# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## EXPERIMENTAL STUDY OF DIFFERENT HOT FLUE AIR SPEED EFFECTS ON YOUNG COCONUT GRAIN MOISTURE LEVEL AND RESULTING RETENTION TIME AT FIXED HOT FLUE AIR TEMPERATURE

This report is submitted in accordance with the requirement of UniversitiTeknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours

by


**NUR HANISAH BINTI JASMI**

**B071210565**

**911220-08-6262**


FACULTY OF ENGINEERING TECHNOLOGY

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TAJUK: : **Experimental Study of Different Hot Flue Air Speed Effects on Young Coconut Grain Moisture Level and Resulting Retention Time at Fixed Hot Flue Air Temperature**

SESI PENGAJIAN: **2015/16 Semester 1**

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# APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Department of Mechanical Engineering Technology) (Hons.). The member of the supervisory is as follow:

……………………………….

(PN.NorainbintiIdris)

# ABSTRACT

The high demand on renewable energy nowadays is due to the fossil fuel depletion. Biomass is one of the renewable energy sources and coconut can be constituted by converting it into biomass pellets. However, the coconut that been used is only from old type because the moisture content that contains in virgin coconut type is too high and not suitable for biomass pellet production which need low moisture content. This paper reports the optimum moisture level of young coconut waste and hot flue air speed in drying that waste based on retention time and moisture level consistency with the constant temperature hot flue air of 53.3$^{o}$ C. The materials were crushed and sieved to get grain form with size below 0.08 mm before be dried with speed 7.40 m/s, 10.45 m/s and 12.54 m/s to obtain optimum moisture level that stipulated between 8% to 20% with a high moisture level consistency and low retention time. The samples of grain then were characterized by produce a pellet with compression method by hot press machine with temperature 120$^{o}$ C, 130$^{o}$ C and 140$^{o}$ C while pressure of 5 MPa, 7.5 MPa 10 Mpa and 12.5 MPa besides retention time of 3, 4 and 5 minutes. The 8 % is the optimum moisture level and the speed of 7.40 m/s is the optimum hot flue air speed that give low retention time and consistency moisture level besides low cost on electric energy consumption.With optimum value of hot flue air speed in drying process, the optimal and consistency of moisture level and retention time for new biomass pellet production that functions as a green fuel and burner has been achieved and indirectly overcome the issue of land side fulfilment and environment pollution besides accommodating the fossil fuel depletion and gain income from waste sources.

# ABSTRAK

Permintaan yang tinggiterhadaptenagabolehdiperbaharuipadamasakiniadalahdisebabkanolehkekuranganbahanapifosil. Biomass adalahsalahsatusumbertenaga yang bolehdiperbaharuidankelapaadalahsalahsatusumbernyadenganmenukarkannyamenjadipeletbiomas.Walaubagaimanapun, jeniskelapa yang digunakanhanyalahkelapatuakeranakandungankelembapanpadakelapamudaadalahterlalutinggidantidaksesuaiuntukpengeluaranpeletbiomas yang memerlukankandungankelembapanrendah.Kertaskerjainimelaporkantahapkelembapan optimum sisakelapamudadankelajuanudaraserombongpanassemasapengeringansisakelapamudaberdasarkanmasatahanandankonsistentahapkelembapandengansuhu malar udaraserombongpanas 53.3$^{o}$ C. Bahan-bahan yang telahdihancurkandandisaringuntukmendapatkanbentukbijirindengansaiz di bawah 0.08 mm sebelumdikeringkandengankelajuan 7.40 m / s, 10.45 m / s dan 12.54 m / s untukmendapatkantahapkelembapan optimum yang ditetapkan di antara 8% hingga 20% dengantahapkonsistenkelembapan yang tinggidanmasatahananrendah. Sampelbijirantelahdisifatkanmelaluipenghasilanpeletdengankaedahpemampatanoleh mesintekanpanasdengansuhu 120$^{0}$ C, 130$^{o}$ C dan 140$^{o}$ C manakalatekanan 5 MPa, 7.5 MPa 10 Mpadan 12.5 MPaselainmasatahanan 3, 4 dan 5 minit. 8% adalahtahapkelembapan optimum dankelajuan 7.40 m / s adalahkelajuan optimum panasserombongudara yang memberimasatahanan yang rendahdantahapkonsistenkelembapanselainkosrendahkepadapenggunaantenagaelektrik. Dengannilaikelajuanudaraserombongpanas yang optimum dalam proses pengeringan, tahap optimum danketekalankelembapandanmasatahananpadakelapauntukpengeluaranpeletbiomasbaru yang berfungsisebagaibahanapihijaudanpembakartelahdicapaidansecaratidaklangsungmen

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# DEDICATIONS

To my lovely parents, my brother and sister who give me encouragement to success in my studies and not to forget special thanks to my project supervisor and all lecturers and friends that give me guideline and support during my study in UTeM.

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# TABLE OF CONTENTS

# LIST OF FIGURES

# LIST OF TABLE

# LIST OF SYMBOLS AND ABBREVIATIONS

| | | |
|---|---|---|
| EFB | = | Empty Fruit Brunch |
| RE | = | Renewable Energy |
| $CO_2$ | = | Carbon Dioxide |
| OSD | = | Open Sun Drying |
| STD | = | Solar Tunnel Dryer |
| wt % | = | Weight Total Percentage |
| db | = | Dry Basis |
| wb | = | Wet Basis |
| MC | = | Moisture Content |
| OPF | = | Oil Palm Frond |
| PFI | = | Pellet Fuel Institute |
| V | = | Voltage |
| I | = | Current |
| P | = | Power |
| E | = | Energy Consumption |

# CHAPTER 1

# INTRODUCTION

## 1.0 Introduction

Energy has always been an essential element for the socio-economic development of a country and it has been investigated since the last three decades (Saidur et al., 2007). According to Eddrief-Cherfi and Kourbali (2012), the energy consumption and economic growth were related to each other based on the results of research conducted by Yu and Choi on the Philippines in the year of 1985. In Malaysia, the largest consumer of energy is the industrial sector with 48% followed by commercial (32%), residential (19%) and others (1%) (Saidur et al., 2007 and Islam et al., 2009).

## 1.1 Background

The renewable energy (RE) which is demanded nowadays is due to the issues of global climate change and depleting fossil fuels, especially oil and natural gas which is finite in extent. Malaysia has announced renewable energy as the fifth fuel under the Eighth Malaysian Plan 2001-2005 (Choo et al., 2005). The available renewable energy (RE) sources in Malaysia are solar, wind, hydropower and biomass (Islam et al., 2009).

The statistics from Malaysian Green Technology Corporation (PusatTenaga Malaysia) has shown that biomass is one of the important renewable sources of energy in Malaysia with 50% of the total energy consumption (Lim, 2012). For the world statistics, biomass has contributed 10% to 15% of the total energy consumption (Ratnasingam et al., 2015). The main biomass sources come from plantation and agricultural waste. Globally, agricultural waste per annum is estimated around 998 million tonnes and in Malaysia it is about 1.2 million (Tahir and Hamid, 2012).

In Malaysia, according to the equatorial climate of the nation, this plantation and agricultural wastage came from oil palm, rice husk, paddy straw, wood, sugarcane, rubber tree and tropical fruit such as banana, cacao, pineapples and coconut (Shafie et al., 2012 and Ratnasingam et al., 2015).Figure 1.1 shows the statistic data of biomass sources in Malaysia. The most sources of biomass are from oil palm (85.50%) followed by municipal solid waste (9.50%), wood industry (3.70%), rice (0.70%) and sugarcane (0.50%).

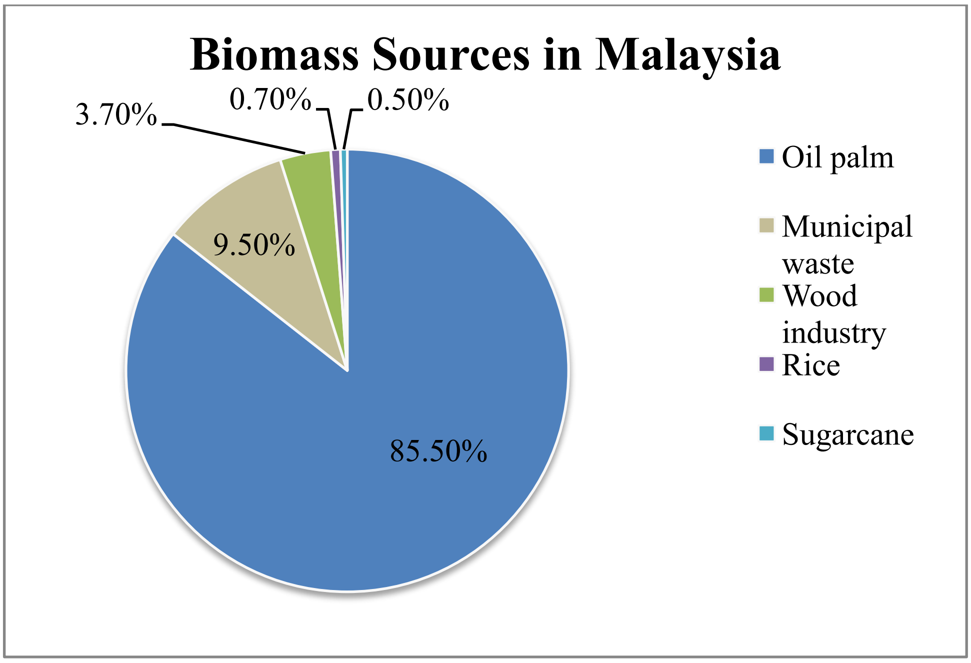


Figure 1.1:Biomass Sources in Malaysia

This biomass sources are used to produce energy. The total energy production produced from each source is dependable on the plantation area or wastage quantity. Commonly, different countries have different sizes and values of plantation area and wastage. Table 1.1 shows the quantity of biomass energy production for Malaysia from the wastage of oil palm, paddy rice husks, coconut husks, bagasse, logging residue and wood residue.

Table 1.1: Category of Biomass Production and Estimation of The Biomass Energy Productivity in Malaysia

| Crops / Activities | | Potential biomass energy production (PJ) |
|---|---|---|
| Oil Palm | Empty fruit bunches (EFB) | 92.95 |
| | Fruit fibres | 8.98 |
| | Palm shell | 66.47 |
| Paddy plant | Rice husks | 4.88 |
| Coconut tree | Coconut husks | 2.97 |
| Sugarcane | Bagasse | 1.47 |
| Logging | Logging residue | 42.92 |
| Wood industry | Wood residue | 59.17 |

The parts of coconut that can be used to produce biomass are its shell, husk and fronds (Shafie et al., 2012). Table 1.2 shows the coconut production and its potential value to be used as energy in the year of 2000-2009. From the table, it shows that the part that has the most potential to produce energy is husk. However, coconut is divided into two categories. They are old and young coconut. For old coconut type, the husk part is drier compared to young coconut which is full with moist. This abundant moist level does not fulfil the specification in producing biomass pellet with consistent optimal moisture. However, this issue can be faced by doing an extraction or a drying process by considering the parameters of grain size, speed and temperature.

Table 1.2: Coconut Production and The Potential Energy Generated from it during 2000–2009

| Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Coconut (Mt)** | 0.73 | 0.71 | 0.71 | 0.58 | 0.62 | 0.57 | 0.51 | 0.50 | 0.46 | 0.46 |
| **Husk (Mt)** | 0.27 | 0.26 | 0.26 | 0.21 | 0.23 | 0.21 | 0.19 | 0.18 | 0.17 | 0.17 |
| **Energy (PJ)** | 4.32 | 4.18 | 4.18 | 3.41 | 3.67 | 3.36 | 3.01 | 2.96 | 2.68 | 2.70 |
| **Shell (Mt)** | 0.12 | 0.11 | 0.11 | 0.93 | 1.00 | 0.91 | 0.82 | 0.81 | 0.73 | 0.74 |
| **Energy (PJ)** | 2.11 | 2.04 | 2.04 | 1.67 | 1.80 | 1.64 | 1.47 | 1.44 | 1.31 | 1.32 |
| **Empty bunches (Mt)** | 0.04 | 0.04 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 |
| **Energy (PJ)** | 0.55 | 0.54 | 0.54 | 0.44 | 0.47 | 0.43 | 0.39 | 0.38 | 0.34 | 0.35 |
| **Frond (Mt)** | 0.17 | 0.16 | 0.16 | 0.13 | 0.14 | 0.13 | 0.12 | 0.11 | 0.10 | 0.10 |
| **Energy (PJ)** | 2.64 | 2.56 | 2.56 | 2.09 | 2.25 | 2.06 | 1.85 | 1.81 | 1.64 | 1.66 |
| **Total energy (PJ)** | 9.62 | 9.32 | 9.32 | 7.60 | 8.17 | 7.48 | 6.72 | 6.60 | 6.00 | 6.02 |

Malacca, which is located in the south of Malaysia, is a popular state with its coconut shake business. The young coconuts are used in making this coconut shake. Due to the high demand from customers, the use of coconut is increased and this means that the quantity of waste from young coconut shells will also increase and contribute to the fulfilment of the landfill. This occurs because the waste is assumed useless since the content of moisture on coconut coir will not be able to produce source of biomass like old coconuts which have dry shells. This fulfilment landfill issue does not correlate with the vision of '*Melaka MajuNegerikuSayang*, *Negeri Bandar TeknologiHijau*'. This study is about the development of young coconut as a pellet for biomass sources by varying speed and retention time to obtain consistent moisture content.

## 1.2 Problem Statement

Nowadays, the energy demand has increased due to the social, economic and population development. Due to depletion of fossil fuel, the strategies to search variable renewable energy sources should be planned to stabilize this growth. The survey shows that young coconut waste which is known as agricultural waste is high due to its commercial usage in making coconut shake food products. This waste is one of the factors that contribute to landfill which has caused pollution issues. Therefore, it is reasonable to reuse this young coconut waste that it becomes something useful for supporting fuel sources such as producing a biomass pellet, similar to the one applied on old coconut waste. Pellets should have low moisture content and high bulk density to make them easier to transport and store. However, the characteristics of the young coconut coir waste which has high moisture content and is still attached to its shell compared to old coconut or copra will be the problem. This characteristic will cause the shredding process of young coconut waste coir into grains to be difficult besides being an obstruction in producing it as good pellets, which needs low moisture content to enable it to function as fuel. Thus, the drying method by hypothesizing the speed and retention time is one of the ways to produce biomass pellets with consistent optimal moisture and high quality.

## 1.3 Objective

The objectives of this experimental study are as follows:

a. To find the optimum moisture level of young coconut waste grain.
b. To achieve the optimum hot flue air speed in drying young coconut waste grain based on retention time and moisture level consistency.

## 1.4 Scope of Research

The scope of this experimental study embraces finding the optimum moisture level of young coconut waste grain by using a device of moisture meter, as well as achieving the optimum hot flue air speed in the drying process of young coconut grain waste based on retention time moisture level consistency, through the uses of the hair dryer with three variable speed controller and a fixed temperature value. This experimental study scope is important to enable the young coconut waste grain to be used in manufacturing quality biomass pellets which can function as a fuel.

# CHAPTER 2

## LITERATURE REVIEW

### 2.0 Introduction

This chapter will discuss mainly on the theory of drying method on biomass sources phase and parameter of moisture content and hot flue air speed that have been considered during drying process.

### 2.1 Biomass

Biomass is an organic material that comes from living organisms without contamination from others substances. This biomass resource comprises of forest and mill residue, agricultural crops and waste, wood and wood wastes, municipal solid waste, aquatic plants and algae, animals waste and waste from food processing (Ciubota-Rosie et al. 2008). The basic of biomass building block is caused by carbohydrates derived from the reaction between carbon dioxide ($CO_2$) in the air, water and sunlight, via photosynthesis process. There are several uses of biomass such as for energy and chemical feedstock application.

#### 2.1.1 The Uses of Biomass

The uses of biomass can be classified into three main products. Two out of three are related to energy that is used for power generation and transportation fuel such as generating electricity, heating homes, fuelling vehicles and providing process heat for industrial facilities while the other one as a chemical feedstock (Ciubota-Rosie et al. 2008). One of biomass form that used for energy applications is through biomass pellet product.

### 2.1.2 Biomass Pellet

Pellet is the most form produced from biomass waste sources such as oil palm, sugarcane, bagasse, husk and shell of coconut and others. It has been used to generate fuel for various applications and industry. This biomass pellet form has advantages in term of specific gravity, moisture content and economic (Mani et al., 2006). According to (Mani et al., 2006 and Afzal et al., 2010) this pellet form will increase the specific gravity to more than 100 $kg/m^3$ besides containing low and uniform moisture content which constitutes the required characteristics for quality biomass that is useful in generating fuel or electricity. In addition, the pellet form also makes it easy and safe to be handled or stored using well developed handling systems for grains (Mani et al., 2006). However, this pelletization biomass production requires a proper process which is drying, size reduction, densifying, cooling, screening, and warehousing to ensure its quality in the specific range and standard. This experimental study focuses on drying process, the method of drying is outlined in next subtopic 2.2.

## 2.2 Method of Drying

Dryingis an important process in producing the residue waste as a biomass product. It reduces moisture content of biomass in order to be effectively functional as required. There are several methods of drying like by open sun drying (OSD), solar tunnel dryer (STD) and rotary drum dryer.

### 2.2.1 Open Sun Drying

Open sun drying (OSD) is a traditional method that uses sunlight directly in the drying process and it has low operating cost. However, this process needs a skilful worker to conduct it. It is also exposed to contamination from various sources such as insects, birds, rain, dust and others that will damage the structure of residues. In addition, it is a slow or intermittent drying process and needs a large space