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"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Plant And Maintenance)"

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ANALYSIS OF PREVENTIVE MAINTENANCE PLANNING FOR HYDROGEN MANUFACTURING UNIT (HMU) IN SHELL MDS (M) SDN BHD

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This Thesis Is Submitted In Partial Fulfilment of Requirement For Degree of Bachelor of Mechanical Engineering (Plant & Maintenance)

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DECLARATION

"I hereby declare that the work in this thesis is my own except for summaries and quotations which have been duly acknowledged."

Signature: ……………………………………

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Date: ………..…………………………

This thesis is dedicated to God Almighty who has been my eternal rock and source of refuge, and for His word in Habakkuk 2:1-3 that kept me all through the journey of completing this fine work. I also dedicate this work to my supervisor, Puan Nur Izyan Binti Zulkafli and family for being great pillars of support.

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ABSTRACT

This paper discussed the preventive maintenance planning in one of the process plant in Bintulu Sarawak which is SHELL MDS SDN.BHD. Preventive maintenance (PM) planning is method in which the maintenance activities are planned and scheduled based on predetermined counter intervals in order to prevent breakdowns and failures from occurring. This study investigates the effect of the maintenance performance in the Hydrogen Manufacturing Unit (HMU) and to estimate the total cost incurred within the maintenance planning time horizon. The scope of this study is to investigate the effect of maintenance performance related to the size of the labor force, preventive frequency and spare part inventory and the budget estimation that include the economic losses, PM cost, labor cost and inventory cost. Begin with process flow diagram (PFD) of the plant to determine the equipment that needed in this research. By identify the failure mode of the equipment, all the related parameter will be listed out such as the rate of failure, rate of PM, Mean Time Between Failure (MTBF) and also the rate of repair. From these parameters, the maintenance planning can be scheduled and the data can be simulated using the selected model. The application of the model resulted in the prolonged of the MTBF for each equipment, increases in the availability of the machine under the control parameters and the frequency of equipment down for PM increases to reduce the failure. A good preventive maintenance planning is found to decrease the system failure and the downtime. The most important is the availability of the equipment which to be always considered in all calculations.

Keywords: Preventive maintenance, Hydrogen Manufacturing Unit (HMU), process flow diagram (PFD), mean time between failure (MTBF),downtime, availability.

ABSTRAK

Kajian ini membincangkan perancangan penyelenggaraan pencegahan di salah sebuah loji pemprosesan di Bintulu Sarawak iaitu SHELL MDS SDN.BHD. Perancangan penyelenggaraan pencegahan (PM) adalah kaedah di mana aktiviti-aktiviti penyelenggaraan dirancang dan dijadualkan berdasarkan selang yang telah ditetapkan untuk mengelakkan kerosakan dan kegagalan daripada berlaku. Kelemahan dalam perancangan penyelenggaraan pencegahan (PM) boleh membawa kepada akibat yang serius yang boleh menyebabkan kerugian ekonomi dan prestasi penyelenggaraan pencegahan yang tidak memuaskan. Hasil pengeluaran sesebuah loji pemprosesan bergantung kepada kebolehpercayaan mesin, dan apabila pengeluaran diberhentikan, kerosakan, atau apa-apa yang berkaitan, akan mempengaruhi produktiviti keseluruhan loji. Penyelidikan yang dilakukan pada masa kini lebih cenderung untuk mengenal pasti perancangan penyelenggaraan pencegahan yang lebih cekap dari segi kos dan masa. Dalam laporan ini mengkaji kesan pelaksanaan penyelenggaraan di Unit Pembuatan Hidrogen (HMU) dan untuk menganggarkan jumlah kos yang ditanggung dalam masa perancangan penyelenggaraan. Kajian ini dijalankan bermula dengan gambarajah aliran proses (PFD) loji untuk menentukan mesin yang diperlukan dalam kajian ini. Dengan mengenal pasti mod kegagalan peralatan, semua parameter berkaitan akan disenaraikan seperti kadar kegagalan, kadar PM, Waktu Min Antara Kegagalan (MTBF) dan juga kadar pembaikan. Daripada parameter tersebut yang sudah dikenalpasti, perancangan penyelenggaraan ini boleh dijadualkan dan data boleh disimulasikan dengan menggunakan model yang dipilih. Aplikasi model tersebut akan dibentangkan. Satu perancangan penyelenggaraan pencegahan yang baik didapati mengurangkan kegagalan sistem dan masa yang terhenti. Apa yang paling penting adalah keberadaan sesebuah mesin yang perlu sentiasa dipertimbangkan dalam semua pengiraan dan diutamakan.

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LIST OF SYMBOLS

$\lambda fail$	= failure rate of a system/equipment
$\mu fail$	= repair rate of a system/equipment
λpm	= rate of a system/equipment down for preventive maintenance
μpm	= rate of a system/equipment preventive maintenance performance
$A\nu$	= rate of availability for system/equipment.
τ	= Duration
η	= Characteristic Life

LIST OF ABBREVIATION

CM	= Corrective Maintenance
PM	= Preventive Maintenance
FMEA	= Failure Mode and Effect Analysis
PM_{opt}	= Preventive Maintenance Optimization
L_{PM}	= Size of Preventive Maintenance Labour Force
LOC	= Worker Operating Condition
P_{normal}	= Probability of system to work normally (Availability)
P_{pm}	= Probability of system down due to PM
P_{fail}	= Probability of system down due to failure
MTBF	= Mean Time Between Failure
MTTR	= Mean Time To Repair
TPM	= Total Productive Maintenance
RPN	= Risk Priority Number
PFD	= Process Flow Diagram
GA	= Generic Algorithm

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CHAPTER I

INTRODUCTION

This research will focus on the Preventive Maintenance (PM) planning. The PM planning is an organized method to execute the maintenance strategies in the plant. Together with the implementation of PM planning, budget estimation will be the primary factor that must be taken into account. It is seen that careful planning of the methods is needed to achieve an optimum and cost effective maintenance strategies.

1.1. Background Research

R.Chumai (2003) said that maintenance is defined as the work of keeping an operating system in good condition or putting it in working order again after it fails. Maintenance refers to the collection of activities that include inspections, overhauls, repairs, preservation of parts and replacements carried on an operating equipment to preserve its functions, avoid consequences of failure and ensure its productive capacity. Therefore, a good maintenance planning in production plants have major impacts on product delivery, product quality and production cost.

Preventive maintenance (PM) is a time based maintenance method in which the maintenance activities are planned and scheduled based on predetermined counter intervals in order to prevent breakdowns and failures from occurring. There are many ways to develop a PM planning in the plant but the plan must be easy to execute. First of all, the right time to implement the PM must be identified. The scheduling process can be done by a computer system or other scheduling methods. In this research will focus on the Markov PM model to determine the maintenance performance of the plant with respect to the budget estimation. In this study will investigate the reliability and availability of the units in relation to implementation of preventive maintenance planning.

In this opportunity, this report is made to assess the PM planning on the process plant beside to propose the good PM planning for the chosen company which is the Hydrogen Manufacturing Unit (HMU) of Shell (M) Middle Distillate Synthesis Sdn.Bhd shown in **Figure 1.1**. This analysis will use the concept and technique of Markov PM Model to improve the current PM planning used by the company. It shows that this process plant has to undergo a change in their PM planning in order to optimize their productivity and profit to maximum level. All the analysis and recommendations are stated in this report for future consideration.

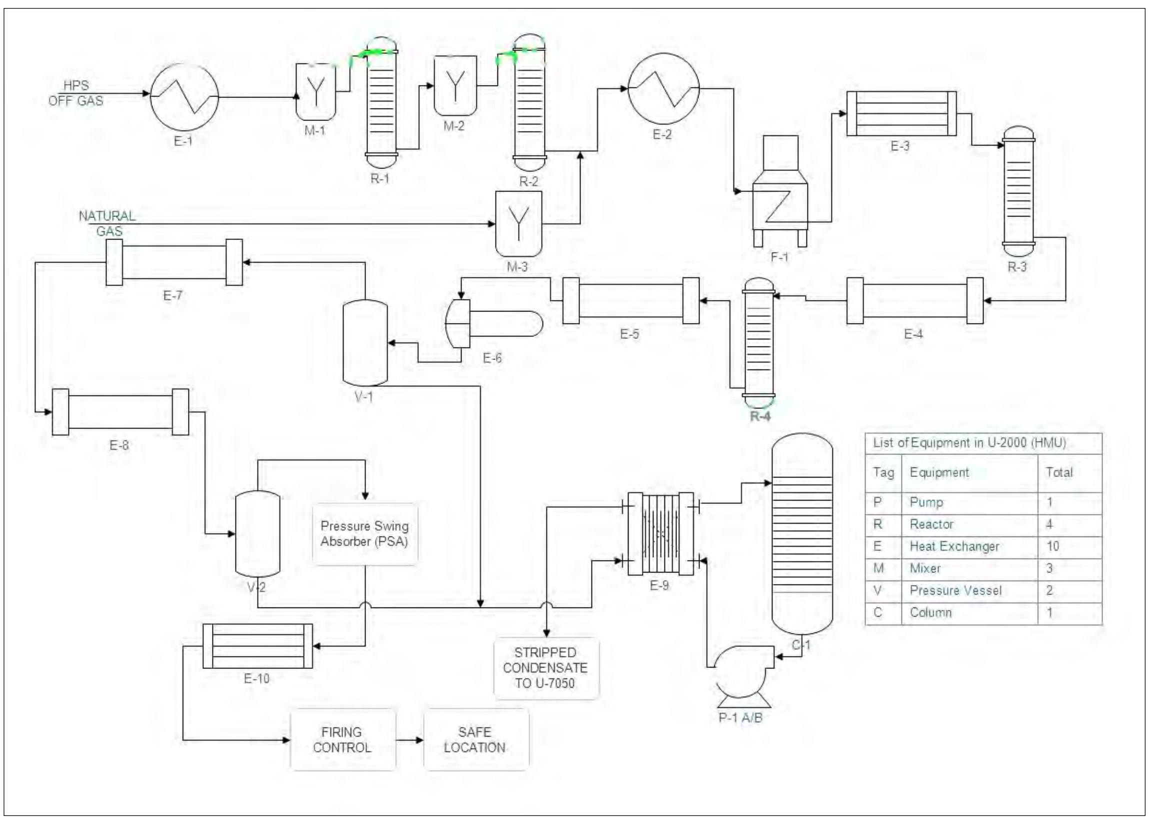

Figure 1.1: PFD of HMU draw using Edraw Max (trial version)

The purpose of the Hydrogen Manufacturing Unit (HMU U-2000) is to manufacture pure hydrogen gas from natural gas and off-gas of the Heavy Paraffin Synthesis Unit (HPS U-3000). Both gas is mixed in the mixer (M-1) before it goes to reactor (R-1). R1 is the first stage of conversion takes place over an iron oxide catalyst at „high" inlet temperature and is very exothermic. The reforming process produces carbon monoxide as well as hydrogen. This carbon monoxide must be converted (shifted) to carbon dioxide and hydrogen to increase the yield of hydrogen. The process gas leaving R1 and R2 is used to pre-heat boiler feed water (BFW). The hydrocarbons are converted with steam over nickel catalyst to produce a hydrogen rich gas. The hot flue gases and reformed gases generate steam in exchangers. Their residual heat is further utilized for process pre-heating purpose. The Reformer F-1 and its convection bank contains six (6) exchangers. To prevent polymerization and cracking in the Reformer tubes, the olefins (unsaturated hydrocarbons) in the feed gas must be hydrogenated to paraffins (saturated hydrocarbons). This occurs over a palladium catalyst in R-3. In pre-shift conversion stage, to prevent carbon formation and deposition in the Reformer tubes, the carbon monoxide in the feed gas must be converted to carbon dioxide. This occurs over an iron oxide catalyst in the R-4. The gases then stored in V-2 after going through six (6) exchangers. From V-2, the hydrogen rich gas is purified by cyclic pressure swing absorption (PSA) process. The PSA off gas is utilized as fuel in F-1. The hydrogen leaving the PSA process has a purify of 99.5 mol%. Excess steam in the hydrogen rich gas upstream the PSA Unit is condensed out. This condensate is sent to a Condensate Stripper C-1 where dissolved gases (mainly hydrogen and carbon dioxide) are stripped out with LP steam. The condensate is then sent to T-7002 (Storage Tank). The net HP steam production is sent to U-7000 HP steam distribution system. The hydrogen is compressed to two pressure levels. The lower level (at 42barg) is supplied to the HPS Unit (U-3000) which is the major consumer of hydrogen. The higher level (at 52barg) is supplied to all other consumers, they are :

I. Shell Gasification Process (U-1000)
II. Hydro Conversion Distillation (U-4000)
III. Hydrogenation Unit (U-5100)
IV. Wax Hydrofinishing Unit (U-5500/U-5600)

1.2. Problem Statement

Based on preliminary observations in one of the process plant in Bintulu Sarawak, it was found that the plant is not doing well with their PM planning. This indication can be seen from the previous internship experience where some of the work orders are redundant and not fully accomplish during the whole day. It also seen that some of the equipment that failed took quite a long time for the workers to figure out the problem before do the repair. The impact of this situation is to the total cost and economic loses that incurred within the maintenance planning time horizon. Poor PM planning will affect the productivity. Moreover, based on the observations unorganized PM planning in turn made great increment of economic losses and the effect of maintenance performances.

1.3. Objective

The objectives of this research are:

I. To study the effect of maintenance performance in a process plant.

II. To estimate the total cost and economic losses that incurred within the maintenance planning time horizon.

1.4. Scope Of Study

The scope of this study is to investigate the effect of maintenance performance related to the size of the labor force, preventive frequency and spare part inventory and the budget estimation that include the economic losses, PM cost, labor cost and inventory cost.

CHAPTER II

LITERATURE REVIEW

2 Introduction

In this chapter, all of the information related to the preventive maintenance planning and also the maintenance performances with respect to the estimation of the total cost and economic lose was elaborated. The literature review is an important step to get all information related to this research.

2.1 Overview Of Preventive Maintenance

Many researches, experiment and documents in the past that studied the techniques, modeling and policy of the preventive maintenance. Preventive Maintenance is one of the maintenance strategies that apply the philosophy of " Fix It Before It Breaks " and a predetermined time interval to perform the maintenance with the goal to prolong the useful life of equipment components. Preventive maintenance also helps to:

I. Protect the asset and integrity
II. Decrease cost of replacement
III. Improve system reliability
IV. Reduce the system downtime due to failure
V. Protect the workers in term of reduced the injuries due to equipment failure.

Preventive maintenance, therefore, is a very important in preventing any equipment failure that could interfere with the operation and it should be integrated into the productivity.

Richa Chouhand et al. (2013) stated that, a well implemented preventive maintenance model can help to minimize the repair efforts and the maintenance costs in a production system. The maintenance department in the plant played an important role to run the PM activities routinely to avoid unplanned downtime because of the failure that occurred in the system.

2.2. Markov Model

In the journal by Richa Chouhan et al. (2013), Markov Model for Preventive Maintenance discussed in this section represents a system that undergo a complete fail or a routine preventive maintenance within the time horizon, as shown in **Figure 2.1**. According to Jaroslaw Sugier (2011), Markov Model approach is valid for the equipment that having a constant rate of failure or in a steady state condition. There will some main point to be elaborated in this writing which may include the explanation of the method, mathematical formulation, output variable and also the implementation of result.

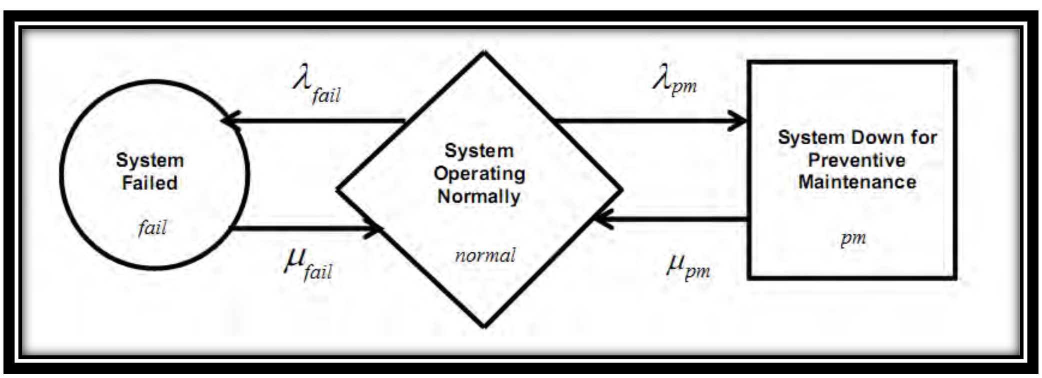

Figure 2.1: State Transition Diagram for the PM Markov Model (Source: Richa Chouhand et al., 2013)

2.2.1. Explanation Of Method

By using this preventive maintenance planning, the result is to determine the probability of system availability, probability down for PM and the probability down due to failure. For this type of model, several assumption has to be made such as the following:

I. The equipment has a PM rate, repair rate and failure rates which is constant.

II. The equipment is assume to be well functional just after the maintenance activity being carried out.

All of data that are needed in this PM model will help to implement the model and analysis of result. The data are collected from the previous PM data of the equipment.

The input variables used in this model are as follows:

λ_{fail} = failure rate of a system/equipment

μ_{fail} = repair rate of a system/equipment

λ_{pm} = rate of a system/equipment down for preventive maintenance

μ_{pm} = rate of a system/equipment preventive maintenance performance

$A\nu$ = rate of availability for system/equipment.

2.2.2. Mathematical Model Formulation

This formula is needed to plot the graph to study the scenario. The data all the four parameter is obtained from the real life situation to make this model more reliable.