System Improvement of Maintenance Procedure for MB Manufacturing LLC

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Abstract

This paper aims to improve MB Manufacturing LLC's Maintenance Department System by establishing a Weekly Preventive Maintenance Standard Operating Procedure. As the record shows in Breakdown Maintenance Report in 2021, MB Manufacturing LLC has a loss of approximately 297 Production hours/ USD198,801 In this paper, the researcher uses various tools such as McKinsey's 7's, Decision Analysis using Kepner-Tregoe Approach, Why-Why Diagram, and How-How Diagram to identify the root cause of the problem and propose a System Design for the Maintenance Department Standard Operating Procedure. As a result, the researcher has been able to provide the Maintenance Department with the steps for the Solution Planning and Implementation as well as with Failure Mode and Effects Analysis the team should be more focused on improving process controls or re-engineering the process step, shall there be any new issue arises.

Keywords
System Analysis, System Improvement, Preventive Maintenance, Manufacturing, Standard Operating Procedure (SOP)

1. Introduction
Maintenance management is critical for guaranteeing continuous equipment performance improvement and ensuring quality operation while keeping the safety of the people and the environment. (Jiang, 2015). Maintenance for a repairable system aims to restore it as necessary, but primarily to enhance the system's reliability. (Rausand and Hoyland, 2004). As a result, a system's reliability analysis gives information about its failure process, assisting in the understanding of system operation and what to expect from its performance so that maintenance planning may be better adjusted. (Barringer, 2004). The need for the Maintenance function to keep up with the industrial system's continual changes and complexities necessitates that it should be well-structured and organized. (Guariente et al, 2017). And with global competition increasing, the focus is now on optimizing asset effectiveness, avoiding failures, and maximizing gains (Santos et al, 2019).

To reduce equipment failure or service degradation, Preventive Maintenance should be carried out which is indicated in the manufacturer's instructions for use or technical documentation. (Iandanza, 2020). Therefore, planned maintenance includes works that will predict possible breakdowns to ensure higher equipment availability, thus, the tasks are needed to be done in advance. (Amaral FD, 2016).

In MB Manufacturing LLC, it is observed that most maintenance activities involve breakdown maintenance, making the equipment reliability decrease instead of enhancing its reliability. Though an Annual/Bi-annual Preventive Maintenance System has been established, there is still a high rate of Breakdown Maintenance resulting in production loss thus showing the insufficiency of the current system. To keep up with the industrial system's continual changes and to optimize asset and/or equipment effectiveness, avoid failures and maximize gains, the researcher, therefore, focused on Preventive Maintenance System improvement.

1.1 Objective

The objective of this study is to select and provide a priority problem using different system analysis tools to improve MB Manufacturing LLC's Maintenance Department System and to provide steps for effective implementation.

2. Literature Review

Root cause analysis (RCA) is a tool designed to help identify what, how, and why an event occurred. Once the investigators can determine why an event or failure happened only then they will be able to take corrective measures that will prevent future events (Rooney et al, 2004).

Decision analysis can be defined as "a formalization of common sense for decisions problems which are too complex for informal use of common sense". It can also be described as a philosophy, with a set of logical axioms, methodology, and a set of systematic procedures for analyzing the integral complexities of decision making. The purpose of the decision analysis is to construct insights into a problem to address the possible alternatives' consequences and the preferences of the decision-makers. (Keeney R., 1981).

Kepner-Tregoe Decision Analysis method indicates that it is far less complicated to define what the problem is not, rather than what it is. And to clarify its importance, the problem and its solution are prioritized with other problems. Kepner and Tregoe's method of problem analysis is (1) to identify the problem, (2) to define the problem, (3) to prioritize the problem, and (4) to test the relationships of the cause-effect. (Lunenburg, 2010).

Standard Operating Procedures (SOP) is a document that describes the methods on how the operator should perform a certain operation, it includes the purpose, equipment, required materials, how to perform the process, illustrations, and necessary checklist. (Akyar I, 2012). Well-written SOPs and other quality documents' importance in achieving the Company's business objectives cannot be ignored. It serves as a passport for success in assisting the Company's achievement of high-quality processes, procedures, and systems, as well as with high-quality products and services. (Manghani K, 2011)

Failure Mode and Effect Analysis is a process carried out to prevent failures in implementing new changes in processes and products. To be effective and to ensure the highest yield, quality, and reliability, FMEA identifies corrective actions required to prevent failures in reaching the customers (M. Ben-Daya, 2009). In other words, FMEA is also an engineering technique used to define, identify, and eliminate the system, design, process, and/or services' potential problems and/or known errors. (Omdahl, 1988; ASQC, 1983).

3. Methods

The researcher has conducted a system analysis and problem analysis of the MB Manufacturing LLC.
Company Introduction and Internal Scanning using McKinsey's 7s and SWOT Analysis. MB Manufacturing LLC is an ISO Certified Manufacturing company that produces and supplies color and additive masterbatch, serving niche markets that require tailored products and sustainable products. The company was strategically located in one of the largest ports. The company also provides technical support, certifications, and testing for its customers. The company has an established system that includes a process flowchart as per Integrated Management System Policy and ISO Standards. The company has 150 experienced and qualified employees with various degrees that share the same value as per the company's Vision and Mission. The company is following an Organizational Structure that has different management styles across each Department.

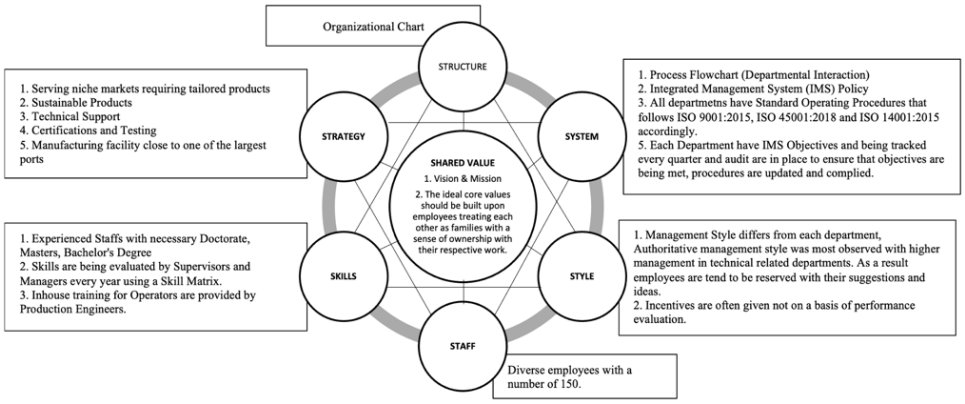

Figure 1. MB Manufacturing LLC's McKinsey's 7s Analysis

The SWOT analysis shows the Strengths, Weaknesses, Opportunities, and Threats within and outside the organization. SWOT shows that one of the weaknesses of the organization was the internal processes reviews and follow-throughs opening an opportunity for internal process improvements to be more efficient and effective when focused on.

Table 1. MB Manufacturing LLC's SWOT Analysis

Strengths	**Weaknesses**
1. Serving niche markets requiring tailored products	1. Wide variety of available products
2. Availability of Sustainable Products	2. Large inventory of Raw Material (Sourcing)
3. Certifications and Testing Facility	3. Dependent on Middle East and Africa market
4. Company located near the largest port	4. Non-availability of Bio-plastic Products
5. Major player in supplying Color Masterbatch in Middle East and Africa Region	5. Internal processes reviews and follow throughs
Opportunities	**Threats**
1. Expansion into other Regions (East Asian & European)	1. Increased competition in Local Market
2. Development of Bio-plastics products	2. Competitors other Regions currently producing Bio-plastic Products
3. Technological Advances in Testings	3. Changing Environmental Policies
4. New development of Distributors in other Regions	4. Diplomatic Issues resulting in Trade Bans
5. Internal process improvements to make in more efficient and effective	

In conducting an internal analysis of the Maintenance department, the main problems were later found to be (1) The increasing cost of machine spare parts, (2) Unavailability of local suppliers for special machine spare parts repairs causing longer machine downtime, and (3) High Rate of breakdown maintenance.

To focus on and solve a problem, the researcher has conducted a decision analysis using Kepner-Tregoe Approach. As per Table 2 based on the rating scale in Table 3, the priority problem selected for the Maintenance was the "High Rate of Breakdown Maintenance" with a 158 total weighted score.

Table 2. Decision Analysis on the 3 problems in Maintenance Department

Must Criteria		The increasing cost of machine spare parts		Unavailability of local suppliers for special machine spare parts repairs causing longer machine downtime		High rate of breakdown maintenance	
Cost Relevance		YES		YES		YES	
Want Criteria	**Importance**	*Criterion Rating*	*Weighted Score*	*Criterion Rating*	*Weighted Score*	*Criterion Rating*	*Weighted Score*
Effect in Production	9	5	45	5	45	5	45
Risk Level	9	3	27	3	27	4	36
Effect in Employee Morale	8	3	24	3	24	4	32
Management Control	9	1	9	1	9	5	45
Total Weighted Score		**105**		**105**		**158**	

Table 3. Rating Scale for the Decision Analysis using Kepler-Tregoe Approach

Rating Scale	**Effect in Production**	**Risk Level**	**Effect in Employee Morale**	**Management Control**
1	No production loss	No risk	Employees are highly motivated	No control
2	Can Shutdown production line for 2hrs	Low	Employees are moderately motivated	Low control
3	Can shutsdown production line for 8hrs	Minor	Employees are slightly motivated nor demotivated	Average Control
4	Can shutsdown production line for 12hrs	Moderate	Employees are slightly demotivated	High control
5	Can Shutdown production line for more than 24hrs	High	Employees are demotivated	Full control

The Maintenance Standard Operating Procedure implemented in MB Manufacturing LLC's scope defines the system for plant equipment maintenance. In this paper, the researcher has focused the study on the procedure for Breakdown Maintenance and Annual/Bi-annual Preventive Maintenance of the Production Equipment as per the result of the decision analysis using the Kepner-Tregoe Approach conducted.

Breakdown maintenance requests shall report to MM/ME through Maintenance request. MM/ME shall allocate MT who shall carry out maintenance based on the nature of the problem. After identifying the nature of the problem, MM can coordinate with machine manufacturers (manual shall be referred). Once the Maintenance Request is closed, the initiating department's signature and MM are taken on it. In case of incapability to carry out repairs internally, MM shall approach subcontractors for maintenance. On completion of maintenance, machine conditions shall be reported to MM. Relevant details shall be posted in the maintenance request.

For the Annual/Bi-annual Preventive Maintenance, the process will start with MM shall support/advise in framing/reviewing the preventive maintenance schedule. MM/ME shall initiate Preventive Maintenance based on Preventive Maintenance schedules. They will be carried out by MT under the supervision of ME. The daily maintenance report will be submitted by the ME. Plant Equipment Action Plan will be prepared quarterly indicating the major work done and required on the critical equipment.

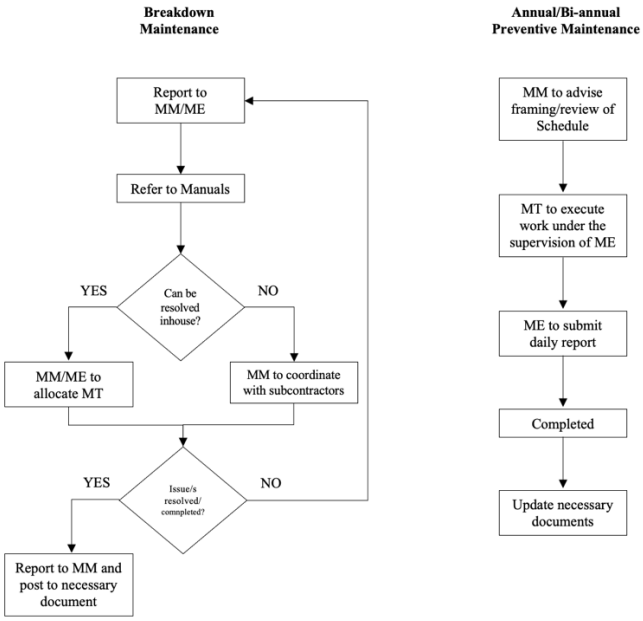

Figure 2. Process Flowchart of the Breakdown and Annual/Bi-annual Preventive Maintenance

Maintenance Department Root Cause Analysis and Problem Statement. To further the analysis, by the end of the year 2021, the Maintenance Manager has generated a report regarding the breakdown maintenance in coordination with the Production Manager. The generated report shows that the total production hours lost due to Breakdown Maintenance were approximately 297 hours, amounting to approximately $198,801.33/-.

The researcher has conducted a Root Cause Analysis using Why-Why Diagram to address the problem, as shown in Figure 3. The Why-Why diagram shows that the Root cause for the High rate of breakdown maintenance was because there is no frequent Preventive Maintenance included in the Standard Operating Procedure thus not addressing the issues early on to mitigate loss in the production hours.

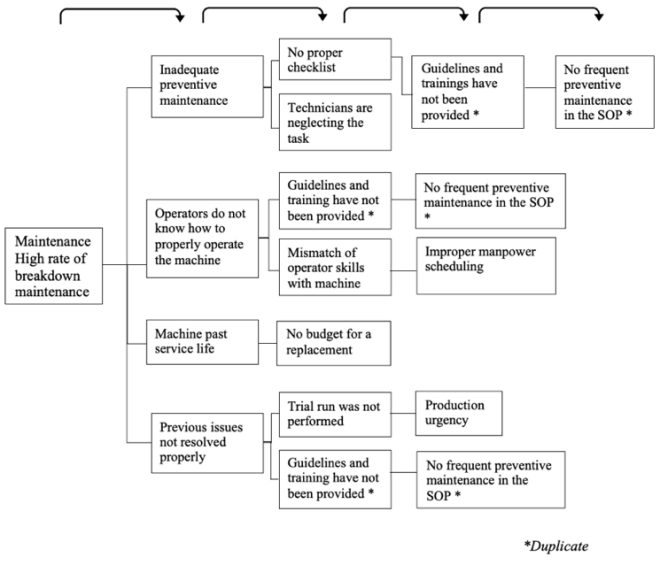

Figure 3. Why-Why Diagram

Maintenance Department System Design. In this stage, given the root cause of the high rate of breakdown maintenance an addition of frequent preventive maintenance in the SOP will mitigate the loss in the production hours. The researcher has constructed a How-How Diagram to find a solution that will permanently fix the root cause. The diagram shows that as per production machine availability and maintenance technicians' tasks schedule review the most efficient frequency for the additional preventive maintenance is weekly.

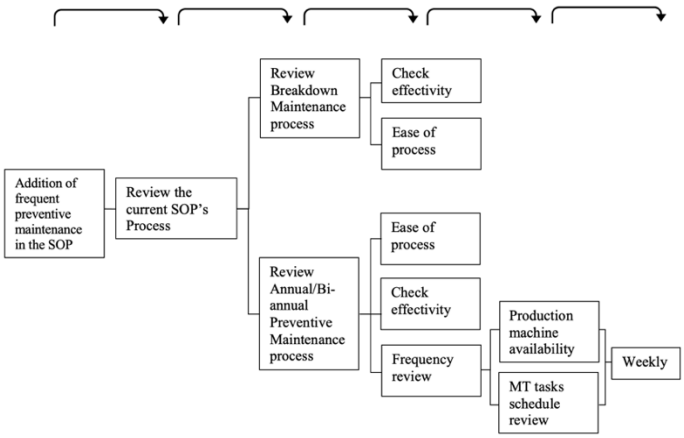

Figure 4. How-How Diagram

After reviewing the current SOP through a How-How Diagram, the researcher has re-designed the current Breakdown and Preventive Maintenance. In addition to the existing Breakdown and Annual/Bi-annual Preventive Maintenance, Weekly Preventive maintenance will be included in the process. This process will include routine checks as per the standard checklist (Table 4) reference to the Machine Suppliers Manual.ME will assign MT as per the weekly preventive maintenance schedule to carry out routine checks. MT will execute the routine checks and update the checklist, shall there be any issues found the process will continue as per the Breakdown Maintenance Process. Accordingly, all the necessary documents shall be updated.

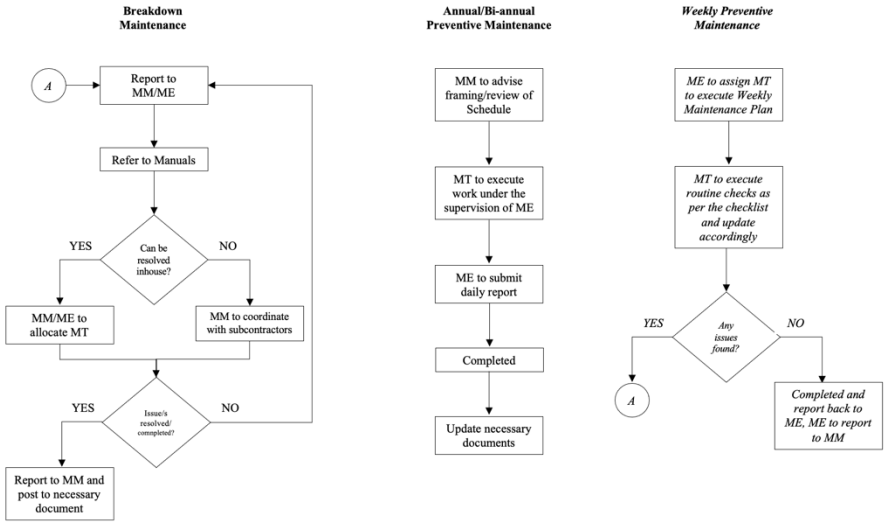

Figure 5. Proposed Process Flowchart of the Breakdown and Annual/Bi-annual Preventive Maintenance with the addition of Weekly Preventive Maintenance

The Weekly Preventive Maintenance (Table 4) for Production Equipment Checklist was developed as per the Manufacturer's recommendation in the Manual. Activities include the primary checks needed to be done in the major points in a Production Line of the MB Manufacturing LLC and shall there be any issues found in the MT that should be noted in the remarks section.

Table 4. Weekly Preventive Maintenance

MB Manufacturing LLC	Weekly Preventive Maintenance for Production Equipments Checklist	Form No.:
		Rev No.:
		Effective Date:

Weekly Activities	C-1	C-2	C-3	F-1	F-2	F-3	F-4	F-5	O-1	O-2	Z-1	Z-2	Z-3	L-2
Main Motor														
Any unusual sound?														
Temperature reading														
Gear Box														
Is there any unusual sound?														
Check oil level														
Is there any leakage?														
Extruder														
Any leakage from the fitting?														
Any leakage from the adaptor?														
Clean the strainer														
Screw														
Any unusual sound?														
Mixer														
Any unusual sound?														
Any leakage from the seal?														
Is safety switch of lid working?														
Feeder														
Any unusual sound?														
Remarks														

Maintenance Technician: _____ Reviewed by: _____ Maintenance Engineer/Manager

Date: _____ Date: _____

3.1 Solution Planning and Implementation

To put the solution into action, the researcher made a proposed Solution Planning and Implementation table for maintenance management reference. Week 01 will start when the Maintenance Manager starts to work on the revision of the SOP. As per Table 5, the implementation will take 9 weeks.

Table 5. Proposed Solution Planning and Implementation

SR	WHAT	HOW	WHO	WHEN	WHERE	HOW MUCH	REMARKS
1	SOP Revision	Coordinate with Management Representative (MR) to update in the system	Maintenance Manager	Week 01 - Week 02	-	-	*All Resources are available inhouse*
2	Create a new Checklist	Refer to Manuals and coordinate with MR to updated in the system	Maintenance Manager/ Maintenance Engineer	Week 01 - Week 02	-	-	*All Resources are available inhouse*
3	Provide trainings MT about the new SOP	Make training materials such as powerpoint presentations	Maintenance Engineer	Week 03	Production Training Rooms	-	*All Resources are available inhouse*
4	Create a Schedule	Spare a time in the daily tasks schedule that will not hinder the operation	Maintenance Engineer	Week 04	-	-	*All Resources are available inhouse*
5	Track the process if being followed	Collect and review the completed checklist	Maintenance Manager/ Maintenance Engineer	Week 05 - Week 09	Production Plant	-	*All Resources are available inhouse*

Potential Problem Analysis using Failure Mode and Effects Analysis

To address the problems that may arise and their severity, the researcher conducted a Failure Mode and Effects Analysis that will help the Maintenance Department to recognize process changes to lower severity and occurrence, those can be other controls to increase detection to further improve the system design. Scores are subjects as per the scale in Table 6, scores can be anywhere between 1 to 10 depending on the severity, occurrence, and detection level. Risk Priority Number (RPN) is the product of the scores for severity, occurrence, and detection. An event with a high RPN requires instant response while events with lower RPNs are less risky.

Analysis shows that priority should be given to Process Step - *Provide training and created a training schedule for MT about the new SOP.*

Table 6. Failure Mode and Effects Analysis for the Proposed Solution Planning and Implementation

Process Step	Potential Failure Mode	Potential Failure Effect	SEV	Potential Causes	OCC	Current Process Controls	DET	RPN
SOP Revision	MR might indicate a wrong SOP/Form Number and forget to update it in the IMS System.	Audit findings during Certification	6	Lack of communication	5	Internal Audits and annual process reviews	5	150
	Risk of inadequacy of steps and unclear explanation	SOP audience confusion	5	Trying to keep it as clear and easy to understand	4	Internal Audits and annual process reviews	6	120
Create a new Checklist	Incomplete Manuals	Engineer will make incomplete checklist	6	Inadequate safekeeping and monitoring of in/out of the documents	6	Control of Maintenance Equipment and Manuals	6	216
	MR might indicate a wrong SOP/Form Number and forget to update it in the IMS System.	Audit findings	6	Lack of communication	5	Internal Audits and annual process reviews	6	180
Provide trainings and create training schedule MT about the new SOP	Inadequacy of Training Materials	MT confusion in the new process	4	Trying to keep it as clear and easy to understand	5	Internal Audits and annual process reviews	5	100
	MT unavailability		6	Emergency maintenance (breakdown)/unforseen tasks	7	Rosters	7	294
Track the process if being followed	Concerned employees might view it as an additional work and may neglect the task	Employees might get demoralized	5	MT's resistance to change	6	Trainings	7	210
	Follow through for the reviews and revision will be an additional task for the department head considering the current workload		5	No proper delegation of task to other competent employess	5	None	6	150

Table 7. FMEA Score Scale

Severity Score	Score Description
10	High-impact events
1	Low-impact events.
Occurrence Score	**Score Description**
10	Frequently occurring events
1	Events with low occurrence
Detection Score	**Score Description**
10	Inconspicuous event
1	Event that can be easily detected by a process control

4. Conclusions

Conducting a system analysis using McKinsey's 7s, internal analysis of the current system design, and decision analysis using the Kepner-Tregoe Approach helps the researcher to come up with a logical selection of the priority problem. In conducting a Why-Why Root Cause Analysis, the researcher has been able to address the problem accordingly. After all the analysis, the problem statement was finalized as *The High Rate of Breakdown Maintenance was because there is no frequent Preventive Maintenance in the Standard Operating Procedure thus resulting in a loss in Production hours*. Using a How-How diagram a rational frequency of weekly preventive maintenance was established, this triggers the new system design for the Maintenance Standard Operating Procedure. By using a Solution Planning and Implementation, this paper provides Maintenance Department with how to put the solution into action. In conducting a Potential Problem Analysis using Failure Mode and Effects Analysis, the Maintenance Department will be able to prioritize which step they should be more focused on to improve process controls or re-engineer the process step, shall there be any new issue arises.

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Biography

Eunique D. Salazar is a current MS Engineering Management student from Mapúa University, Manila. She received her bachelor's degree in Mechanical Engineering from New Era University, Quezon City. Her professional experiences include but are not limited to Project Management from feasibility studies to project execution and completion, Twin-Screw Extruder screw design standardization, and development.

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