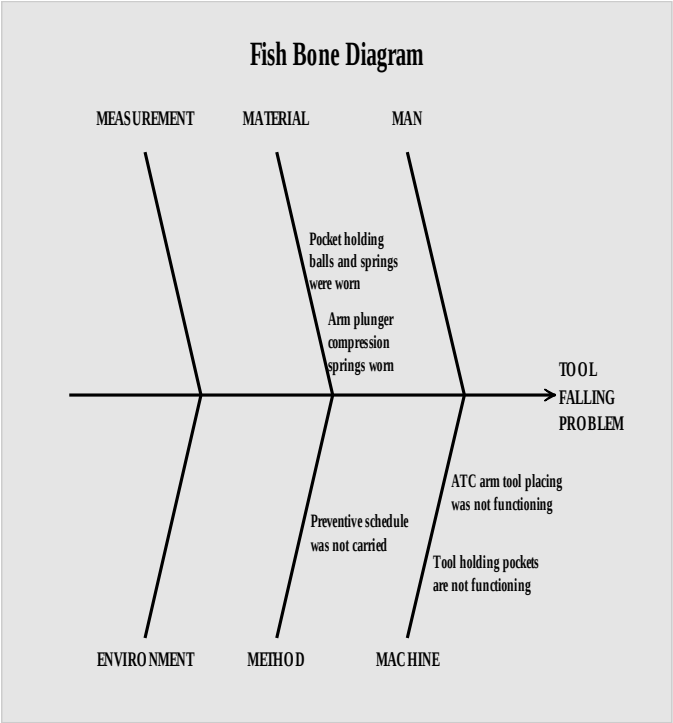


FIGURE 1: FISH BONE DIAGRAM

TABLE 2: 5 WHY ANALYSIS

5W METHOD	
Machine name: Maxpro H650	
COMPLAINT: Tool falling problem	
DEFECT: Tool falling from ATC arm	
1st WHY?	Tool holding pockets are not functioning
2nd WHY?	ATC arm tool placing was not functioning
3rd WHY?	Pocket holding balls and springs were worn
4th WHY?	Arm plunger compression springs worn
5th WHY?	Preventive schedule was not carried
ROOT CAUSE:	Worn out springs and pocket holding balls
IMMEDIATE ACTION	Tool pocket balls, springs and ATC arm springs replaced
PREVENTIVE MEASURE	Periodic replacement of the springs, Preventive maintenance has to be maintained.
HORIZONTAL DEPLOYMENT	All BFW Machines

VII. RESULTS AND DISCUSSION

1. Availability:

Availability is the total time of utilization of a machine. Availability is the reciprocal of the difference between the total available hours and total breakdown hours to the total available hours.

Availability =

$$\frac{\text{Total available hours} - \text{Total breakdown hours} \times 100}{\text{Total available hours}}$$

2. Mean time between failures: (MTBF):

MTBF is the time between two failures. When failure rate is constant, the mean time between failures is thereciprocal of the constant failure rate or the ratio of the test time to the number of failures.

MTBF =

$$\frac{\text{Total available hours} - \text{Total breakdown hours (hrs.)}}{\text{Total number of breakdowns}}$$

3. Mean time to repair: (MTTR):

Mean Time to Repair is the average time that it takes to repair machine after a failure.

MTTR =

$$\frac{\text{Total breakdown hours(hrs.)}}{\text{Total number of breakdowns}}$$

Calculations of Availability, MTBF and MTTR before RCA

TABLE 3: MONTHLY DOWNTIME REPORT IN 2015

Sl. No.	Month	Total Available hours	Total Break down hours	Total Utilized hours	Total no. Of Breakdowns
1	January	572	43.87	528.13	6
2	February	528	39.36	488.64	7
3	March	572	48.20	523.80	6
4	April	572	48.73	523.27	8

Total available hours from 1/01/2015 to 30/04/2015 is 102*22= 2244 hours

Total breakdown hours from 1/01/2015 to 30/04/2015 is 180.16

1) Availability= $\frac{2244 - 180.16}{2244} \times 100$

= **91.97** %

2) MTBF = $\frac{2244 - 180.16}{27}$

= **76.43** hours

3) MTTR= $\frac{180.16}{27}$

= **6.67** hours

Calculations of Availability, MTBF and MTTR after RCA

TABLE 4: MONTHLY DOWNTIME REPORT IN2016

Sl. No.	Month	Total Available hours	Total Breakdown hours	Total Utilized hours	Total no. Of Breakdowns
1	Jan	572	21.75	550.25	5
2	Feb	550	27.50	522.50	5
3	March	572	25.50	546.50	5
4	April	572	27.00	545.00	6

Total available hours from 1/01/2016 to 30/04/2016 is 103*22= 2266 hours

Total breakdown hours from 1/01/2016 to 30/04/2016 is 101.75 hours

1) Availability

$= \frac{2266 - 101.75}{2266} \times 100$ = **95.50**%.

2) MTBF

$= \frac{2266 - 101.75}{21}$ = **103.05** hours.

3) MTTR

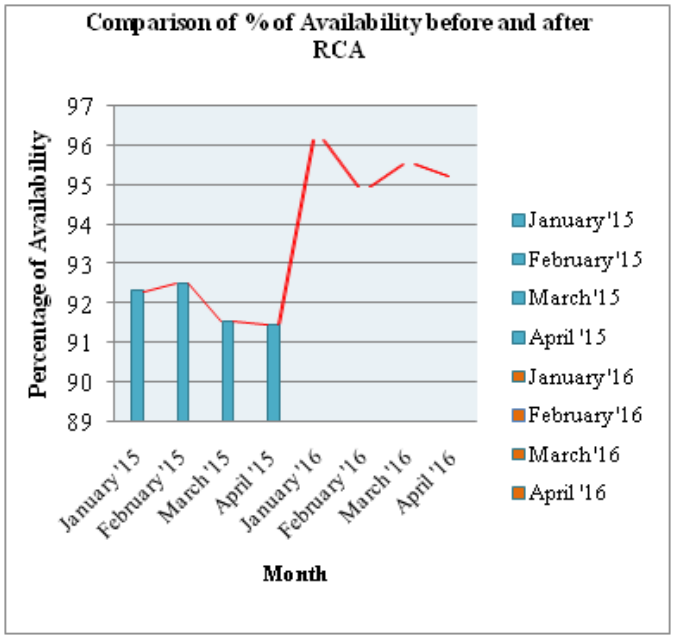
$= \frac{101.75}{21}$ = **4.84** hours.

Comparison of Availability, MTBF and MTTR before and after RCA

Availability:

TABLE 5: COMPARISON OF AVAILABILITY BEFORE AND AFTERRCA

Before RCA		After RCA	
Month	Percentage (%)	Month	Percentage (%)
January '15	92.33	January '16	96.19
February '15	92.54	February '16	95
March '15	91.57	March '16	95.54
April '15	91.48	April '16	95.27



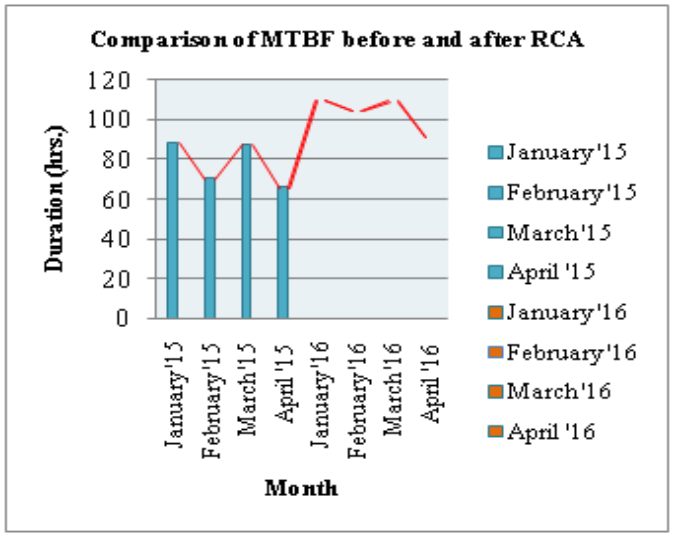
GRAPH 1: COMPARISON OF AVAILABILITY BEFORE AND AFTER RCA

From the above graph we can come to the conclusion that Availability after root cause analysis has been increased considerably than the Availability before root cause analysis.

MTBF:

TABLE 6: COMPARISON OF MTBF BEFORE AND AFTER RCA

Before RCA		After RCA	
Month	Duration (hrs.)	Month	Duration (hrs.)
January '15	88.02	January '16	110.05
February '15	69.80	February '16	104.50
March '15	87.30	March '16	109.30
April '15	65.40	April '16	90.83



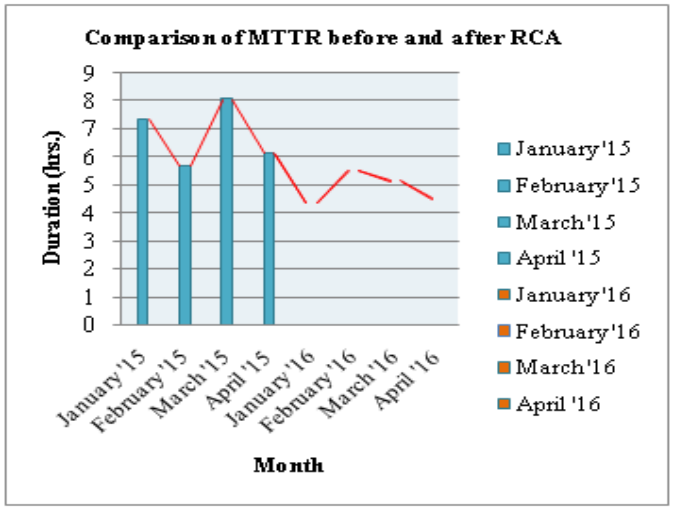
GRAPH 2: COMPARISON OF MTBF BEFORE AND AFTER RCA

From the above graph we can come to the conclusion that MTBF after root cause analysis has been increased considerably than the Availability before root cause analysis.

MTTR:

TABLE 7: COMPARISON OF MTTR BEFORE AND AFTER RCA

Before RCA		After RCA	
Month	Duration (hrs.)	Month	Duration (hrs.)
January '15	7.31	January '16	4.35
February '15	5.62	February '16	5.50
March '15	8.03	March '16	5.10
April '15	6.09	April '16	4.50



GRAPH 3: COMPARISON OF MTTR BEFORE AND AFTER RCA

From the above graph we can come to the conclusion that MTTR after root cause analysis has been decreased considerably than the MTTR before root cause analysis. Therefore the above graph shows the mean time to repair decreased and it has been improved considerably after root cause analysis.

TABLE 8: AVERAGE VALUES OF AVAILABILITY, MTBF AND MTTR BEFORE AND AFTER RCA

Before Root Cause Analysis			After Root Cause Analysis		
Average value of % of availability	Average value of MTBF (in hrs.)	Average value of MTTR (in hrs.)	Average value of % of availability	Average value of MTBF (in hrs.)	Average value of MTTR (in hrs.)
91.97	76.43	6.67	95.5	103.05	4.84

1. Percentage increase in Availability of a machine

Percentage increase = $\frac{\text{Final average Availability after RCA} - \text{Initial average Availability before RCA}}{\text{Initial average Availability before RCA}} \times 100$

$= \frac{95.50-91.97}{91.97} \times 100 =$ **3.83**%.

Note: Increase in the Availability of a machine is **3.83%** i.e. **3.83%** of initial Available hours in January, February, March, April month are 572, 550, 572 and 572.

January = $\frac{3.83 \times 572}{100}$

= 21.90 hrs.

Therefore Increase in the Availability of a machine in January is 21 hours and 53 minutes.

Similarly Increase in the Availability of a machine in February, March and April are 21, 21.90 and 21.90 hours respectively

2. Percentage increase in MTBF of a machine

Percentage increase = $\frac{\text{Final average MTBF after RCA} - \text{Initial average MTBF before RCA}}{\text{Initial average MTBF before RCA}} \times 100$

$= \frac{103.05-76.43}{76.43} \times 100$

= **34.82**%

3. Percentage decrease in MTTR of a machine

Percentage decrease= $\frac{\text{Initial average MTTR before RCA} - \text{Final average MTTR after RCA}}{\text{Initial average MTTR before RCA}} \times 100$

$= \frac{6.67-4.84}{6.67} \times 100$

= **27.43**%

VIII. CONCLUSION

The project is carried out on BFW Maxpro H650 machine. Root causes of the breakdowns are identified and effective preventive measure is implemented. The availability of Maxpro H650 machine after Root Cause Analysis is increased to **3.83%**. Also the MTBF of machine after Root Cause Analysis is increased to **34.82%** and MTTR is decreased to **27.43%** respectively. After RCA there is an improvement in the availability and MTBF of the machine. Also there is a decrease in MTTR of a Maxpro H650 machine in a particular company.

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