

EVALUATION OF ENERGY USAGE FROM PALM OIL MILL INDUSTRY USING  
CLEANER PRODUCTION APPROACH

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**EVALUATION OF ENERGY USAGE FROM PALM OIL MILL INDUSTRY  
USING CLEANER PRODUCTION APPROACH**

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**This thesis has been done  
in partial fulfilment of the requirement for  
Bachelor of Mechanical Engineering (Thermal - Fluid)**

**Faculty of Mechanical Engineering  
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### **SUPERVISOR DECLARATION**

“I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Thermal-Fluids)”

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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 “

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Date : .....

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## ABSTRACT

The emission of greenhouse gases from palm oil mill industry occur in the production of products which is due to inefficient use of energy. This will caused greenhouse gases occur in large quantities and thus will enter the room air and cause ozone depletion. In order to prevent the greenhouse effect, this research will analyze the energy consumption in crude palm oil production and evaluate options for Cleaner Production implementation in crude palm oil production process. Data consists of two type that are qualitative data and quantitative data. In order to gathering data, a few step is consider. To determine the qualitative data, step use are direct observation and structure interview while for the quantitative data are detailed audit and Cleaner Production Implementation Tools (CPIT). Analyzing environmental management systems introduced on the basis of Cleaner production projects demonstrates, that Cleaner production supplies management and employees with systematic tools to decrease the environmental impact and at the same time save costs from inefficient use of materials and energy and motivates the organization as well by creating awareness throughout the enterprise. As a result, the value of waste energy occur is shown in chart which is from data that been obtain. Then the possible options for Cleaner Production implementation in crude palm oil production process is determined to improve the production process and most important to reduce the utility cost and to reduce greenhouse gases which can affect the environment.

## ABSTRAK

Pelepasan gas rumah hijau daripada industri kilang minyak sawit berlaku dalam pengeluaran produk disebabkan penggunaan tenaga yang tidak efektif, ini akan menyebabkan gas rumah hijau berlaku dalam kuantiti yang besar dan akan memasuki ruangan udara bilik dan menyebabkan penipisan lapisan ozon. Untuk mengelakkan kesan rumah hijau, kajian ini akan menganalisis penggunaan tenaga dalam pengeluaran minyak sawit mentah dan menilai pilihan untuk pelaksanaan Pengeluaran Bersih dalam proses pengeluaran minyak sawit mentah. Data terdiri daripada dua jenis yang data kualitatif dan data kuantitatif. Dalam usaha untuk mengumpul data, beberapa langkah yang dipertimbangkan. Untuk menentukan data kualitatif, penggunaan langkah adalah pemerhatian langsung dan temubual struktur manakala bagi data kuantitatif adalah audit terperinci dan Alat Pelaksanaan Pengeluaran Bersih (CPIT). Analisis sistem pengurusan alam sekitar diperkenalkan atas dasar mendemonstrasikan projek pengeluaran bersih, bahawa pengurusan bekalan pengeluaran bersih dan pekerja dengan alat sistematik untuk mengurangkan kesan alam sekitar dan pada masa yang sama menjimatkan kos daripada penggunaan yang bahan dan tenaga yang tidak cekap serta mendorong organisasi dengan mewujudkan kesedaran di seluruh perusahaan. Sebagai hasilnya, nilai tenaga sisa berlaku ditunjukkan dalam carta iaitu daripada data yang telah diperolehi. Maka pilihan yang mungkin bagi pelaksanaan Pengeluaran Bersih dalam proses pengeluaran minyak sawit mentah ditentukan untuk meningkatkan proses pengeluaran dan yang paling penting untuk mengurangkan kos utiliti dan mengurangkan gas rumah hijau yang boleh menjejaskan alam sekitar.

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**NOMENCLATURE**

|                 |   |                                      |
|-----------------|---|--------------------------------------|
| CPO             | - | Crude Palm Oil                       |
| GHG             | - | Greenhouse Gas                       |
| CP              | - | Cleaner Production                   |
| CO <sub>2</sub> | - | Carbon Dioxide Gases                 |
| CH <sub>4</sub> | - | Hydrocarbon Gases                    |
| UNEP            | - | United Nations Environment Programme |
| FFB             | - | Fresh Fruit Bunch                    |
| EFB             | - | Empty Fruit Bunch                    |
| POME            | - | Palm Oil Mill Effluent               |
| CDM             | - | Clean Development Mechanisms         |
| MW              | - | Mega Watts                           |
| GWh             | - | Giga Watts Hour                      |
| RSPO            | - | Roundtable on Sustainable Palm Oil   |

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## CHAPTER 1

### INTRODUCTION

#### 1.0 RESEARCH OVERVIEW

Malaysia is one of the largest producers of palm oil product. The palm oil industry has contributed the biggest income to the country for many years. Moreover, palm oils has emerged as one of the most important oils in the world's oils and the market of fats. About 90% of palm oil is used as food related products worldwide, and the other 10% is used for basic raw material for soap (Mahlia et al, 2001).

Despite its significant contribution to the economic growth, palm oil mill produces harmful gases such as CO<sub>2</sub> and other greenhouse gases. CO<sub>2</sub> emitted due to fossil fuel consumption and anaerobic conversion of palm oil mill effluent. The production of these gases can cause harm to human health and environment.

Pollution prevention and resource efficiency have become the ethos for the present day industries. Pollution prevention reduces the amount of pollution generated by a process, whether it is consumer consumption, driving, or industrial production. In contrast, to the most pollution control strategies, which seek to manage a pollutant after it is formed and reduce its impact upon the environment, the pollution prevention approach seeks to increase the efficiency of a process, thereby reducing the amount of pollution generated at its source. Although there is wide

agreement that source reduction is the preferred strategy, some professionals also use the term pollution prevention to include pollution reduction.

One of the methods in preventive environmental strategy is Cleaner Production. Cleaner Production is the continuous application of an integrated, preventive environmental strategy towards processes, products and services in order to increase overall efficiency and reduce damage and risks for humans and the environment. Cleaner Production (CP) belongs to the family of Pollution Prevention. It was formally defined by United Nations Environment Programme (UNEP) as an integrated strategy for increasing efficiency and minimization of residuals and risks for products, processes and services back in 1989. The adoption of CP by manufacturing entities worldwide has been phenomenal.

### **1.1 Problem Statement**

One of the factor contribute to the emission of greenhouse gases are from the ineffectively used of energy in a production process. It is gives negative impact to the environment with the high amount of energy usage (Karadağ & Korkut 2012). Furthermore it is also highly affect the utility cost for the production. Therefore, the problem statements of this research are:

1. The greenhouse gases emission that contains CO<sub>2</sub> and CH<sub>4</sub> (Karadağ & Korkut 2012).
2. Cycle of production process not to efficient (Karadağ & Korkut 2012).

### **1.2 Objective**

This research aim to measure the energy consumption in crude palm oil production and evaluate options for Cleaner Production implementation in crude palm oil production process.



### 1.3 Scope

From the objectives that have been listed, this research focus on three scopes in order to achieve the objective successfully. First, this study will measure the amount of energy utilisation in each unit operation in production of crude palm oil. Next, this study will investigate the root causes contribute to high energy usage. Finally, this study will evaluate Cleaner Production implementation options in order to reduce the energy consumption.

### 1.4 Outline of Thesis

This thesis consists of six (6) chapters where it separated into three section that are Introduction, Body of Paragraph and lastly Conclusion and Recommendation. The Introduction should contain thesis statement or the topic of research as well as the purpose of the study. Generally, Introduction should state briefly all the major points of your topic your readers will be reading about.

Next is Body of Paragraph where in this section it consists of four chapter that are Literature Review, Methodology, Results, and Analysis. The Literature Review contain all the previous study about or related to the project which in this thesis it consists of Cleaner Production (CP) study, palm oil mill industry, and analysis of heat or energy on production process. The Methodology contain of step in order to gathering data or information involving energy usage on production proces. Methodology consists of direct observation, detailed audit, structured interview and Cleaner Production Implementation Tools (CPIT). The Result shows the data or information that been obtained based on methodology that have been performed and The Analysis shows the calculation on energy usage for overall production process in order to determine amount of energy usage on palm oil industry for one month production.

Lastly is The Conclusion and Recommendation. The Conclusion and Recommendation is where form a summary of all arguments and state final stand for the project. More than that if there any possible options in order to improve the process or equipment, it will be stated in this chapter.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.0 INTRODUCTION**

This chapter describes about the general concept of using cleaner production in palm oil mill industry. Literature review is the most important ways to retrieve the information related in the topic. It also enable researcher to reproduce the methods and objectively to accept the result of review or not. In the first section, it explains the overall concept of Cleaner Production (CP) and the review of CP implementation related to the optimization of energy consumption. Next, this chapter focuses the review of CP implementation in palm oil industry and represents several case studies for references in this research.

#### **2.1 Cleaner Production**

Cleaner production is the continual effort to prevent pollution by reduce the use of energy, water and material resources, and also minimise waste in the production process. Cleaner production results in savings and in line with environment protection. Noor, 2009 state that CP can be define as the continuous application of integrated preventive environmental strategy applied to processes, products, and services to increase overall efficiency and reduce risks to human and

the environment. It involves rethinking of products, product components and production processes so as to achieve sustainable production. Cleaner production is about considering the entire life cycle of products, including; product design, selection of raw materials, production and assembly of the final product, consumer use, and managing all used products at the end of their life. Another terminology of CP is also known as cleaner technology. CP can be description as many as possible according to the options, cases involved, and how this CP can help a community with the same goal as general meaning.

General meaning of CP can be the one of the options that prevents from too many emitted of pollutant to the environment or on how to get the optimum production with less emitted of pollution. According to Feng and Chen, 2013, they considered the CP to be an important meaning of how effective to control the pollution as the win-win situation can be the leading of improving economic and give the benefits to the environment.

A few CP strategies of prevention method are highlighted while achieving to gives the benefits to the environment. There are good housekeeping, input substitution, better process control, equipment modification, technology change, product modification and on-site recovery or reuse (Staniškis, 2011). Other researcher defines the CP as the inclusion of environmental sensibility to all processes from designing to planning, an approach to reduce the industry's environmental pressure and prevent pollution before it appears (Karadağ & Korkut 2012).

### **2.1.1 Benefits of Cleaner Production Implementation in Industry**

The benefits of cleaner production has totally change the environmental issues, due to reducing the emission and long-term the technique to eliminate waste. Montalvo & Kemp, 2008, state that the development and application of cleaner production offer multiple benefits for the adopter that is: less waste and cost saving from reduced resource use, reduced the emissions, and also savings on waste costs. There are three main benefits that contain in cleaner production implementation in

Malaysian Industries. Those three benefits are ; improved company image, reduction of ecological damage, reduction of operating cost.

#### **2.1.1.1 Improved Company image**

CP program improving the company image by positively toward management of the place on providing safe working environment. In order to providing the safety working environment, cleaner production has fulfil the requirement by solving the dust emission from stack, water pollution and boundary noise level in Malayan Cement Industries Sdn. Bhd (Montalvo & Kemp, 2008).

#### **2.1.1.2 Reduction of Ecological Damage**

CP provides obvious benefits for the natural environment. For Examples, in a case study of Texas Instruments Malaysia SDN. Bhd. Cleaner production implemented in the process simplification and reduction of chemical and oil usage, due to that the benefits of cleaner production has been eliminate use of oil and solvent (TCE) degreasing process and totally eliminate usage of waste oil and solvent (Montalvo & Kemp, 2008).

#### **2.1.1.3 Reduction of Operating Costs**

CP program can be reducing material costs by adopting production and packaging procedure that consume fewer resources. In case study of Taiyo Yuden (Sarawak) Sdn. Bhd. Due to the benefits of cleaner production implemented in the industries, it has reduces the water usage up to 40 %, Energy consumption save to 95% and material packaging labelling and transportation to 30 % (Montalvo & Kemp, 2008).

## 2.2 Palm Oil Mill Industry

There are more than 400 palm oil mills in the country and the processing capacities of these palm oil mills can vary from less than 15t/h (tones per hour) to more than 90t/h of FFB (Ismail, 2012). Conventional palm oil mills are considerable polluters of the environment and don't follow the principles of sustainability (Unilever 2003; RSPO 2005). In the RSPO principle 5 taken from 'Environmental Responsibility and conservation of natural resources and biodiversity' describes that "waste is reduced, recycled, and disposed of in an environmentally and socially responsible manner" and "plans to reduce pollution and emissions, including greenhouse gases, are developed, implemented and monitored".

Under these aspects, the palm oil industry will be forced to implement new environmental friendly treatment technologies in their oil mills. Concepts, technical solution and practical experiences for new concepts as EFB composting in combination with POME and biogas production from POME/sludge are available since several years. However, energy demand is increasing continuously due to rapid growth in population and industrialization development. The major energy demand is provided from the conventional energy sources such as coal, oil, natural gas, and so on.

### 2.2.1 Palm Oil Mill Production and Process

There are several unit operations are involved in order to extract palm oil after the fresh fruit bunches (FFB) are transported to the palm oil mills (Virgilio, 2009). Two types of oils are produced from oil palm, one is the palm oil from the fibrous mesocarp and another is lauric oil produced from the palm kernel. In order to gain crude palm oil, there are three main process; sterilization, stripping or threshing, digestion and palm oil extraction.

### **2.2.1.1 Sterilization Process**

Sterilization or cooking means the use of high-temperature wet-heat treatment of loose fruit. Cooking normally uses hot water; sterilization uses pressurized steam. According to (Sukaribin & Khalid 2009), in sterilization process, large and medium scale of palm oil mill were used as steam sterilization process which has pressurized the bunches of 15-45 psi for 90 min at a temperature more than 100 °c. These are important in producing good quality of palm oil mill. On the other side, steam sterilization process has produced many waste of water when doing the process, because consist large amount of water used when producing it (Virgilio, 2009).

### **2.2.1.2 Stripping or Threshing Process**

After completed with the process of sterilization, the fresh fruit are stripped and separated and put in to rotary drum stripper. Fruit are lifted and dropped to the stripper to detach out from the bunch. The bunched are remove as they do not contain any oil. In addition, threshing is responsible for separating the fruitlets from bunch and it also a process between sterilizer and digestion (Virgilio, 2009).

### **2.2.1.3 Digestion Process**

Digestion is the process of releasing the palm oil in the fruit through the rupture or breaking down of the oil-bearing cells. The digester commonly used consists of a steam-heated cylindrical vessel fitted with a central rotating shaft carrying a number of beater (stirring) arms. Through the action of the rotating beater arms the fruit is pounded. Pounding, or digesting the fruit at high temperature, helps to reduce the viscosity of the oil, destroys the fruits' outer covering (exocarp), and completes the disruption of the oil cells already begun in the sterilization phase (Virgilio, 2009).

#### 2.2.1.4 Palm Oil Extraction Process

Homogeneous oil mash coming out from the digester is passed through a screw press followed by a vibrating screen, a hydrocyclone and decanters to remove the fine solids and water. The oil is purified by using the centrifuge and vacuum drier before sending it to the storage tank. The crude oil slurry is then fed into a clarification system for oil separation and purification. The fiber and nuts are separated by passing through the depericarper (Virgilio, 2009).

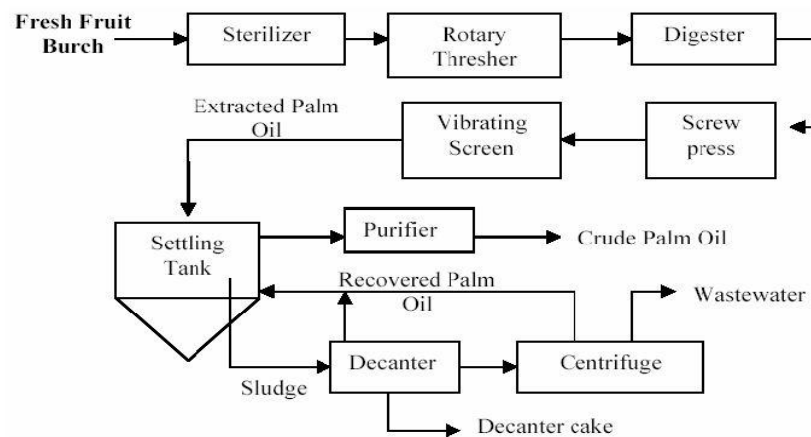


Figure 2.2.1.4 : Schematic diagram of palm oil milling process

#### 2.2.2 Greenhouse Gases from Palm Oil Mill Industry

Human activities such as transportation and industrializing are releasing and accumulating green house gases such as carbon dioxide (CO<sub>2</sub>) and certain other trace gases including methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), chlorofluorocarbons (CFCs), and tropospheric ozone (O<sub>3</sub>) in the atmosphere. These gases will deplete the ozone layer and more than that will cause the climate change which can be harmful for us living things. Climate change is considered to be one of the biggest threats facing nature and humanity today. Climate refers to the representative or characteristic atmospheric conditions for a region on Earth. Climate is important, not only because they affect human activities, but because they are primary determinants of biomass and ecosystem distribution. There are many factors identified to cause and influence climate change. These factors could be global, national and localized factors.

Meanwhile, the Malaysian oil palm industry is an important industry but the waste organic from palm oil mill effluent (POME) is a contributed to global warming phenomena base from the greenhouse gases effect.. The experiment for capture gas methane, CH<sub>4</sub> will be one of the alternative ways to encounter this problem. The way is increase the gas CH<sub>4</sub> and decrease the gas CO<sub>2</sub> to a biogas production. The parameters that have been focused throughout identified condition temperature and monitoring optimum day in bioreactor. Temperature in the pilot plant is not to control but the result is take for analysis (Noor, 2012)

### **2.3 Energy Pinch Analysis**

One of the most practical tools to emerge in the field of process integration in the past 20 years has been pinch analysis, which may be used to improve the efficient use of energy, hydrogen and water in industrial processes. Pinch analysis is a recognized and well-proven method in each of the following industry sectors: Chemicals, Petrochemicals, Oil refining, Pulp and paper, Food and drink, and also Steel and metallurgy.

Pinch Technology provides a systematic methodology for energy saving in processes and total sites. The methodology is based on thermodynamic principles. A Pinch Analysis starts with the heat and material balance for the process. Using Pinch Technology, it is possible to identify appropriate changes in the core process conditions that can have an impact on energy savings. After the heat and material balance is established, targets for energy saving can be set prior to the design of the main part in the network. The Pinch Design Method ensures that these targets are achieved during the network design. Targets can also be set for the utility loads at various levels (e.g. steam and refrigeration levels). The utility levels supplied to the process may be a part of a centralised site-wide utility system (e.g. site steam system). Pinch Technology extends to the site level, wherein appropriate loads on the various steam mains can be identified in order to minimise the site wide energy consumption. Pinch Technology therefore provides a consistent methodology for energy saving, from the basic heat and material balance to the total site utility system.