CHAPTER II

LITERATURE REVIEW

This chapter will be explained about the literature studies that divided into two studies, which are inductive study and deductive study. Inductive study is a study from previous research that already has a reputation and the latest journal in the last 5 years (2013-2018). The other study is deductive study, the deductive study is a study that would be explained about the basic theory from the books or journals that has a relation with the research that would be conducted.

2.1. Inductive Study

Maintenance is one of many cores in manufacturing company that influences many aspects of production and value of the product. Based on (Fraser, 2014) the cost of maintenance activities is ranged from 15 to 70% of the total production costs in one machine. This result indicates the significance of maintenance process cost.

Generally, maintenance strategies have been developed by following the development of the manufacturing process. The classification of maintenance strategies is followed based on the time of maintenance to conduct corrective maintenance, preventive maintenance and design-out maintenance (Ruiz, Foguem, & Grabot, 2013). The maintenance activity that is carried out when the failure happens called as corrective maintenance. While, the maintenance that performed before the failure occurrence is called as preventive maintenance.

Go, Kim, & Lee (2013) determined the maintenance and operation scheduling for container ships with many subsystems as long as the ship sailed based on pre-determination of navigation schedule. The purpose of this study is to determine the start time of each care work with the time of work. Due date on each maintenance work has been determined by a mixed integer programming model and a heuristic algorithm. The main constraints of scheduling are subsystem requirements, labour availability, work time limits and time between maintenances.

The selection of the Analytical Hierarchy Process (AHP) machine maintenance strategy and design of maintenance strategies with the Reliability Centered Maintenance (RCM) method can be applied to process-based manufacturing (Vishnu & V, 2016). This study aims to propose an RCM model that is suitable for all process-based manufacturing conditions where there are complex relationships and critical components. The proposed RCM model can be a guideline for companies in developing a database system to oversee RCM maintenance activities, the level of conditions and needs of each machine and component in the factory with a cost-effective way to increase availability and profitability. This RCM model has been applied to Travancore Titanium Products Ltd with critical component results identified and the average time between failures and appropriate maintenance strategies for each critical component so that the extra costs that arise by adopting preventive maintenance will be balanced with the cost savings of application of failure maintenance.

Chemweno et al (2015) proposed a machine maintenance strategy approach by integrating risk management elements into asset improvement. He uses the ISO 31000: 2009 standard as a criterion for decision making. Criteria are obtained such as software tools, software modules, decision support tools, data collection schemes, statistical models, performance measurements, procedures, and personal skills. Then the analytical network process is used for selection based on these criteria. The results of the selection are then continued on the analysis of causes and effects such as FMEA and FTA.

Genetic Algorithms as the main optimization approach have been widely presented in optimization journals. Levitin and Lisnianski (2000) examined multi-state systems with components that have different levels of performance. The model minimizes costs with established reliability. To do the analysis, they applied the universal generator function technique and used genetic algorithms to determine the best maintenance strategy. Wang and Handschin (2000) built a new genetic algorithm by modifying basic operators, crossover operators and mutation operators on standard genetic algorithms. Using this new algorithm, convergence will be achieved faster and prevent the resulting solution from being feasible or not in accordance with the actual conditions.

Zhao, Chan, & Burrow (2009) developed the AG model as a cost suppressor in the renewal of railroad components by providing solutions to non-linear problems by adopting AG on large and continuous variables such as the number of railway lines that cannot use integer programming methods. After the use of ordinary AG with AG partitioning and integration (GAPI) differences were found in terms of the optimal solution speed (number of generations) as much as 17.4% slower than only based on basic AG.

Based on the explanation stated in previous studies on this issue, these studies are related to determine maintenance schedules with diverse constraints. For the case that occurred in this study is to solve a problem with the aim of setting the start time of each maintenance work based on constraints of equal distribution of workers, limitations on the availability of workers and time limits that exist, with the final results to reduce maintenance costs. In order to resolve the objectives with the solutions, hence Genetic Algorithms (AG) will be used.

2.2. Deductive Study

2.2.1 Maintenance Scheduling

Manufacturing company should be organized with the strategy of maintenance by following the character of the machine. In research by Ruiz, et al (2013) stated the classification of maintenance strategies based on the time of maintenance activities and failure include corrective maintenance, preventive maintenance, and design-out maintenance. Maintenance flow process might be conducting to reduce the risk existence of waste. On maintenance activity, the manufacture should consider several attributes that influenced the activity. Because the maintenance of each machine is different, the failure also different. Each step-in maintenance process should be analysed in detail to create an effective and efficient process.

Maintenance management is the management that determines the purpose of maintenance activities, maintenance strategies, and responsibilities along with their implementation (Márquez, 2007). In general, the goal of care management is divided into 3 major groups, namely:

1. Technical objectives.

This objective depends on the industrial sector of a business entity operates. In general, the technical objectives of a company are to maintain or increase the availability and operational capability of an asset and improve work safety.

2. Legal objectives/government regulations.

   This objective is set up to cover the quality standard in one project or activity. Legal objectives for normal care management are only to meet the existing rules for various things. This objective is arranged by the executive leader under government's regulation.

3. Financial goals.

   The financial objectives of care management are to meet technical objectives with minimal costs. From a long-term point of view, the overall life-cycle cost of the equipment should be minimal.

Maintenance activity in this factory works as the periodic project periodically that did in every year after fulfil the demand of production. To avoid the maintenance during the production period, this factory was doing the predictive maintenance as their maintenance strategy. The Maintenance activity is implemented based on the urge of the production process. There are 2 types of strategies that described as follows:

a. Preventive maintenance

   Preventive maintenance is a maintenance that is carried out by supervising the components/systems so that they are in optimal operational condition by conducting checks, early detection, and systematic improvements before failure or developing a sign of failure in the system (Dhillon, 2002). Preventive maintenance objectives include reducing damage to critical components, minimizing production losses due to component failure, and increasing the productive life of a component. In preventive maintenance, there are 7 elements which consist of inspection, servicing, calibration, testing, alignment, adjustment, and installation.

b. Corrective Maintenance

   Corrective maintenance which is also commonly called maintenance breakdown, fix when fail maintenance, run-to-failure maintenance, or maintenance repair. This approach changes the component/machine only when the component or machine does not work according to its function. The assumption in this approach is that each component, machine or system has the same probability of being damaged.

2.2.2 Genetic Algorithm

Genetic algorithm (GA) is a form of concept or search method that can be used to solve problems and model systems of biological evolution (Holland, 1975). The software implementation used for this study is model in stages such as those in the GA in general. GA is a powerful technique that is used in various fields to find a solution that is almost optimal when searching for the optimal is too expensive. Even though it is attractive and elegant in the laboratory, scalability problems are prevented from being effectively implemented into real problems.

GA moves from a population of chromosomes represented in a prospective solution to the new population through three stages, namely: selection, crossover and mutation. Chromosomes are each member of a set that can represent a solution to a problem. Chromosomes are an evolved population in an iteration known as the generation, each chromosome is evaluated based on its evolutionary function (fitness function). The chromosomes will then be selected based on each fitness value (Harman, 2007).

There are several things that must be done in genetic algorithms, including the following:

- Define individuals: which can be expressed as one solution (solution) of the problem raised.
- Define the fitness function value: which makes a benchmark whether or not an individual or a solution is achieved.
- Determine the initial population generation process: things that are done by random generation.
- Determine the selection process to be used.
- Determine the crossover process and the mutation of the gene to be used.

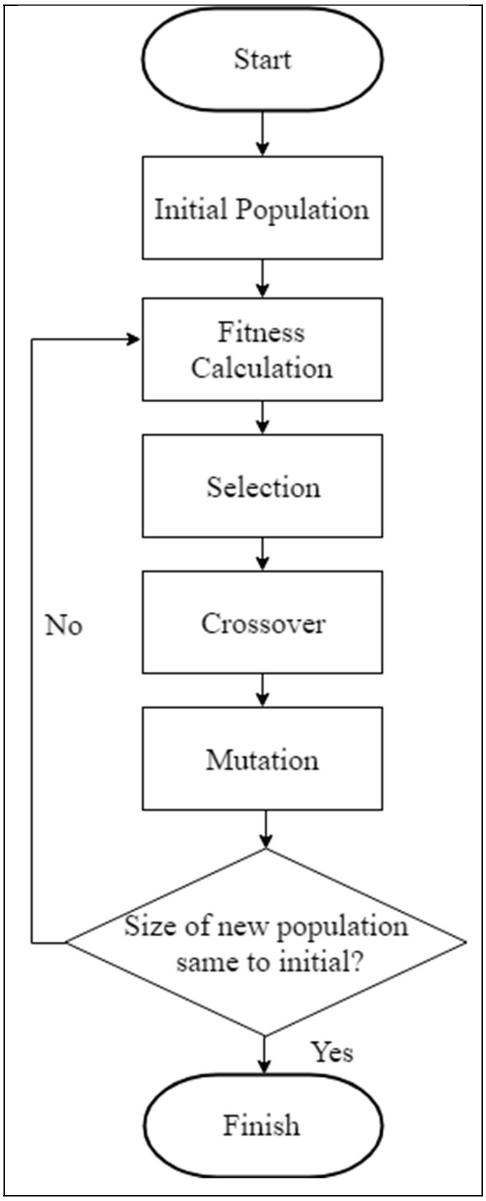

Figure 2. 1 Genetic algorithm process flowchart

In each iteration, all members of the population will be evaluated based on the fitness that has been made, with members of the initial population randomly created. A new population will be formed from the evolution of the parent chromosomes through an iteration called generation. The results of the generations that have been carried out will produce offspring from the use of genetic operations such as crossover and mutation. The newly formed population has gone through the stages of chromosome elimination based on the best fitness values from parent and child, so the population size is constant.

2.2.3 Genetic Algorithm for Optimization of Maintenance Scheduling

Duarte et al (2006) mentioned that the present a heuristic algorithm for maintenance scheduling of a system that has a set of components. In this study, all components are assumed to have a rate of damage which increases with the value of a constant increase factor. This paper proposed GA techniques for representing variables in a preventive maintenance scheduling model that uses heuristic and metaheuristic optimization algorithms.

Asjad & Khan (2017) applied AG to optimize maintenance costs for higher performance with AG as a tool to develop operations and maintenance activities for mechanical systems. From the three case studies that were given that high maintenance costs resulted in the availability of small machines due to maintenance, so that if preventive maintenance intervals were increased, availability would also be higher. After doing sensitivity analysis, it is found that fixed cost factors have the greatest effect on the cost of care.

2.2.4 Asset Management

The ISO standard provides the definition of AsM is coordinated activity from an organization to realize the value of assets (ISO, 2014). The same standard defines assets as goods, objects or entities that have potential value or actual for an organization. Asset Management based on ISO 55000 is asset management involved in the balance between costs, opportunities and risks facing performance expected of an asset, in order to achieve the goals of an organization. Balance these need to be considered based on different time periods.

In asset management, there are four main factors for understanding the asset life cycle. There are four main factors in the asset life cycle, which will be classified and explained as follows:

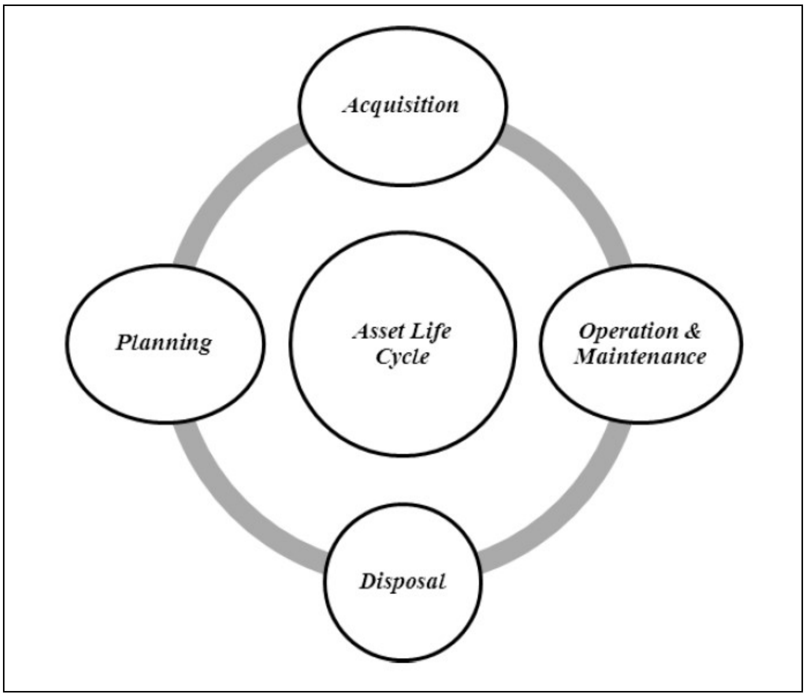

Figure 2.2 Asset Life Cycle

1. Planning

Planning is the first stage of the asset life cycle. This stage sets and verifies the asset requirements. Determination of asset requirements is based on evaluating existing assets and potential assets to meet service needs. identification of management strategies is needed to enter and analyse the need for an asset. Throughout the planning phase, it is important to ensure that ongoing development adds value to the organization.

2. Acquisition

Making the best decision in choosing the best option can only be done after determining the costs and requirements. The choice will be the Acquisition stage. Acquisition includes activities involved in buying assets with the aim of ensuring cost-effective acquisitions. This includes activities such as designing and holding an asset. The appropriate application of this activity guarantees that the asset is suitable for use.

Initially, the organization must decide whether the asset will be bought or built permanently. Next, make a budget for the acquisition of assets along with the time frame for acquisition and purchase requirements. Practical budgets and cash flows must be put in place as insufficient funds or project management can jeopardize the asset acquisition process. Every time this requirement is met, the project team must carry out a process to ensure that all acquisition process activities will be completed to meet service delivery and other organizational goals.

3. **Operation & Maintenance**

Operation and Maintenance show the application and management of assets, including maintenance, with the aim of providing services. An asset management plan must have a high focus on asset maintenance issues. Long-term assets, in most public sector assets, especially roads and buildings require special treatment during their life cycle. So far, assets must focus on maintaining, monitoring and increasing the right potential to exceed any adjustments in operational requirements.

4. **Disposal**

When an asset reaches the end of its useful life, it can be treated as a surplus, or vice versa considered an asset that performs poorly. Disposals must be treated in the perspective of decision effects on service delivery and departmental responsibilities. Special focus must be placed on cultural heritage where there are detailed requirements that must be considered by the organization. If assets must be disposed of in the near future, so that maintenance is required, maintenance strategies must be adjusted accordingly.

2.2.5 Engineering Asset Management

Engineering Asset Management (EAM) is an emerging interdisciplinary field that combines technical issues of asset reliability, safety and performance with financial and managerial requirements (Hodkiewicz & Pascal, 2006). EAM is concerned with assets throughout the lifecycle. The time interval that commences with the identification of the need for physical assets, through defining the requirements, the acquisition and system implementation processes, in-service operations and maintenance management, and asset decommissioning and disposal. The emphasis of EAM is on sustainable business outcomes, risk management and value. The entire process involves a wide range of disciplines and requires a range of technical and management tools and skills.

Companies who own and operate physical assets rely on what we commonly call "maintenance" teams or maintain the asset (s) and ensure that it can deliver on the desired function. The process of 'doing' maintenance has changed, but not limited to equipment design, computerization, electronics and communication, cost management and societal acceptance of risk and failures. As maintenance absorbs a significant percentage of operating costs (Tomlingson, 2005), it is now on the radar of senior management attention. The evolution of the term "engineering asset management" is largely in response to the desire to better manage maintenance and associated efforts, and align internal processes with strategic objectives.

Therefore, we will argue that the commitment of the safety workplace will only be shown if it is synergistic with the organizational goals, and management clearly articulates the message in detailing work orders and rewarding employees' performance. Further, we argue that organizations promote a focus on proactive maintenance of assets (fixing it before it breaks), rather than a reactive organizational culture (fixing only those foundations in place to ensure safe outcomes).