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Study and Analysis of Equipment Availability Using TPM Tools in an Extrusion Plant

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***Abstract*—Extrusion is a critical process which involves a number of steps like casting of logs, heating of logs and dies to the preset temperature. Maintaining extrusion pressure and temperature at the press plays a major role in extruding of profiles. Precautionary measures have to be taken for suitable alignment of container and setting of dummy block. Breakdowns occur due to the use of equipments like conventional container, die, dummy block which directly implies on less recovery. By upkeeping the equipments, plant performance will increase and higher productivity can be achieved. By adapting maintenance tools Total Productive Maintenance (TPM) tools we can improve the plant performance considerably. TPM tools such as Kaizen and Why-Why analysis are adopted here to improve the plant performance.**

This work is envisaged to analyze the breakdowns, their causes and actions to be taken and thereby study their effect on equipment availability and to improve the plant performance.

Keywords— Total Productive Maintenance, Root Cause Analysis, Kaizen, Why-Why Analysis, Extrusion

1. INTRODUCTION

Extrusion is a process used to create objects of a fixed cross-sectional profile. Here material is pushed through a die of the desired cross-section. The advantages of this process over other manufacturing processes are its ability to create very complex cross-sections, and to work materials that are brittle, because the material encounters compressive and shear stresses.

It also forms parts with an excellent surface finish. It is a critical process which involves a number of steps like casting, heating of logs and dies to the preset temperature. in this process maintaining extrusion pressure and temperature at the press is very essential to achieve the desired shape and size. Suitable alignment of container and setting of dummy block plays a vital role in this process. Breakdowns occur due to the use of equipments like conventional container, die, dummy block which directly implies on less recovery, which leads to reduction in plant performance ease of use.

2. OBJECTIVE

The objective of this work are to study breakdown data, analyze their causes and actions taken and its effect on equipment availability and to implement new ideas through TPM tools like Kaizen and Why-Why analysis.

3. DATA COLLLECTION

The data pertaining to breakdowns in extrusion process like downtime were collected and shown in table 1 and table 2. The term downtime is used to refer a period when a system is unavailable. Data pertaining to both mechanical and electrical failure were collected separately for a period of six months. These data were used to determine equipment availability Performance rating were also determined.

Table 1: Total downtime in hours

Equipment	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Tank 1	12	2.58	2.17	8.58	1	3.83
Tank 2	24.5	0.75	3.33	0.5	10.25	3.25
Tank 3	0	14	0	0	4.5	0
Coloring Tank	0.5	70.58	0	0	5	0.5
Crane 1	1.5	1	0	0	0	10.84
Crane 2	19.5	1.75	0	0.25	0	0.17
Crane 3	8.65	2	0	3.5	0	0
Chiller 1	2.5	1	0	0	0	3
Chiller 2	4	2.25	0	0	0	0.17
Chiller 3	0	1	0	0	0	0
Chiller 4	0	0	0	0	0	0
Thermo Pac	0	0	0.33	0	0.83	0
Total	77.17	96.9	45.83	60.83	66.58	40.76

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Table 2: Overall frequency of downtime

Equipment	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Tank 1	5	2	2	2	4	2
Tank 2	8	1	3	2	4	1
Tank 3	0	4	2	5	3	0
Coloring Tank	1	6	2	0	2	1
Crane 1	1	1	0	1	2	3
Crane 2	5	2	0	1	0	1
Crane 3	3	1	3	0	0	0
Chiller 1	2	1	0	0	2	2
Chiller 2	2	1	0	0	0	1
Chiller 3	0	2	0	2	0	3
Chiller 4	1	0	2	0	4	0
Thermo Pac	2	0	3	0	0	4
Total	32	21	17	13	21	18

4. DETERMINATION OF EQUIPMENT AVAILABILITY AND PERFORMANCE RATING

Equipment Availability:

The simplest representation for availability is a ratio of the expected value of the uptime of a system to the aggregate of the expected values of uptime and downtime

$$Availability = \frac{\text{Uptime}}{(\text{Uptime} + \text{Downtime})}$$

$$Availability = \frac{\text{Total Operating hours}}{(\text{Total Operating hours} + \text{Total down time})}$$

Performance Rating:

A procedure for determining the value for a factor which will adjust the measured time for an observed task performance to a task time that one would expect of a trained operator performing the task, utilizing the approved method and standard working conditions.

$$Performance\ Rating = \frac{\text{Design cycle time} \times \text{Production}}{\text{Total operating hours}} \times 100$$

Calculation of Equipment Availability and Performance Rating is shown in table 3

5. ROOT CAUSE ANALYSIS

Root cause analysis (RCA) is method used to identify the root cause of the problems or events. By directing corrective measures at root causes, it is more probable that problem reoccurrence will be prevented. However complete prevention of re occurrence is not always possible. RCA is often considered to be an iterative process and is frequently viewed as tool of continuous improvement.

This analysis is performed by

- Cause and effect diagram
- Why-Why Analysis
- Kaizen

1. Cause and Effect Diagram

It is used to determine the primary and secondary causes for the breakdown of various equipments. In this analysis the causes of breakdown are classified into major categories like machine, materials, people, methods, policies etc. Identify all possible causes and label each causes under appropriate category. Analyze the causes and rank the most likely ones for further consideration and study.

The cause and effect diagram for the breakdown of anodizing tank, crane, motor, pump, chiller and rectifier was prepared and the primary and secondary causes for the breakdown of the above equipments were identified.

2. Why-Why Analysis

It is conducted to identify solutions to a problem that addresses its root causes. Rather than taking action that are merely band aids, a why-why helps you to identify how to really prevent the issue from happening again.

To solve a problem using why-why analysis, initially identify the problem and then ask “Why is the problem taking place”. This will end up with number of answers. Repeat this process at least five times for each of the answers, so that the root causes are identified.

The Why-why analysis for anodizing tank, crane, motor, pump, chiller and rectifier was prepared and the root causes for the breakdown of the above equipments were identified.

3. Kaizen

‘Kai’ means change, ‘Zen’ means good, Basically Kaizen is for small improvements, but carried out on a continual basis and involve everyone in the organization. It requires no or very little investment. The principle behind this is “A very large number of small improvements are more effective in an organizational environment than a few improvements of large value”

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Table 3: Calculation of Equipment Availability and Performance Rating

Months	Planned Availability	Actual Production	Total Downtime	Total Available Time	Total Operating Time	Equipment Availability	Performance Rating
Month 1	95	164	109.15	720	614.85	84.924	88.821
Month 2	95	152	128.9	744	615.09	82.674	82.29
Month 3	95	164	85.83	720	630.17	88.012	86.662
Month 4	95	157	92.83	744	651.17	87.522	80.287
Month 5	95	160	98.58	744	645.42	86.75	82.55
Month 6	95	162	80.76	720	638.24	88.76	84.523

6. RESULTS

After performing root cause analysis data collected are shown in table 4 and table 5. Equipment Availability and Performance rating are determined as shown in table 6.

Table 4: Total downtime in hours

Equipment	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Tank 1	8.36	13.38	2.77	1.51	2.87	1.47
Tank 2	0.85	1.6	11.6	0.78	0	6.39
Tank 3	0	1.19	0.11	9.49	0	5.75
Coloring Tank	0	6.97	1.99	0	3.77	0
Crane 1	2.16	1.33	0	1.63	0	12.66
Crane 2	1.3	0	0	0.23	1.69	1.98
Crane 3	0	0	4.37	0	0	0
Chiller 1	0	0	0.26	0	0	0
Chiller 2	0	0.78	0	0	0	0
Chiller 3	0	0	1.11	0	0	0
Chiller 4	0	0	0	0	0.31	0
Thermo Pac	1.38	0	2.28	0	0	0
Total	14.5	25.25	24.5	13.64	8.64	28.25

Table 5: Overall frequency of downtime

Equipment	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Tank 1	4	6	1	2	2	1
Tank 2	2	1	1	1	0	4
Tank 3	0	2	1	2	0	2
Coloring Tank	0	3	2	0	3	0
Crane 1	2	1	0	1	0	2
Crane 2	2	0	0	1	1	1
Crane 3	1	0	3	0	0	0
Chiller 1	0	0	1	0	0	0
Chiller 2	0	2	0	0	0	0
Chiller 3	0	0	2	0	0	0
Chiller 4	0	1	0	0	1	0
Thermo Pac	3	0	2	0	0	0
Total	13	16	13	7	7	10

Table 6: Calculation of Availability and Performance Rating

Months	Planned Availability	Actual Production	Total Downtime	Total Available Time	Total Operating Time	Equipment Availability	Performance Rating
Month 7	95	200	46.05	744	697.95	93.810	95.42
Month 8	95	188	57.25	720	662.75	92.048	94.46
Month 9	95	197	64.5	744	679.5	91.330	96.54
Month 10	95	200	45.64	744	698.36	93.866	95.36
Month 11	95	201	40.64	574	533.36	92.920	94.21
Month 12	95	189	60.25	720	665.8	91.701	94.52

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Comparison of Equipment Availability and Performance Rating before and after root cause analysis

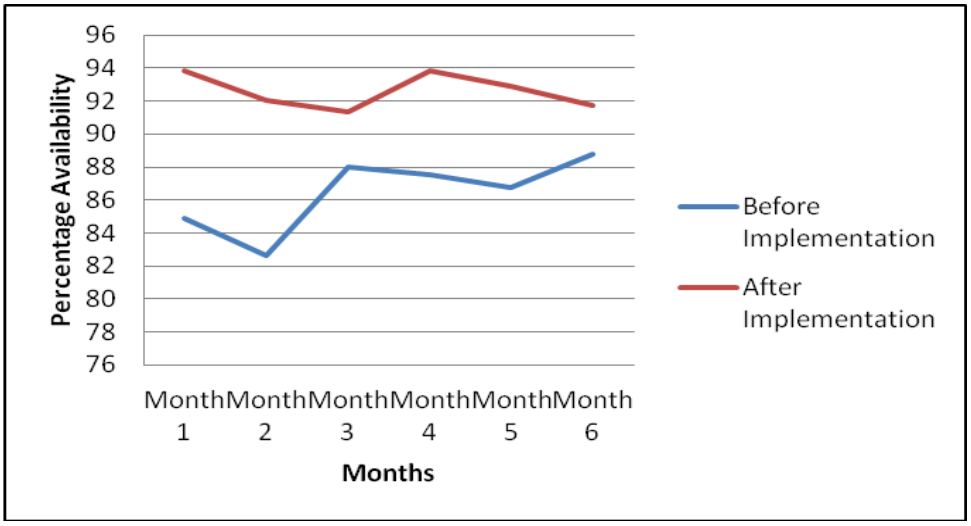

Fig.1 Comparison of Availability before and after root cause analysis

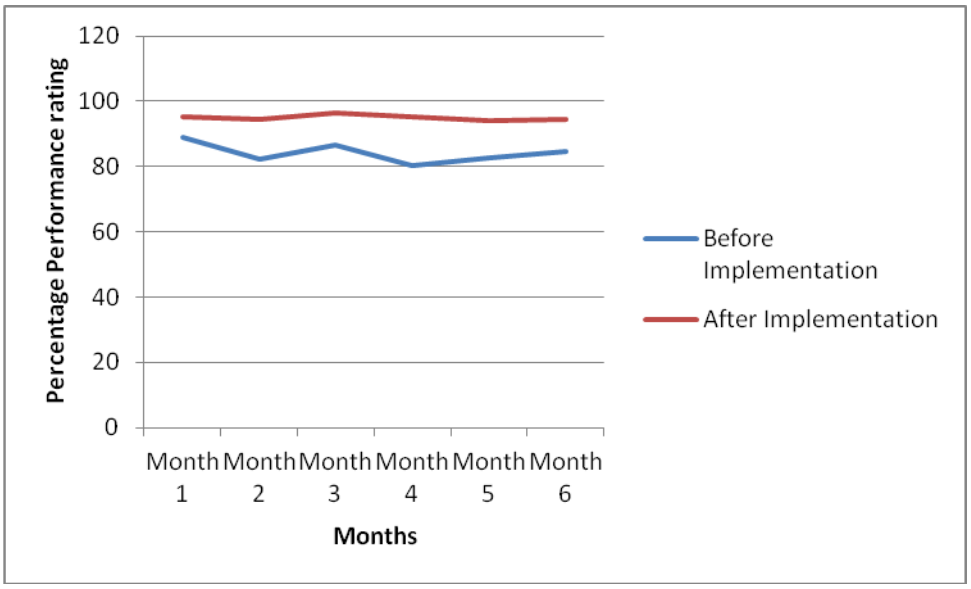

Fig.2 Comparison of Performance Rating before and after root cause analysis

7. CONCLUSION

After performing root cause analysis and implementing kaizen for certain machines/equipments it is observed that equipment availability and performance rating has increased. This is because of proper diagnosis of the problem through root cause analysis and by bringing some improvements to the existing system through kaizen implementation. Whenever a breakdown occurs the root causes for such breakdowns has to be identified and some improvements should be made to prevent the occurrence of similar breakdowns.

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