

ENHANCING THE EFFICIENCY PROCESS FOR SEPARATION  
OF DRY SHELL AND PALM KERNEL

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ENHANCING THE EFFICIENCY PROCESS FOR SEPARATION OF DRY  
SHELL AND PALM KERNEL

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the requirements for the award of the degree of  
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I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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*To my beloved parent, families, and friends,  
who gave me everlasting inspiration,  
never ending encouragements and  
priceless support towards  
the success of this research.*

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# ENHANCING THE EFFICIENCY PROCESS FOR SEPARATION OF DRY SHELL AND PALM KERNEL

## ABSTRACT

Palm kernel is one of the products from palm oil mills. In kernel recovery plant, the separation of kernel and shell from cracked mixture is carried out using a combination of dry and wet separation. The objective of this study were to enhance the efficiency process for separation of dry shell an palm kernel as well as to maximizing the recovery of dry kernel and shell based on the installation of four stage winnowing column. This user friendly and compact separation device uses forced draught principle instead of the usual induced draught. The air flow velocity in each separating column can be adjust via the blower (damper) located at the ground or an elevated level. The effect of velocity and fan air speed in activity of separation must take in consideration. The parameter that has been monitored during the trials was dirt & shell content in production kernel, kernel losses and effect of velocity on efficiency of separation. The system was also equipped with a unit of a small vibro clay bath to minimize the kernel losses by recovering the very fine kernel pieces generated from the screw press. The system was capable separate drier kernel shell. The total kernel loss from dry and wet separation also could be minimized. This four stage winnowing system also reduces the waste effluent from the mill promoting more environmental friendly technology for the oil palm industry.



# MENINGKATKAN KECEKAPAN PROSES UNTUK PENGASINGAN SHELL KERING DAN ISIRONG SAWIT

## ABSTRAK

Kernel sawit adalah salah satu produk yang dihasilkan dari kilang sawit. Dalam sistem kernel, pemisahan kernel dan shell dari campuran yang telah retak dijalankan menggunakan gabungan pemisahan kering dan basah. Objektif kajian ini adalah untuk meningkatkan kecekapan proses untuk pemisahan shell kering sawit dan memaksimumkan pemulihan kernel kering dan shell berdasarkan 4 stage winnowing column. Penggunaan peranti pemisahan mesra alam dan padat ini, menggunakan draf prinsip. Halaju aliran udara dalam setiap kolum memisahkan boleh menyesuaikan diri melalui blower (peredam) yang terletak di tanah atau tahap yang tinggi. Kesan halaju dan kelajuan kipas udara dalam aktiviti pemisahan perlu mengambil dalam pertimbangan. Parameter yang telah dipantau semasa ujian adalah kotoran & shell kandungan dalam kernel pengeluaran, isirong dan kesan halajup ada kecekapan pemisahan. Sistem ini juga dilengkapi dengan satu unit mandi tanah liat kecil Vibro untuk meminimumkan kerugian kernel dengan memulihkan kepingan kernel yang sangat halus yang dihasilkan daripada penekan skru. Sistem itu mampu kering berasingan kernel shell. Kerugian kernel jumlah dari pemisahan kering dan basah juga boleh dikurangkan. Inijelasnya peringkat empat system juga mengurangkan sisa efluen dari kilang menggalakkan lebih teknologi mesra alam untuk industry minyak sawit.

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## LIST OF SYMBOLS

$\%$	Percent
$g$	Gramme
$kg/h$	kilogramme per hour
$^{\circ}C$	Degree celcius
$SG$	specific gravity
$kW$	<i>kilowatt</i>

## **LIST OF ABBREVIATIONS**

FFB	Fresh fruit bunch
Wt	Weight
CPO	Crude palm oil
POME	Palm Oil Mill Effluent
EFB	Empty fruit bunch
pH	Potential hydrogen
RPM	Rotation per minutes



## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Introduction**

Malaysian palm oil industry has developed tremendously and continues to be one of the major contributors for the socio-economic development of the country. Being amongst the world's largest palm oil producers, the industry continues to grow to meet the high global demands for oils and fats. In 2008, Malaysia processed 88.53 million tonnes of fresh fruit bunch (FFB) and produced 17.73 million tonnes of crude palm oil. Besides that, the industry also produced 4.58 and 2.13 million tonnes of palm kernel and palm kernel oil respectively. (Wikipedia)

Palm kernel which constitutes about 5-7% in fresh fruit bunch (FFB), is a secondary product from palm oil mills. It is obtained from palm fruitlet after the removal of mesocarp fibre and shell. The production of palm kernel starts with the cracking of palm nuts using palm nut cracker followed by with the separation of shell

and kernel in the cracked mixture using a combination of dry and wet separation. In a typical kernel recovery plant, two units of winnowing columns operated based on the dry separation principle. They were used to remove the low tension dust particles, broken kernel and other particles of the cracked mixture. The heavier mixture of shell and kernel is then subjected to wet separation using either clay bath or hydrocyclone. Basically, the separation ratio (weight basis) of dry to wet separation 20:80 based on the total cracked mixture fed into the kernel recovery plant. (Rohaya et al 2004)

The commercial dry separation systems uses either forced or induced draught. The wet separation process of cracked mixture is based on the difference between the specific gravity of shell and kernel. The wet technique either through hydrocyclone or claybath is considered less environmentally friendly as it requires a large volume of water and clay which contribute towards a high production volume of waste effluent. Through this conventional process, kernel is produced and collected in a wet condition and requires drying operation prior to stage.

In order to enhance the recovery of dry shell and kernel in palm oil mills. We need to develop an improved dry separation system via a four stage winnowing column (MPOB, et al 2004).

## 1.2 Problem Statement

The knowledge and capability to understand the principle of velocity and draught forced is become important role in order to separate the kernel and shell. A suction fan will provide the air velocity required to lift the fibers and transport it to the fiber cyclone. Since the conventional system lack in efficiency of product, therefore new technique is required to improve the conventional method.

Based on the commercial performance evaluation of the system in certain palm oil mills show that, the amount of cracked mixture for wet separation is about 60-80 percent. This shows that the system is ineffective based on separation technique. More likely, it will generates less dry shells for fuels and for making activated carbon. This will make the operational cost is highly. On the operational cost, the system is capable of minimizing the clay and water consumption by the conventional system to a minimum. Also, palm oil mill wastewater treatment systems are one of the major sources of greenhouse gases in Malaysia due to their biogas emission (36 % CH<sub>4</sub> with a flow rate of 5.4 l/min.m<sup>2</sup>) from open digester tanks and/or anaerobic ponds (Yacob *et al.*, 2005). Therefore, palm oil mills in Malaysia face the challenge of balancing environmental protection, their economic viability, and sustainable development after the Department of Environment enforced the regulation for the discharge of effluent from the crude palm oil (CPO) industry, under the Environmental Quality order and regulations, 1997. Thus, there is an urgent need to find an efficient and practical approach to preserve the environment while maintaining the sustainability of the economy.

### **1.3 Objectives**

The purpose of the research is

- To maximizing the recovery of dry kernel and shell via a four-winnowing column.
- To study the effect of velocity and fan air speed damper in activity of separation.
- To compare the conventional separation method with new separation technique.

### **1.4 Scope of the research work**

To achieve the objective, scopes have been identified in this research. The scopes of this research are listed as below:-

- Identification of problem in separation of palm kernel and dry shell
- Identification of the right equipment for separation process
- Study the winnowing column in order to enhance the separation
- Consider the air velocity, fan speed on 4 winnowing column.

The range for air speed is between 2500 to 2950 rpm.

## **1.5 Rationale and significance of study**

- i. The best velocity is required to get minimum kernel losses and increase the efficiency of the method.
- ii. Accurate design of separation unit for recovery plant can help minimize the operating cost, low maintenance cost, and reduction in kernel losses.
- iii. The range of kernel losses with the month is between 0.9-2.1 percent.
- iv. The accurate design of separation process can boost the production of oil, hence eventually can help reducing the effect to the environment.

At the same time, the separation process can improved the kernel quality of the palm shell in which is can reduced the dirt content in kernel.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 The Palm Oil**

The oil palm, was first introduced into Malaysia in 1870, through the Botanic Gardens in Singapore. The oil palm industry was introduced to Malaysia in 1917 . The real impetus for the large scale plating of oil palm came about with the government's policy on crop diversification in 1960. As a result of the diversification and modernization strategy implemented through the various agencies, the composition of crops has undergone a shift from rubber to oil palm. By 1970, the hectare under oil palm increase to over a quarter million hectares reaching the 1 million mark ten years later in 1980. By early 1990's the area under oil palm in Malaysia exceeded 2 million hectares an expected to reach 3 million hectares by the end of this century. The growth of oil palm areas is shown in Table 1. (Elaeisgineensis Jacquin, 1990)

The increase in hectare led to a corresponding increase number of oil palm mills and production of crude palm oil. The palm oil industry is primarily export-oriented. Currently, there are 326 oil palm mills in Malaysia with a total production more than 8.32 million tonnes per years (Aon, 2000). In 1974 oil palm industry enter a new phase on its development with the establishment of the first palm oil refineries. Currently, there are 45 palm oil refineries in Malaysia with a total capacity of 12.73 million tonnes crude palm oil per years. Further downstream of the oil palm industry took place in 1982 when the first oleochemical plant was set up in this country and currently there are 13 oleochemical plants ae in operation. Malaysia ranked as the world's largest producer and exporter of palm oil. (Yusof and Ariffin, 1996).

There is no denying that the industry has an impact on the environment. The oil palm industry as a whole generates a number of by-products and residues. It could be expected to occur both upstream in relation to the cultivation of the crops ad also in the downstream processing activities.

The main residues from the milling of the fruit bunches are the mesocarpfibre, shell, palm kernel cake, boiler ash, empty fruit bunches, palm oil mill effluent (POME) and bunch ash. These by products are obtained at different stages of the milling process. The mesocarp fiber and shell are but as fuel in the boiler to produce steam and electricity for various mill processes.(MPOB, 2004)

Table 2.1: Area of oil palm plantation in Malaysia

Year	Hectares	% Change
1871-1910s	<350	-
1920	400	-
1930	20600	-
1940	31400	-
1950	38800	-
1960	54638	0.0
1970	261199	169.4
1980	1023000	59.4
1990	2029464	36.9
1995	2540087	25.2
1996	2692286	6.0
1997	2819316	4.7
1998	30778116	9.2

*Source: Statistics of Commodities, Ministry of Primary Industries*

Based to the mature hectares in 1997 at 2,455 million hectares and in year 2000 at 2,813 million hectares, the amount of dry matter based on the fresh weight obtained(Chan et al 1981) for EFB, Fiber, shell and POME are shown in Table 2.

Table 2.2: The amount of by-product from palm oil mills

Year	Location	By- products in million t/year			
		EFB	Fibre	Shell	POME
1997	Penisular	7.823	4.797	1.947	23.806
	Sabah and Sarawak	3.028	1.856	0.754	9.213
2000		10.851	6.653	2.701	33.019
	Penisular	8.288	5.081	2.062	25.219
	Sabah & Sarawak	4.146	2.542	1.032	12.616
		12.434	7.623	3.094	37.835

Source: Chan, 2000



The palm oil mill generally has excess fiber and shell which are not used and to be dispose of separately otherwise contribute to environmental pollution.

## **2.2 Palm Kernel Shell**

Palm kernel shell that we are referring is palm kernel from oil palm fruit. As showed in the image, every oil palm fruit is consists of oil palm nut, and mesocarp (the meat). In palm oil industry, the crash shell without nut is referring to palm kernel shell.

At crude palm oil process, after the Cyclone Separation process, mesocarp fibre and oil palm nut will be separated. The oil palm nut will go through nut drying process and then later for nut cracking. Kernel will be separated for kernel oil process and the nut shell will become the palm kernel shell. Palm kernel shell will be pile up and store at open space.

Palm kernel shell can be considered as pellet form because of its nature form, due to its high grade solid, low ash and low sulphur content, palm kernel shell has been used as a burner for power plant. One of the most favorable use of palm kernel shell is to process become charcoal.

Furthermore, the burned palm kernel shell charcoal has other economy value too. Palm kernel shell charcoal has also been used as activated carbon for water purification, promote organic farming, and also an active agent for soil improvement. Apart, we also read some articles that researcher already study to include palm kernel

shell as a coarse aggregate in road binder courses with emphasis on strength of the asphalt concrete.

In short, researchers have put in afford to develop application for palm kernel shell, and we believe palm kernel shell be much more valuable from biomass aspect (HCT Company, 2009)

### **2.3 Application of Palm Kernel Shell**

Palm kernel shell has become one of the valuable commodities in palm oil industry, many usages or application has been developed. Due to high calorific value of palm kernel shell, this commodity has been one of the key biomass material in order to replace fossil fuel for steam power plant, however due to more and more study conducted, it value has been elevated. Carbonize Palm Kernel Shell can be used as charcoal which can be pressed into bio-fuel briquette, these form of charcoal could be directly sell to consumer such for BBQ or family use. We also seeing part of the carbonize Palm Kernel Shell also being processed into activated carbon which use in liquid and gaseous phase filtration or adsorption. More advance study has carried out at university, the research reveal the advantage on palm kernel shell as partial replacement for coarse aggregate in asphalt concrete.

### 2.3.1 Charcoal

Charcoal is a very useful item but many people usually take it for granted. They know that it is used in barbecue cooking and other broiled food, but more often they do not realize that it has countless other uses, especially in industry. All species of wood can provide charcoal that suitable for general use such as fuel for homes and industry (Anon, 1957). Charcoal is also an important commodity for the reduction of steel, production of carbide and activated carbon in Malaysia.

### 2.4 Chemical Composition for Palm Kernel Shell

Palm kernel shell can be considered as pellet form because of its nature form, due to its high grade solid, high calorific value, low ash and low sulfur content. From biomass aspect, the calorific value 20100kJ/kg and solid form has become one of the most favorable biomass media. It always mixes with EFB fiber in certain ratio to burn in the biomass boiler. (MPOB,2004)

Table 2.3: Property and value of palm kernel shell

Property	Value
Moisture %	13
Caloric	20100kJ/kg
Sulphur	0.09
Ash %	3

## 2.5 Depreciating or nut/fiber separation

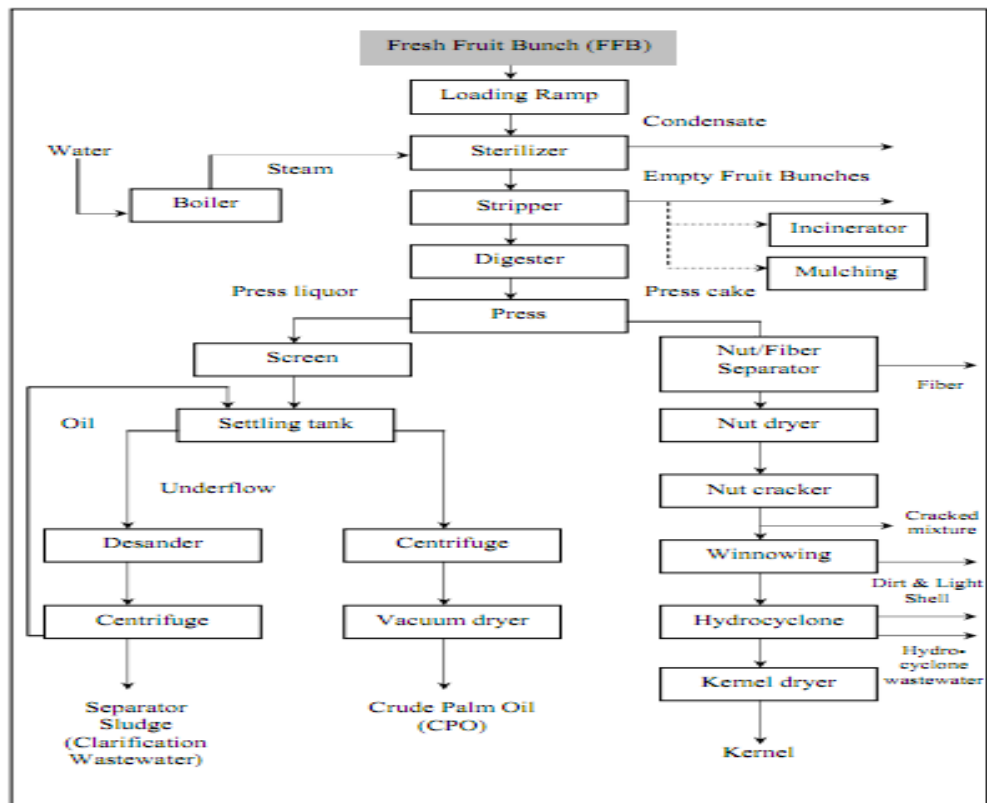


Figure 2.1: Process for separating kernels and shells

The matte or press cake discharged from the screw press consists mainly of moist oily fibres and nuts and fibre mixture is conveyed to the deprecicarper. The covenyer normally used is fitted with paddles and these paddles help to break-up the press cake as it is transported to the deprecicarper. (This conveyor is often referred to as the cake breaker conveyor). The depericarper consists basically of a vertical duct connected at its top to a powerful suction fan and the discharge from this fan is led to a cyclone. The bottom of the duct discharges into a rotating drum. The broken-up press cake is fed into the duct near to its top and the fibres being lighter than the nuts are carried up-wards by the air current and discharged at the lower outlet of the cyclone. These fibers are used as biler fuel. The nuts being heavier than the fibres

drop down the duct into the rotating drum where any remaining fibres are removed from the nuts (MPOB et al 2004)

## **2.6 Nuts drying and cracking**

The nuts from the depericarper are conveyed to nut drying silo where they are held for 16 to 24 hours depending on whether any heat is applied to the silo. In some mills hot air is blown into the mass of nuts being dried and then the smaller retention time is sufficient to “dry” the nuts. The main aim of drying or conditioning of the nuts is to shrink the kernel away from the shell thus assisting the breaking of the shell with the minimal damage to the kernel.

After drying the nuts are cracked by centrifugal force. In this type of nut cracker the nuts are forced into a high speed rotor which throws the nuts against surrounding cracking ring. The material leaving the cracker i.e kernels, pieces of shell and free uncracked nuts, is referred to as ‘cracked mixture’.(Rohaya et al 2004)

## **2.7 Separation of kernels and shell**

Hydrocyclone are mainly used for separating the cracked mixture and basically a hydrocyclone separator consists of two tanks, each with suitable pumps, and two cyclones. Due to the difference in specific gravity between kernels and shell

under the storage centrifugal action within the cyclones heavier particles are forced outwards and downwards whilst the lighter particles are held in the vortex and move inwards and upwards. The first cyclone separates the kernels from the first cyclone, i.e. shell plus a little kernels, is sent to the second cyclone from which the shell is sent to the boiler house as fuel. By suitable screening the shell discharged from the second cyclone and any uncracked nuts are separated and returned to the system for further treatment (currently there is trend for mills to revert to the old system of using clay bath with air separation or winnowing for separating the cracked mixture).(MPOB, et al 2004)

## **2.8 Winnowing column**

The invention relates to a specially designed winnowing system to improve the present separation efficiency of the cracked mixture at the kernel recovery plant. A dry separation system is used to separate a mixture of kernels and shells (cracked mixture) derived from the oil palm nuts after cracking. (Rohaya et al 2004)

The dry separation system consists of a series of equipment: a four-stage winnowing column, a cyclone, a blower fan and air lock. Each column was designed with different parameters (e.g. air velocity, fan speed, column height, inlet and outlet levels, feeding ratio, etc.) in order to achieve the desired shell and kernel ratio separation at each outlet point. The four-stage winnowing column uses forced draught principle instead of induced draught and the air flow velocity is adjusted via the blower (damper) located at ground or an elevated level. Each column is operated

by a 25 HP forced draught fan. This approach simplifies the process and ensures ease of control, as well as possesses the ability of eliminating the effluent generated from the wet separation. (Hur Far Engineering et al 2006)

The system is also equipped with a unit of a small vibro clay bath to minimize the kernel losses by recovering the very fine kernel pieces. The presence of this mini claybath depends on the mill's requirement and the capability of the mill to recover the broken kernels generated from the screw press. However, most of the broken kernels can be recovered through mesh plate scree which was placed surrounding the polishing drum. It was found that about 10-15 kg of broken kernel can be collected hourly and conveyed directly to the kernel silo. The removal of small stone can be done by pacing of 4 pieces of mesh plate screen also at the polishing drum. Therefore, it is not necessary for the mini clay bath to be installed because the separation of kernel and shell can be carried out using completely dry separation. (MPOB, et al 2006)





## **2.9 Wet separation**

The two popular wet separation systems popular in Malaysia are

- Hydro-clay bath
- Hydro-cyclone

### **2.9.1 Hydro-clay bath separation**

This is very ancient system of separation using the principle of density difference of fractions in a mixture for separation and usually gives good results as far as separation is concerned. The present day systems for clay-bath separation use continuous separation equipment. The cracked mixture is fed into a conical tank containing the clay-bath. The level of the bath is maintained by bending the underflow discharge pipe upwards to the required level followed by another downward bend to discharge it into a perforated rotary drum for collection

The specific gravity of the bath is the key factor in determining separation efficiency in hydro-bath separation systems. For kernel-shell separation the specific gravity of the bath is maintained between 1.16 -1.20. If nuts are found to escape in shell a second hydro-bath separator can be set up with higher specific gravity to separate nuts for eventual recycling. As the investment cost for a hydro-bath separator is in the vicinity of RM 25000 the mills having high loss of nuts in wet should evaluate the economic viability of installing one unit of hydro-bath separator irrespective of what the first stage separator is( viz : hydro-bath or hydro-cyclone).

In hydro-bath the kernels will float and over-flow into an annular space at the outer edge of the cone, from where they are discharged into perforated rotary washing drum for collection. Both the shell and kernel washing drums are situated side by side. After de-watering the separated fractions are transported to their respective destinations. The washing liquid also joins the clay bath stream and is collected in the bottom slurry tank. Specific gravity corrections are made from time to time by adding kaolin or suitable salts like calcium carbonate. If kernel loss in shell is high the specific gravity of the bath has to be increased to enable the kernel to float. Likewise if the shell in kernel is high the specific gravity of the bath is in excess and water dilution is necessary. Periodic drainage of the slurry tank is necessary to remove accumulated sand and other contaminants. The clay being mildly acidic, addition of alkaline solution like sodium hydroxide or soda ash would raise the pH level to favorable alkaline range (Ir. N.Ravi Menon, PORIM et al 2004)

### **2.9.2 Hydro-cyclone**

The first hydro-cyclone was patented in 1891 but failed to make any impact in the industry till after the Second World War. It started off in mineral processing and mining industry followed later by chemical industry, power generation, petrochemicals, textile industry, metal working industry as well as a host of other industry. Hydro-cyclones have wide applications and varying configurations for different applications but the separation principle remains the same.

Hydro-cyclone operation is complicated and a number of research works is in progress to find out more about them. By no means is their operation completely

understood due to lack of methods to investigate the behavior of individual parameters which influence its performance. The separation efficiency of a cyclone is proportional to pressure drop within the cyclone up to a point after which the returns are negligible.

Hydro-cyclones used in palm oil mills do not have adjustable orifices, which is a distinct set back as the mills are unable to optimize the right size orifice that can give the best results based on the characteristics of the cracked mixture peculiar to the mill (B. Yusof, D. Arifin, A.N. Ma & K.W. Chan, et al 2005)

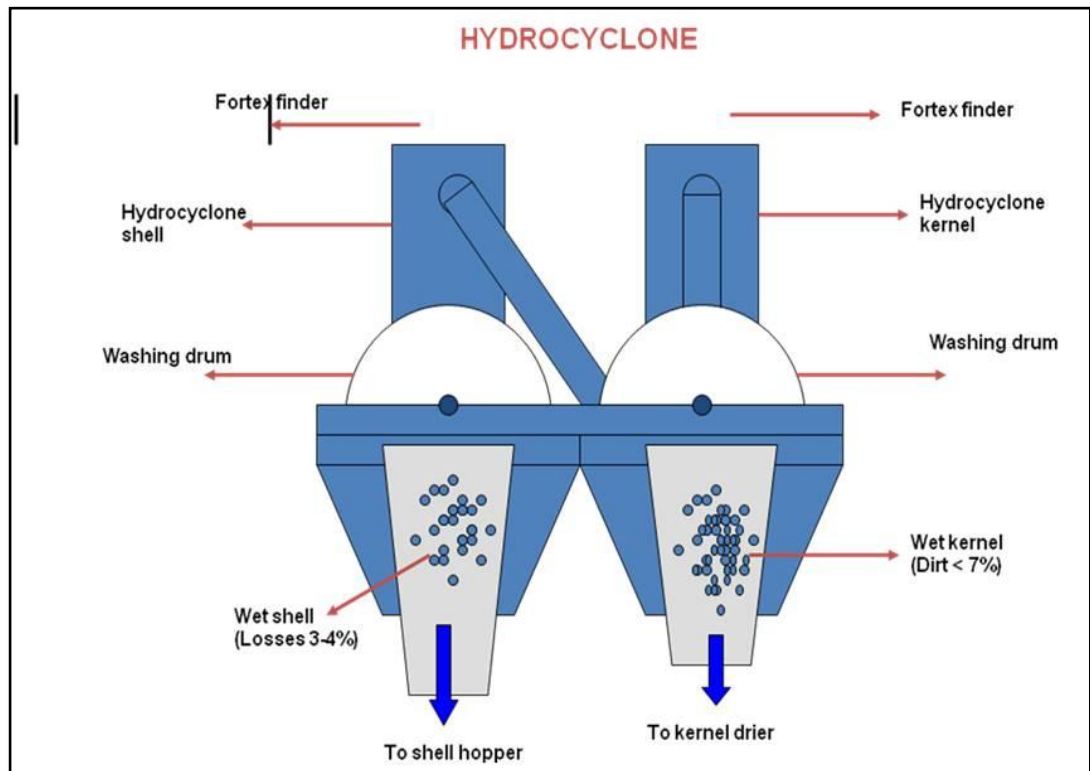


Figure 2.3: Process diagram in hydrocyclone

## **2.10 Dry separation**

Dry separation methods include systems exploiting the winnowing principle followed by handpicking, reciprocating inclined plane, vibrating and reciprocating screens, rotating screens, indented cylinders, and pneumatic conveying in a vertical tunnel (O. A. Koya, 2006). The traditional hand picking method gives a high separation efficiency but it is time consuming, tedious, and of very low capacity of about  $60 \text{ kg h}^{-1}$  (Akubuo & Eje, 2002). Efficiencies reported in respect of other mechanical systems need considerable improvements (Hartley, 1977; Akubuo & Eje, 2002; Badmus, 1991; Olie & Tjeng, 1974). Aerodynamic forces required in pneumatic systems are quite unstable and uneven because the densities of kernel and shell are close, while the shell particles also have irregular shapes and are of varied sizes. Generally, shell particles and kernels having comparable sizes make screening and other proprietary devices inefficient.

## **2.11 Advantages of winnowing**

- Electricity requirement
- High recovery of dry shell
- Compact and tailor (MPOB et al 2004)

### **2.11.1 Electricity requirement**

The use of 4 stage winnowing column could reduce the power consumption in the kernel station. The 4 stage winnowing column with mini clay bath requires about 163 kW compared to 203 kW needed for a conventional system of shell and kernel separation. This 40 kW saving helps the palm oil mills to reduce power consumption and eliminates the use of hydrocyclone.

### **2.11.2 High recovery of dry shell**

Another significant advantage of the system is the production of more dry shell as a boiler fuel. Besides using as fuel for mill boiler, the shell could be sold to nearby industries in lower price. This dry shell is clay free thus preventing clinker formation in the boiler.

### **2.11.3 Compact and tailor**

The system was compactly designed and requires small space for the installation or retrofitting in the existing mills. The design is flexible and could be tailor-made to suit the need of the mill. For a complete system, it offers additional features to be integrated into the system in order to enhance efficiency such as installation of gravel (chipped stone) removal system and broken kernel recovery winnower at the polishing drum.

## **CHAPTER 3**

### **METHODOLOGY**

#### **3.1 Introduction**

The separation system comprises a feed inlet with an airlock that admits the cracked mixture into the separating column (velocity box) where it is subjected to an air flow caused by a forced draught fan. The air velocity (based on rpm value at each column) is varied using an adjustable flap, located at the bottom of separating column until only clean kernel descends through the discharge chute. This process is repeated in stage 2 but with progressively settings to ensure only clean shell exit through the shell discharged. However, stage 3 and 4 will be biased for clean shell exit through the shell discharge chute. Kernel shell mixture will discharge into the third stage and the final stage will discharge some kernel fragments and shell through the kernel chute into a small hydro clay bath separator (5HP motor) so that the smallest fragments of kernel can be recovered.

The parameters that have been identified during the trials were effect of velocity on separation, dirt & shell content in production kernel and kernel losses

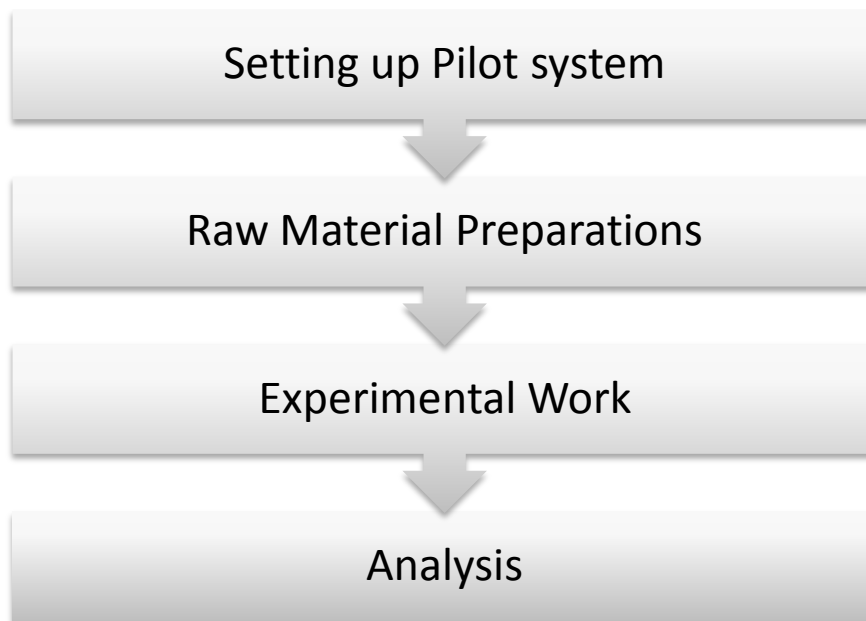


Figure 3.1: Main Methodology Flow Chart

### 3.2 Setting up pilot system



Figure 3.2: Setting up pilot system

The press cake discharged from the screw press consists of moisture, oily fiber and nuts (including broken one and kernels), and these are conveyed to a depericarper for the nut and fiber separation. The conveyor is fitted with paddles which breakup the press cake on the way to the depericarper. The fiber and nuts are separated by a strong air current induced by a suction fan. The fiber is sent to the boiler house and is used as boiler fuel. The nuts are sent to a rotating drum where any remaining fiber is removed before they are sent to a nut cracker. (M.H Rohaya, et al 2004).

Nuts coming from the nut fibre separator are usually still warm, and large number may have the kernels sticking to the shell. Cracking of the nut at this stage, by the conventional centrifugal-type nut-cracker, will result in the splitting of the nuts and any kernels sticking to the broken shell will be lost. Thus, cooling of the nuts to loosen the kernels before cracking will result in better cracking efficiency and



kernel recovery. Moreover, warm nuts are more difficult to crack as the shells are more elastic.

The methods employed to separate the kernels and shells are based on the difference in specific gravity (SG) between the kernels and shells. Undried kernels and shells have a SG of about 1.07 and 1.15-1.25, respectively. Thus, a separation medium consisting of clay suspension or salt solution with a SG of 1.12 will effectively separate the kernels and shells. The choice of which depends on the availability, costs and maintenance of the materials and equipment. Presently, the most popular separator is the hydrocyclone which is much easier to operate and maintain. (MPOB, 2004)

### **3.3 Experimental material**

Sample of kernel and shell was collected from Felda Seriting Hilir Palm Oil Mill, Negeri Sembilan from every column. Sample from every column is collected at every 1000 g of sample.



### 3.4 Experimental work

The air flow velocity in each separating column can be adjusted via the blower (damper) located at the ground or an elevated level. Each column is operated by a 25HP forced draught fan. During the project, there 4 types of winnowing column need to be considered. Every single winnowing column has differed in velocity and air speed damper. Product for every column is taken and the speed is measure.

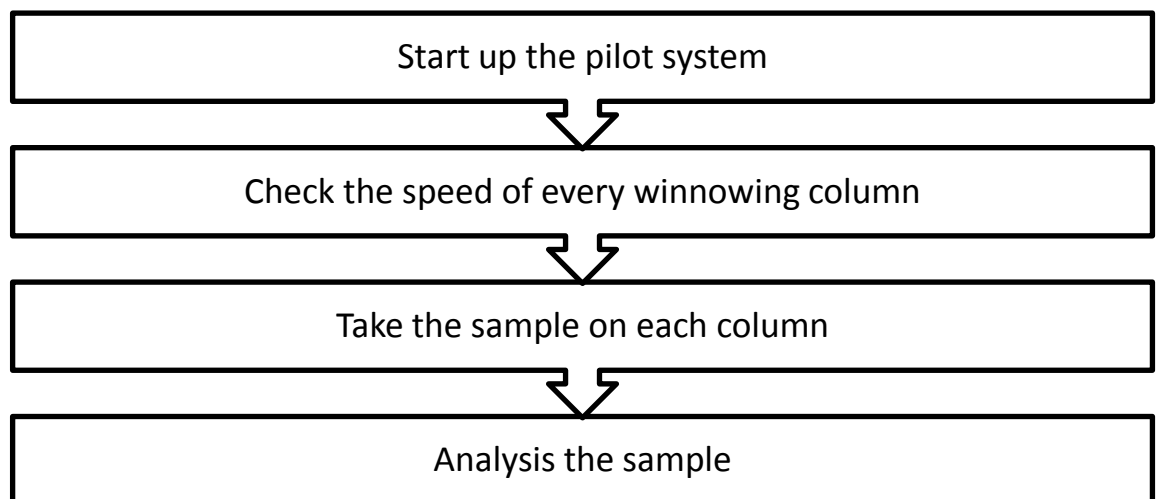


Figure 3.3: Flow diagram of experimental work



Figure 3.4: Damper to adjust the flowrate



Figure 3.5: 4 stage winnowing column



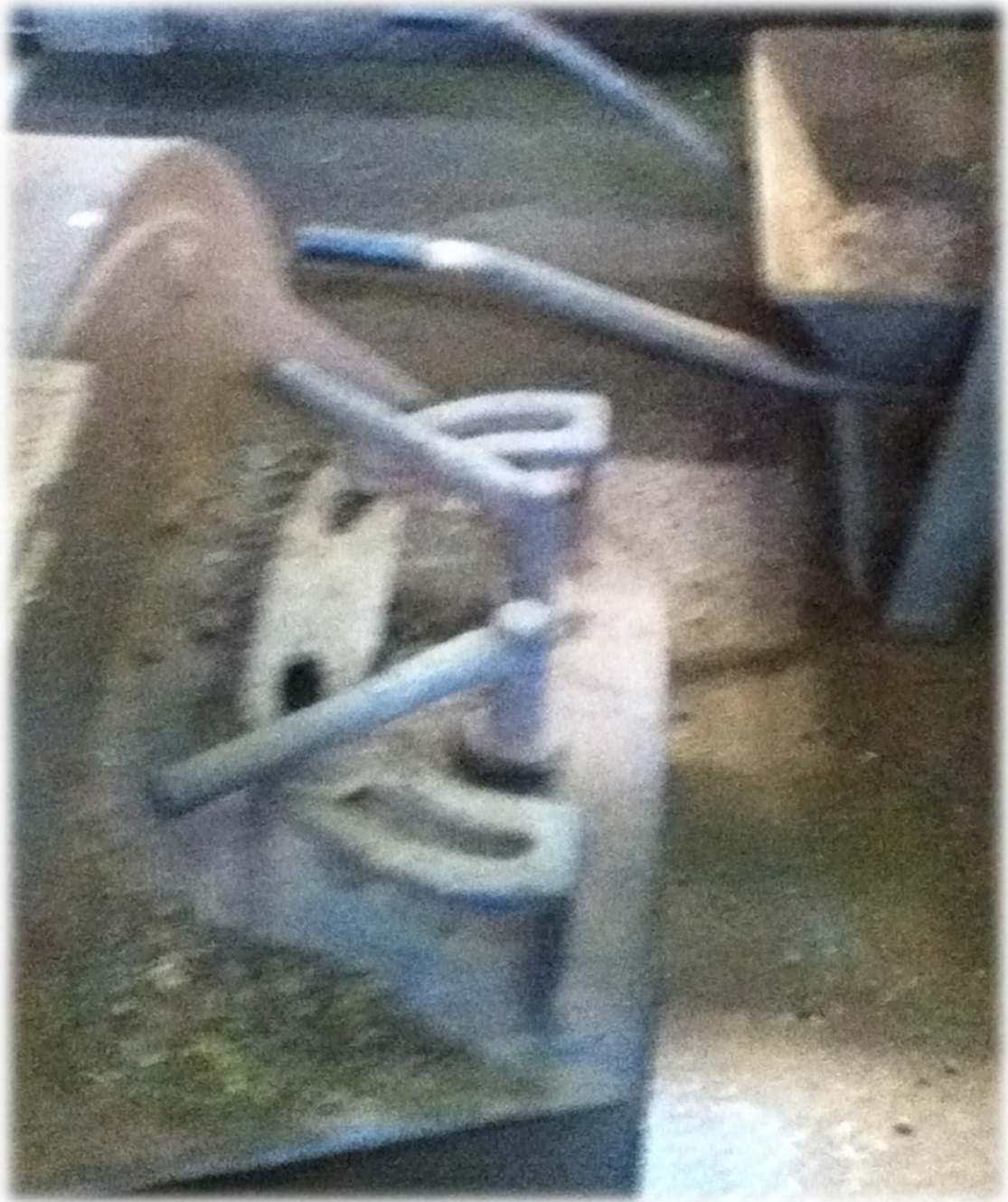


Figure 3.6: Airlock to control the flow of air



Figure 3.7: Production of kernel and shell

### 3.5 Analysis

Sample is collected from every column. Calculation on kernel losses and dirt and shell content is determined to know the efficiency of winnowing column.

#### 3.5.1 Determination of Shell and Dirt (Total Dirt) in Palm kernels

1.0 kg of the kernel sample is weighted and spread on the clean surface. The sample is separated kernel, half cracked, uncracked nut, loose shell and dirt. The shell is removed from the half cracked and uncracked nuts and added to the losses shell and dirt. The shell and dirt is weight together to the nearest 0.5 g.

Formula in calculating dirt in palm kernel:-

$$\% (h) = \frac{A}{B} \times 100$$

Where A= weight of shell and dirt in sample

B= weight of sample taken for analysis



Figure 3.8: weighing the sample on analytical balance

#### 3.5.2 Determination percentage of kernel losses in shell



- i. From a sample of 1000 grams of shell, the kernel is removed, by hand
- ii. If there any half cracked or uncracked nuts present, then the kernels in these nuts must be taken out of the shell first.
- iii. The percentage of kernel particles is determined by the weight of initial sample of the shell which is 1000 g.

Calculation:

$$\frac{\text{weight of kernels only}}{\text{total sample weight}} \times 100 \%$$

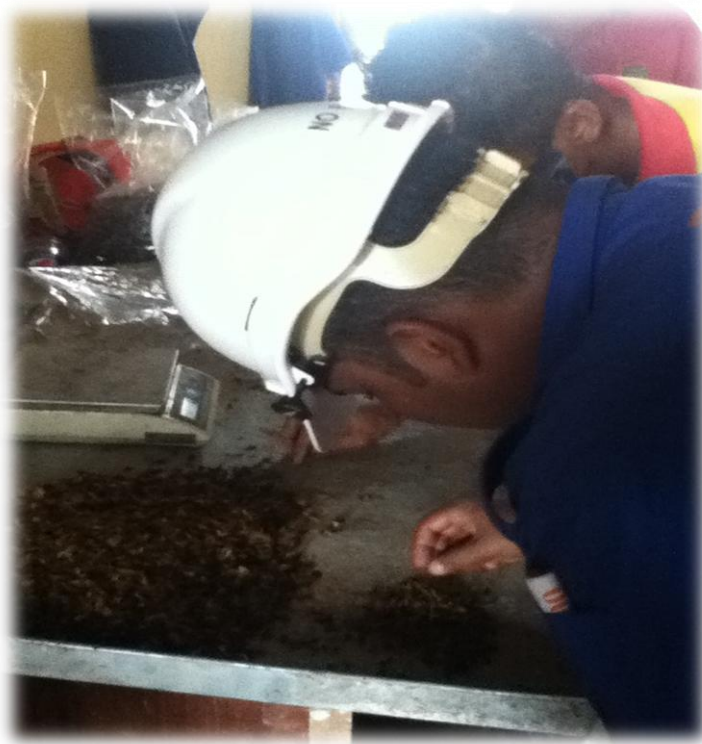


Figure 3.9: Separation of kernel from shell by hand



## CHAPTER 4

### RESULTS AND DISCUSSION

#### 4.1 Introduction

This chapter discuss based on data from the experimental work that had been carried out. The result is described in the analysis of the percentage of kernel and shell losses in a mill based on 4 stage winnowing column. In this research, the parameter that involved is the effect of velocity on separation, kernel losses in a shell, and dirt and shell in a kernel.



Big whole kernel from column 1



Whole and broken kernel from column

2



Small shells and small broken kernel  
from column 3



Big shell and small broken kernel  
from column 4

Figure 4.1: dry kernel and shell from winnowing column

## 4.2 Effect of velocity

Separation of kernel and shell is based on rpm

### 4.2.1 (a) Result on stage 1

Table 4.1: Stage 1 (Big whole kernel)		
Velocity (rpm)	Dirt and shell (g)	% dirt and shell in kernel
2900	18	1.8
2920	24	2.4
2950	25	2.5

### 4.2.1(b) Discussion

Based on the result obtained, the percentage of dirt and shell in first stage of winnowing column increase with the increasing of the velocity. At 2900 rpm, the percentage of dirt and shell in kernel is the lowest. This shows that, the efficiency of separation is enhanced at that speed

#### **4.2.2(a) Result on stage 2**

Table 4.2: Stage 2 (whole and broken kernel)

Velocity (rpm)	Dirt and shell (g)	% dirt and shell in kernel
2720	18	1.8
2740	23	2.3
2770	24	2.4

#### **4.2.2( b) Discussion**

Based on the result obtained, the percentage of dirt and shell in second stage of winnowing column increase with the increasing of the velocity. At 2720 rpm, the percentage of dirt and shell in kernel is the lowest. Faster the speed, the rate of losses is higher. This shows that, the efficiency of separation is enhanced at that speed.

#### **4.2.3(a) Result on column 3**

Table 4.3: Stage 3 (small shells and small broken kernel)

Velocity (rpm)	Kernel losses (g)	% kernel losses
2500	35	3.5
2530	27	2.7
2550	45	4.5

#### **4.2.3(b) Discussion**

Based on the result obtained, the percentage of kernel losses is the lowest at 2530 rpm while at 2550 rpm is the highest. The efficiency at 2530 rpm

#### **4.2.4(a) Result on column 4**

Table 4.4: Stage 4 (big shell and small broken kernel)		
Velocity (rpm)	Kernel losses (g)	% kernel losses
2500	35	3.5
2530	27	2.7
2550	45	4.5

#### **4.2.4(b) Discussion**

Based on the result obtained, the percentage of kernel losses is the lowest at 2530 rpm while at 2550 rpm is the highest. The deviation in speed is due to losses in the strain deformation during impact. This means that part of kinetic energy of the palm nut is lost to heat. Sound and decreases the strain energy.

### 4.3 Kernel losses in a shell

Table 4.5: percentage kernel losses in a shell

Sample (day)	Column 3		Column 4		Total %
	Broken kernel (g)	% Losses	Broken kernel (g)	% losses	
1	8	0.8	7	0.7	1.5
2	6	0.6	5	0.5	1.1
3	7	0.7	10	1.00	1.7
4	8	0.8	10	1.00	1.8
5	9	0.9	6	0.6	1.5
6	10	1.00	7	0.7	1.7
7	6	0.6	4	0.4	1.0
8	12	1.2	8	0.8	2.0
9	11	1.1	9	0.9	2.0
10	9	0.9	11	1.1	2.0
11	12	1.2	9	0.9	2.1
12	7	0.7	8	0.8	1.5
13	9	0.9	7	0.7	1.6
14	7	0.7	6	0.6	1.3
15	4	0.4	5	0.5	0.9
16	3	0.3	9	0.9	1.2
17	3	0.3	8	0.8	1.1
18	9	0.9	6	0.6	1.5
19	7	0.7	10	0.1	1.7
20	11	1.1	8	0.8	1.9

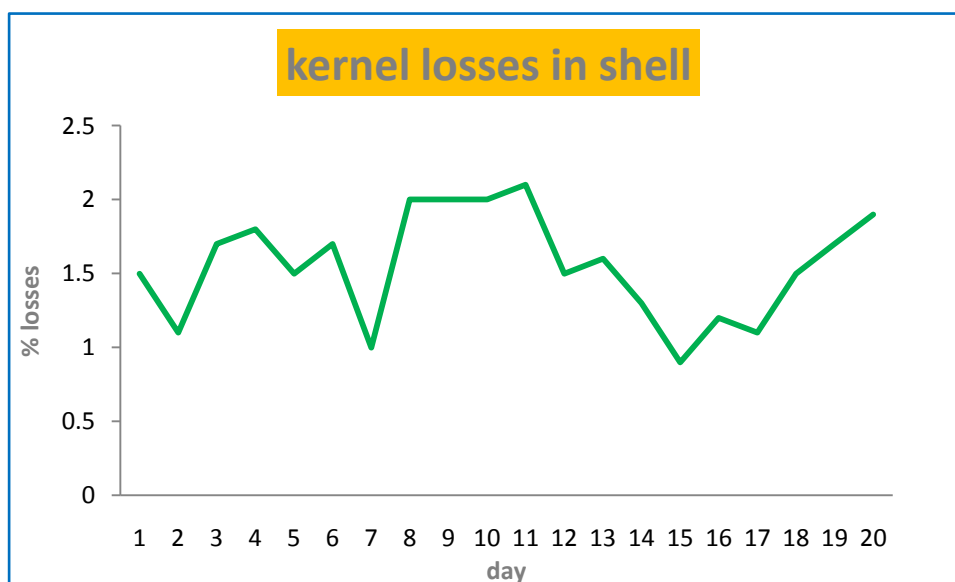


Figure 4.2: Graph of percentage of kernel losses

#### **4.3.1 Discussion**

Based on observation from table 4.3 and graph 4.3, the percentage of kernel losses in a shell is lower than 2.1 %. This is due to total elimination of the hydrocyclone unit from the kernel recovery plant and the reduction of cracked mixture loading for claybath unit ( Rohaya et al, 2001 ).

The percentage of kernel losses is determined in 3 stage and 4 stage winnowing column. 1 kg of sample is taken from both columns. In column 3 and column 4, factors that cause the kernel losses are high percentage of broken nuts in cracked mixture. For determination of kernel losses, the sample was separated into 2 parts according to its broken kernel and free shell. The mass of broken kernel is weighted

In preventing the kernel losses, nut cracker should be well functioned. The position of damper in every column should be checked. The speed of the fan should be maximized to get low percentage of kernel. For the case of fibre cyclone, the low efficiency of hydrocyclone is one of the factors for kernel losses. Moreover, the kernel losses are high when FFB are not well-treated during sterilization. The percentage of kernel loss in fiber cyclone should not higher than 2 %.

#### 4.4 Dirt and shell in kernel

Table 4.6: dirt and shell contain in the kernel

Sample (day)	Column 1			Column 2			Total (%)
	Dirt (g)	Shell (g)	Total dirt and shell (%)	Dirt (g)	Shell (g)	Total dirt & shell (%)	
1	21	3	2.4	19	4	2.3	4.7
2	11	4	1.5	15	3	1.8	3.3
3	15	3	1.8	17	7	2.4	4.2
4	19	5	2.4	13	9	2.2	4.6
5	21	4	2.5	13	5	1.8	4.3
6	13	2	1.5	15	3	1.8	3.3

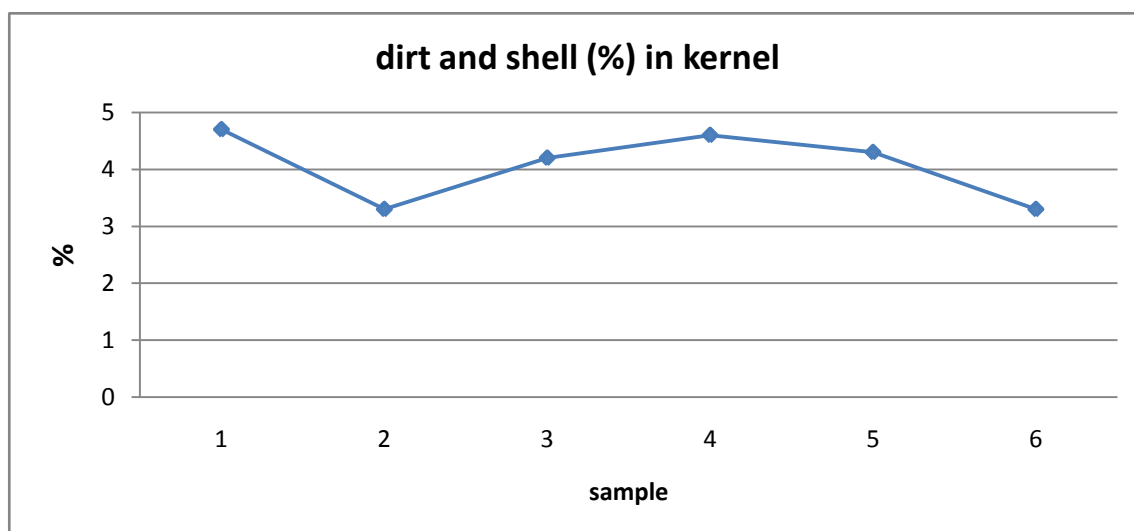


Figure 4.3: Graph for percentage of dirt and shell in a kernel

#### **4.4.1 Discussion**

From the sample analysis, the dirt and shell in kernel ranged from 3.3-4.7% or in average of 4.52 %. The result show that the dirt and shell in kernel decreases. This figure was slightly lower compared to 4.69 % of dirt and shell in kernel produced using the previous system. This show that the installation of 4 stage winnowing system decreases the amount of dirt and shell in kernel. Dirt depends on cracking efficiency of Rolek. There are small stones along the kernel at the first stage of winnowing column that contributes to the production of impurities like dirt and small stones rise. Some small stones can be removed in polishing drum with setting rpm on the fan to get less than 5% impurities and lose 1 % depend on the efficiency of the Rolek. Besides the efficient separation, the low % dirt and shell in kernel also contributed by the superior quality of cracked mixture that enhanced the dry separation process.



## **CHAPTER 5**

### **CONCLUSION AND RECOMMENDATION**

#### **5.1 CONCLUSION**

The study show that 4 stage of winnowing is another breakthrough technology for palm oil mills. The system enhances the efficiency in separation of kernel and shell. The system also reduces the dependency of wet separation technique of clay bath and hydrocyclone used by mills. Based on the velocity that have been study show that the lowest percentage of kernel losses in dry shell to get higher efficiency of product is at 2530 rpm. Meanwhile, the lowest percentage of dirt and shell content in kernel is at 2900 rpm for column 1 and 2720 for column 2.

From the experimental also, the percentage of kernel losses in dry shell decreases compare with previous technology. The percentage of shell contain in column 3 and 4 is approximately 98 % compare to conventional method that is 94 %. Meanwhile, the percentage of kernel contain in column 1 and 2 is 96 % compare wothconvetional method that is 92 %. With the special features offered, the system is

not only beneficial to the millers in terms of profit, kernel quality and maintenance but it also promoted user friendly concept by reducing the water and chemicals used by the wet separation

## **5.2 RECOMMENDATIONS**

As for the recommendation there are many factor can be enhance the efficiency of separation of kernel and shell done during this study because of availability of equipment and limited of research time for example

- The amount of flow rate entering and out of winnowing column should be measured by using flow rate meter
- The system of winnowing should be connected to new system which is can control all the part of winnowing column by online.
- Use filter such as screening as a medium to determine the amount of kernel and shell for each column
- Make sure the operator doing the work systematically, the velocity of the column should be maintained to gain the maximum product.

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