



Chapter 2

Theoretical Consideration

2.1 Introduction to Maintenance system

During the period of economic competition the major of successes in the competition are cost of production and time in production. The customer controls the cost of the product so the plant must spend lowest in every cost during production process. Machine breakdown is a waste of time during processing is a direct increase in cost of product and makes loss opportunity in selling goods. It will affect to customer satisfaction that no one wants it to be.

According to SALIH O. DUFFUAA, A. RAOUF and JOHN DIXON CAMPBELL (1999), page 43. If maintenance is defined as ensuring that a facility, equipment system, fleet, or other physical asset continues to perform its intended functions, then preventive maintenance is a series of preplanned tasks performed to counteract known causes of potential failures of those functions. This is in contrast to a maintenance repair, which is normally considered the replacement, refurbishment, or overhaul of the component(s) in an equipment or system to make it capable of performing its intended function.

Firstly, utilization in equipment needs to be considered, because the equipments are very costly and very complicated to change or take time to change. Down time due to unscheduled machine breakdown is one of the primary problems. It is necessary to schedule maintenance plan and increase the working life of the equipment.

Poor maintenance causes many problems such as:

- 1) Increased down time
- 2) Poor efficiency in production
- 3) High cost of product
- 4) Loss of opportunity in production
- 5) Waste time and manpower
- 6) Low customer satisfaction
- 7) Low working life of the equipment

Improve in maintenance system give more advantage as follow:

- 1) Reduce downtime
- 2) Increase production efficiency
- 3) Decrease cost of product
- 4) Reduce loss of opportunity in production
- 5) Decrease waste time and manpower
- 6) Better in customer satisfaction
- 7) Increase working life of the equipment

Proper maintenance can make the machine run smoothly. Lubrication is done correctly, regularly and following the timetable. Spare parts are changed close to the working life or before it breakdowns. All of these can keep the machine running with high efficiency. All of this will reduce cost of production and increase opportunity in production.

2.2 Type of maintenance

Maintenance can be classified into three types as follow:

- a) Breakdown maintenance (BM)
- b) Preventive maintenance (PM)
- c) Corrective maintenance (CM)

Breakdown maintenance (BM)

Maintaining after machine breakdown, it happens when the machine is broken and stop running. The breakdown can occur to any machine at any time. The maintenance section has to fix it with or without scheduling. There cause many disadvantages such as:

- 1) It is urgency in order to bring the machine back to work and hence the machine may not be adequate maintenance.
- 2) Waste of material in process.

- 3) Interrupt production plan.
- 4) Staff overtime in maintenance section.
- 5) Waiting for spare part, etc.

Preventive maintenance (PM)

According to SALIH O. DUFFUAA, A. RAOUF and JOHN DIXON CAMPBELL (1999), page 43,44. Preventive maintenance is the preferred approach to asset management:

- It can prevent premature failure and reduce its frequency.
- It can reduce the severity of failure and mitigate its consequences.
- It can provide warning of an impending or incipient failure to allow planned repair.
- It can reduce the overall cost of asset management.

Preventive maintenance is carried out to ensure equipment availability and reliability. Equipment availability can be defined as the probability of a piece of equipment being able to operate whenever needed. Equipment reliability is the probability that the equipment will be functioning at time t . The aim of preventive maintenance is to maximize equipment availability and reliability by carrying out planned maintenance, which commonly is known as preventive maintenance. One of the major characteristics of well-designed equipment is that it is repairable/maintainable during the time specified for it. This is known as maintainability and can be defined as the probability of its being repaired/maintained during a specified time. Preventive maintenance is also a means of providing feedback to equipment designers for enhancing its maintainability.

Preventive maintenance is maintain to prevent problem or maintain due to schedule, it can do by fix, clean, and change it when it has a sign of expired before it breakdowns. The reason is to protect unpredicted stops and the processes that cause machine breakdown. Preventive maintenance can be separated in to two types: 1) maintains every day. The user

can maintain the machines every day 2) another type is maintained due to schedule. In this case we require maintenance team to do it. Preventive maintenance is importance because the machine is used all the time. If the machine breakdown, the production line would be stop. It directly affect the cost of production, labor cost during waiting for maintenance, opportunity in sale the product, quality of the product, and customer satisfaction. Preventive maintenance can reduce the number of machine breakdown by two ways. (a) Set the schedule for technicians to maintain the machine, check lubricant, inspect and clean the part, test and change the part that expired by maintenance team. By this way it will easy and spends less time. (b) Let the machine technicians participate in maintain the machine that he or she is using everyday. By using this activity, it will cause of more efficiency in production line. There are five activities as follow:

- Clean the machine
- Lubricant
- Inspect noise, heat, physical, smell, and vibration
- Condition check
- Function test

Step to preventive maintenance are as follows:

- (1) Set up preventive maintenance plan.
- (2) Increase number of machine.
- (3) Change the part due to schedule.
- (4) Train machine user to use machine properly.
- (5) Over design machine that can work longer.
- (6) Try to separate the part in to unit set that easier to change.
- (7) Increase ability or number of maintenance staff.

Correction maintenance (CM)

This type of maintenance is to improve the ability of the machine. The staff may change the part in order to make it run longer than the original. Or change some design that

suitable to each production line. Some design of machine has to change for more easily in maintenance.

2.3 Analyze the type of equipment

At first, every part of the machine needs to consider that it needs preventive maintenance or not. It may not be economical to have preventive maintenance on every part. The certain situation breakdown maintenance should be economical.

In order for it to be economical it is necessary to categorize all of equipment. The importance of the equipment or part depends on its function. Normally the manual of the machine is already showing the part that should be take care. Process and maintenance engineers that who are expired or experienced can do the comparison. Some of the factors that should be taken into consideration are:

- 1) The equipment is continuous running and unscheduled breakdown of the equipment wills causes the machine to stop the production line.
- 2) Time in changing the equipment or part.
- 3) The spare part is available all the time.
- 4) It is a hazard to another part or equipment in case of it breakdowns.

As above, the result of each piece of equipment can be indicated by production and maintenance staff in order to arrive at the criticality. Machine that are similar to can group together it will help to determine type of maintenance require.

2.4 Inspection

Inspection is basic of preventive maintenance. Inspection of the machine is carried out in systematic way periodically in order to determine the condition of the part. Some parts may loose due to vibration, some may deteriorate and wear out. Heating may be the cause of

breakdown. These defects may cause of breakdown if it is not corrected properly. Corrective action can be taken if they are noticed well in time, and machine breakdown can be avoided. By inspection it will be possible to check the condition and take preventive measures and include repair, replacement of defective parts.

Methods of Inspection

Inspection can be classified in to two methods. First method is *external* and second method is *internal*.

The external method can be visual, which can be seen outside such as corrosion, color, cracks, and other external defect such conditions such as abnormal sound. Vibration can be observed. Temperature of bearing and similar part can be gauged and felt. The external inspection can be done when the machine is running or stopping.

The internal method is more detail. It needs to be done when the machine is stopping. A detail of inspection may become necessary as a result defects noticed during external checking. It may be necessary to use certain inspection equipment to determine the detail.

Importance of check-list

The way to ensure correct and proper inspection, checklist is a grade tool. It is a guide indicating all equipment that needs to be inspected. The list may include what and how to check. It includes the standard of acceptable condition of equipment. To set up the checklist it requires considerable skill, experience and machine manual. Proper checklist can help inspector to be ensuring that on equipment or defect is overlooked and the way to inspect is correct. The report is necessary corrective action by maintenance team. The condition of the machine become apparent during inspection and the action will be taken depend on the report of the inspector. Otherwise it will cause a lot of danger if the report is not correct. Inspector should be a skilled and experienced person. Inspector should have knowledge of the machine

that is inspected. The level of inspector can depend on type of process, nature of equipment and machine etc. inspector will have to use his discretion for taking corrective action himself when the situation demands the same. Such actions may include undertaking of repairs or advising a shut down when inspector believe that the defect will lead to a major problem.

2.5 Lubrication

Lubrication is one of the importance activities for maintenance system. There are so many functions that need lubrication. The proper lubricant can reduce the friction between moving parts. By reducing the friction between moving parts it will make the equipment has more long working life. The type of lubricant should be considered. Wrong type of lubricant may cause of decline in the part. So the type of lubricant should follow the spec of the part. The lubricant has many types such as hydraulic oil, Gear oil, Greases and etc.

After we know the proper type of lubricant in the part. Lubrication needs planning because it is a routine work and it needs the proper period cycle. So the schedule should be prepared for each part of the machine that need lubricant and the point of lubricant should be announce. It can be daily or weekly plan and the staff can understand what he should do for lubricant activity. Normally the lubricant staff is the lowest level staff of the section. But he has to train and understand the work instruction of lubrication very well in order to protect the staff from danger and protect the part from make a miss take.

2.6 Maintenance quality

According to Weiss (1997), page 305-306. In recent years, more and more plants have used quality control strategies in carrying out the maintenance function. This has resulted in several worthwhile benefits to the plants. Through an effective quality control program, you can:

- Upgrade the maintenance function.
- Increase the efficiency of maintenance personnel.

- Serve the production department better.
- Reduce the costs of the maintenance department.

To operate efficiently and provide the service expected of it, a maintenance department must practice the principles of quality control. With higher standards of performance now expected of equipment and facilities plus more governmental regulation of design and operation, the quality of maintenance has had to improve.

Yet there is still a strong need for maintenance employees to do higher quality work as well as more of it. And there will always be a need for management to find ways to reduce and eliminate repetitive repairs. Controlling the quality of maintenance may be a big job, but it is not beyond the capability of plant personnel. The job should be approached in several ways because many factors must be considered. Here is how you and other managers should go about it:

Purchasing. Controlling the quality of maintenance begins with purchasing. If the company buys top-grade material, the repairs made to equipment and facilities are more likely to also be first class. You can expect a paint job to look better and to hold up longer if you use good quality industrial paint. A wooden structure should last longer if your carpenters have high-grade lumber to work with.

The same logic applies to the tools you provide employees. A maintenance employee who has only makeshift tools won't be able to do a high quality repair job, nor will he or she take pride in the work done. Special tools, such as ergonomically designed ones, which you purchase or rent for the department, will enable employees to handle tough jobs more safely and efficiently, and their workmanship will also be better.

Work performance. One of the ways to determine the quality of maintenance in the plant is to analyze the performance of the maintenance employees. While this is logically your responsibility, it may be difficult for employees to be efficient and cost-effective when they are occupied principally with breakdown work because there is little if any time for planning. Since much of this work consists of troubleshooting, the skill of the craftsman is critical. But the fact that breakdown work must be performed

quickly should not be an excuse for you to accept poor quality workmanship. You can still control the quality of the work with close supervision.

Variances of quality. Perhaps the most crucial practice from a quality viewpoint is performance of maintenance work in an irresponsible and inept manner. The employee who damages equipment and machines when making repairs cannot be tolerated. Nor can the craftsman who makes improper adjustments, fails to replace covers, caps, bolts, and nuts, and does work that results in stripped threads on connections. Other variances of quality workmanship concern how machines and work areas are left after the maintenance work is performed. Spills should be cleaned up, and worn-out parts as well as waste material should be properly disposed of.

Failure to do a thorough and complete job on an inspection or repair assignment is another example of poor-quality maintenance. If a work order calls for several operations to be performed such as determining motor load, testing for vibration, and making drive adjustments, then the work should not be considered complete or acceptable until all of these operations are handled.

You can control the quality of maintenance only if you set standards of performance and make employees aware of them. Establishing standards is especially appropriate when formulating a plant's preventive maintenance program. Standard procedures must be followed with inspections, oiling and lubrication, painting, winterizing, putting machines and equipment in standby condition, and other preventive procedures.

2.7 Requirement of control

According to Weiss (1997), page 315. There are five basic requirements of planning and scheduling to facilitate control of the maintenance function:

1. A formal procedure for defining, approving, and authorizing maintenance work to be done. The procedure should be spelled out in a manual so both

maintenance personnel and the receivers of maintenance service will know how the other is to operate regarding maintenance work.

2. A work-order system that clearly communicates the need for work to be done so jobs are completed as requested. This includes a work-order form with sufficient spaces to identify the job and supply control information such as work-order and cost accounting numbers.
3. A priority system that classifies the job as to urgency and need date.
4. A scheduling system that states when the job is to be done.
5. A control and follow-up procedure to determine whether or not the planning and scheduling process is reducing maintenance costs.

2.8 Work order

According to W.H. Weiss (1997), page 317. The work order is the basic instrument of a plant maintenance system. Job origination, identification, and authorization materialize with work orders. You make job assignments with work orders, and you get information on job costs, equipment history, and worker performance from the completed work order. Maintenance work orders are of two types:

1. Those suited for planning involve work that requires scheduled equipment downtime. Such orders must represent enough expenditure of manhours or dollars to justify estimating and scheduling the job. Another requirement of a planned work order is that the lead time must be sufficient to permit the time it takes to process an order.
2. Those not suited for planning involve jobs that are of such high priority that work must begin too soon for planning to be effective, or those that are of short duration and do not require scheduling of equipment downtime. Unplanned work orders are often referred to as verbal work orders, or as breakdown work order.

2.9 Mean Time Between Failure (MTBF)

This is a measure tool in order to measure the mean time of working life in each part. By the formula it can be calculated the mean time of the breakdown in the particular part. The data of Mean time between failures is very useful. It can be as a guide in order to set up the preventive maintenance schedule and it can calculate by the formula.

$$\text{MTBF} = \frac{\text{Productive(time)}}{\text{No.breakdown}}$$

Productive time is the total running time of machine during the concentrate period. It means that during the concentrate period, if the machine is stopped the Productive time will equal the number of concentrate period minus the number of stop time. For example the concentrate period is one year and in one year has holiday for twenty days. The concentrate period of one year is 365 day so Productive time is equal 365 days minus 20 days that the answer is 345 days. If during one year has the stop time occurs it will bring to minus.

Number breakdown is the frequency of breakdown in each particular part. For example the concentrate period is one year and in one year has the breakdown in particular part 5 time it means that Number breakdown is equal 5.

From the calculation, if the number of MTBF is increase, it means that the particular part has longer working life. So the number of MTBF should be as high as possible.