A

Minor Project report

On

"IMPLEMENTATION OF MAINTENANCE OPTIMIZATION PLAN FOR INDUSTRIAL PLANTS"

-a methodology of total productive maintenance

Submitted to

Institute of Technology
Guru Ghasidas Vishwavidyalaya
(A Central University)
Bilaspur (Chhattisgarh)

In partial fulfillment of requirement for the award of degree

Of

Bachelor of Technology

In

Industrial and Production Engineering

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INSTITUTE OF TECHNOLOGY
GURU GHASIDAS VISHWAVIDYALAYA
(A CENTRAL UNIVERSITY)

CERTIFICATE OF SUPERVISOR

This is to certify that the work incorporated in the project.

"IMPLEMENTATION OF MAINTENANCE OPTIMIZATION PLAN FOR Industrial plants" Record of research work carried out by Mr. Ritesh gupta bearing Enrollment No. GGV/18/1259respectively. Under my guidance andsupervision for the award of degree of Bachelor of Technology in the Institute of Technology, Guru Ghasidas Vishwavidyalaya(A Central University), bilaspur, Chhattisgarh, India. To the bestof my knowledge and belief the project.

- Embodies the work off candidate himself.
- Has duly been completed.
- Fulfills the requirement of the ordinance relating to the Bachelor of Technology of theUniversity
- Is up to the desired standard both in respect of content and language for being refereed to examiner.

……. …….

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DECLARATION BY THE STUDENT

I, the undersigned, declare that the project work entitled "**Implementation Of Maintenance Optimization Plan For Industrial Plants**'' is based on the work carried out during course of study under the guidance and supervision of **Mr. C.P. dewangan**, **Associate Professor, Department of Industrial and Production Engineering, Institute of engineering Technology, Guru Ghasidas Vishwavidyalaya, (A Central University), Bilaspur(Chhattisgarh)**

We assert that the statements made and conclusions drawn are the outcome of our study.

Mr. Ritesh gupta

Date……

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Completing this project, although was a challenge for me, would not have achieved without support,inspiration, encouragement and contribution of many people. First of all, we would like to express our deep Sense of gratitude towards our supervisor **Mr. C.P. dewangan (Associate professor) Department of Industrial and Production Engineering, School of Engineering and technology, Guru Ghasidas Vishwavidyalaya (A Central University),** for his valuable guidance, constant encouragement and kind help at different stages for the execution of this dissertation work.

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Mr. Ritesh gupta

CERTIFICATE BY THE EXAMINERS

This is to certify that project work entitled:

"**Implementation Of Maintenance Optimization Plan For Industrial Plants**''

Submitted By:

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Has been examined by the undersigned as a part of examination for the award of Bachelor of Technology degree in industrial and production engineering of institute of technology Guru Ghasidas Vishwavidyalaya (A central university) Bilaspur, (Chhattisgarh)

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ABSTRACT

Machine breakdown due to unplanned maintenance (sudden failure) will increase the repair cost and machine downtime (production lost). This has brought the function of maintenance to be an important activity in the manufacturing industry in order for daily operation to become stable. The introduction of several philosophies such as Corrective Maintenance (CM), Preventive Maintenance (PM) or Total Productive Maintenance (TPM) have allowed extra solutions to a process planning problem faced by company in comparison to the conventional fire-fighting syndrome. This main purpose of this study was to focus on developing a framework of maintenance strategy, From an extensive review of literature for Total Productive Maintenance (TPM), twelve disciplines beginning with basic to advanced elements were identified for effective Maintenance Management Systems.

Keywords: *Total productive maintenance (TPM), maintenance management system framework, Reactive maintenance, Preventive maintenance, Predictive maintenance.*

INDEX

Chapter 1

INTRODUCTION

INTRODUCTION

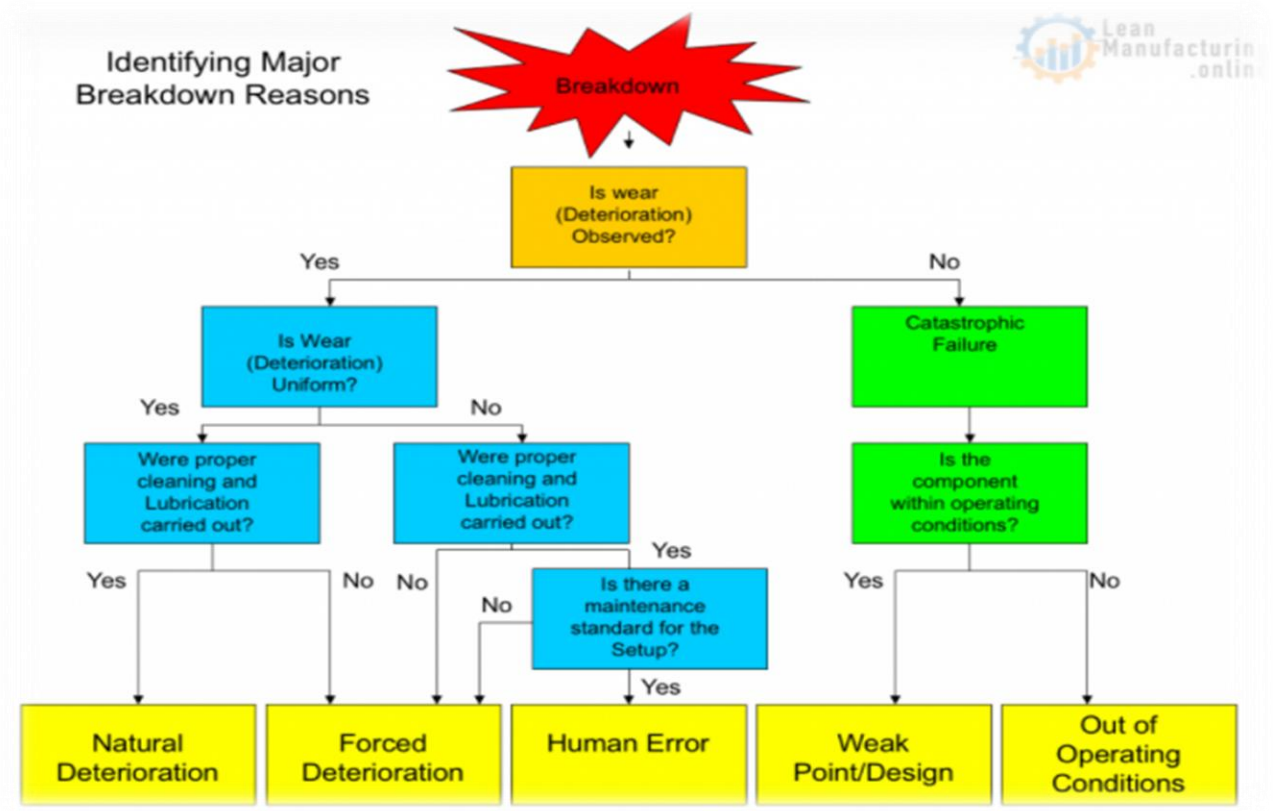
In its most basic form, plant maintenance is the application of best practices to increase equipment up time in manufacturing facilities. This helps plants avoid unplanned downtime and ensures production stays on schedule. Understanding plant maintenance will help ensure your employees are protected from injury and your products are safe for the end-user.

The field of business operations and management is becoming more competitive in recent decade, which makes industries interested in developing modern management system in order to stay competitive in managing their business operations. Such

competitive advantage can help companies to become more successful. In term of the business operations, companies are re-examining their maintenance department function as an effective management system in order to identify opportunities for improvements. Traditionally, maintenance role always relate to fire-fighting and stop-the-bleeding scenario. However, in recent years, many companies start to embark into new maintenance management systems that utilize latest technology. This trend has been steadily growing in many industries, such as in the airline industry, manufacturing industry and heavy industries likes cement plant, quarry plant, fertilizer plant and oil and gas industry. The problems which are of companies concern are high downtime and maintenance of there equipment's they wants the strategies to improved reliability of processes, improved spare parts management, reduced cost of production losses and improved corporate competitive advantage. Finally, we conducted before and after comparison, to evaluate the system performance in terms of its downtime reduction and production cost of losses justification.

1.1 Main Cause of failure in Plants

- Improper operation
- Failure to perform preventive maintenance
- Too much preventive maintenance
- Failure to continuously monitor equipment
- Bad reliability culture



1.2Causes of Accidents:

The industrial safety experts have classified the various causes of accidents into three broad categories:

A). Unsafe Conditions

B). Unsafe Acts

C). Other Causes

These are discussed, in brief.

A). Unsafe Conditions (work-related):

Unsafe working conditions, the biggest cause of accidents. They are associated with tools, machines, equipment, materials etc... These causes are known as 'technical causes'. They happen due to

- Improper guarded equipment's,
- Defective equipment's,
- Faulty layout and location of plant,
- Inadequate lighting arrangements and ventilation,
- Unsafe storage, inadequate safety devices, etc.

Also the psychological reasons such as working overtime, monotony, fatigue, tiredness, frustration and anxiety are also some other causes that cause accidents.

Safety experts identify that there are some high danger zones in an industry. These are, for example, hand lift trucks, wheel-barrows, gears and pulleys, saws and hand rails, chisels and screw drivers, electric drop lights, etc., where about one-third of industrial accidents occur.

B). Unsafe Acts:

Industrial accidents occur due to certain acts on the part of workers. These acts may be the lack of knowledge or skill on the part of the worker, certain bodily defects and wrong attitude.

Some Examples of these acts are:

- Operating without authority.
- Failure to use safe attire or personal protective equipment's,
- Careless throwing of material at the work place.
- Working at unsafe speed, i.e., too fast or too low.
- Using unsafe equipment or using equipment's unsafely.
- Removing safety devices.
- Taking unsafe position under suspended loads.
- Distracting, teasing, abusing, quarrelling, day-dreaming, horseplay
- One's own accident-prone personality and behavior.

C). Other Causes:

These causes include unsafe situational and climatic conditions and variations. They comprise of:

- Excessive noise,
- Very high temperature and humid conditions,
- Bad working conditions and unhealthy environment,
- Slippery floors, excessive glare,
- Dust and fume,
- Arrogant behavior of domineering supervisors, etc.

Industrial accidents have become common happening in our country. Brief information of major accidents in the recent past in India is here:

It is reported that in every twenty seconds of every working minute of every hour throughout the world, someone dies as a result of an industrial accident. Industrial accidents cause losses to the employees and organisations as well. Below table gives an idea about the various losses that accidents have caused in our country. Accidents causing losses to the industrial establishments need to be avoided. Adequate safety measures can avoid accidents.

S. No.	INDUSTRY NAME	DATE OF ACCIDENT	LOCATION	LOSS
1.	Union Carbide plant (methyleisocynanite ga leak)	December 1984	Bhopal (M.P)	Over 4000 people killed, Thoushands injured
2.	Chasnala coal mine (SAIL) (Explosionand flooding)	December 1975	Dhanbad (Jharankand)	372 died
3.	Sriram Food and Fartilizers plant (Oleum gas leak)	December 1985	Delhi	Thoushand workers and civilians

				affected
4.	Rourkela Steel Plant (Blast Furnace accident)	December 1985	Rourkela (Orisa)	18 workers affected
5.	Durgapur Chemical Factory (chlorine leak)	June 1987	Durgapur (W.B)	Over 100s people affected
6.	Bharat Petroleum Refinery (fire)	November 1988	Mahul, Bombay (Maharashtra)	32 killed, 100s affected.
7.	Fertilizers Corporation of India (Major gas leak)	September 1989	Ramagunaam (Telengana)	17 killed, over 100s workers affected
8.	Indian petrochemicals (Explosion)	November 1990	Nagothane	80 killled, over70 workers injured(70%Burns)

9.	Hindustan Organ ic chemicals	July 1991	Bombay	12 workers killed & some injured
10.	Dyeing Dpt. of GRASIM Unit (blast)	December 1991	Gwalior (M.P)	14 killed & 22 severely injured.
11.	National Fertilizers Plant (Ammonia leak)	August 1992	Panipat (Hariyana)	11 killed & many injured.
12.	NTPC, Kahalagon (Boiler explosion)	October 1996	Kahalagon	15 killed & several injured
13.	Jaipur oil depot fire, IOC (fire)	September 2019	Jaipur (Rajasthan)	12 killed, over 130 injured, Million civilians affected
14.	NTPC, Unchahar (Boiler Explosion)	October 2017	Raebareli (u.p)	Atleast 8 killed & more than 100 injured
15.	Bhilai steel plant (SAIL)	October 2018	Bhilai (C.G)	Atleast 9 killed

Table 1.1: Some Major Accidents (In India)

S. No.	Name of Organization	Date of occurrence of accidents	Estimated Loss (Rs in Crore)
1.	Madras Ref. Manali	January 1987	4.85
2.	HPL Refinery Vizag.	November 1987	3.40
3.	JK Synthesis	January 1988	6.92
4.	Monica Electronics	September 1988	3.86
5.	Zeninth Chem.Tarapur	May 1988	4.00
6.	IOC Mathura	August 1988	4.63
7.	IEL Gornia	September 1988	5.00
8.	BPCL	November 1988	9.00
9.	***IPCL Baroda***	***February 1989***	***41.82***
10.	***IAAI, Bombay***	***February 1989***	***43.00***
11.	Voltas, Warora	February 1989	5.00
12.	ONGC, Pasariapudi	January 1995	41.44

Table1.2: Estimated financial loss

1.3 Types of Plant Maintenance

1.3.1.1 **Reactive maintenance** This strategy performs repairs on equipment only after it has broken down. This is similar to the theory "if it isn't broke, don't fix it". Maintaining your equipment this way will save money in the short term. However, it will cost you in efficiency loss and premature failure in the long term.

1.3.1.2 **Preventive maintenance** Preventative plant maintenance utilizes timed intervals based on industry standards to maintain equipment with the goal of preventing it from breaking down. This involves systematic maintenance and ensures routine task like belt and filter changes are taken care of in a timely fashion.

1.3.1.3 **Predictive maintenance** This refers to the maintenance strategies used to determine the current condition of in-service equipment. Based on the equipment condition, a specific maintenance schedule is followed. This approach promotes a safe work environment because your equipment is continually monitored. This can reduce operating costs by 12-18% over time

1.4 Management System

Management system is a key to control hazards and accidents. it provides a eco friendly environments to workers where they able to utilize their full potential and feel safe in terms of job and health. So it is established at national level as well as international level.

1.5 Objective of this project:

- To study current state of affairs regarding maintenance management.
- What is the attitude of people with respect to maintenance management.
- Main cause of breakdown (sudden failure) and downtime (production lost).
- To study the problems been confronted by employees at Industries regards to maintenance management.
- To show relationship between productive maintenance and maintenance management system framework.
- To put forth suggestions to make effective work without breakdown and minimum repair cost.

1.6 Scope of this project:

Plant maintenance services provide attention for the maintenance of machines and equipment's due to their frequent use and strategic position in the entire production function. A machine is the name given to a mechanism consisting of the services of sequential components each performing its specific function which is part of the whole system or mechanism.

For any machine some of its parts are fixed while other are replaceable. Such equipment or mechanical devices and their components require constant and continuous services such as cleaning, lubrication, repair and replacements etc. so that their operational efficiency can be maintained.

Further it may be noted that plant maintenance service is not confined to the equipment and machines.

Under the wide spectrum of the plant maintenance service, the maintenance of the buildings power plant, material handling equipment's, heating and air conditioning equipment's, waste disposal systems, wash rooms, water supply, jigs and fixtures and fire-fighting facilities etc., also need attention. The activity of the plant maintenance service also includes the provision of maintenance equipment and stock of repair parts and maintenance materials.

Chapter 2

LITERATURE REVIEW

LITERATURE REVIEW

[1]

Conducted a study to determine the relationship between plant maintenance in manufacturing industry. The purpose of this study is to know the attitude with respect to machine maintenance and plant maintenance because it involves high risk factor mainly in chemical plants.

[2]

The main focus of the study is to identify existing gaps on plant maintenance management. The review adds value to existing electronic database through integration of researches' results. To identify existing gaps, a systematic literature review approach has been used. The reviews were undertaken through keywords and maintenace related topics.

[3]

presented the strengths and weaknesses in the current management practices to improve safety performance in construction. This study is conducted by administering a questionnaire survey comprising.

[4]

researched the use of employees' survey to measure maintenance management and as a diagnostic tool for improvement efforts. Statistical tools were employed to achieve the objectives. Survey enabled the development of effective plans to improve safety performance.

[5]

Examined the TPM (total productive maintenance) Practices that can be applied in manufacturing industry and identified the importance of Occupational maintenance Practices. Besides that, this study also identified different types of hazards, injury and accidents happen in the workplace. The important part of this study is to enhance the knowledge of the smart maintenance management Practices.

[6]

Measured employees' perceptions on maintenance management practices and self-reported management knowledge, management motivation, management compliance and management participation by conducting a survey using questionnaire

2.1 Overview of TPM

Total Productive Maintenance (TPM) is a methodology to form a corporate culture focus on maximizing the efficiency of overall production system through cross-functional section (Venkataraman, 2017). According to Angeles (2019), TPM can be described as a plant improvement methodology which enables continuous and rapid improvement of the manufacturing process through the use of employee involvement, employee empowerment and closed-loop measurement of results. It is a production driven improvement methodology that is designed to optimize equipment's reliability and ensure efficient management of plant assets. TPM also aims on building up a corporate culture that thoroughly pursues production systems efficiency improvement and Overall Equipment Efficiency (OEE). From both definition, it can be seen that they both describes a synergistic relationship among all organizational functions, but particularly between production and maintenance, for continuous improvement of product quality, operational efficiency, capacity assurance, safety and enhancement of the people who work within the company. It emphasizes maximizing Overall Equipment Effectiveness (OEE) through employee involvement. TPM activities involved all employees, starting from top management till ground floor operators. TPM program is marked to increase production while at the same time, increase employee morale and job satisfaction. In order to set up Total Productive Maintenance (TPM) framework, the understanding of it must be total. According to Nakajima (1989), the goal of Total Productive Maintenance (TPM) is continuously improve all operational conditions, within a production system by motivating the daily understanding of all employees.

2.2 Requirement of Establishing a Framework

Many authors have used the phrase "framework" without defining it properly. At this moment, there is no agreement on the true definition of the frameworks. Some authors define it as a set of principles or ideas used as a foundation for one decision, while others describe the frameworks through diagrams, flow charts, and graphical or pictorial representations (Yusof, 2000). Meanwhile, Struebing and Klaus (1997) understood that a framework should be define what the

organization does, what it is trying to do, how it is going to do it and ensure that each step is done in the correct sequences. Then again, Popper (1994) as quoted by Yusof (2000) defines a framework as a set of basic fundamental principles, which can help to promote discussions and actions. According to Abdul Rahim and Nabi Baksh (2003), the framework ideally should consist of a conceptual and an operational structure. The conceptual structure is a crystallization of ideas in abstract form into a written form includes various interactive elements. The conceptual structure is actually a basic foundation of further works to be carried out. It should address the entire development process and act as a master plan for downstream activities. The operational structure is the derivative of the conceptual structure. At this level, the structure should be more detailed and practical in nature and self explanatory. The operational structure is normally divided into phases to make it more manageable. Procedures and process flowcharts can be derived from the operational structure. Table 1 summarized the requirements needs for establishing a framework.

Framework requirement	Framework specification
Levels of framework	Framework divided into different levels to ease implementation
Generic and not prescriptive	Not too prescriptive like a cook book, should be able to be applied in many normal instances
Indicate clear direction design goals	Simple, straight forward, easy to understand, not expensive to implement, minimum time for implementation
Easy-to-follow approach	Smooth flow of the phases, reduce reverse flow, easy to follow
Aid in documentation process	Indicate important documentation requirement and document history
Key characteristics of design process	Indicate the activities of design process
Facilitate communication among functions and third parties	Involvement of marketing, purchasing, sales, after sales service, design, manufacturing, maintenance, suppliers, contractors, customers and service providers
Simple and practical plan for implementation	Simple and easy to understand without detailed explanation, self explanatory
Serve as a control mechanism	Structured plan with review and milestone, checklist to avoid omission
Integrate concurrent engineering tools	Integrate QFD, FMEA and DFA tools. Indicate when to use such tools
Include human interface	Human factors such as cross-functional team, teamworking, co-location, training

Table 1: Framework requirement and specification

2.3 Maintenance Strategy

Maintenance strategy is a long-term plan, covering all aspects of maintenance management which sets the direction for maintenance management and contains firm action plans for achieving a desired future state for the maintenance function.

2.3.1 Basic Maintenance Strategy

To become world class in maintenance management, the discipline should start from the basics of maintenance. Basic discipline is the fundamental activities that should be performed on the equipment before going to any other stages. It is waste of money if company goes on enhancing straightly to advance strategy if the basics condition has not been well established. Company want things done faster all the time and addressing that the basic things is useless. According to Angeles (2019), there are 5 disciplines in Basic Maintenance Strategies which are:

2.3.1.1 Training and Education
2.3.1.2 Maintenance Indices and KPI
2.3.1.3 Autonomous Maintenance (AM)
2.3.1.4 Basic Equipment Condition
2.3.1.5 Understanding of Preventive Maintenance

2.3.2 Intermediate Maintenance Strategy

This strategy can be implemented once the basic strategy has been established. According to Angeles (2019), there are 5 disciplines in Intermediate Maintenance Strategies which are:

2.3.2.1 Root Cause Failure Analysis (RCFA)
2.3.2.2 Lubrication Strategy
2.3.2.3 Reliability Initiatives
2.3.2.4 Life Cycle Management
2.3.2.5 Spare Parts Management

2.3.3 Advanced Maintenance Strategy

Savings generated through the application of basic and intermediate strategy can be well spent on the acquisition of these technologies. According to Angeles (2019), there are 2 disciplines in Advanced Maintenance Strategies which are:

2.3.3.1 Condition-based Monitoring (CBM)
2.3.3.2 Computerized Maintenance Management Systems (CMMS)

Chapter 3

RESEARCH METHODOLOGY

RESEARCH METHODOLOGY

The methodology of this project started from identifying the problem statement, selecting the case study to conduct, collecting and analyzing data, then proposes solution and makes conclusion.

Figure 1 shows the detail flow chart of this project methodology.

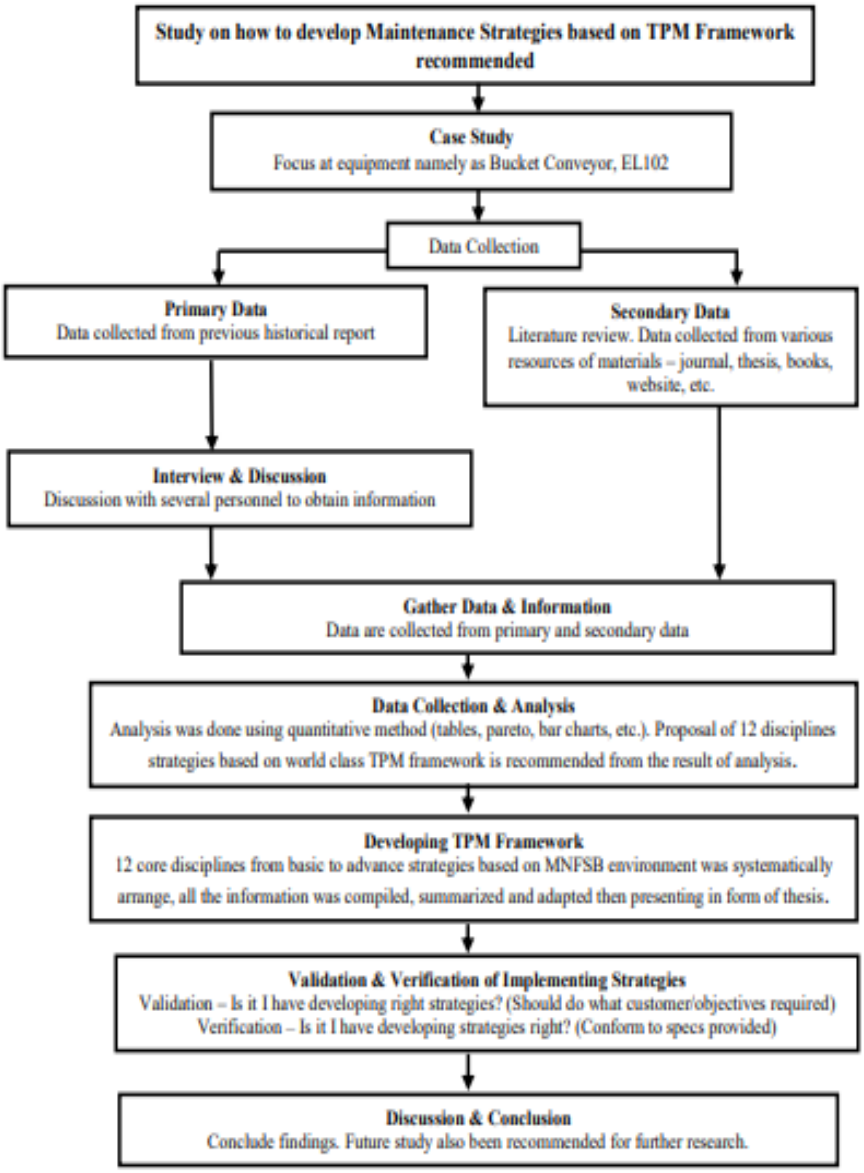


Figure 1: Flow chart for methodology of the project

Data collected was analyzed using quantitative methods. Data collected from various resources likes observation in plant, historical data recorded, interview and discussion session. The findings and way forward will be discussed in the following section.

3.1 Data collection method (Qualitative method)

Primary data

Primary data is the data that is collected by face to face consultation which is considered to be one of the most popular and oldest methods of data collection. Face to face interview is based on structured questionnaire. Respondent's answers are immediately recorded in questionnaire form. Face to face interview method ensures the quality of the obtained data and it also increases the response rate. The primary data has been collected by from an interview with various members of Industriess. A successful interview can provide useful information to complete this project. Following are the set of interview questions:

3.1.1 Aspect demography

a. May i know your name and age?

b. what is your position in this industry?

c. How long you have been in this industry?

4.1.2 Aspect maintenance management practices?

a. Does this industry provide smart maintenance management practices?

b. May i know what kind of maintenance plan apply in workplace?

c. Does this industry have management department committee?

4.1.3 Aspect type of mechanical failure in industry?

a. What type of failure happen in this industry?

b. Did the industry do something to reduce break down?

4.1.4 Aspect types of accidents/injury due to machines?

a. what type of failure frequently happen in this industry? Secondary data

Secondary data is the information that has been collected from the other sources. Common sources of secondary data are books, articles, journals, conference media, research papers etc. Researcher had studied various research papers for better understanding of the topic.

3.2 Conceptual framework

Conceptual framework shows the relationship between safety and health practices and injury management. Injury management is dependent on safety and health practices that are applied in industry. It is always suggested to have better safety policies to avoid accidents in workplace. Safety policies vary from industry to industry.

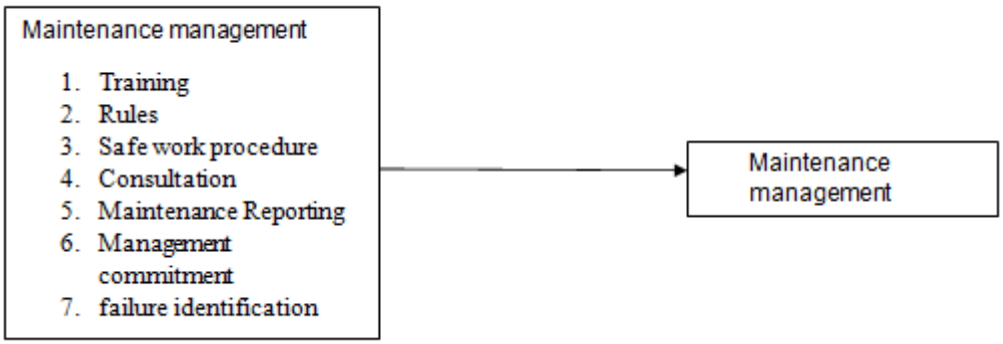


Fig3.1: Conceptual framework

Chapter 4

PROPOSED FRAMEWORK

PROPOSED FRAMEWORK

This section will analyze and describe detailed verification regarding the implementation of 12 core maintenance disciplines in order to become world class maintenance management system. As discussed in previous section, Bucket Conveyor EL102 contributes almost 375 hours or 7.4% downtime since plant commissioning. The conveyor already replaces twice in 5 years services. In order to achieve 14 hours/month target downtime set by management in 2011, proper plan should be made. This framework covers from basic to advanced disciplines.

4.0 Discipline 1 – Training and Education

The basic step is to train and teach all technicians on how to perform and handle the task given. For EL102, there are several selected training course that are related. Below stated a few training course attended by PLANTS technician and engineers after TPM program set up in:

a) Reliability Centre Maintenance (RCM) – This training is provided to engineer level. It is used to track and ensure types of maintenance activities performed. By attending this training, the engineer can estimate the lifetime of conveyor, roller, coupling, bearing, gearbox or pulley.
b) Root Cause Failure Analysis – This training is suitable for both levels - technician and engineer. It helps on how to discover failure using approaches such as 5-Why, Ishikawa Diagram, Fault Tree Analysis, FMEA and others. In modern maintenance practice, people want to know the root cause, not the probable cause of the problem.
c) Approach to Focused Improvement – This training is useful for both levels because it discusses on the step by step improvement analysis.

Other than the ones listed above, training on bearing technology, importance of conveyor preservation, lubrication strategy and understanding of rotating equipment are also important in maintaining EL102 condition.

4.1 Discipline 2 – Set Maintenance Target

To become world class maintenance, measuring maintenance performance is vital. Starting from year 2019, PLANTS has set Key Performance Indicator (KPI) to every staff, align with organization goals and direction. For EL102, equipment performance can be measured by:

a) Breakdown/downtime hours
b) Repair and maintenance cost
c) Types and no. of breakdown occurrences
    - Aging factor, repeated failure, etc.
d) Equipment availability,%
    - (Available time – Downtime)/Available time
e) Equipment utilization,%
    - (Loading time – Downtime)/Loading time
f) Equipment performance rate,%
    - (Ideal cycle time X output)/Operating time
g) Mean Time Between Failure (MTBF)
    - Operating time/Breakdown occurrence
h) Mean Time To Repair (MTTR)
    - Machine downtime/Breakdown occurrence
i) Mean Time To Fail (MTTF)
    - MTBF – MTTR

By measuring performance, one can determine which strategies, initiatives or activities that deserve additional focus and priority. Measuring performance can also indicate which equipment is within the budget and over the budget allocated. So it is easy for us to allocate budget wisely for the subsequent year.

4.2 Discipline 3 – Autonomous Maintenance

Autonomous Maintenance is based on education and training. It is about raising awareness of the operators on the knowledge and understanding principle operation of machines (Dhariya A, 2016). Equipment is always a shared responsibility for the two parties and not for the maintenance alone. Thus, there are some steps that can be done in order to help Engineering Department such as:

i. Sprinkle Phosphate Rock (PR) at edge of EL102 to preserve the conveyor from becoming wet. From our view, we suggest that PR can be sprinkle three times per day or once per shift. If the EL102 condition is dry, it can also prevent raw material become sticky at the cleat of conveyor. So, we indirectly reduce the load lower than necessary.
ii. Performs daily cleaning at bottom area and outlet chute. It is important to cleaning in bottom side of EL102 to prevent roller malfunction due to dust accumulate at floor area. Poor cleaning activity will cause abrasion to mechanical parts.

Engineering can escape from fire-fighting culture if operation accepting the role of Autonomous Maintenance. Once operators accept this role, maintenance can focus more on performing other maintenance strategies in their equipment. It must be understood that equipments' are shared responsibilities between operators and maintenance personnel.

4.3 Discipline 4 – Understanding of Basic Equipment Condition

World class industry understands the essence of establishing basic equipment condition in their equipment. Majority of catastrophic failures definitely can be avoided if operation and engineering works together towards common goal on addressing the basic equipment condition. For EL102, what basic conditions that we must understand are:

i. Clean – Keep the equipment clean as per standard. Inspection sometimes cannot be done if EL102 is in improper condition. Cleaning equipment means removing any forms of unwanted object from the equipment such as dirt, dust, scaling, grime etc. However, we must understand that PLANTS nature is different from electronic company. Cleaning for EL102 can be define as the conveyor is in proper state – no wet condition, all roller can function as usual, cleat in clean condition etc. If the cleaner can meet this entire requirement, it is easy for maintenance engineering to maintain it.
ii. Proper lubrication – Purpose of lubrication is to reduce friction for rotating mechanical parts such as bearing, coupling, gearbox etc. EL102 can be

categorized as low speed of rotating equipment. So, lubrication for it is easy to manage. Just apply grease to each roller bearing at least once per week to prevent

bearing from become abrasive. It already stated in ISO requirement about time interval of replacing gearbox oil, greasing activities for bearing and so on.

iii. Detail inspection – It is importance for mechanical to do daily detail inspection for EL102. By doing this inspection, we can early address about leaking condition, misalignment, roller jammed, abnormal sound etc.

Major problem are always caused by accumulation of small things, however it often being ignored and neglected. Catastrophic breakdowns can be reduced if basic equipment condition is in place. Sometimes lack of bolting, loose bolt and screw and not sufficient tightening can lead to excessive vibration which then produces secondary damage to equipment.

4.4 Discipline 5 – Implementation of Preventive Maintenance

Preventive Maintenance is a basic maintenance performed on a schedule basis in order to extend the lifetime of equipment and endure the equipment meets their capacity required.

Correct frequency of parts replacement will a good strategy suited with age- related and random failure. The goal of preventive maintenance is to anticipate, prevent, prolong or delay the process of failure from occurring. One step to become Proactive Maintenance is successful implementation in Preventive Maintenance activity.

4.5 Discipline 6 – Spare Parts Management

Spare parts management simply means that acquiring the right parts at the right times when maintenance needs it. Most of the problems occur in organization related to spare parts management are disorganized storeroom/warehouse,

inaccurate inventories and obsolete parts are still being ordered. At PLANTS, spare parts are controlled by Logistic section. One important issue is open line communication between both parties, Logistic and Engineering. Centralized warehouse is being used by the company. By having centralized warehouse, it is easy to monitor and control the spare parts availability

Computerized system will help a lot regard to this matter. In PLANTS, all parts that are use or taken out by user, will be re-order by logistic. As this plant already establish almost 6 years, re-analysis of amount of spare parts required is necessary.

4.6 Discipline 7 – Life Cycle Management

LCM is a business management approach that can be used by all types of business (and other organizations) in order to improve their sustainability performance. A method that can be used equally by both large and small firms, its purpose is to ensure more sustainable value chain management. LCM can be used to target, organize, analyze and manage product-related information and activities (Remmen et al,. 2017) towards continuous improvement along the product life cycle.

Life-cycle costing (LCC) = capital cost + lifetime operations cost + lifetime maintenance costs + disposal costs.

4.8 Discipline 8 – Lubrication Management

Lubricants are design to reduce friction and wear between contacting surfaces (Mang, 2017). It is means that to reduce friction between rotating contact surfaces, area of contacted should be lubricated. For EL102, the lubrication activity is very simple. It is because this equipment is slow speed types. All the lubrication activities already embedded in ISO requirements.

Even though the lubrication activities already set in ISO requirements, detail inspection for it should be done daily. WD40 is use to apply spray lubricant to roller bearing if there produce abnormal sound or seems roller tends to fail. WD40 also use for EL102 to prevent corrosion to roller bearing.

4.9 Discipline 9 – Value of Reliability

Reliability is the probability that a machine part or product will function properly for a specified time under stated condition (Blank, 2004). Most of companies today focus on productivity, quality and safety in their daily operation. Nobody cares about reliability.

4.10 Discipline 10 – Root Cause Failure Analysis

Root Cause Failure Analysis (RCFA) is used to understand the core reason of problems. It is not a tool to fully eliminate equipment failure by overall, repair or replace new equipment, but we could prevent from reoccurrence of the problems by analyzing through RCFA. By doing RCFA, at least we can prevent or predict the timing of failure (MTBF). RCFA can anticipate, delay, prolong or control the process failure. There are several tools can be used to do RCFA likes Fishbone Diagram, FMEA, Pareto Analysis, Fault Tree Analysis and others. Maintenance people traditionally have culture to have fast solution by jumping into repairing and modification without knowing or tackle the root cause of problems.

For EL102, there are several times of failure occurring since plant commissioning. However, there are no RCFA documentation has been done during this 5 years period. Maybe lacks of training or knowledge and culture of nature regarding this matter makes PLANTS not get on into RCFA when problem occur. Start from 2020, RCFA start to be implemented after instruction from management aligns with our TPM initiatives. All major equipment problems need to submit abnormalities report with an RCFA attachment.

Quick troubleshooting is no longer an effective strategy to world class organization. In today's competitive world, an activity for RCFA if the equipment fails must be a priority.

4.11 Discipline 11 – Condition Based Maintenance

Condition Based Maintenance (CBM) is an advance strategy for any organization towards world class maintenance. It is very difficult to see the achievement if the basic and intermediate discipline was ignored. Some investment needs to spend in order to explore this advance maintenance strategy. It is because for establish this strategies, several instruments needs to acquire. CBM is design to enhance current practice of Preventive Maintenance in a plant. Due to human sense are limited, CBM will further look into the equipment with the aid from diagnostic measuring instruments to get better result.

4.12 Discipline 12 – Computerized Maintenance Management System

The role of Computerized Maintenance Management System (CMMS) is to automate the maintenance daily activities process. CMMS application can improve many aspects likes monitoring balance of spare parts, control triggers, assist and predicting future needs, studying critical parts lifetime based on parts replacement and so on. The role of CMMS also must be apply to whole departments likes purchasing, warehouse, operation, logistic and operation.

Chapter 5

DATA COLLECTION AND ANALYSIS

DATA COLLECTION AND ANALYSIS (data is from internet and some data is assumed for reference, because in this pandemic it is tough to get data from plants)

Data of equipment breakdown was collected from mechanical section in engineering department starting from 2015 until 2020. Figure 3 shows bar graph for mechanical equipment downtime since plant commissioning in 2015 until 2020.

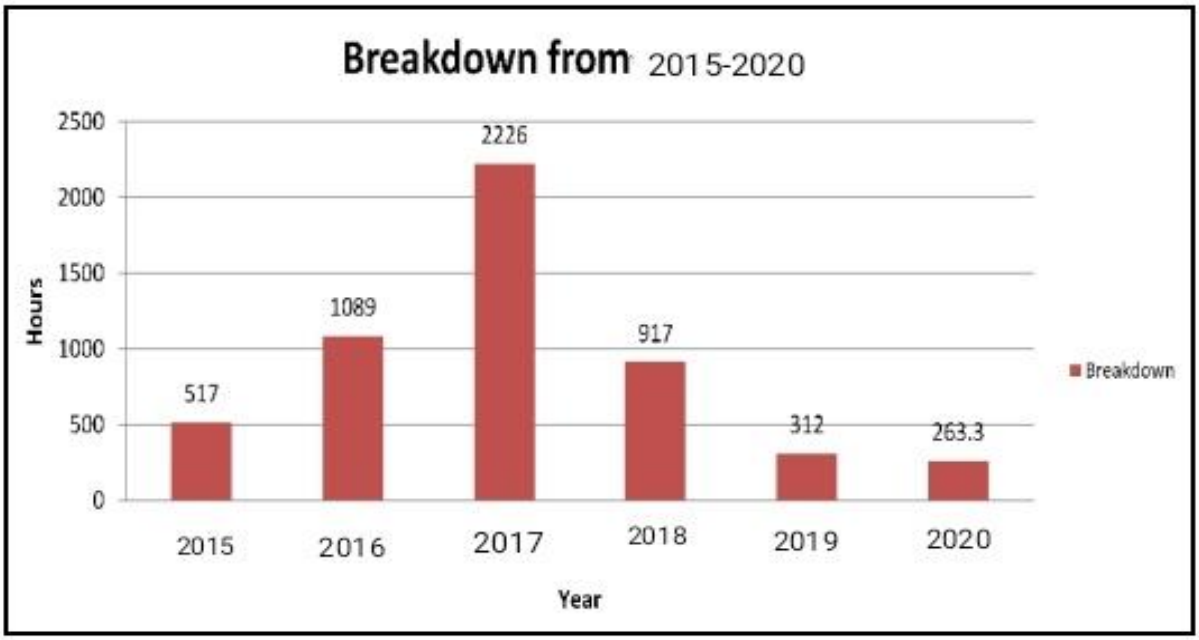


Figure : Mechanical equipment downtime from 2015 to 2020

As shows in the bar graph above, 2017 was the highest recorded downtime for mechanical section, total to 2226 hours, followed by 2016, 1089 hours and year 2018, 917 hours downtime. 2020 recorded the lowest downtime for mechanical section since plant commissioning, which contributed only about 263.3 hours followed by 2019, 312 hours downtime. In 2017, after all the PLANTS main contractor was ended their service contract, the downtime shoot up double compare to the previous year. It shows that, lack of knowledge in troubleshooting an equipment, can lead to higher downtime to plant and equipment.

Downtime seems reduce start on year 2018 onwards. One of the reason is because management decided to re-appoint one of the leader during PLANTS is under service contract staff. Others, management also add several experience technician for mechanical section to strengthen the section from 10 personnel in mechanical section in 2015 to 14 personnel in 2020 including engineer. TPM kick-off at PLANTS start from 2019. Detail equipment inspection start this year align with Preventive Maintenance (PM) pillar in TPM initiatives. Start from 2020, each technician have been given specific area to be concern for such as piping, conveyor, drum, screen and others. After more than 5 years running the plant, operation site also have gain some knowledge about equipment capability and limitations. They always ask for advice rather than force running equipment that seems to be abnormal. It actually helps mechanical section to reduce unplanned equipment breakdown. Others, there are also introduction of bi-weekly planned shutdown since end of year 2019 until 2020. In 2011, we plan to do plan shutdown on 3weeks interval basis. Before 2019, shutdown is done on once a month basis. Start from 2011, PLANTS wants to move on to another destination which is called World Class Maintenance Management System in Total Productive Maintenance (TPM). Some of the training already have been done in 2020 such as Importance of 5S, Autonomous Maintenance and others.

In PLANTS, there are about 80 rotating and static equipment such as conveyor, crusher, screen, drum, bucket elevator, bucket conveyor, fan, pump etc. All of this equipment contributes to machine downtime. Pareto Chart will be construct in order to identify the most critical equipment that contribute to machine downtime. Figure 4 shows Pareto Chart for percentage of 37 machines that contribute to downtime from 2015 until 2020.

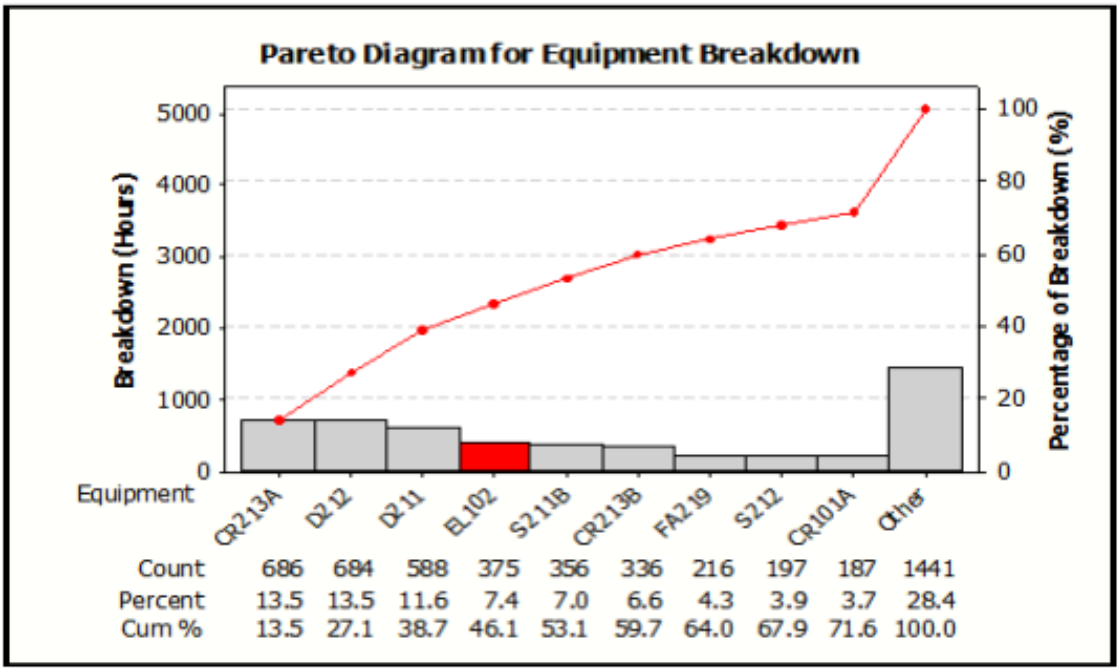


Figure : Pareto chart for mechanical equipment downtime from 2015 to 2020

From the Pareto Chart, it shows the most critical model that contributes to the highest downtime was CR213B, followed by D212, D211, S211B, EL102, CR213A and so forth. EL102 contribute almost 7.4% downtime during 5 years plant operates. EL102 was selected as a case study although the equipment is not the most critical downtime contribution because:

i. CR213B - Highest downtime for CR213B occur because there are problem on crushing efficiency and activity for replacing roller on year 2018. After that, all replacing roller activity was only done during annual Turnaround events. So, the downtime is not significant for the improvement analysis because it is not repetitive failure. It is more about internal factors rather than proper planning.
ii. D212 - Highest downtime for D212 occur because there are problem on fluid coupling on year 2016 (600 hours downtime) and at that time, there are no spare part for fluid coupling. Until 2020, those types of breakdown do not happen again. So, the downtime is not significant for the improvement analysis.
iii. D211 - Highest downtime for D211 occur because there are activity on replacing rubber panel that contribute almost 463hrs since 2015 until 2018. After improving the quality of rubber, until now, that types of breakdown do not happen again. So, the downtime is not significant for the improvement analysis.
iv. EL102 – This is recent and repetitive failure. Downtimes happen on 2015, 2017, 2018 and 2020. After so many improvement we already made during this period,

the failure still occur. Rubber quality is not an issue because only one manufacturer supplies this bucket conveyor. PLANTS can order the material from super high quality rubber manufactures likes Bridgestone, Yokohama or Goodyear Rubber but the return of investment taken so many years. So it can be considered as non-valuable investment in terms of financial. In order to pro-long this bucket conveyor lifetime is by having proper planning of maintaining it.

In 2020, target downtime for mechanical section setting by management was 17 hours/month based on 2019 downtime basis. Although there is a lot of reduction in downtime year-to-year, 2011 bring a new challenge to achieve target downtime. Downtime target set by management for mechanical section in 2011 was 14 hours/month. In order to achieve 2011 target, proper plan need to be done. All mechanical personnel need to be focus on maintaining equipment either normal crew or shift.

Employees must be educated and convinced that TPM is not just another "program of the month" and that management must totally commit to the program and the extended time frame necessary for full implementation. This project will bring 12 disciplines as a core framework to the efficient planning in order for PLANTS to achieve world class maintenance management system.

5.1 Cost Benefit Analysis

Cost benefit analysis is a term that refers to assess the project or policy created to make decision based on economically approach. It will determines how well is our plan goes in terms of financial concern. The production cost of losses is calculated by using formula below:

$$\text{Unit Cost (RM)} \times \frac{\text{Prod. Output in a Year (tone)}}{8760} \times \text{EL102 downtime (hrs)} \quad (1)$$

5.2 RESULTS AND DISCUSSIONS

- There will be minimum breakdown by taking all the suggestion's.
- There should be minimum repair and maintenance cost.

- Equipment availability is enough.
- Equipment utilization is best in there class.
- Equipment performance rate is high.
- There should not be single risk factor which is hazardous for living things.

5.3 CONCLUSION AND FUTURE RESEARCH

Today, most industries have ambition to become world class organization. Most of industries not born as world class organization but transition from reactive to proactive are vital to compete in today's world. Fire-fighting syndrome, shouting, hero stuff, stop- the-bleeding syndrome and pressure management must be left out in today's world of maintenance. A journey to world class maintenance must be done on a wide approach which covers totals employees in the process. A lot of resistance needs to be passing through.

Based on the problems, methodology is prepared to establish a plan towards world class maintenance management system. Numerous books, journal, websites and thesis have been reviewed to give some insight towards progression of this project. The historical downtime data is then analyzed to uncover breakdown hours occur in PLANTS by using several tools such as Bar Graph and Pareto Chart. After conducting several analyses, a framework would enable PLANTS to be world class maintenance management system refers to the 12 disciplines stated that cover from basic to advance disciplines had been proposed.

The verification is important to provide some knowledge on how to embed the disciplines to the real application. Validation of the project is done in the subsequent section to prove that the framework is valid to the objective declare. Financial analysis is done to show amount of RM losses due to equipment breakdown.

There are two recommendations, first by applying all these maintenance disciplines to equipments other than EL102. Thus, we can see some potential cost savings regards to this matter. Second, by focusing only one discipline and apply it to a specific process flow. By doing this, it suppose to see some sort of improvements in terms of reliability of equipment.