Study of physiochemical characteristics of EFB briquettes and its potential use as dual fuel in CVCC.

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DECLARATION

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

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ABSTRAK

Briket tandan kosong (BTK) telah menjadi sisa tumbuhan berpotensi untuk ditukar menjadi bahan bakar gas alternatif melalui pembakaran briketnya. Briket BTK merujuk kepada pemampatan biomas seperti BTK ke dalam bentuk padat kepadatan tinggi. Ramai penyelidik mendapati bahawa menggunakan pengikat akan memperbaiki keadaan anjal dan ubah bentuk plastik briket BTK. Walau bagaimanapun, masih terdapat banyak peluang dalam meneroka formula yang lebih baik antara BTK dengan nisbah pengikat. Tujuan kajian ini adalah untuk meningkatkan sifat fizikal dan kimia briket BTK melalui pencirian kaedah briket dan komposisi pengikat. dan untuk menguji briket BTK dalam penggubal jenis penggali gas untuk pengeluaran gas penghasil biomassa. Gas pengeluar biomas dari pengeboran briket BTK dibersihkan, dikompres dan disimpan dalam tangki gas untuk kajian ciri penyemburan dan pembakarannya. Berdasarkan kajian ini, potensi gas penghasil biomas sebagai bahan bakar gas alternatif untuk aplikasi enjin ditentukan. Pengas bawah tanah dipilih dalam kajian ini kerana kelebihan penggali ini menghasilkan kandungan larutan rendah dalam pengeluaran gas penghasil biomassa. Gas pengeluar akan diuji melalui ujian pembakaran terbuka untuk menentukan penyemburan dan pembakaran gas pengeluar briket BTK adalah sebanding dengan bahan api gas komersil seperti Gas Petroleum Cecair dan NGV. Dalam pemakaian bahan api gas dalam enjin pembakaran dalaman, kandungan tar mestilah rendah dengan ketara iaitu kira-kira 50-100 mg / Nm3. Secara ringkasnya, kekuatan mekanik briket EFB berkarbonat bertambah empat kali ganda lebih tinggi sebagai pengikat pada pembentukan kanji ubi. Nilai kalorinya meningkat daripada 36% berbanding dengan briket EFB sebelumnya. Penyebaran api gas penghasil biomassa adalah sebanding dengan penyebaran api LPG dan NGV melalui ujian pembakaran terbuka. Dengan bantuan bahan api diesel semasa permulaan, titik penunjuk gas pengeluar biomas adalah 360 darjah. C

ABSTRACT

Empty fruit bunch (EFB) briquette has become a potential plantation wastes to be converted into alternative gaseous fuel via combustion of its briquettes. EFB briquetting is referring to compacting biomass such as EFB into high density solid form. Many researchers found that using binder will improve the elastic condition and plastic deformation of EFB briquette. However, there is still a lot of opportunities in exploring a better formula between EFB to binder ratio. The aims of this study are to improve physical and chemical properties of EFB briquette through characterization of briquetting method and binder composition. and to test the EFB briquettes in downdraft type gasifier for the production of biomass producer gas. The biomass producer gas from EFB briquettes gasification was cleaned, compressed and stored in the gas tank for its spraying and combustion characteristics study. Based on this study, the potential of biomass producer gas as an alternative gaseous fuel for engine application was determined. Downdraft gasifier was chosen in this study due to the advantage of this gasifier in producing a low tar content in the production of biomass producer gas. Producer gas will be tested via open burning test in order to determine the spraying and combustion of producer gas of EFB briquette is comparable to commercial gaseous fuel such as Liquefied Petroleum Gas (LPG) and NGV. In the application of gaseous fuel in internal combustion engine, the tar content must be significantly low which is approximately 50-100 mg/Nm^3. In summary, Mechanical strength of carbonized EFB briquettes improved four times higher as binder at the formulation of tapioca starch. Its calorific value improved from 36% compared with previous EFB briquettes. The flame propagation of biomass producer gas was comparable to the flame propagation of LPG and NGV via open burning test. With the aid of diesel fuel during start-up, the flash point of biomass producer gas was at 360 deg. C.

CHAPTER 1

INTRODUCTION

1.1 Overview

Malaysia is the second largest oil palm producer after Indonesia. By referring to the research by (N. Abdullah and F. Sulaiman 2013) the total oil palm planted area in Malaysia increased by 2.8% to 4.17 million hectares in 2006. [1] The area expansion occurred mainly in Sabah and Sarawak with a combined growth of 4.5% compared to 1.6% in Peninsular Malaysia [1]. Sabah remained the largest oil palm planted state with 1.24 million hectares or 30% of the total planted area [1]

The success of these oil palm plantation companies is strongly supported by responsible government agencies like the Malaysian Palm Oil Board (MPOB), Malaysian Palm Oil Council (MPOC), Palm Oil Research Institute of Malaysia (PORIM), and Forest Research Institute Malaysia (FRIM). [2] Based on Figure 1(a) show the increase number of oil palm plantation from 1960 to 2014.

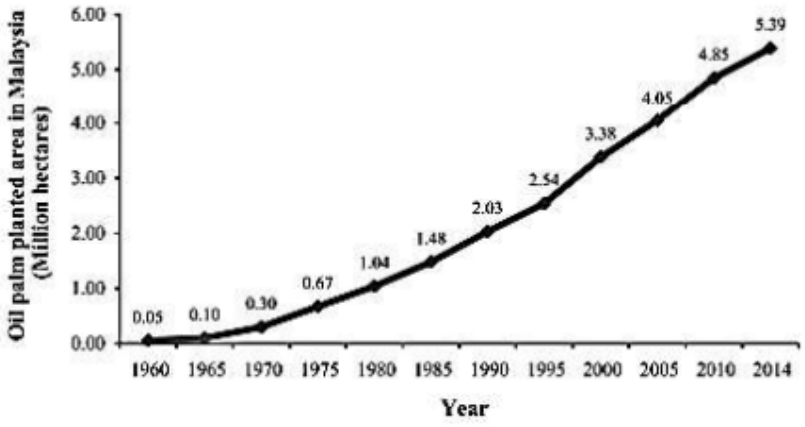

Figure 1(a): Expansion of oil palm plantations cultivation in Malaysia area [2].

In the palm oil mill, palm oil consists only 10% of the total biomass, while the rest (90%) biomass are discarded as wastes [2].One way to handle the waste of oil palm wastes is

by recycled the application such as transforming oil palm waste to empty fruit bunch (EFB).The oil palm biomass empty fruit bunch (EFB) generated from milling process, has long been identified and utilised as the sustainable renewable energy in Malaysia. [3] Briquetting process by compacting the loose raw material into high density and solid form.

For the future innovation, EFB briquettes a source of renewable energy such as palm oil is affordable to become automotive fuel in view of the current fossil fuel shortage and its rising price in the marketing. The process involves to transforming EFB into producer gas by using gasification process.

Gasification defined as the thermo-chemical process limited to a partial combustion and pyrolysis. [4] To achieve the potential of producer gas from EFB to become fossil fuel, tar content inside the producer gas must very lower. Hence, need to choose type of gasifier that suitable to producer gas and has good cleaning agent such as water treatment and oil bath filter to minimize the tar content inside the producer gas.

Finally, briquettes also provide for sustainable renewable energy because of the abundant supply of biomass from oil palm plantations in Malaysia. The increasing global concern for green energy, economically viable production and renewable energy incentives will continue to boost the potential of palm biomass briquettes.

1.2 Problem Statement.

Combustion produced from fossil fuels are not only depletion, but it also emitted pollution to the air. The production of polluted air will affect the ozone layer and will also increase the temperature of the surrounding. Due to this issue the researches that deals with this utilization, characterization and analyse of biomass resources as the alternative replaces of fuel for internal combustion (IC) engine application have been increase lately. However not many of the researcher deal with the potential of biomass producer gas as gaseous fuel in IC engine.

Empty fruit bunch (EFB) briquette has become formulation on turning waste of biomass in briquetting into alternate fuels such as biofuel. EFB briquette has high density with compact solid form. Binder is using to see the properties effect form different binder and EFB ratio use in this experiment. However, there is still a lot of opportunities in explore the better formulation to create more high qualities of EFB briquette but in low cost.

Therefore, in this study new formulation of briquettes technique by using different type of binder and different ratio. At the same time, the different ratio EFB briquettes with binder properties need to be analysing to define strength analysis, ultimate analysis, proximate analysis and calorific value. The best result will be use in gasification process to obtain producer gas.

1.3 Objectives

The objective of this study is as follow:

1. To study the physiochemical characteristic of the EFB briquettes as a source of fuel.
2. To test EFB briquettes as in downdraft gasifier for producer gas production
3. To study spraying and combustion characteristic of producer gas from EFB briquettes gasification as dual fuel with diesel (Open Combustion).

1.4 Scope of Work

The main scope of this project is to focus on demonstrating and analysing spraying and combustion characteristics of producer gas from EFB briquettes gasification. To run this experimental, Detail about the process of briquetting of biomass materials need to be studied. The process involves drying and crushing as well as characterizing binder composition EFB. For briquetting, the EFB samples will be tested by using bomb calorimeter test and compressive load test to determine the calorific value and maximum compressive load. Finally, the potential of application of producer gas from EFB briquetting as gasification with diesel will be studied via its spraying and combustion characteristics experiments and analysis.

1.5 Outline of the reports

This thesis is divided into five main chapters. The first chapter discusses on production of palm oil in Malaysia, EFB potential to become new renewable energy, overview of EFB briquettes of biomass as new alternative fossil fuel in future. This chapter also contains the project objectives, project scope of work and outline of the project report.

In chapter 2, the literature review based on empty fruit bunch from biomass, type of gasifier that suitable for cleaning tar and open combustion chamber.

In chapter 3, the methodology based on how to prepare the sample of EFB with different type of binder, step to run the gasification and open combustion experiment.

In chapter 4, the results in term of calorific value, thermogravimetric analysis value, compressive load analysis, proximate analysis, ultimate analysis, gas chromatograph analysis, spraying and combustion of producer gas.

In last chapter, the conclusion of the project will be made in chapter 5. Some suggestions and recommendations are given for improvement in future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Empty fruit bunch (EFB) briquetting.

Empty fruit brunch (EFB) briquette is a compressed solid block of raw biomass such as charcoal, sawdust, wood chips, rubber seed kernel, wooden pallet and palm oil shell. It produces higher density; high maximum load and less moisture contain compared to its raw biomass. Briquetting of EFB can be done using various techniques, either with or without binder addition.

Treated EFB fibre and powder forms and sawdust are the raw materials used for production of palm biomass briquettes (Figure 2.1.1). No binder is added. Two types of briquettes can be produced: 100% palm briquettes from EFB powder and palm-based briquettes EFB in fibre or powder and at least 50% sawdust. The products are shown in Figure 2.1.2. The products are made as logs 490 mm long and 55 mm in diameter, weighing 1.1 kg at bulk density of 1300 kg m-3.

However, the length of the products can be customized into 5 or 10 kg packs. The surface of the briquettes is partially carbonized for easy ignition and to minimize the absorption of moisture. The product is designed with a hole through the centre for better air circulation during combustion. The properties of the palm biomass briquettes are given in Table 2.1.1. [3]

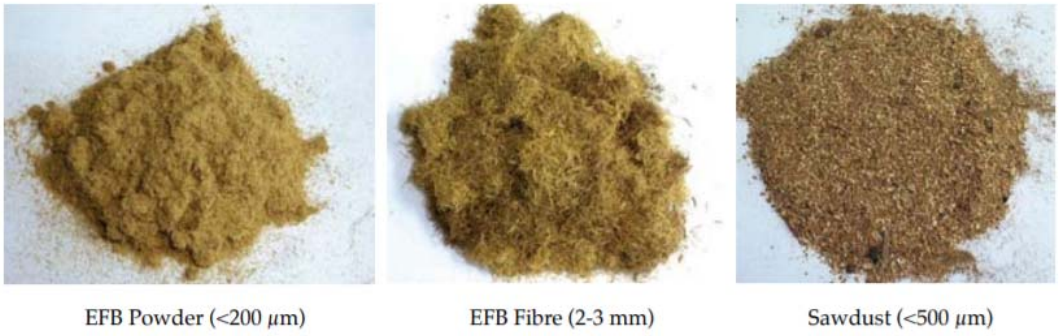

Figure 2.1.1: Binderless briquettes made from oil palm-based biomass and sawdust.[3]

EFB Powder Briquettes | EFB Powder + Sawdust Briquettes (50:50) | EFB Fibre + Sawdust Briquettes (40:60)

Figure 2.1.2: Raw materials for production of palm-based biomass briquettes. [3]

Raw materials/products	Calorific value, kJ kg^{-1}	Moisture content (%)	Ash content (%)	Compressive strength (MPa)	Elasticity (MPa)
Pulverized EFB (PEFB) < 212 μm	17 000	12.0	2.41	-	-
EFB fibre (2.5 mm)	16 641	14.0	4.60	-	-
Sawdust (SD) < 500 μm	18 506	10.0	2.31	-	-
100% EFB powder briquettes	17 823	7.39	2.85	7.5	0.34
EFB powder + sawdust briquettes (50:50)	18 273	7.22	1.63	7.5	0.52
EFB Fibre + sawdust briquettes (40:60)	18 775	7.32	2.99	6.5	0.24
Sawdust briquettes (control)	18 936	6.81	1.63	7.8	0.80

Table 2.1.1: Properties of the raw materials and palm-BASED biomass briquettes [3]

The compaction of biomass during the briquetting process is attributed by two conditions, which are elastic condition and plastic deformation [4,5]. There are two major aspect to be considered in the compaction of the biomass material, which the ability of particles to form briquette with extensive mechanical strength and the ability of process to enhance the durability of the biomass material. [6] In order to achieve to achieve better strength and densification of EFB briquette type of binder will be used in this project.

In Figure below shown the variation of maximum compressive load (MCL) of the terrified biomass material of rubber seed kernel (RSK) and palm oil shell (POS). Both RSK and POS is mixing with certain amount compositions of binder addition (% S) and water (% W). As we can see from Figure 2.1.4 the MCL of RSK 600N and POS 400N is higher compare to Figure 2.1.3 the MCL of RSK 140N and POS 100N.

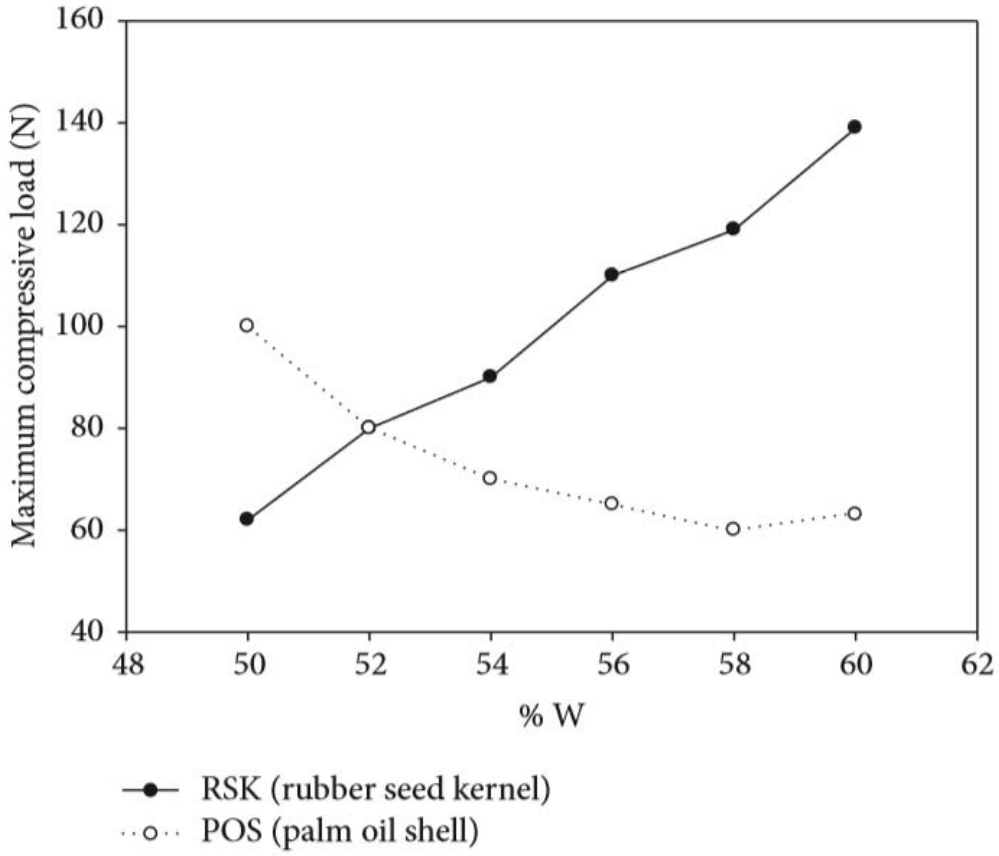

Figure 2.1.3: MCL as a function of varying water (constant5%binder addition) [6]

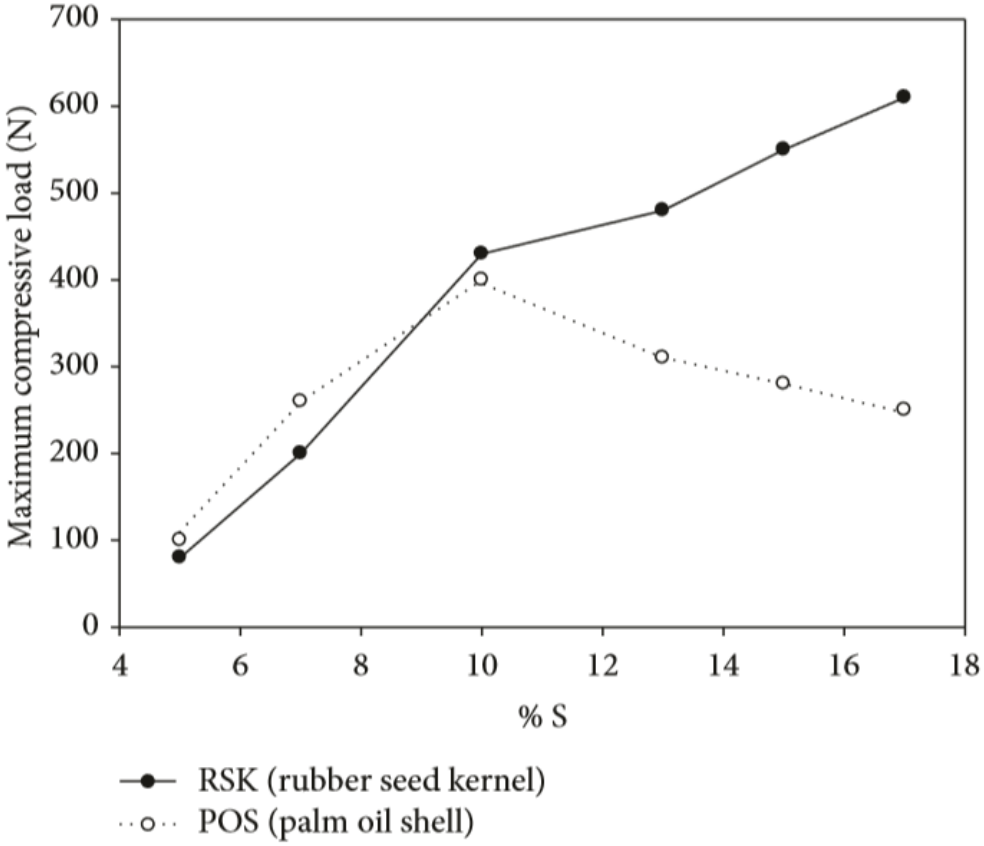

Figure 2.1.4: Figure 9: MCL as a function of varying binder addition (constant 50% of water). [6]

As conclusion, we can see that the EFB with binder produce high calorific value, low moisture content, and low ash content in this Table 2.1.1 from previous researcher. The high calorific value is better when undergo gasification process. From the trend of Figure 2.1.4 we can see that the composition of binder with EFB briquettes create a high strength of the briquettes.

2.2 Downdraft Gasifier.

Gasification is a process of conversion of any solid or liquid carbon-based material (feedstock) into gaseous fuel through its partial oxidation with air, oxygen, water vapor or their mixture. It could also be defined as the thermo-chemical process limited to a partial combustion and pyrolysis [7].

To produce the low tar content of producer gas, downdraft gasifier is the most suitable type of gasifier to be used in this study. As our aim is to test the producer gas from EFB briquettes. We need to produce the low tar content because to test in the diesel engine the tar content must be very low.

The main advantage of downdraft gasifier is the lower tar concentration in the producer gas and high car conversation. The lower tar concentration is due to gas passing through a high temperature zone (the combustion zone), which enables the cracking of the tars formed during gasification process. [8]

As conclusion, I choose downdraft gasifier to producer gas from EFB briquettes in my study because it produces low tar content which is very important before test the gas in dual fuel engine.

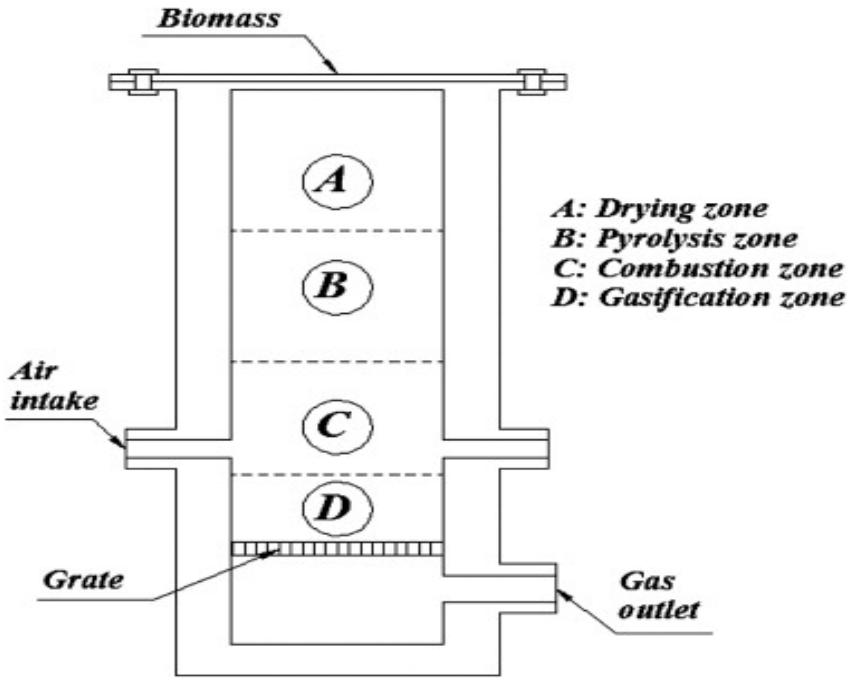

Figure 2.2.1: Convention of downdraft gasifier. [6]

2.3 Test producer gas characteristic in Open Combustion Chamber.

The quality of producer gas as a fuel is considerably poorer compared to gasoline and natural gas. Hence engines require certain design modifications to be carried out to be able to run on producer gas. Spark ignition and diesel engines fuelled with artificial gas with a quality like that of producer gas were studied by Muñoz et al. [9].

Many researchers conclude that using producer gas is hardly to produce higher compression ratio. Martin et al. (1981) had conducted experiments using charcoal gas and biomass-based producer gas on a SI engine and had found a de-rating of 50% and 40 respectively at a Compression ratio of 7. They also claimed a 20% de-ration while working with producer gas at a CR of 11. An upper limit of Compression ratio of 14 and 11 for charcoal and biomass based producer gas respectively was proposed by Martin et.a [10]

They have concluded that higher the capacity of the engine than the required capacity to be selected because the producer gas dual fuel engine could run only at maximum of 50–60% of maximum load condition. The power generation cost while using biomass is much cheaper than the conventional power generation cost. [11]

On the same paper said that the major challenge to face the use of producer gas as internal combustion engine fuels because of the combability with internal combustion engine material need to be further study and analyse the combustion techniques in combustion chamber with different composition of producer gas. [11-12]

CHAPTER 3

METHODOLOGY

3.1 Overview

Information and previous research paper can relate to this project can be obtained from the internet such as ScienceDirect and ResearchGate. Study and read the potential of oil palm to become empty fruit bunch briquette, carbonize material, briquetting process, type of binder, gasification process, producer gas and open combustion system.

The EFB briquetting in this project will be mixed with binder agent such as tapioca starch, corn starch and molasse starch with different ratio of EFB to binder. The physical of the EFB briquette will be tested using compressive load test to obtain maximum load stress and using bomb calorimeter to get calorific value of the EFB briquette. Thermogravimetric analysis (TGA) is to determine which of the EFB briquette sample that has the lowest change in mass over the changes of the temperature. Ultimate Analysis is laboratory analysis to determine Carbon, Hydrogen, Oxygen, Nitrogen, Sulphur and moisture inside the EFB briquette.

Downdraft type of gasifier will be chosen for this project because we need the producer gas of EFB briquette in low tar contain. Gas chromatographic (GC) of the producer gas shown the graph of contain gas in the gas sample such as Hydrogen, Oxygen, Nitrogen, Carbon Dioxide, Methane and Carbon Oxide.

Lastly, open combustion chamber is to determine the spraying and combustion of the producer gas of EFB briquette. Figure shown the flow chart implementation plan for the project.

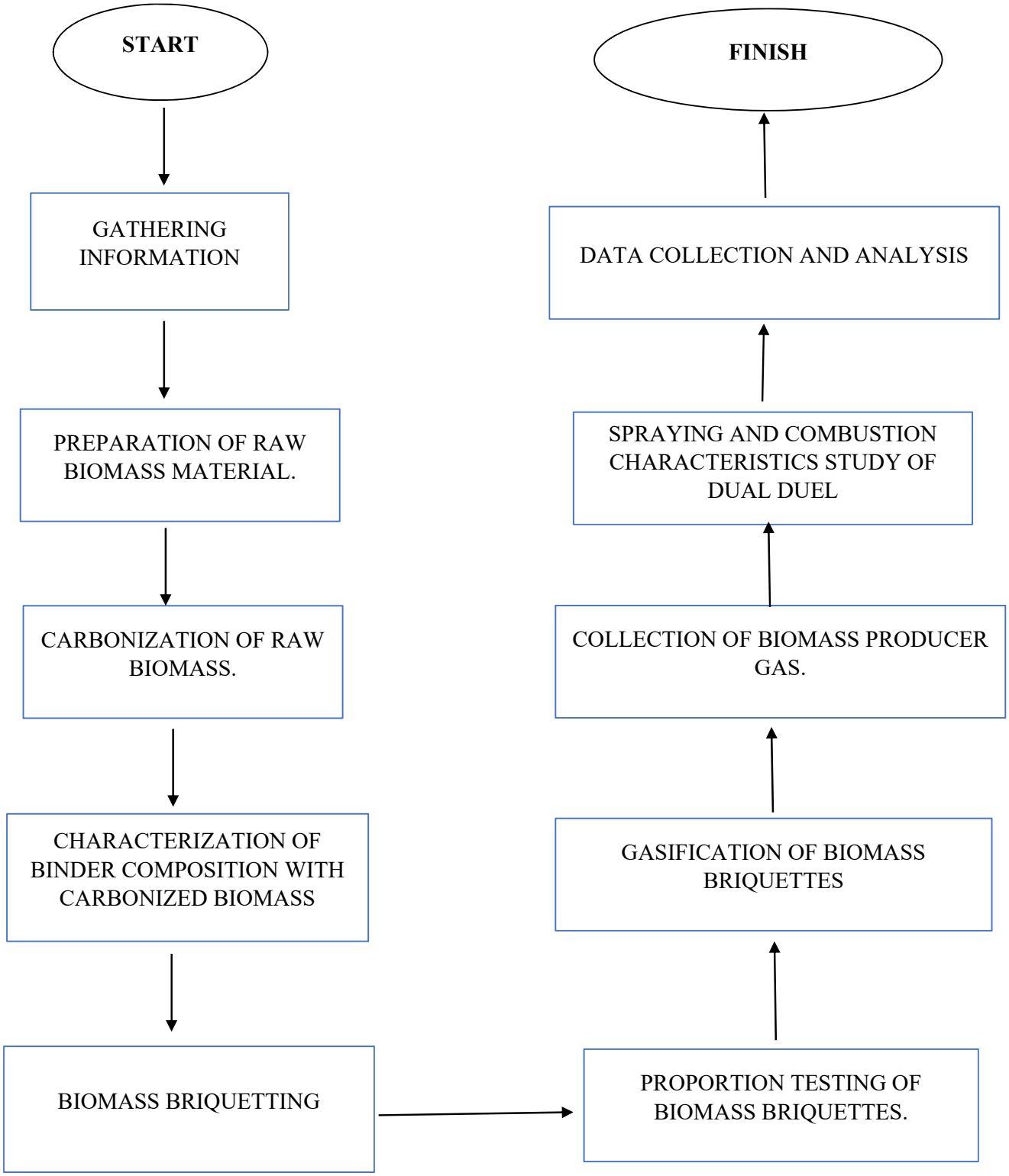

Figure 3.1: Flow chart of the implementation project progression