



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**BIOFUEL FIRE STARTER FROM EMPTY FRUIT BUNCHES OF
OIL PALM FRUIT WASTE**

This report submitted in accordance with requirement of the Universiti Teknikal
Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology
(Process and Technology) (Hons.)



by

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BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: Biofuel Fire Starter from Empty Fruit Bunches of Oil Palm Fruit Waste

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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 in Manufacturing Engineering Technology (Process and Technology) with Honors. The member of the supervisory is as follow:



ABSTRAK

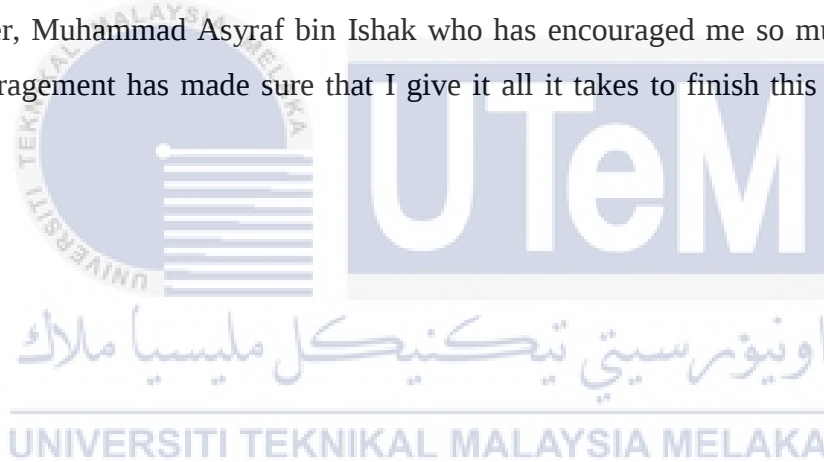
Penyala api adalah produk keluaran kilang dibina untuk dijadikan kayu api. Penyala api direka untuk menjadi murah, dan membantu untuk mewujudkan api dan lebih cekap daripada api kayu. Penyala api secara tradisinya dihasilkan menggunakan dua kaedah. Pertamanya, hanya menggunakan hampas kayu yang dimampatkan dan kedua adalah campuran hampas kayu dan paraffin yang dimampatkan sekali ke dalam bentuk tertentu. Penyala api baru yang bersih pencemaran kini telah dibangunkan dengan menggunakan sisa gentian daripada tandan kelapa sawit, EFB. Tidak seperti penyala api hampas kayu, penyala api ini dibakar tanpa perlu menebang pokok untuk penghasilannya. Penyala api ini telah dicipta menggunakan EFB dan minyak kelapa dara, VCO sebagai pengikat. Sebuah jig khas telah direka dan digunakan dalam membuat 20 sampel penyala api. Jig ini menggunakan daya mampatan dari berat yang berkuantiti 6 kilogram. Daya dikenakan pada EFB melalui sebatang rod keluli berdiameter 15 milimeter, mm selama 10 saat dan daya (berat) dikenakan adalah lebih kurang sekitar 59 Newton. Diameter acuan yang digunakan ialah 15mm lebar X 20mm tinggi. Semua sampel perlu dikeringkan selama 24 jam. Hasil daripada pembakaran ujian menunjukkan bahawa masa pembakaran meningkat dengan jumlah pengikat kuantiti yang lebih tinggi. Keadaan ini mungkin disebabkan oleh VCO berlebihan dalam EFB. Daya dikenakan semasa proses fabrikasi memaksa VCO untuk meresap lebih ke dalam EFB. EFB mempunyai ciri higroskopik. Kesimpulannya, penyala api yang terbaik daripada EFB adalah dari sampel 3ml VCO kerana ia menunjukkan masa pembakaran yang paling lama di kalangan sampel lain.

ABSTRACT

A fire starter is a manufactured product constructed to be used as wood fuel. Fire starter are designed to be inexpensive, and helps to create fire and more efficiently than fire wood. Fire starter are traditionally made manufactured using two methods. The first used only compressed sawdust and second used sawdust and paraffin, which is mixed and extruded into a certain shape. A new cleaner fire starter has now been developed using waste fibre from oil palm fruit bunches, EFB. Unlike sawdust logs, it burns without having trees to be felled off due to producing fire starter. This firestarter were created using EFB and virgin coconut oil, VCO as binder. A special jig has been fabricated and used in making 20 samples of firestarter. This jig used compression force from 6kgs of weight. The force applied on the EFB through a steel rod in diameter of 15 milimeters,mm for 10 seconds and the force (weight) applied is approximately around 59 Newton. The diameter of the mold used is 15mm in diameter X 20mm height. All samples need to be dry for 24 hours. The result from burning test shows that the burning time increased with higher binder volume quantity. This situation may be due to excess VCO in the EFB. The force applied during fabrication process force VCO to diffuse more into EFB. EFB has hygroscopic properties. As the conclusion, the best fire starter from EFB is the 3ml of VCO because it shows the longest burning time among other samples.

DEDICATION

I dedicated this project to my loving family, my strong pillar. They have been so supportive throughout completing this project. This project is dedicated to my mother, Normala binti Abu Samah, my father, Ishak bin M Roni and not to forget my brother, Muhammad Asyraf bin Ishak who has encouraged me so much and whose encouragement has made sure that I give it all it takes to finish this project. Thank you.



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Above all, thank you to Allah S.W.T for giving me the strength, patience and courage that enables me to successfully completed this project. Peace and blessing be upon Muhammad S.A.W, the true messenger of Allah for his munificent bond of love to his community.

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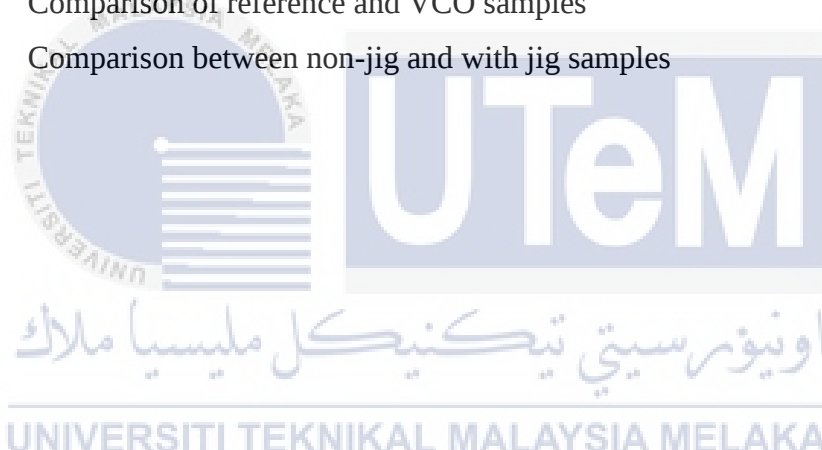
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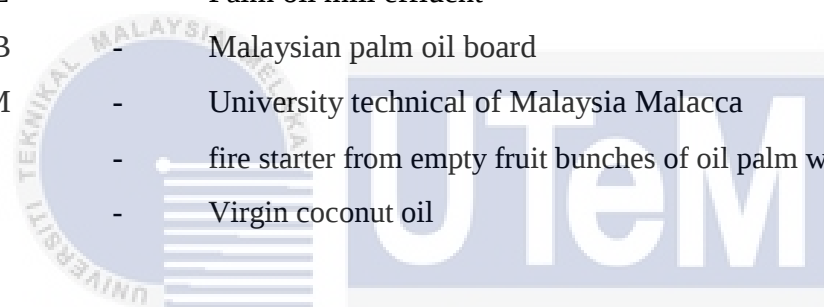


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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

TGA	-	Thermal Gravimetric Analysis
DSC	-	Differential Scanning Calorimetry
FTK	-	Faculty of Engineering Technology
OPT	-	Oil palm trunk
OPF	-	Oil palm frond
EFB	-	Empty fruit bunches
MF	-	Mesocarp fruit fibre
PKS	-	Palm kernel shell
POME	-	Palm oil mill effluent
MPOB	-	Malaysian palm oil board
UTEM	-	University technical of Malaysia Malacca
FEFB	-	fire starter from empty fruit bunches of oil palm waste
VCO	-	Virgin coconut oil



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CHAPTER 1

INTRODUCTION

1.0 Background of Research

Fire creation, fire igniting or fire skill is the method of starting a fire artificially. Fire is a crucial tool in primary human cultural progress. It needs completing the fire trio, usually by starting the burning of a suitably combustible material. That is the traditional way of creating fire. Nowadays, there are much easier way in creating fire. There are few fire ignite tools in this modern day. One of it is matches which is a bunch of small made of wood sticks or firm paper with a coating that can be easily catch fire by friction. Another common fire ignition tool is lighters. It used ferrocium “flint” for the spark, and gas fuels such as butane or liquid naphtha/gasoline-impregnated wick as the tinder and fuel. It is so simple to ignites, often using a wheel mechanism that when turned with the thumbs creates friction on the internal rod of ferrocium “flint” and flings a shower of white -hot sparks into the tinder.

A fire starter is a man-made item developed to be utilized as wood fuel. Fire starter are designed to be low-cost, while being easy to ignite, burn longer, and more efficiently than fire wood. Fire starter are conventionally manufactured using two methods. The first use only compressed sawdust and the second uses compressed sawdust and paraffin, which is mixed and extruded into a certain form.

A new cleaner fire starter has now been developed using oil palm fruit bunches waste. Unlike sawdust logs, these burns without having no trees need to be chopped off to produce it. By using oil palm fruit waste, the wastes can be used to

good by producing useful product. This will help the oil palm industry save their financial on handling the waste

There are some improvements that can be made is to enhance the properties of fire starter. One of it is by using organic binder like virgin coconut oil that will improve it burning period. Therefore, analysis technique that can be done is burning test. On this burning test, all the firing time of samples that will be fabricated will be recorded to makes comparison. Furthermore, this project will be held only in Faculty Engineering Technology (FTK).

1.1 Problem Statement

According to statistic year 2009, Malaysia has 3.75 million hectare of oil palm estate. Malaysia is the second largest maker and exporter of oil palm in the world, through crude production of 13.35 million tonnes per year. Production of bio-waste included kernel, shell, empty fruit bunch and fibre as below:

- i. Kernel shell = 4.6 million tonnes per year
- ii. Empty fruit bunches = 15.3 million tonnes per year
- iii. Fibre = 8.6 million tonnes per year

Since Malaysia is the second highest producer in this industry, it has high potential to commercialize the biomass waste to produce a useful product. On top of that, using bio-waste to fabricate biofuel fire starter using organic binder to support national agenda which is green technology.

1.2 Objectives

The objectives of this study:

- i. To fabricate biofuel fire starter from oil palm fruit waste using virgin coconut oil as the binder.
- ii. To fabricate biofuel fire starter samples using a special jig.

1.3 Scope of study

Scopes for this project that will be carry out:

- i. To fabricate biofuel starter from oil palm fruit waste using virgin coconut oil as organic binder.
- ii. To fabricate biofuel fire starter samples using a special jig.



CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this chapter, a review of biofuel fire starter from biomass waste of oil palm fruit is provided. References and understanding were taken from various sources which are from SMK Lenga student's, journals, books and internet. Each source was selected based on similarity with the scope of study. The focus in this literature is about the properties of oil palm and fire starter.

2.1 Oil palm industry

Oil palm tree has been cultivated and grown immensely in Malaysia. This tree produces palm oil which is used for food and other goods. In this chapter, the critical information on the oil palm, and the administration and usage of waste produced by palm oil industry are displayed.

2.1.1 Oil palm

Oil palm is the most ingenious oilseed yield on the planet because of its high profitability per hectare. It has oil production effectiveness (oil produced/land area) of 4000 kg/ha which is higher than the main oil seeds and oil plant. Moreover, long life expectancy of oil palm with fairly long economic life span of 25-30 years, giving a solid supply to oil generation. Alongside the high creation

proficiency, this has driven the quick development of oil palm ranch far and wide. (Kurnia et al., 2016)

2.1.2 Environmental problems in the palm oil industry

Since oil palm products global demand has stood increasing, it has driven the rapid growth of oil palm plantation around the world. (Kurnia et al., 2016).

In Thailand, oil palm has been used for biofuel production. This caused increase demands and leads to growing oil palm growth. This growing growth donates to environmental problem like biodiversity loss and pollution caused by emissions of nutrients, air contaminants and greenhouse gases from estates and palm oil mills. (Saswattecha et al., 2016)

Although, the crude palm oil mill effluent discharge standards by stages but still the present air pollution control measures in CPO mill are still inadequate for full compliance of regulatory requirements. Further studies should be conduct in areas like boiler design technology, solid fuel treatment and combustion, fly ash control system, and energy conservation concept in relation to complete combustion. The preparation of the crude palm oil must meet with the environmental friendly standard. The self-regulation approach by the industry will certainly complement the present environmental management system and the national environment as a whole. (Yusoff, 2006)

The ebb and flow transfer for POME is to store it in anaerobic and high-impact processing lakes before being discharged into conduits. This method needs a large area of land and always creates a problem of discharging POME into water and also can gives to the greenhouse gas emissions. Biomass watse as well as makes a considerable measure of waste as utilized cooking oil. The used cooking oil dumping is straight release into the water drainage system that pose severe environmental dangers. (Kurnia et al., 2016)

2.1.3 Oil palm wastes: current utilization and disposal scenario

Huge quantity of wastes or residues that has been created by palm oil industry. This wastes or residues can be process to produce biofuel. In the oil extracted from the oil palm establishes just 10% of the aggregate biomass created while other 90% is waste. The outgrowth delivered from palm oil creation incorporates oil palm trunk, OPT, oil palm frond, OPF, discharge organic product bundle, EFB, mesocarp natural product fiber, MF, palm piece shells, PKR and palm oil process emanating, POME. Except for POME, these wastes have high fibre content. (Kurnia et al., 2016)

OPF is accessible in the estate consistently. OPT is accessible just amid the replanting season. Oil palm trees have a long future and when they accomplished the end of their business future they should be supplanted by new plants. The current practice that is leave the dead trees between the lines of palm trees creates a risk. It will attract harmful insects to reproduce. Furthermore, leaving the trunk in the plantation will block re-plantation activity. The ash produced in boilers is transported back to plantations and burning the dead trees to utilize them as soil fertilizer. It will decrease risk of insects but it will result in pollution that should be avoided which is air pollution. Other than use OPF as fertilizer, it also can be cut into small pieces to be use as livestock feed. Fuel in mill boilers are normally EFB, MF and PKS. Mentioned here that the contains of EFB which is high moisture content, low heating value leads to air pollutions shows that it cannot be burned directly and hence, it should be dry to decrease the moisture content. That makes MF and PKS are more indispensable as evaporator fuel while EFB is ordinarily disposed of in homes. MF additionally been use as fillers really taking shape of canteen plastics and thermoset composites. While EFB can be utilized to create bioplastics. The biomass from oil palm likewise been use to create sponges for harmful gas and overwhelming metal. The main fluid waste created from the palm factory is POME. It contains high

groupings of natural mixes makes it reasonable as plant manure on the off chance that it is effectively treated. (Kurnia et al., 2016)

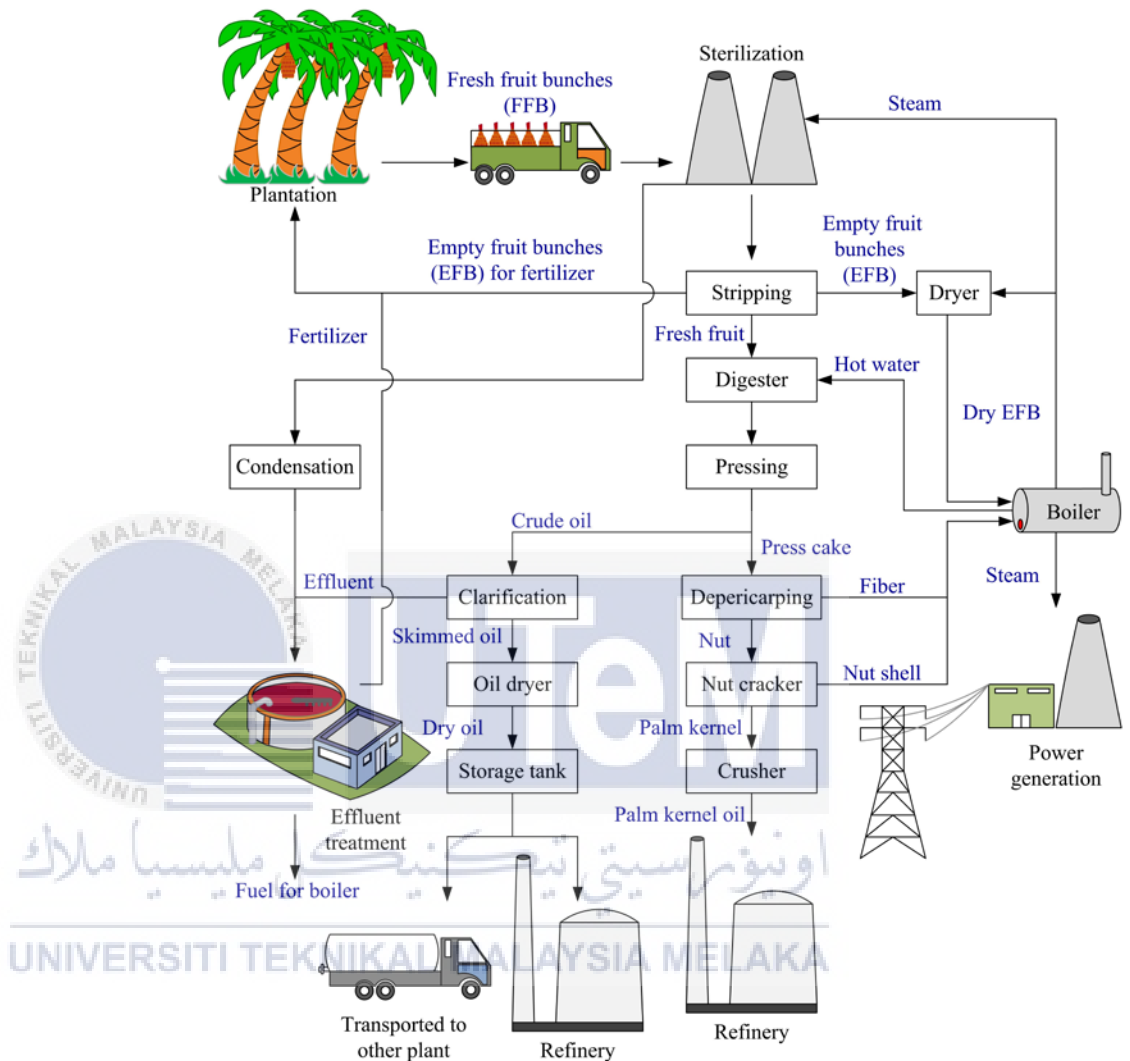


Figure 2.0: Palm oil production process (Kurnia et al., 2016)

Some scientists and companies are trying to use oil empty fruit bunches and palm kernel shells harvested into renewable electricity, cellulosic ethanol, biogas, bio hydrogen and bio plastic. Thus, helps reducing greenhouse gas emissions. Some oil palm manors use biomass by burn it to create power. Scientists treat palm oil mill effluent to extract biogas in efforts to reduce greenhouse gas emissions. Biogas can substitute for natural gas for use at factories after purification. (Wikipedia 2016)

Aziz et. Al proposed an integrated small-scale in-situ energy generating process utilizing EFB and POME. This project said it can lower environmental impact.(Aziz et al., 2016)

2.2 Oil palm fibre

2.2.1 Extraction of fibre

In retting process, oil palm fibre, OPF is extracted from empty fruit bunches, EFB. List of the available retting processes are mechanical retting (hammering), chemical retting (boiling with chemicals), steam/vapor/dew retting and water/microbial retting. According to Raju et al., the most popular retting process is water retting. The only environmentally friendly extraction is mechanical extraction while other methods pollute water bodies. (Shinoj et al., 2011)

There are enormous requests of lightweight materials for use in transportation and development areas. Characteristic fibres (NFs) in fortified polymer composites are generally lightweight. Be that as it may, NFs have a few confinements because of their dampness affinity, poor wettability furthermore, low warm solidness amid preparing with engineered polymers. These disadvantages have been overcome by viable physical and substance medications of NFs. Among different NFs, oil palm biomasses (OPBs) are promptly accessible in some tropical nations and have gotten extraordinary consideration in the composite enterprises. In this part, the execution of untreated and distinctively treated OPB fibres, strengthened thermoplastic and thermoset composites arranged through expulsion, pressure and infusion moldings have been talked about in detail. (M. D. H. BEG et al, 2015)

2.2.2 Morphology and properties

Figure 2.1 shows sketch of OPF and fibre arrangement of EFB cross section. Tables 2.0 and 2.1 indicates synthetic arrangement and physical-mechanical properties of OPF as testified by different specialists. OPF suitable for composite applications due to high cellulose content and high toughness. There is 4.5% residual oil contains in OPF which unfavourably affects fibre-matrix compatibility. Surface modifications can improve fibre properties substantially. (Shinoj et al., 2011)

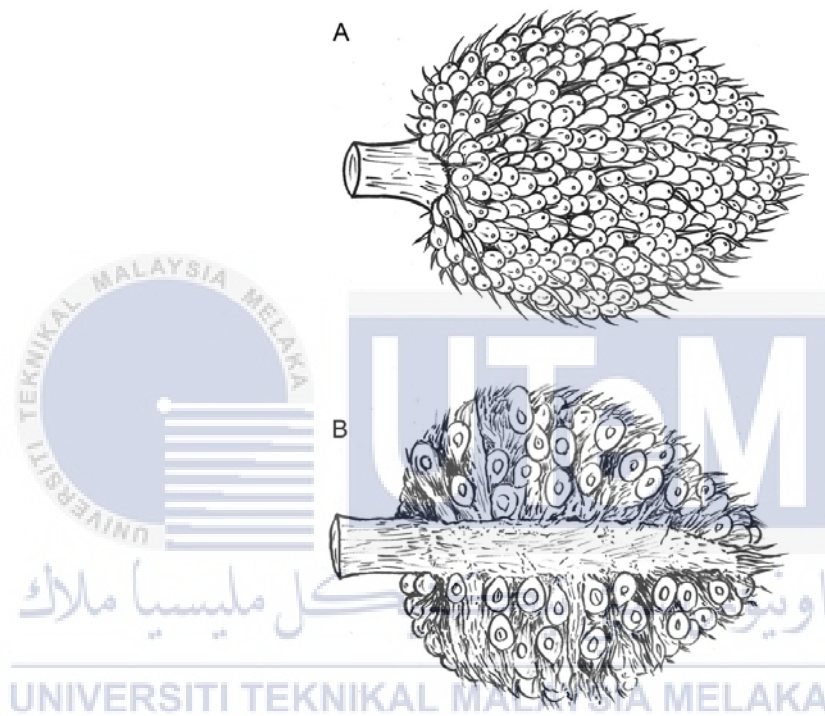


Figure 2.1: Sketch of (A) OPF (B) fibre arrangement of EFB cross section

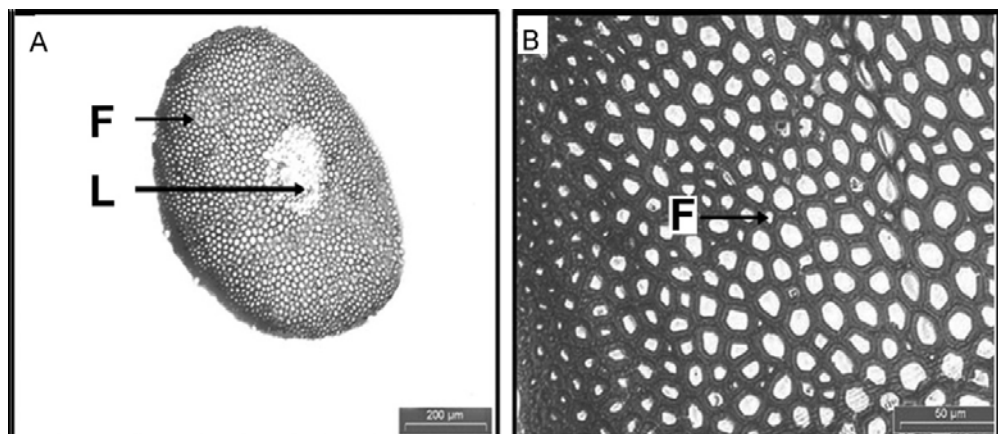


Figure 2.2: images of transverse sections of OPF (4×).

Table 2.0: Chemical Composition of OPF (Shinoj et al., 2011)

Property	Range
Cellulose (%)	42.7–65
Lignin (%)	13.2–25.31
Hemicellulose (%)	17.1–33.5
Holocellulose (%)	68.3–86.3
Ash content (%)	1.3–6.04
Extractives in hot water (100 °C) (%)	2.8–14.79
Solubles in cold water (30 ° C) (%)	8–11.46
Alkali soluble (%)	14.5–31.17
Alfa-cellulose (%)	41.9–60.6
Alcohol–benzene solubility (%)	2.7–12
Arabinose (%)	2.5
Xylose (%)	33.1
Mannose (%)	1.3
Galactose (%)	1.0
Glucose (%)	66.4
Silica (EDAX) (%)	1.8
Copper (g/g)	0.8
Calcium (g/g)	2.8
Manganese (g/g)	7.4
Iron (g/g)	10.0
Sodium (g/g)	11.0

Table 2.1: Physical-mechanical properties of OPF (Shinoj et al., 2011)

Property	Range
----------	-------

Diameter (μm)	150–500
Microfibrillar angle (°)	46
Density (g/cm ³)	0.7–1.55
Tensile strength (MPa)	50–400
Young's modulus (GPa)	0.57–9
Elongation at break (%)	4–18
Tensile strain (%)	13.71
Length-weighted fiber length (mm)	0.99
Cell-wall thickness (μm)	3.38
Fibre coarseness (mg/m)	1.37
Fines (<0.2 mm) (%)	27.6
Rigidity index, (T/D) ³ × 10 ⁻⁴	55.43

Table 2.2: Effects of surface treatments on properties of OPF (Shinoj et al., 2011)

Property	References
Merцерization	Amorphous waxy cuticle layer leaches out.
Latex coating	Partially masks the pores on the fiber surface.
γ irradiation	Partially eliminates the porous structure of the fiber and causes microlevel disintegration. It degrades mechanical
Silane Treatment	Imparts a coating on fiber surface
Toluene diisocyanate (TDI) treatment	Makes fiber surface irregular as particles are adhered to surface.
Acetylation	Removes waxy layer from the surface and makes the fiber
Peroxide treatment	Fibrillation is observed due to leaching out of waxes, gums and
Permanganate treatment	Changes the colour and makes fibers soft. Porous structure is observed after treatment.
Acrylation	Imparts a coating on fiber surface and removes pits containing silica bodies and keeps surface irregular. It improves
Silane treatment	Keeps the fiber surface undulating and improves mechanical
Titatanate treatment	Smoothens fiber surface.

Alkali treatment	Makes the surface pores wider and fiber become thinner due to dissolution of natural and artificial impurities.
Benzoylation	Imparts a rough surface to the fibers and makes pores prominent, which helps improving the mechanical interlocking
Oil extraction	Imparts bright colour to the fiber. Removal of oil layer exposes surface pits and makes surface coarse.

2.3 Empty fruit bunches

EFB are incinerated for its ash to utilize waste and been use as fertilizer/soil conditioner. Incineration of EFB has been discourages by Department of Environment because it creates smoke problem. Even though it is harmless, it still has an aesthetic effect to nature surroundings. High plant nutrient and fertilizer equivalent contains in EFB creates a growing interest in the utilization of EFB. Plantations that near the palm oil mill utilized more EFB because of the practice using EFB as their own fertilizer. In cultivating crops, fertilizers, pesticides, herbicides and energy is a crucial contribution. By utilizing EFB it can reduce the negative contribution of smoke problem and others environmental problem such as global warming. (Yusoff, 2006)

2.4 Binder

Material or substance that holds or draws other materials together to form a cohesive whole mechanically, chemically, or as an adhesive is called binder. Logically, any substances that change from mixture-like to stone like conditions and, hence, added bind filler power/particles into it. Binders are roughly classified as organic and inorganic. (Wikipedia 2016)

In this study, market virgin coconut oil has been suggested to be the organic binder for fire starter production. Famously edible oil that widely consumed in tropical country is coconut oil. It is also used in baking industries. According to Department of Lipid Science & Traditional Foods of Central Food Technological Research Institute in India, no hostile effects to the health of people on consuming high diets of coconut oil. Malignancy and viral diseases medications were as well utilizing coconut oil. Table 2.4 shows the physico-chemical characteristics of coconut oil. The oil is profoundly steady towards air oxidation. The oil is described by a low iodine esteem, high saponification esteem, high soaked unsaturated fats content and is a fluid at room temperature of 27°C. (Gopala Krishna et al., 2010)

Table 2.3: Physico-chemical Characteristics of coconut oil (Gopala Krishna et al., 2010)

	Virgin coconut oil from wet coconut	Unrefined coconut Oil from copra	Refined coconut oil
Appearance	Colorless	Slight brownish	Colourless
Odour	Coconut smell	Coconut smell	Odourless
Melting point °C	24	24	24
Moisture (%)	<0.1	<0.1	<0.1
Iodine value (cg I ₂ /g)	12-15	12-15	10-12
Peroxide value (meq. O ₂ /kg)	0-1	0-1	0-1
Saponification value (mg KOH/g)	245-255	245-255	250-255
Phospholipids (%)	0.1	0.1	0.0
Unsaponifiable matter (%)	-	0.42%	0.19%
Tocopherols mg/kg	150-200	150-200	4-100
Physterols mg/kg		400-1200	
Total phenolics mg/kg	640	618	20
Fatty acid compositions			

(relative %)			
Saturates	92.0	92.0	92.0
Monounsaturates	6.0	6.0	6.0
Polyunsaturates	2.0	2.0	2.0

Coconut oil has melting point in range of 21-26°C. The viscosity at 20°C is in range of 17 – 20 cp. The auto-ignition temperature and the decomposition temperature both is > 300°C. (Classification et al., 2015)

2.5 Virgin coconut oil

Virgin coconut oil is also known as unrefined coconut oil or pure coconut oil. It is extracted from fresh coconut meat rather than dried. Then it goes two processes which is wet milling and quick drying. Coconut milk is expressed from the fresh meat and boiled, fermented from the milk using enzymes or centrifuge in wet milling. While in quick drying, the coconut meat is quickly dries and the oil is mechanically expressed. Bleaching or additives were not essential due to the speedy production process. The coconut flavor and odor remains. (Healthy eating, 2016)

Another strategy in light of the cholesterol level was created to distinguish the nearness of creature fats in virgin coconut oil (VCO) by Xu et al. In this study, the sterols in VCO and creature fats was isolated utilizing customary one-dimensional gas chromatography and extensive two-dimensional gas chromatography. Cholesterol, a primary sterol found in creature fats, spoke to under 5 mg/kg of VCO. The review showed that the assurance of the cholesterol level in VCO could be utilized for solid recognition of the nearness of fat, chicken fat, lamb fat, meat fat, or their blend in VCO at a level as meagre as 0.25%. (Xu et al., 2015)

2.6 Solid fuel from empty fruit bunch fibre and waste papers

EFB were provided by Malaysian Palm Oil Board (MPOB). The EFB utilized as a part of the composites was in a cleaved strand shape allude figure 2.3. Reused papers are utilized as a lattice material as a part of the strong fuel briquette manufacture. This is on the grounds that paper has great properties for burning and it can go about as a binder. The papers were acquired from waste papers and paper destroyed machine allude figure 2.4. Paper from shredder machine have standard size and measurement after it is shredded inside the shredder machine. The standard size and measurement guarantees the mixing with EFB is uniform. (Yuhazri et al., 2009)



Figure 2.3: EFB fibrous form



Figure 2.4: Shredded paper in shredder machine

Table 2.4: Properties of EFB as raw materials (Yuhazri et al., 2009)

Raw Material	Average size of Materials	Calorific Value kJ/kg	Moisture Content %	Ash Content %
Pulverized EFB	<212 μ m	17000	12.0	2.41
EFB Fibre	3 cm	16641	16.0	4.70
EFB Fibre	2.5 mm	16641	14.0	4.60

The sample briquette measurement that had been delivered amid test readiness is 40 mm in diameter and 73 mm long with normal weight around 67.64 grams. The proportion of briquette delivered as in Table 2.5.

Table 2.5: Sample ratio and its serial number (Yuhazri et al., 2009)

Ratio of EFB to Paper	Serial Number
90:10	S/N 1
80:20	S/N 2
70:30	S/N 3
60:40	S/N 4
50:50	S/N 5
40:60	S/N 6

Figure 2.5 shows samples of solid briquettes. The vital method in this audit is the waste papers ought to be submerged in water for 24 hours and after that it is blended using a blender to squash up the waste papers. By then, the blended papers are weighted again to get the largeness of squashed papers with water. After the EFB and decimated paper were confined by extents, the EFB is blended up with the crushed paper. Next, the compacting step happened by compacting the mixing of EFB and waste paper into a solid briquette by using water controlled press machine and chamber shape. The measure of the shape is 100 mm long and 40 mm in width. The mixing was compacted into the frame until it gets to the needed length which is 73 mm. The measure of weight associated is 3 bars. Last walk is the solid briquette

were put inside a drying stove at temperature 100°C for 24 hours to clear the water procured in the midst of the compacting strategy. (Yuhazri et al., 2009)

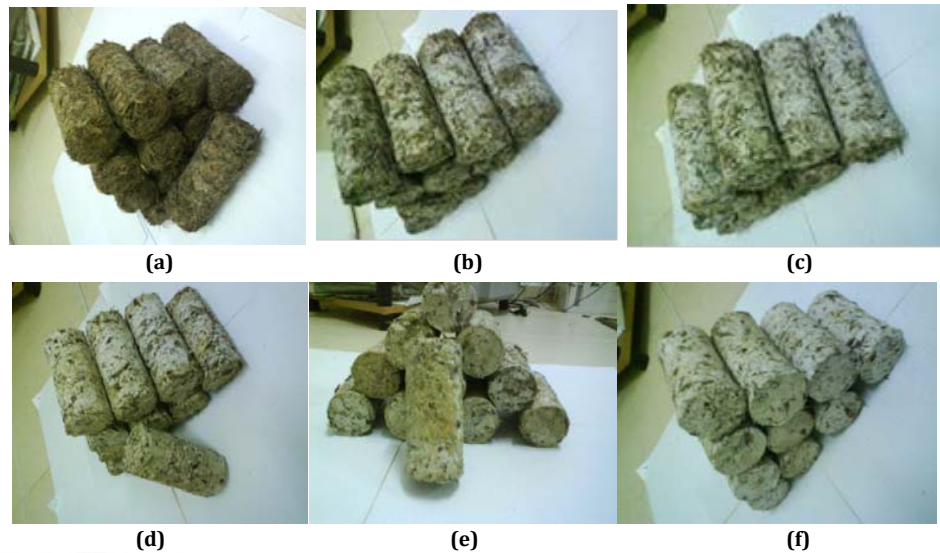
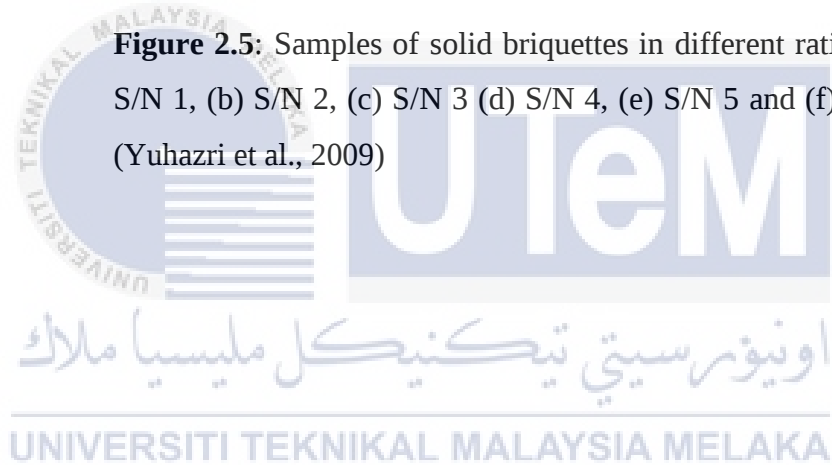


Figure 2.5: Samples of solid briquettes in different ratios; (a) S/N 1, (b) S/N 2, (c) S/N 3 (d) S/N 4, (e) S/N 5 and (f) S/N 6 (Yuhazri et al., 2009)



CHAPTER 3

METHODOLOGY

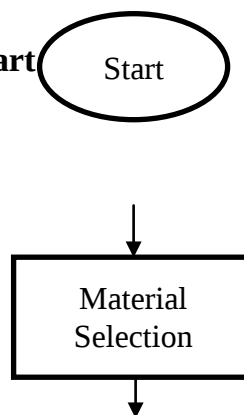
3.0 Introduction

This chapter describes the research methodology of this study. The research methodology that is used describes the process required in order to complete this study. This includes the preparation of sample, equipment and technique required to analyze the data obtained. It is carried out based on the study objectives and problem statement. The fabrication of biofuel fire starter from biomass waste of oil palm fruit was synthesis and characterized by using following material and instrument.

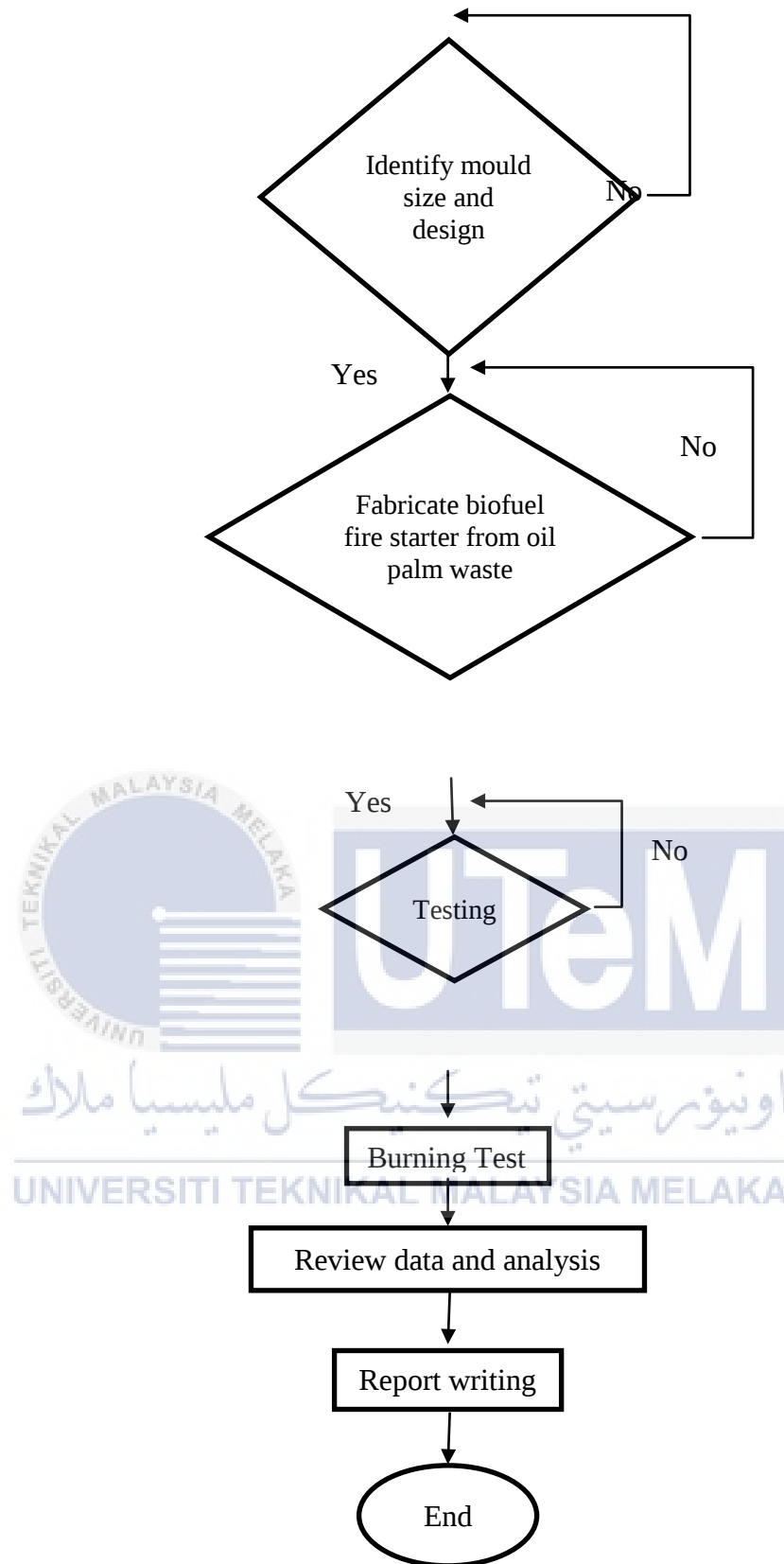
1. Material
 - 1) Empty fruit bunches, EFB
 - 2) Virgin coconut oil as organic binder
2. Testing methods
 - 1) Burning Test



3.1 Methodology flow chart



The burning test is a simple way of finding out the burning time period of samples. All samples will be burn and the burning time period will be recorded. The result of burning time period will be obtained in seconds.



3.1.1 First phase

The flow chart starts with problem defining according to objectives and problem statement. By knowing the problem, the next step can be done which is gathering literature review and generate a concept.

Figure 3.0: Flow chart of methodology

3.1.2 Second phase

Next, start with material selection and gathering. The material use in this study is empty fruit bunch (EFB) and virgin coconut oil as binder. The oil palm waste will be gather at oil palm plantations in Melaka. There will be a mold involves, a simple mold for compressing the EFB. The mold and the design will be created at this phase.

3.1.3 Third phase

If there is no problem with the mold and material gathering. The production of fire starter samples will be started.

3.1.4 Fourth phase

After the production of samples, testing will be done on the samples using burning test method.

3.1.5 Fifth phase

After all the documentation, the findings will be used for report writing.

3.2 Material selection

Material that will be used in this study is empty fruit bunches and virgin coconut oil as the organic binder.

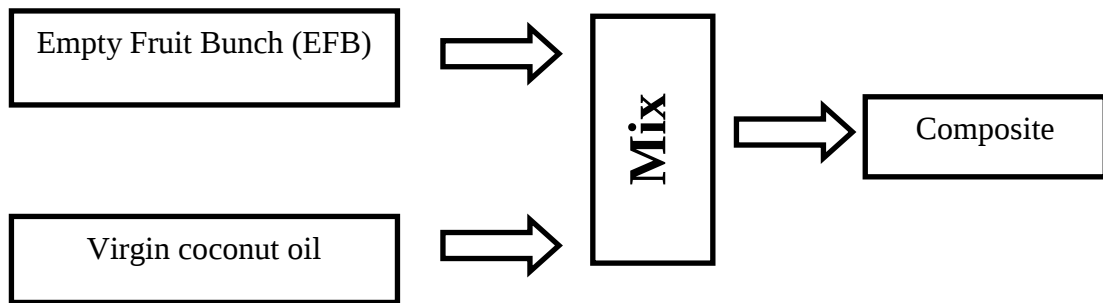


Figure 3.1: Material process

3.2.1 Empty fruit bunch

EFB is the main material for this study. It is easily flammable in proper condition. Since Malaysia is the one of the main producer for oil palm, EFB is easy to get.

3.2.2 Virgin coconut oil

Virgin coconut oil is use as organic binder. A binder is any material or substance that holds or draws other materials together to form a cohesive whole mechanically, chemically, or as an adhesive. It will be use to hold the EFB from loosen itself.

3.3 Production of fire starter from oil palm fruit waste

1. Preparation of EFB
 - 1) Gather the oil palm fruit from the plantations.

- 2) The fibre will be extracted from oil palm empty fruit bunches using hands.
- 3) The fibre extracted will be blend by blender. After blending process, fibre need to be cut using scissors to achieve fine-liked texture.
- 4) Mix the binder (glue and virgin coconut oil) with the fine textured fibre in a container using finger. The binder volume quantity may vary.
- 5) Insert the mixed fibre inside mold that has 15 milimetres, mm in diameter X 20 mm height.
- 6) Start compressing with jig and finger-press according to group samples.



Figure 3.2: Fibre extracted from empty fruit bunches

2. Compressing process (Jig)

- 1) The pressing process started with the mold that filled with mixed fibre placed properly on the jig.
 - 2) 6 kilograms of weight will be put on top of the steel rod for 10 seconds. Compression occurred.
 - 3) Step repeated for other samples.
 - 4) Samples will be dried for 24 hours.
3. Compressing process (finger-press)
- 1) The process started with inserting mixed fibre into mold.
 - 2) Start compressing it with finger according to mold dimension.
 - 3) Step repeated for other samples.
 - 4) Samples will be dried for 24 hours.



Figure 3.3: FEFB samples using VCO and paper glue as binder

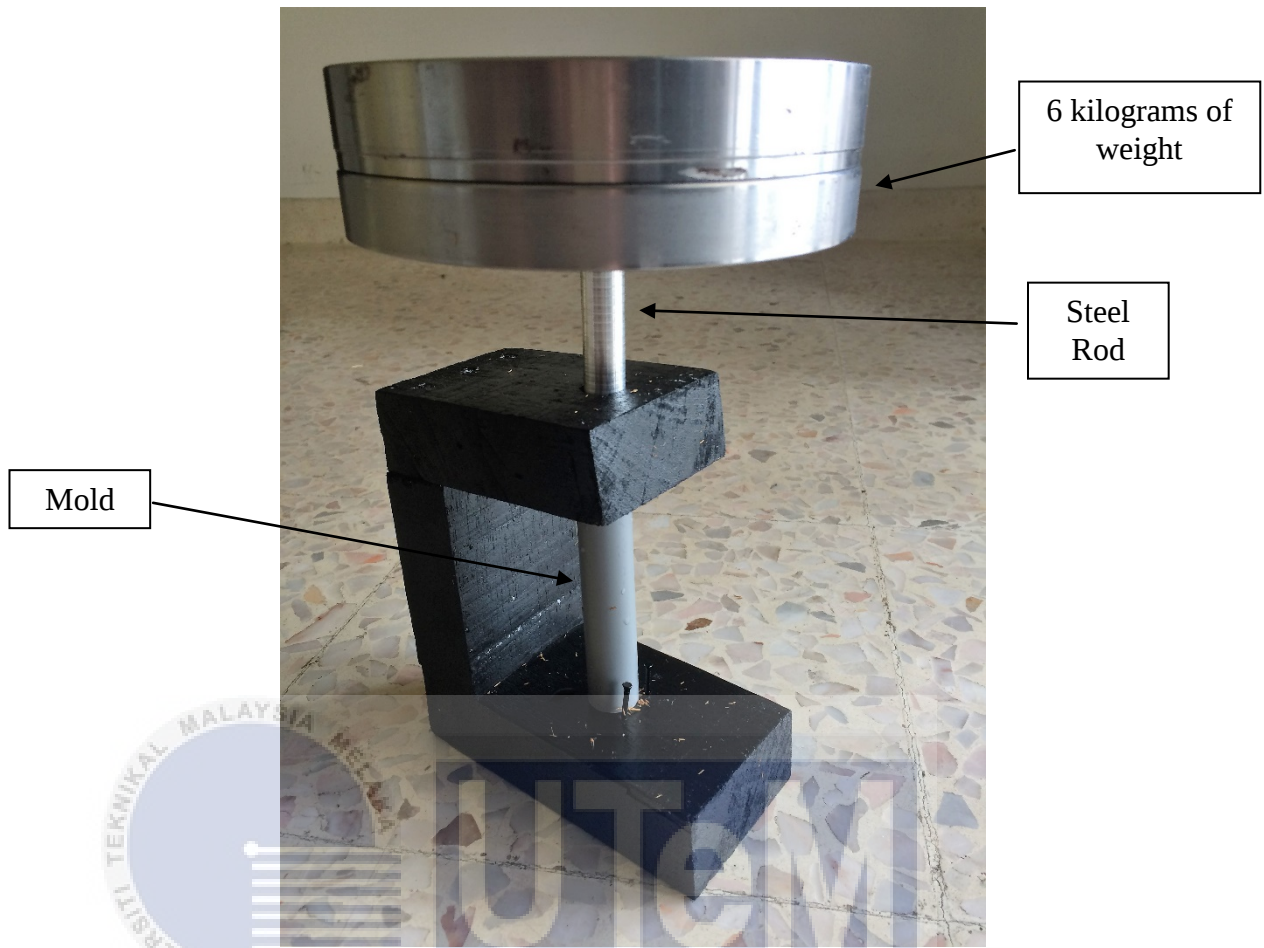
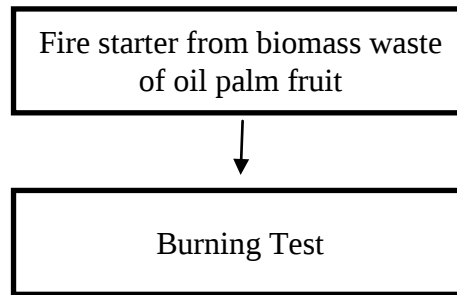


Figure 3.4: Jig used in fabricating FEFB samples

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3.4 Testing



3.4.1 Burning Test

To complete this study, burning test need to be done for stronger project results. Burning test is the testing method that will be use. The burning test is a simple way of finding out the burning time period of samples. All samples will be burn and the burning time period will be recorded. The result of burning time period will be obtained in seconds. It will provide information about the capability of fire starter made from EFB.



Figure 3.5: Burning sample in burning test

CHAPTER 4

RESULT AND DISCUSSION

4.0 Introduction

In this chapter, the results obtained from experiments done on the fire starter from empty fruit bunches of oil palm waste, FEFB will be discussed. The discussion will be focus on the firing time of difference types of binder which is paper glue and virgin coconut oil. Jig fabrication will be included in this discussion.

4.1 Burning time of Firestarter from Empty Fruit Bunches of Oil Palm Waste

4.1.1 Burning Test

Burning time is the burning time period of the FEFB and it is important in proving the efficiency of the fire starter. The FEFB was burnt during the burning time test. There are total of 25 samples fabricated using two types of binder which is paper glue and virgin coconut oil, VCO. Five samples are the references with paper glue as the binder. The reference samples were using 1 gram, g of fibre from empty fruit bunches, EFB and 3 mililitres, ml of paper glue as the binder. Fabrication for another 15 samples were using 1g of EFB and different volume of VCO which is 1 1ml, 2ml and 3ml. All the 20 samples were fabricated using a special jig that use compression method and the compression force (weight) is approximately

around 59 Newton, N. Preparation of 5 reference for non-jig samples were using force that applied by using finger-press. All this samples were done in mold and the dimension of the mold is 15mmx20mm. Before the burning test started, kerosene was added to the Firestarter as accelerator. The time taken was in seconds. Figure 4.0 shows a burning test for 2ml VCO samples.



Figure 4.0: a 2ml VCO sample during burning test

4.1.2 Burning Test for Reference Samples

Figure 4.1 shows the bar chart for burning test of reference samples. The average burning time for five samples is 192 seconds. From the bar chart, the trend shows an arrangement of the burning time is steadily uniform. The longest value for the burning time is 240 seconds respectively shown in sample number 3. The shortest value for the burning time is 167 seconds. Burned reference sample is shown on figure 4.2. The figure shows that the sample is not fully burned out. This condition may be due to its too solid and does not have combustion space.

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Sample Weight (grams)	EFB Weight (grams)	Paper Glue Volume (millilitres)	Samples Time (seconds)					Average Burning Time of Samples (seconds)
			1	2	3	4	5	
4	1	3	167	185	240	200	170	192

ning time of Reference Samples

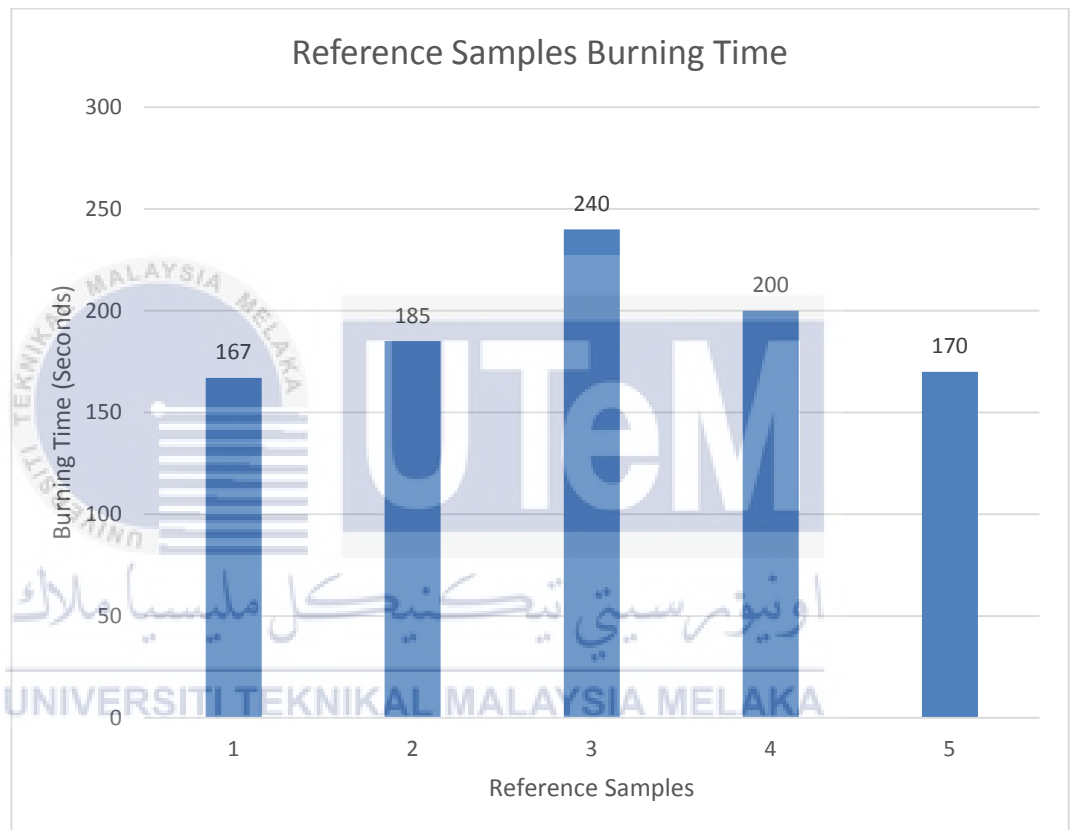


Figure 4.1: burning test result for reference samples.



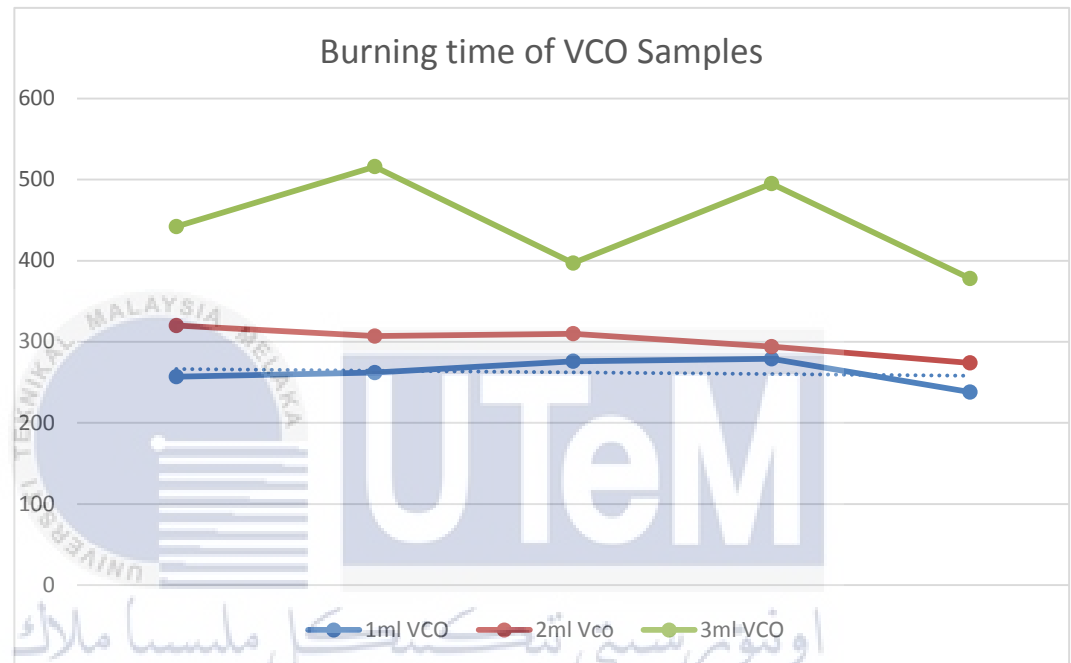
Figure 4.2: burned reference samples

4.1.3 Burning Test for VCO Samples

Figure 4.3 shows the results of burning test for 15 samples of VCO binder. In the chart, trend shows the longest period of burning time in samples using 3ml VCO which is 446 seconds in average. On the other hand, samples using 2ml and 1ml VCO shows a period of burning time of 301 seconds and 262 seconds in average respectively. From the line chart, the tabulation of the burning period for 1ml and 2ml sample are slightly no differences, meanwhile the 3ml shows a major change in burning time of VCO samples. This condition maybe due to excess VCO in the EFB. During the fabrication of the samples, approximately around 59N of force (weight) is applied to 15mmX20mm mold using 6 kilograms of weight. This force will force VCO to diffuse more into EFB. EFB has hygroscopic properties thus explains why 3ml sample of VCO has the longest burning time.

Table 4.1 Burning time of Firestarter (VCO)

VCO Volume (millilitres))	EFB Weight (grams)	Sample Weight (grams)	Sample Time (seconds)					Average Burning Time of Samples (seconds)
			1	2	3	4	5	
1	1	2	257	262	276	279	238	262
2	1	3	320	307	310	294	274	301
3	1	4	442	516	397	495	378	446



Burning time for three different volume quantity of VCO samples

4.1.4 Comparison between Reference and VCO Samples

Figure 4.4 shows the average value of burning time against different types of binder used. In reference and VCO samples, both samples are fabricate using a special jig and mold in dimension of 15mm in diameter X 20mm height. Volume of binder is constant at 3ml for both samples. Weight of EFB use also constant at 1 gram for both samples. This bar chart clearly shows burning time for VCO samples is doubled compare to the reference samples. This situation may be due to combustion in the samples. Combustion related to air space in the samples ad it will influenced the

burning period time. Samples with paper glue has less air space because of the sticky properties and less viscosity compared to VCO binder.

Table 4.2 Comparison of Reference and VCO Samples

Type of Binder	EFB Weight (grams)	Binder Volume (millilitres)	Samples Time (seconds)					Average Burning Time of Samples (seconds)
			1	2	3	4	5	
Paper Glue	1	3	167	185	240	200	170	192
VCO	1	3	442	516	397	495	378	446



Figure 4.4: Aver

4.2 Jig Fabrication

Figure 4.5 shows the design used for the sample jig. This jig is use in the fabrication of the samples. The function is to applied uniform force of compression on the samples to make sure the force is constant. It also to keep the weight and the size of the samples uniform. The parameter that kept constant is force (weight) which is approximately around 59N. This jig is made mostly from recycled pallet wood in

order to support green products and to make use of wasted materials. The weight 6kgs that will be applied is from a solid circle block of stainless steel in 160milimetres, mm in diameter.

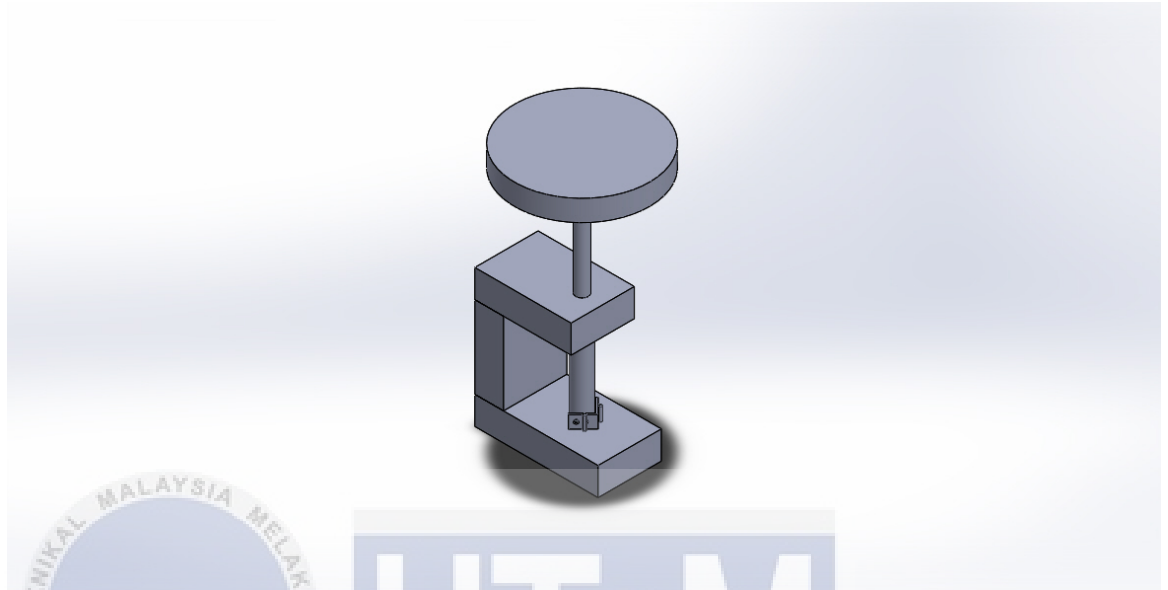


Figure 4.5: Assembled parts design of jig on Solidworks software

4.2.1 Compression Force (weight) and the Area Applied

Figure 4.6 shows the formula used in calculating force (weight). The weight use in producing samples is 58.8N. The weight of steel rod which is 8.9271×10^{-3} N is added with the 58.8N force (weight) and that makes the total force (weight) applied is approximately around 59N. The force (weight) is applied on surface area of samples which is 1.767cm^2 . Calculation of area is using the area of circle formula, $A = \pi r^2$.

$$F_g = mg$$

where m is mass and g is local acceleration of free fall.

Figure 4.6: formula used in calculating force (weight).

4.2.2 Comparison Between Non-Jig Samples and Jig Samples

Figure 4.7 shows the average value of burning time against different types of fabrication method used. The non-jig is a fabricating FEFB method that using finger-press. The blue and red bar in the chart shows non-jig samples and with jig samples burning time. EFB weight and binder volume is kept constant in this comparison. In both chart, the trend shows steadily uniform tabulation. This bar chart clearly shows burning time for with jig samples is better compare to the non-jig samples. This situation may be due to uneven pressure applied that cause solid samples. This can disturbance on combustion of the samples. Combustion related to air space in the samples and it will influence the burning period time. Samples with non-jig has less air space because of the sticky properties, less viscosity compared to VCO binder and uneven pressure applied.

Table 4.3: Comparison between Non-jig and with Jig Samples

Fabrication Method	EFB Weight (grams)	Binder Volume (mililitres)	Samples Time (seconds)					Average Burning Time of Samples (seconds)
			1	2	3	4	5	
Non-jig	1	2	240	207	218	189	199	211
With Jig	1	2	320	307	310	294	274	301

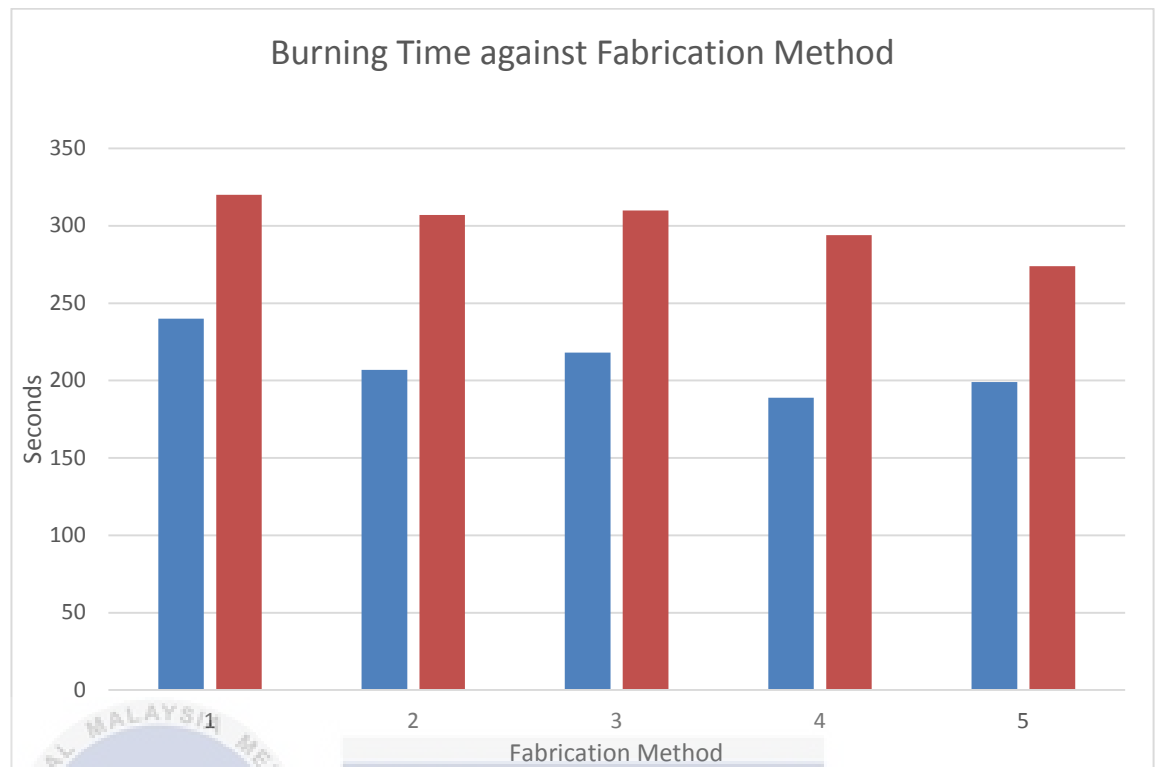
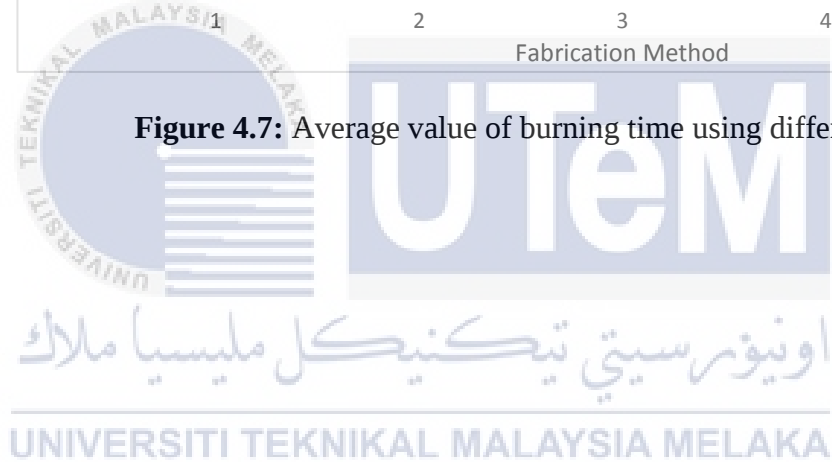


Figure 4.7: Average value of burning time using different methods



CHAPTER 5

CONCLUSION AND FUTURE WORK

5.0 Introduction

Fire starter from empty fruit bunches of oil palm, EFB wastes samples was fabricated to resolve the problem that had been identified in Chapter 1, which is to make use of the oil palm wastes and create a useful product from the wastes.

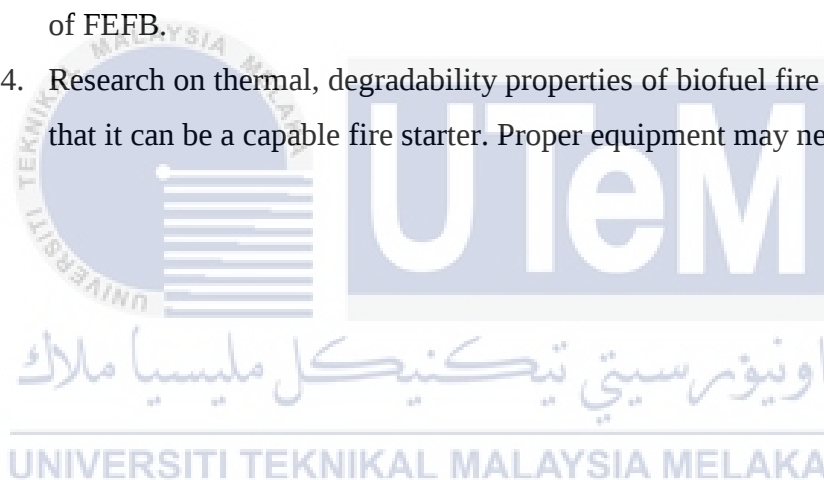
5.1 Conclusion

Fire starter from EFB samples using virgin coconut oil, VCO as binder was successfully created. All the samples have been tested with a visual test called burning test. In this test, the samples of 3 milliliters, ml VCO and fabricated with jig has the longest burning time. All the data shows that burning time is improved with the usage of VCO as the binder. The study on EFB samples was demonstrated in results shown in Chapter 4. The result proves that using virgin coconut oil as the binder improves burning time of the fire starter from EFB compared to reference samples. This is due to reference samples has less air space because of the sticky properties and less viscosity compared to VCO binder. This condition makes reference samples hard to lit and maintain firing.

5.2 Recommendation for Future Work

The current work exposed a number of areas that requires further research work. The suggestions for further work include:

1. Research on making the structure of fire starter from EFB, FEFB stronger for better structured fire starter.
2. Research on how and what type of harmful gases created by FEFB smoke through proper smoke testing. This to support the green product movement.
3. Research on how to makes the FEFB easy to lit rather than using kerosene as accelerator of fire. Addition of another substance that improves ignition of FEFB.
4. Research on thermal, degradability properties of biofuel fire starter to show that it can be a capable fire starter. Proper equipment may need.



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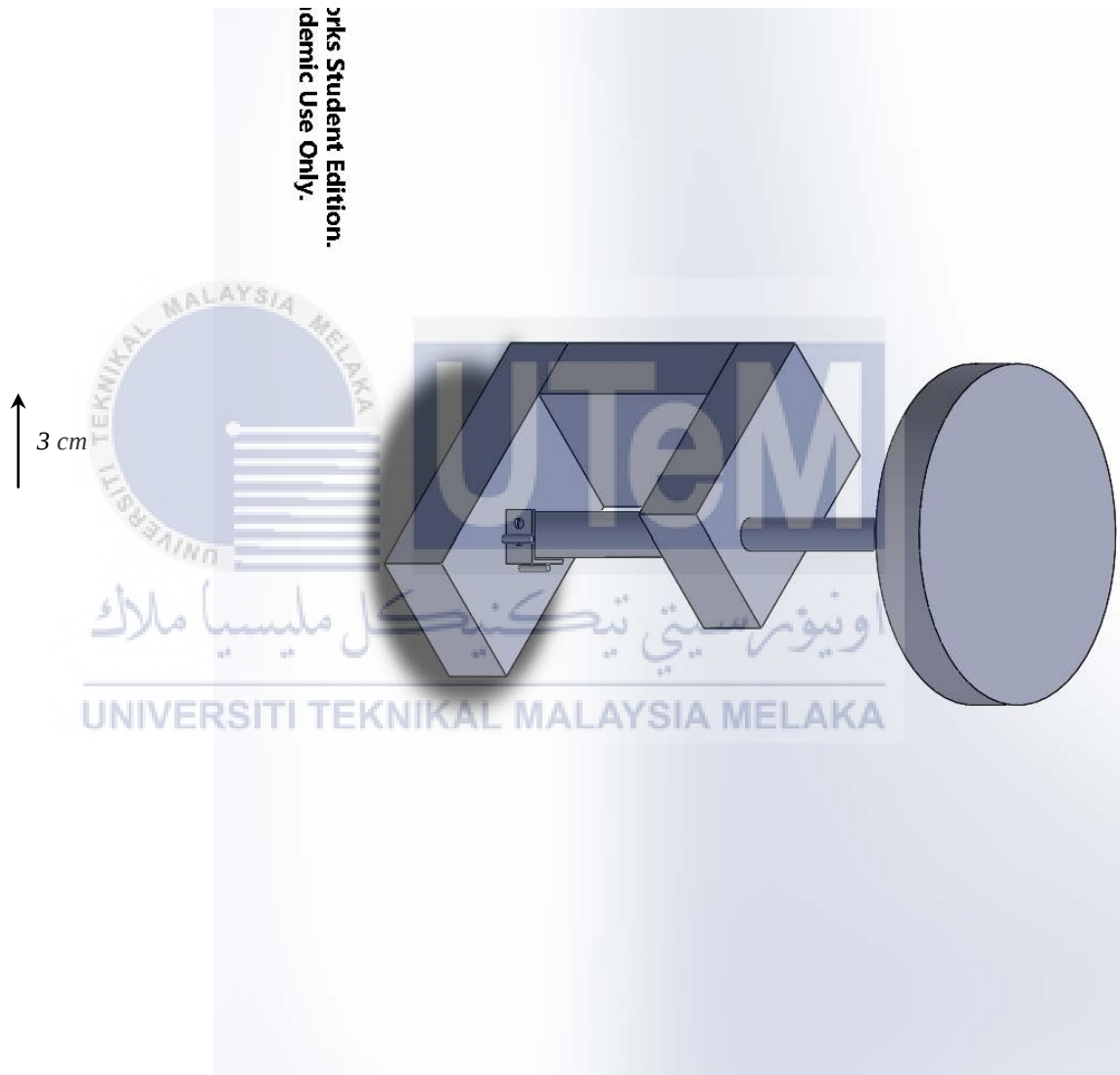
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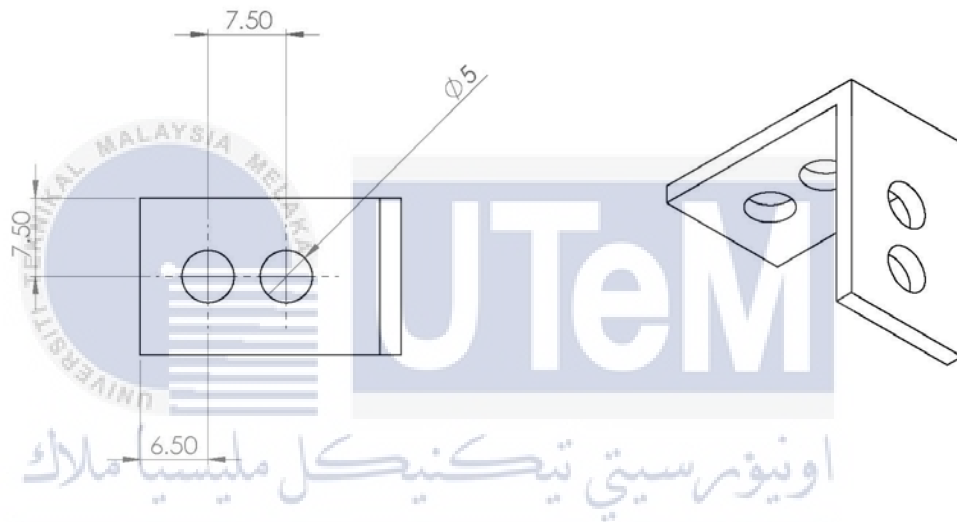
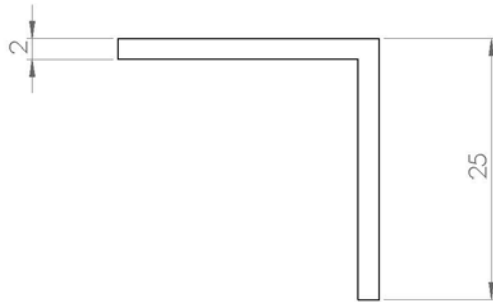
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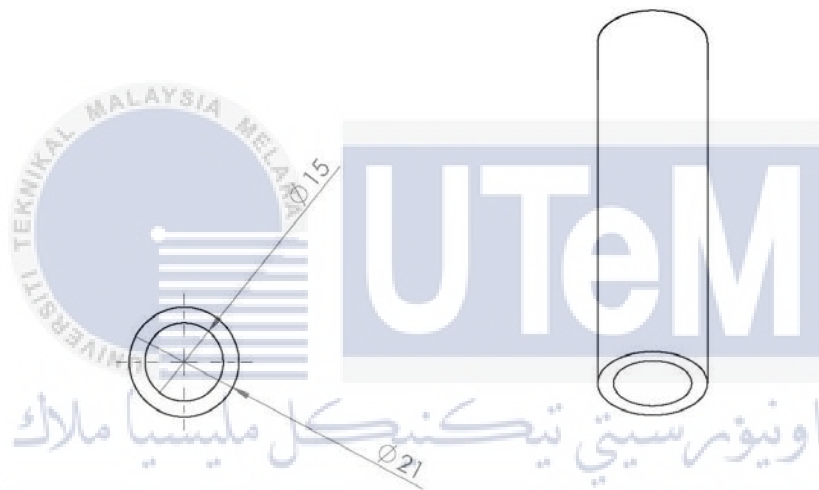
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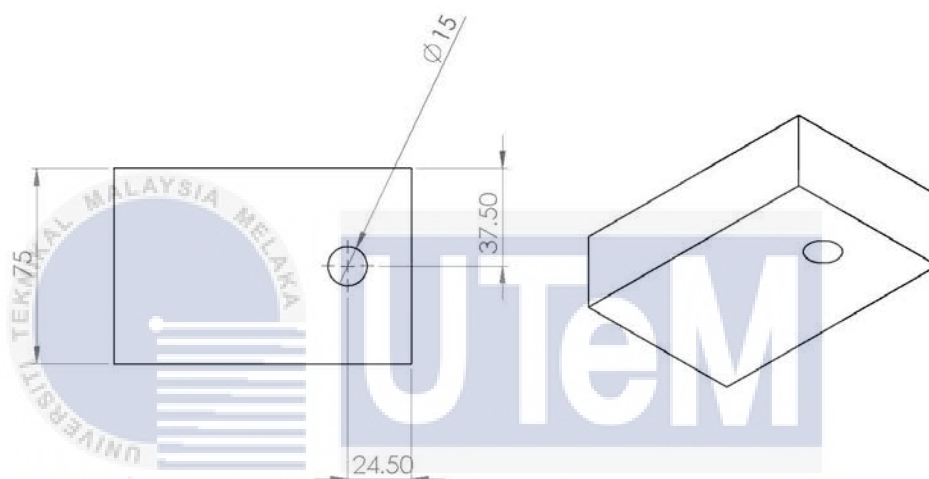


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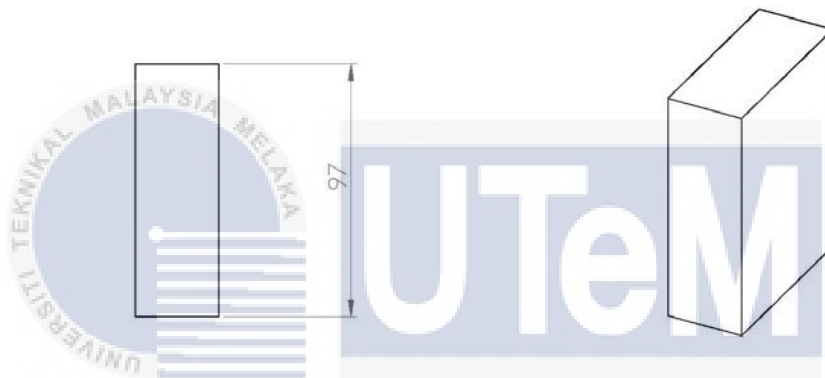
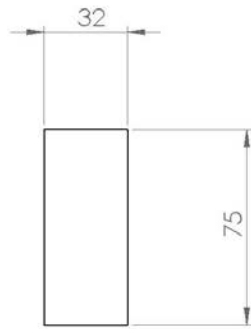
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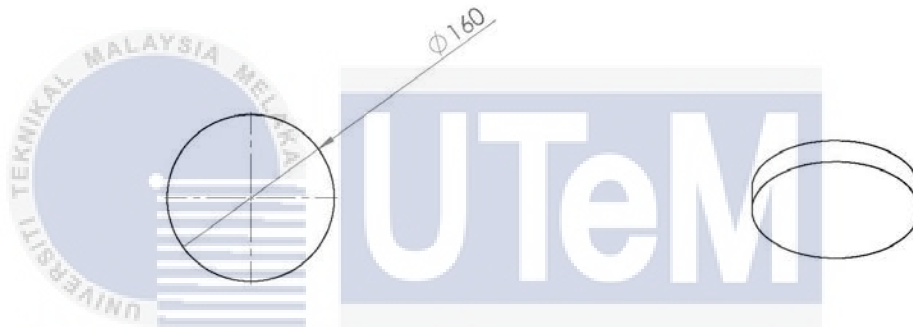
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APP'D											
MFG											
Q.A								DWG NAME		A4	
								COMPRESSOR ROD			
								SCALE: 1:2		SHEET 1 OF 1	



اونيورسيتي تیکنیکل ملیسیا ملاک

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:			FINISH:			DEBUR AND BREAK SHARP EDGES			DO NOT SCALE DRAWING			REVISION					
DRAWN						TITLE:						SolidWorks Student Edition. For Academic Use Only. WEIGHT A4					
CHK'D																	
APP'VD																	
MFG																	
Q.A.																	
WEIGHT:						SCALE:1:5						SHEET 1 OF 1					