International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-08, Issue-11, Feb 2023

Optimizing Production Efficiency: A Case Study on Machine Downtime Analysis and Implementation of Quality Control Tools and Action Plans

Achal Kandoi[1], Jatin Makwana[2]

Undergraduate Student[1], Assistant Professor[2], Department of Production Engineering, Birla Vishvakarma Mahavidyalaya Engineering College, India. kandoiachal@gmail.com

Abstract: This case study examines the application of Quality Control tools in identifying and addressing the root causes of machine downtime in a manufacturing company. The company was facing challenges with machine downtime, impacting efficiency and productivity. The study employed QC tools such as the Pareto principle and cause-and-effect diagrams to analyze and identify the underlying causes of downtime. The study's results demonstrate that the implementation of QC tools effectively identified the primary causes of machine downtime and developed a plan of action to improve overall productivity. The case study's emphasis was on identifying and addressing the root causes of the problem, leading to a sustainable improvement in machine downtime, efficiency, and productivity.

Keywords: **Machine Downtime, Total Quality Management, Fishbone Diagram, Pareto Principle, Action Plan**

I. INTRODUCTION

Downtime is any period of time when a machine is not in production. Common categories of downtime include loading/unloading time, excessive tool changeover, excessive job changeover, unavailability of an operator, machine breakdown, etc. The majority of downtime tracking applications involve monitoring a machine or piece of process equipment for shutdown conditions. This downtime can be caused by a variety of factors, both expected and unexpected. One of the most common challenges production unit face is machine downtime; the time isn't in production. There are almost immediate gaps in knowledge when analyzing the major causes of a company's downtimes.

- How much downtime is there on the shop floor?
- Why are the machines down?
- What is the cost of downtime?
- Where are the largest areas of improvement?

A downtime analysis includes answering these questions. In order to reduce downtime, Production Managers, Process Engineers, and other stakeholders can collect data from the shop floor and run analytics to identify issues, solutions, and other insights.

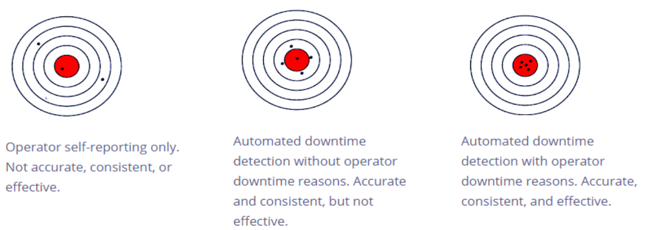


Figure 1: Downtime Accuracy

To track downtime accurately and effectively, we must have both manual and automatically generated machine data, concerning the three factors: accuracy, consistency, and effectiveness.

II. LITERATURE REVIEW

1. Rahman C.M. et al. (2014), conducted a case study to evaluate the implementation of Total Productive Maintenance (TPM) through downtime and mean downtime analysis. In this case study, Pareto analysis and T-Test were used to identify the factors contributing to downtime and the mean downtime.
2. Arjun Kotwal et al. (2015), reviewed that the key factors for decreasing machine downtime include Mean Time Between Failure (MTBF), Mean Time to Repair (MTTR), and Availability. Additionally, Failure Mode Effect Analysis (FMEA) is an effective tool for identifying critical and non-critical components in the process.
3. R. Kalantri et al. (2013), implemented the root cause analysis to eliminate product rejection and improve product lifespan. Techniques such as brainstorming and other Root Cause Analysis tools were used to identify the causes of tube failure and vibration in the tubular strander machine.
4. Ashfaqur Rahman et al., show how useful information may be derived from indoor monitoring data of employees on a factory assembly line. They used two indoor positioning data sets: a real-world (and publicly available) data set of numerous people working on a tricycle production line, and a synthesized data frame of a computer assembly line. Aim to create a collection of

 DOI : 10.35291/2454-9150.2023.0031

data analytics tools for inferring numerous Key Performance Indicators (KPIs) or metrics from worker monitoring data.

5. Lian Duan and Li Da Xu (2021), to better comprehend current research efforts, hot themes, and trending topics on this vital junction, first discussed the essential ideas in Industry 4.0 and data analytics. The merger is then broken down into three components: industry sectors, security systems, and analytical methodologies. Collaborative research efforts on various intersections with various components were also explored and addressed. Finally, a thorough literature evaluation of the interplay among both Industry 4.0 and data analytics is carried out in order to comprehend the current research emphasis and trend.
6. Paul John Blayney and Zhaohao Sun, in there chapter examine how Excel may be utilized in big data research in combination with other applications and analytical methodologies. This study also discusses where and how to perform big data research using spreadsheet software. The key to big data-driven research, according to this chapter, is data purification and big data-driven small data analysis. This chapter's recommended technique may aid in the study and advancement of intelligent big data analytics, and business intelligence.
7. S. K. Subramaniam et al. (2008), this paper states that the factors contributing to production line efficiency are manpower utilization and machine efficiency. Measuring the machine efficiency and manpower utilization should be on line and accurate. This study explains that the relevant and valuable production data helps the management efficiently monitor the process flow. The production data should be very well interpreted and fully utilized in order to optimize available resources within the industrial sector. This will reduce wastage and increase the production yield.
8. J. V. Kovach et al. (2001), this research identified the lean and quality improvement methods that practitioners have successfully implemented within their organizations. They have also examined theperceived effectiveness and the challenges/reasons for failure associated with these techniques.
9. Yrlanda de Oliveira dos Santos et al. (2020), this work aims to identify the production bottlenecks of the manual insertion process of the components - BMI of a factory in the Industrial Pole of Manaus, to apply the theory of restrictions - TOC and the Overall Equipment Efficiency index - OEE of the equipment.

Problem Statement

A manufacturing company is facing challenges with machine downtime, which is negatively impacting efficiency and productivity. The company is looking for ways to improve its performance in this area and is seeking to understand the root causes of the machine downtime so that it can develop an action plan to address the issues and improve its overall productivity. Higher Downtime of machines in production units causes problems in daily operations, and planning affects utilization, and inevitably results in a loss in revenue.

Objective

The objective of this case study is to use Total Quality Management (TQM) tools to identify and analyze the root causes of machine downtime in a manufacturing company. The aim is to understand the underlying issues that are causing the machines to go down so that an action plan to address the root causes could be developed and improve the plant's efficiency and productivity. The outcome of this case study would be to provide the company with a set of specific actions to take in order to improve machine downtime, efficiency, and productivity, with a view to achieving sustainable improvement. Armed with this information, the Production Manager, Process Engineers, Planning team, and Operators can drive continuous improvement to reduce their downtime and improve overall equipment effectiveness (OEE), where downtime is a major contributor.

Pre-requisites

- Support of digiFAC or incorporated Cloud Monitoring Software to collect auto-generated machines data.
- Manual / Excel sheet's data of Daily Production Report (DPR) which includes information like:
  - Downtime category
  - Whether the Downtime is Planned or Unplanned Duration of downtime
  - The machine the downtime occurred on
  - The time the downtime occurred
  - The shift or operator in charge of the machine

III. METHODOLOGY

Start with a 24-hour period from the latest downtime logs or downtime report. This will focus on analysis in a manageable time period and provide enough data to gain insights and prepare for the next day's starting shift. Begin with unplanned downtime, because while planned time can still be reduced, it is unplanned downtime that can cause cascading issues with performance and have an unexpected impact on productivity.

Look day by day to understand when and how long downtime occurred. This will give you a better understanding of what may have caused or exacerbated the downtime.

Downtime Events are typically collected through direct communications with machine operators and digiFAC software. A condition, usually a digital signal, will signify the start of a downtime condition. The same signal or another signal will signify the end of a downtime condition. During the machine downtime tracking, variables

 DOI : 10.35291/2454-9150.2023.0031

will be collected and archived for subsequent reports and dashboards and further analysis.

Procedure

- Check the soft copy of the DPR of every machine for the loading/unloading time of every variety produced on a single day. The varieties include changes in components or changes in the setup of the same component.
- Enter the loading/unloading time for every machine with components produced for that time in the DPR Data Downtime sheet for separate shifts.
- Check the values of every machine's total other downtimes in a soft copy of DPR which includes the sum of Setting Time (ST), Inspection Time (IP), Tool Trouble (TT), No Operator (NO), No Load (NL), Machine Breakdown (MB), Power Failure (PF), Lunch & other allowances in a shift on that day.
- Enter the total other downtime values of every machine for separate shifts in the DPR Downtime sheet.
- Get the summary report of that day in digiFAC format from the DPR Data Downtime sheet.
- Download the Utilization report for that day based on shifts from digiFAC.
- Copy & paste the summary of the DPR Data Downtime sheet into Utilization Report.
- Subtract the Downtime column of the Utilization Report from the sum of loading and unloading time and total other downtimes to get the downtime difference.

Machine DTA Algorithm:

The process of analyzing machine downtime data includes a series of following steps:

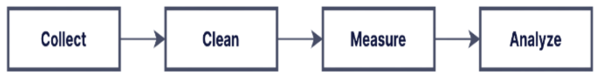


Figure 2: Machine DTA Process Flowchart

- **Collect Phase:**

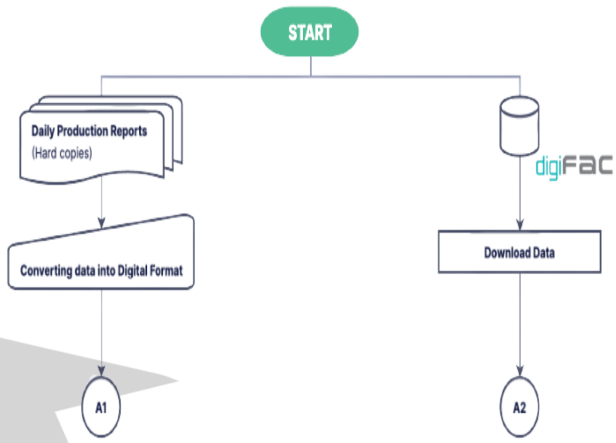
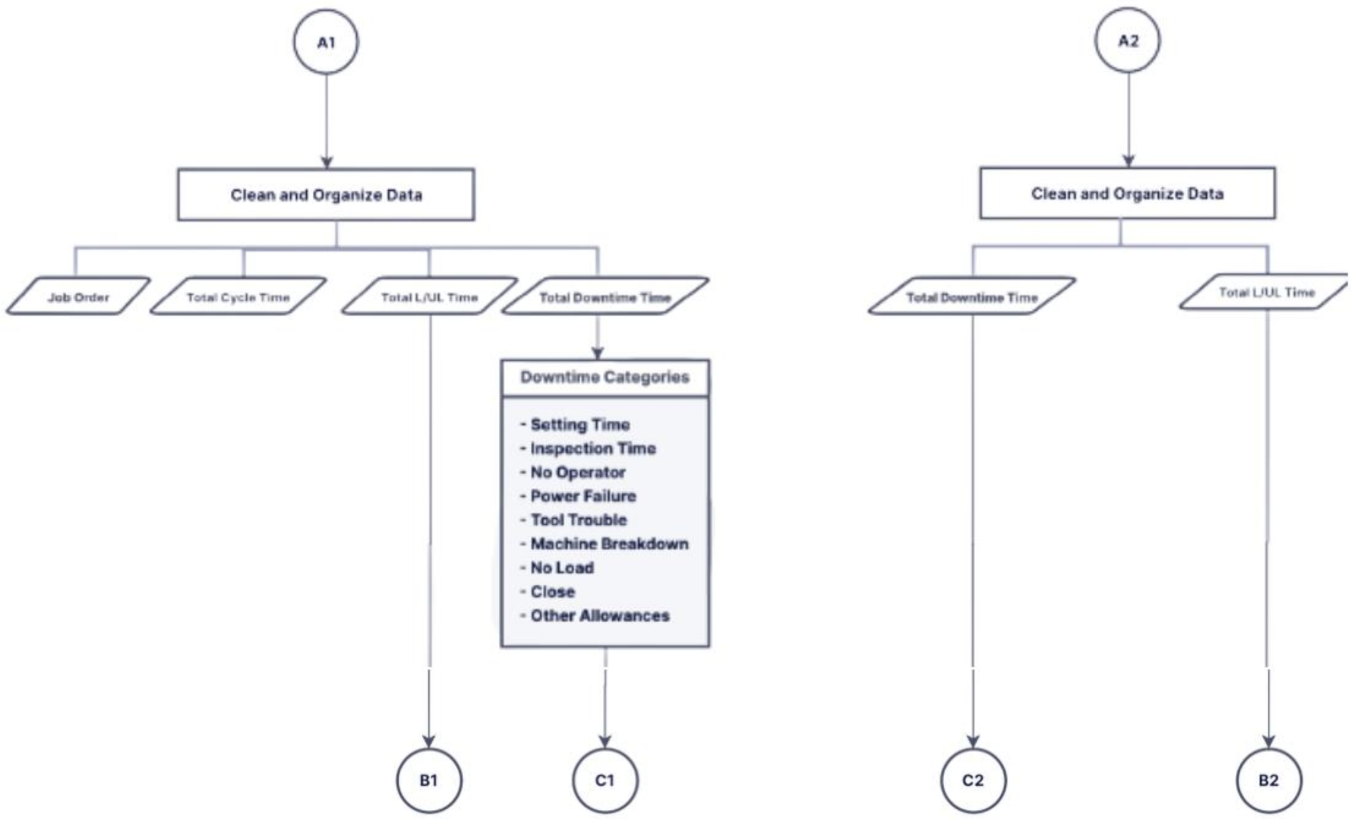


Figure 3: Collect Phase Flowchart

- **Clean Phase:**



DOI : 10.35291/2454-9150.2023.0031

- **Measure Phase:**

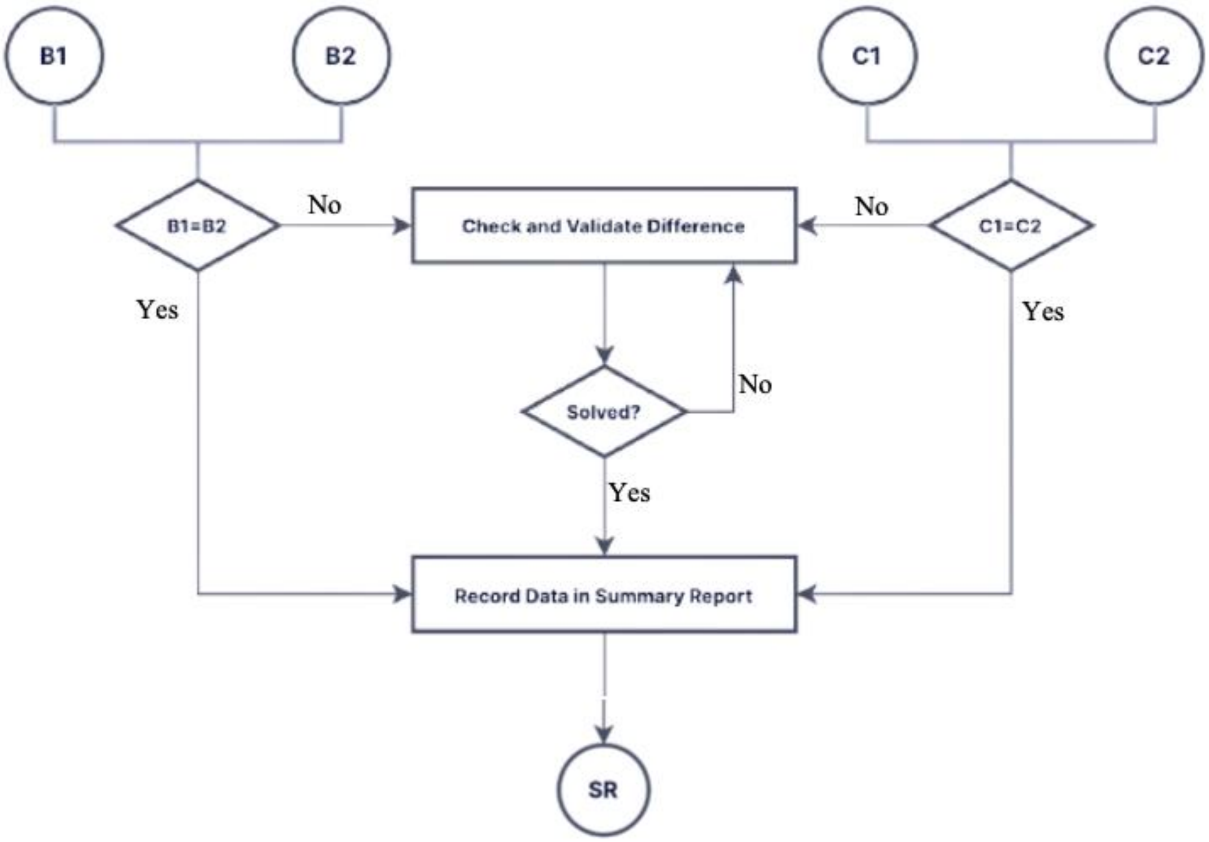


Figure 4: Clean and Measure Phase Flowchart

- **Analyze Phase:**

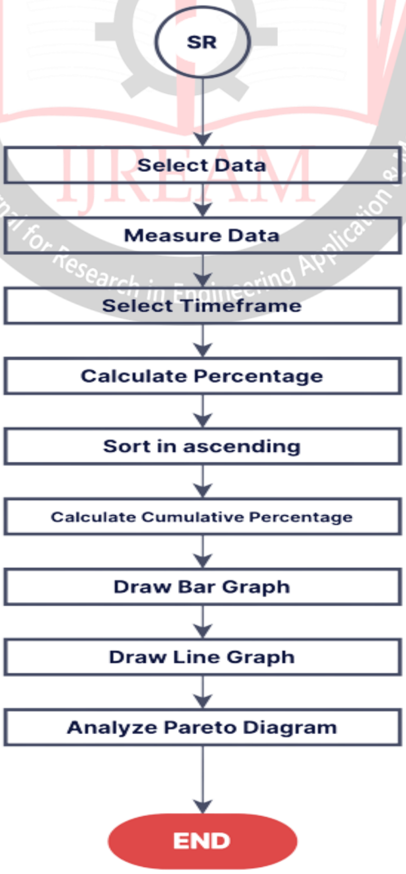


Figure 5: Analyze Phase Flowchart

 DOI : 10.35291/2454-9150.2023.0031

IV. ANALYSIS

Collecting data manually and automatically is not enough. To be analyzed, the data must be compiled into reports. Here, after summarizing all the data of the past quarter from DPR and digiFAC, the final analysis has been done using a Pareto chart and a Cause-and-effect diagram with an action plan.

- **Pareto Chart:**

As a quality control tool, the Pareto Chart governs according to the 80-20 rule. This rule assumes that in any process, 80% of a process's problems are caused by 20% of major factors. The remaining 20% of problems are caused by 80% of minor factors.

RESULTS						
Downtime	**Apr**	**May**	**Jun**	**Quarterly Total**	**Percentage**	**Cumulative Percentage**
Setting time	1291.75	1397.25	1712.8	4401.8	33.28%	33.28%
Loadind/Unloading time	1274.2	1247.76	1265.76	3787.72	28.63%	61.91%
Inspection time	508	592.65	736.017	1836.667	13.88%	75.80%
No Operator	648.5	483	200.75	1332.25	10.07%	85.87%
Close	193.5	198	202.25	593.75	4.49%	90.36%
Power Failure	57.5	398.5	88.75	544.75	4.12%	94.47%
Tool Trouble	141.5	117	152.5	411	3.11%	97.58%
Machine Breakdown	70.5	131.25	114.75	316.5	2.39%	99.97%
No Load	3.5	0	0	3.5	0.03%	100.00%
Monthly Total	4188.95	4565.41	4473.577	13227.937	100.00%	

Table 1: Quarterly Summary of Machine Downtime Data of 2 Units (Hour/s)

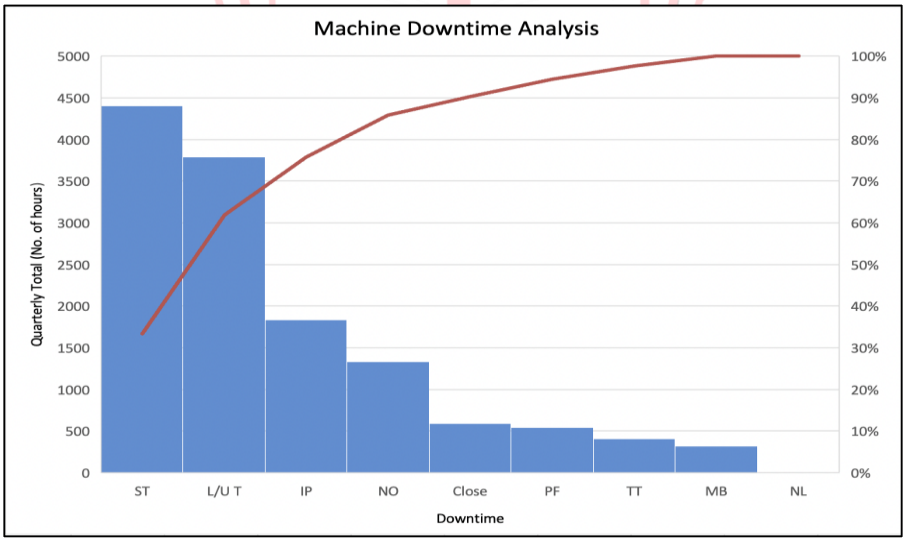


Figure 6: Pareto Chart

The horizontal axis lists the reasons for downtime. The vertical axis indicates how frequently those downtime events occurred. The length of these downtime events is indicated by the line graph. The chart is helping us to figure out where the largest percentage of downtime is coming from.

After studying the chart and the summarized data results, we can see that almost 80% of downtime is occurred due to Setting Time, Loading/Unloading Time, and Inspection Time. Following the 80/20 rule, our main focus should be on these 3 causes. Targeting them and reducing those downtime hours down will improve overall equipment efficiency and for that, we need to deeply analyze their causes using the Fishbone diagram.

 DOI : 10.35291/2454-9150.2023.0031

International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-08, Issue-11, Feb 2023

- **Cause-And-Effect Diagram:**

This quality management tool works by defining a quality-related problem on the right side of the diagram and branching off individual root causes and sub-causes to the left. A Fishbone diagram's causes and sub-causes are grouped into four main groups, including Material, Man, Method, and Machine. These categories can help us identify the probable source of the problem.

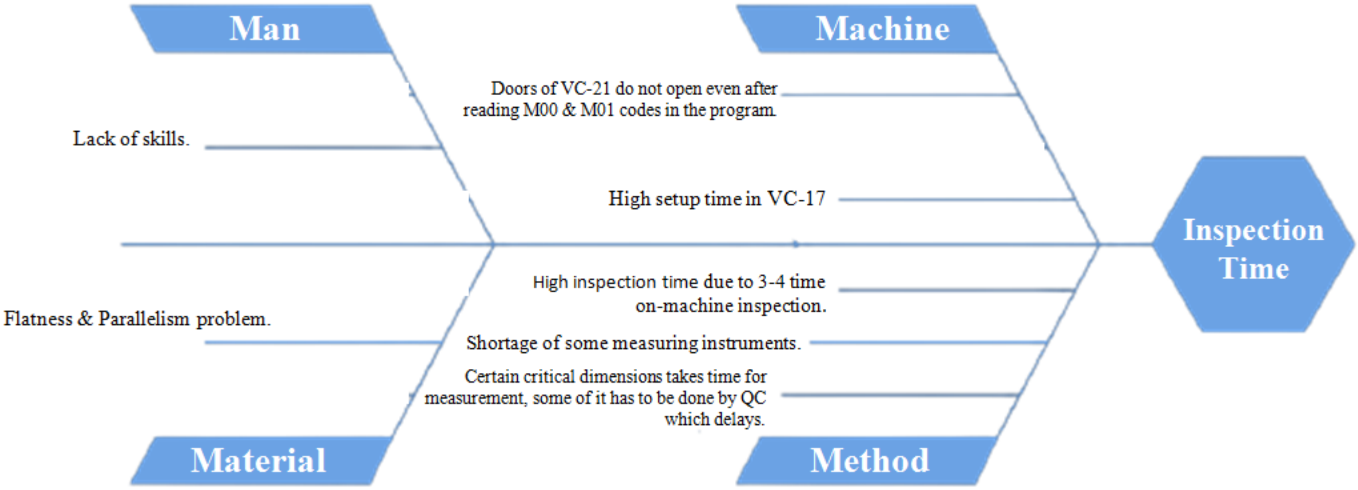


Figure 7: Fishbone Diagram for Inspection Time

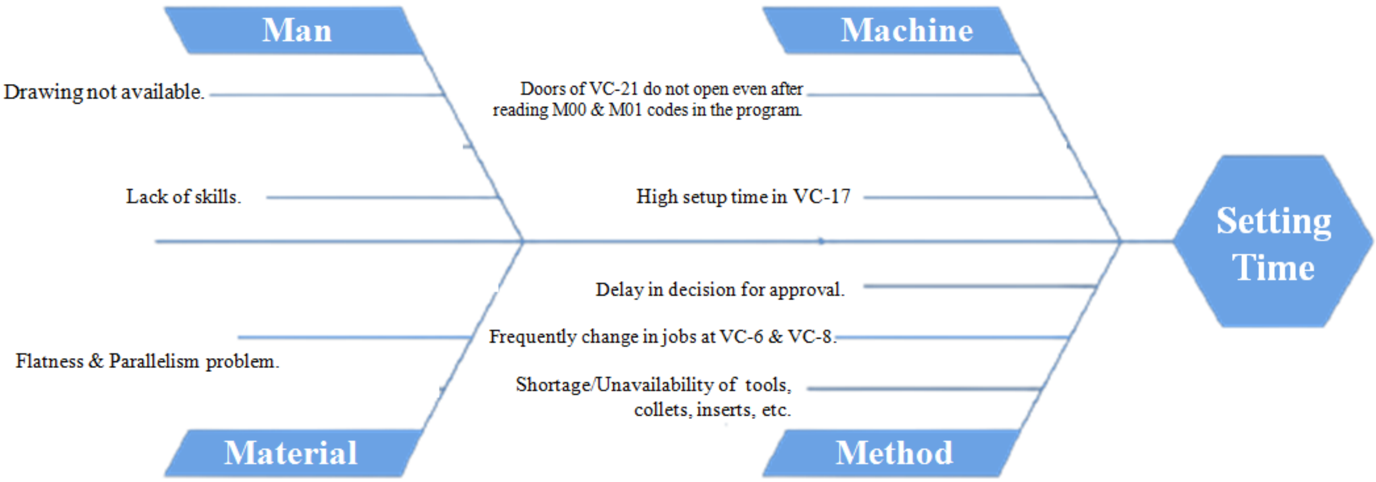


Figure 8: Fishbone Diagram for Setting Time

- **Proposed Action Plan:**

The action plan is an important step after conducting a fishbone diagram, as it allows for the implementation of solutions to address the root causes identified in the diagram. It helps to ensure that the identified issues are effectively addressed and that the improvements made are sustainable. The action plan should include specific targets and timelines, as well as assignments of responsibilities to specific team members. Without a proper action plan, making meaningful progress in addressing the issues identified through the fishbone diagram can be difficult.

 DOI : 10.35291/2454-9150.2023.0031

SETTING TIME						
ACTION PLAN						
No	**Description**	**4Ms**	**Action Target**	**Responsible**	**Target Date**	**Status**
1	High setup time in VC-17 because of large and heavy parts and due to unavailability of crane at the time of loading/unloading.	Machine	We are planning for a separate zip crane for this machine. Management to decide.	Management		
2	Frequently change in jobs due to less quantity of it in TC-6 & TC-8 takes time to change the setup for the next job.	Method	We are planning loading in such a way that the next job has somewhat same setup as previous one.	Planning		
3	Shortage or unavailability of clamps, bolts, collets & holders; this takes time either searching for it or waiting for new one.	Method	We will order sufficient amount of clamps, bolts, collets & holders.	Purchase		
4	Shortage of cutting tools. Sometimes operators have to look/search for tools in another cell/unit.	Method	We will order require amount of cutting tool.	Purchase		
5	Insert of 13.5mm is not available at VC-12. Operator has already informed regarding same but no actions are taken yet.	Method	We are arranging that insert.	Purchase		
6	Flatness & Parallelism problem.	Material	Proper Grinding.	Production		
7	In rare cases, drawing is not available within necessary documents that are been handed to the operator.	Man	To check whether all required documents are available in the file before handing over it to the operator.	Planning/Engineering		
8	Delay in decision for approval in setting due to which it puts halt production.	Method	Decision should be made urgently after checking up the setting so that further operation/production continues.	Engineering		
9	Lack of skills in operator.	Man	We are planning to arrange special training sessions.	Production		
10	Doors of VC-21 do not open even after reading M00 & M01 codes in the program. Operators have to reset the whole program every time to open the doors which consumes a lot of time. This problem should be kept in higher priority.	Machine	Repairing of machine should be done.	Production/Engineering /Preventive Management		

Figure 9: Action Plan for Setting Time

 DOI : 10.35291/2454-9150.2023.0031

INSPECTION TIME						
ACTION PLAN						
No	Description	Cause	Action Target	Responsible	Target Date	Status
1	Flatness & Parallelism problem.	Material	Proper Grinding.	Production		
2	Shortage or unavailability of some measuring instruments. Operators have to search for it in different cell/unit.	Method	We will arrange required amount of measuring instruments.	Purchase		
3	Certain critical dimensions takes time for measurement & some of it has to be done by QC which delays.	Method	Inspection should be done on time to prevent halts in production.	QC		
4	Lack of skills in operator.	Man	We are planning to arrange special inspection training sessions.	QC/Productio n		
5	High inspection time due to 3-4 time on-machine inspection.	Method	Improvement in inspection method.	Production		

Figure 10: Action Plan for Inspection Time

V. RESULTS

Downtime data can assist the maintenance manager in prioritizing preventive maintenance and equipment replacement. Justifying equipment replacement is now easier and more verifiable. Equipment breakdown trends are revealed through statistical analysis, reporting, and charting of downtime history. These trends can then be used to direct your preventive and corrective actions.

Downtime tracking has a profound effect on how, when, and where maintenance resources are used. The time spent logging equipment downtime is easily justified by the time and money saved by the maintenance department and the organization as a whole. The study would also provide insights and learning to the management team and other stakeholders on how they can use TQM tools to improve their performance in the future.

¬ REFERENCES

[1] Rahman C.M. et al. (2014) “Assessment of total productive maintenance implementation through downtime and mean downtime analysis (case study): a semi-automated manufacturing company of Bangladesh)”, International organization of scientific research, Vol. 4(9), 2014, pp.38-47.

[2] Arjun Kotwal et al. (2015), “Evaluation of Machine Downtime and Failure Analysis of Components in Paint Manufacturing Unit: Review Paper”, International Journal of Mechanical and Industrial Technology ISSN 2348-7593 (Online) Vol. 3, Issue 1, pp: (170-174), Month: April 2015 - September 2015.

[3] R. Kalantri et al. (2013), “Root Cause Assessment for a Manufacturing Industry: A Case Study”, Journal of Engineering Science and Technology Review 6 (1) (2013) 62 -67.

[4] Ashfaqur Rahman, Md Mashud Rana, and Peter Baumgartner, “Generating Insight from Indoor Positioning Data in Manufacturing Assembly Line”, Research Square; DOI: https://doi.org/10.21203/rs.3.rs-2437507/v1.

[5] Lian Duan and Li Da Xu, “Data Analytics in Industry 4.0: A Survey”, Information Systems Frontiers, https://doi.org/10.1007/s10796-021-10190-0.

[6] Paul John Blayney and Zhaohao Sun, “Using Excel and Excel VBA for Preliminary Analysis in Big Data Research”, Sun Z (ed) Managerial Perspectives on Intelligent Big Data Analytics. IGI-Global, USA; Chapter · January 2019 DOI: 10.4018/978-1-5225-7277-0.ch007.

[7] S. K. Subramaniam, S. H. Husin, Y. Yusop, and A. H. Hamidon, “Machine efficiency and man power utilization on production lines”, Proceedings of the 8th WSEAS Int. Conf. on Electronics, Hardware, Wireless and Optical Communications.

[8] J.V. Kovach, E.A. Cudney, and C.C. Elrod, “The use of continuous improvement techniques: A survey-based study of current practices”, International Journal of Engineering, Science and Technology Vol. 3, No. 7, 2011, pp. 89-100.

 DOI : 10.35291/2454-9150.2023.0031