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EFFECT OF

AIR VELOCITY AND MOISTURE CONTENT ON

SOLID WASTE COMBUSTION

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Faculty of Mechanical Engineering
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"I hereby declared that this thesis titled
'Effect of Air Velocity and Moisture Content on Solid Waste Combustion' is the result
Of my own effort except as clearly stated in references the source of reference".

Signature: ________________________________

Name of Author: ________________________________

Date: ________________________________

Special dedication to my beloved mother, Ramlah Bte Jumaah who always be on my side taken good care of me. She will always be remembered. Not forgetting as well my brothers and sisters who had been with me all this while

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ABSTRACT

Nowadays, every country all over the world produces a very large amount of solid waste. This solid waste can be treated in various methods according to it classification. One of the most commonly use methods is the gasification process which not only burns the solid waste but also have potential to generate energy. Therefore, this project is aim to analyse the performance of gasifier by using coconut shell as fuel and considering two condition which is air velocity and moisture. Then analyse the product gases that release from the gasification process. The problem that needs to be solved is to analyse the maximum combustion. The scope in this project include running the experiment using varieties of air velocity and using difference of moisture content in solid waste. The equipment that will be use along with the gasifier is air blower, connection pipe, anemometer and data logger. The variety of air velocity can be produce by setting up the combination of air blower and the connecting pipe. Then burning process can be running with difference of air velocity. The thermocouple will measure the temperature every each level in the gasifier and send it to data logger. Data logger then directly sends the data to the computer to the software and displays the readings. Hence the performance of the gasifier can be analysed and identified the product gases release from the gasification process. Lastly, all the research that had been done were conclude where higher moisture content will result in higher moisture evaporation and the burning rate is inversely proportional to the moisture content. Meanwhile the increasing of air velocity will increase the burning rate but will decreasing back if the air velocity is too high. Gas emission of NO, NO_x and CO is decreasing after increasing of air velocity except for O_2. CO is inversely proportional to moisture content while O_2 is directly proportional to moisture content.

ABSTRAK

Setiap negara dipulusuk dunia menghasilkan banyak bahan buangan dalam bentuk pepejal. Bahan buangan dalam bentuk pepejal ini boleh digunakan kembali dengan merawat mengikut klasifikasinya. Salah satu cara yang biasa digunakan sekarang ialah proses gasifikasi dimana cara ini bukan sahaja membakar bahan buangan tersebut tetapi juga berpotensi untuk menjana tenaga. Sehubungan itu, projek ini adalah menentukan prestasi alat gasifier dengan menggunakan tempurung kelapa sebagai bahan api dan mengambil kira keadaan kelajuan angin dan kelembapan bahan buangan yang digunakan. Kemudian menganalisis produk gas yang dibebaskan daripada proses gasifikasi. Alatan lain yang akan digunakan bersama semasa menjalankan experimen termasuklah pam angin, paip penyambung, anemometer dan data pengelog. Kepelbagaian halaju udara boleh dihasilkan dengan mengkombinasi pam udara dan paip penyambung. Kemudian proses pembakaran boleh dilakukan dengan halaju udara yang berbeza. Alat thermocouple akan menyukat suhu di dalam gasifier pada setiap aras yang berlainan dan kemudian menghantar data ke data pengelog. Kemudian data pengelog akan menghantar data terus ke computer untuk dipamerkan. Maka prestasi gasifier boleh dikenalpasti dan dianalisis keluaran produk gas daripada proses gasifikasi. Kesimpulannya adalah di mana kadar kelembapan yang lebih tinggi akan mengakibatkan pengewapan kelembapan yang lebih tinggi dan kadar pembakaran adalah berkadar songsang dengan peningkatan kelembapan dalam bahan api. Sementara peningkatan kelajuan udara akan meningkatkan kadar pembakaran tetapi akan menurun kembali jika kelajuan udara terlalu tinggi. Pembebasan gas NO, Nox dan CO menurun selepas peningkatan kelajuan hawa kecuali untuk O2. CO berbanding terbalik dengan kadar air sementara O2 berkadar terus dengan kadar kelembapan air di dalam bahan api.

TABLE OF CONTENT

LIST OF FIGURE

LIST OF TABLES

CHAPTER I

INTRODUCTION

1.1 Project Overview

Since the beginning, humankind has been generating waste, be it the bones and other parts of animals they slaughter for their food or the wood they cut to make their carts. With the progress of civilization, the waste generated became of a more complex nature. At the end of the 19th century the industrial revolution saw the rise of the world of consumers. Not only did the air get more and more polluted but the earth itself became more polluted with the generation of nonbiodegradable solid waste. The increase in population and urbanization was also largely responsible for the increase in solid waste.

The equipment that used to convert the solid waste is solid waste gasifier. The solid fuel such as wood waste saw dust briquettes and agro-ressidues are converted into a gaseous fuel through a thermo-chemical process. This resultant gas very useful to produce heat which in turn applied in power generation applications. There is few type of gasifier that was commonly used in industries like updraft, downdraft and crossdraft which classified according to the way air is flow into it.

The gasifier will run gasification process which the efficiency of combustion are affected by the air velocity and moisture. In combustion process, a very high of air gases for reaction is one of the important facts in increasing the burning process. The combustion rate will increase when increasing the air velocity but a very high of velocity will also turn out the fire. Therefore, there must be a limit of the maximum that can be for air velocity to get the best combustion possible. Beside that, the moisture content in the solid waste also gives effect to the combustion process. Those, this project are to study the performance of the gasifier and investigate the emission released from gasifier.

1.2 Objective

The main objective in this project PSM are:

1. To study the effect of air velocity and moisture content on the behavior of coconut shell combustion.

1.3 Work Scope

Scope of work in this PSM research includes:

1. To run experimental work on solid waste by varying the:
    a. Fuel type: coconut shell, wood, etc and
    b. Operating conditions: moisture and air velocity.
2. Analyse temperature distribution
3. Analyse updraft gasifier performance
4. Analyse the product gases released

1.4 Problem Statement

In this project, there is no extensive work on the gasifier through experiment or simulation work. Therefore, this study is done to analyse the performance of updraft gasifier in operating condition of moisture content in solid waste and air velocity. In this research, the main equipment that will be use is an updraft gasifier. The updraft gasifier operated with the air that flow all the way through in it start from the bottom to the top of it where all the combustible gases will come out. The rate of combustion of the gasifier is mainly affect by the turbulence in it which involve the air velocity and the moisture content in the solid waste. These two conditions are very important because it related to the reaction mechanism of the gases and the product of gases that will occur. Those efficiency of the combustion can be determined.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

Biomass gasification means incomplete combustion of biomass resulting in production of combustible gases consisting of Carbon monoxide (CO), Hydrogen (H_2) and traces of Methane (CH_4). This mixture is called producer gas. Producer gas can be used to run internal combustion engines (both compression and spark ignition), can be used as substitute for furnace oil in direct heat applications and can be used to produce, in an economically viable way, methanol – an extremely attractive chemical which is useful both as fuel for heat engines as well as chemical feedstock for industries. Since any biomass material can undergo gasification, this process is much more attractive than ethanol production or biogas where only selected biomass materials can produce the fuel. Besides, there is a problem that solid wastes (available on the farm) are seldom in a form that can be readily utilized economically e.g. Wood wastes can be used in hog fuel boiler but the equipment is expensive and energy recovery is low. As a result it is often advantageous to convert this waste into more readily usable fuel from like producer gas. Those the attractiveness of gasification

2.2 Combustion

Combustion or burning is a complex sequence of exothermic chemical reactions between a fuel (normally a hydrocarbon) and an oxidant accompanied by the production of heat or both heat and light in the form of either a glow or flames, appearance of light flickering.

There is several type of combustion that are:

a. Rapid combustion
b. Slow combustion
c. Complete combustion
d. Turbulent combustion
e. Microgravity combustion
f. Incomplete combustion

2.2.1 Rapid Combustion

Rapid combustion is a form of combustion in which large amounts of heat and light energy are released, which often results in a fire. This is used in a form of machinery such as internal combustion engines and in thermobaric weapons. Sometimes, a large volume of gas is liberated in combustion besides the production of heat and light. The sudden evolution of large quantities of gas creates excessive pressure that produces a loud noise. Such combustion is known as an explosion. Combustion need not involve oxygen; e.g., hydrogen burns in chlorine to form hydrogen chloride with the liberation of heat and light characteristic of combustion.

2.2.2 Slow Combustion

Slow combustion is a form of combustion which takes place at low temperatures. Cellular respiration is an example of slow combustion.

2.2.3 Complete Combustion

In complete combustion, the reactant will burn in oxygen, producing a limited number of products. When a hydrocarbon burns in oxygen, the reaction will only yield carbon dioxide and water. When a hydrocarbon or any fuel burns in air, the combustion products will also include nitrogen. When elements such as carbon, nitrogen, sulfur, and iron are burned, they will yield the most common oxides. Carbon will yield carbon dioxide. Nitrogen will yield nitrogen dioxide. Sulfur will yield sulfur dioxide. Iron will yield iron (III) oxide. It should be noted that complete combustion is almost impossible to achieve. In reality, as actual combustion reactions come to equilibrium, a wide variety of major and minor species will be present. For example, the combustion of methane in air will yield, in addition to the major products of carbon dioxide and water, the minor side reaction products carbon monoxide and nitrogen oxides.

2.2.4 Turbulent Combustion

Turbulent combustion is a combustion characterized by turbulent flows. It is the most used for industrial application (e.g. gas turbines, gasoline engines, etc.) because the turbulence helps the mixing process between the fuel and oxidizer.

2.2.5 Microgravity Combustion

Nearly every flame behaves differently in a microgravity environment; for example, a candle's flame takes the shape of a sphere. Microgravity combustion research contributes to understanding of spacecraft fire safety and diverse aspects of combustion physics.

2.2.6 Incomplete Combustion

Incomplete combustion occurs when there isn't enough oxygen to allow the fuel (usually a hydrocarbon) to react completely with the oxygen to produce carbon dioxide and water, also when the combustion is quenched by a heat sink such as a solid surface or flame trap. When a hydrocarbon burns in air, the reaction will yield carbon dioxide, water, carbon monoxide, pure carbon (soot or ash) and various other compounds such as nitrogen oxides.

The quality of combustion can be improved by design of combustion devices, such as burners and internal combustion engines. Further improvements are achievable by catalytic after-burning devices (such as catalytic converters) or by the simple partial return of the exhaust gases into the combustion process. Such devices are required by environmental legislation for cars in most countries, and may be necessary in large combustion devices, such as thermal power plants, to reach legal emission standards.

The degree of combustion can be measured and analyzed, with test equipment. HVAC contractors, firemen and engineers use combustion analyzers to test the efficiency of a burner during the combustion process. In addition, the efficiency of an internal combustion engine can be measured in this way, and some states and local municipalities are using combustion analysis to define and rate the efficiency of vehicles on the road today.

2.3 Gasification

Gasification is a process that converts carbonaceous materials, such as coal, petroleum, biofuel, or biomass, into carbon monoxide and hydrogen by reacting the raw material, such as house waste, or compost at high temperatures with a controlled amount of oxygen and/or steam. The resulting gas mixture is called synthesis gas or syngas and is itself a fuel. Gasification is a method for extracting energy from many different types of organic materials.

There are four steps of level in gasification process:

a) Hearth zone (Oxidation),
b) Reduction zone,
c) Distillation zone (Pyrolysis) and,
d) Drying zone

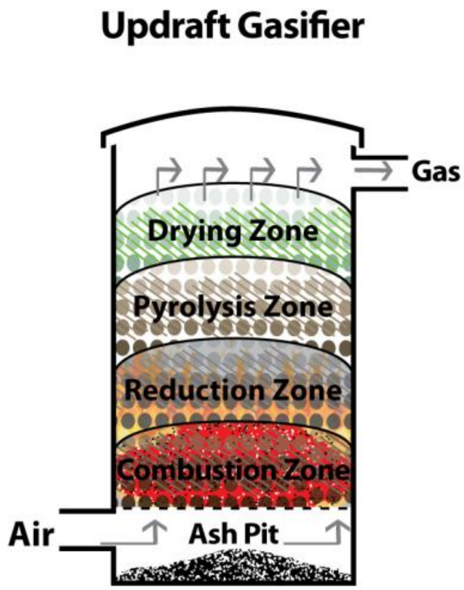

Figure 2.1: Four Zone Process in Updarft-Gasifier

(http://www.gekgasifier.com)

2.3.1 Hearth zone (Oxidation)

Hearth zone or oxidation zone also known as combustion zone which the combustible substance of a solid fuel is usually composed elements of carbon, oxygen and hydrogen. A complete combustion normally carbon dioxide will be produce from the carbon in the fuel and water will be produce from the hydrogen (steam).

The combustion reaction is a complex sequence of exothermic chemical reactions between a fuel that normally a hydrocarbon and an oxidant accompanied by the production of heat. The reaction are:

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

2.3.2 Reduction zone

The activated carbon reacts with water vapour and carbon dioxide to form combustible gases such as hydrogen and carbon oxide. The reduction (or gasification) process is carried out in the temperature ranging up to about 1100ºC.

$$C + CO_2 = 2CO$$

$$C + H_2O = CO + H_2$$

$$CO + H_2O = CO + H_2$$

$$C + 2H_2 = CH_4$$

$$CO_2 + H_2 = CO + H_2O$$

2.3.3 Distillation zone (Pyrolysis)

Volatile gases are released from the dry biomass at temperatures ranging up to about 700ºC. These gases are non-condensable vapours (e.g. methane, carbon-monoxide) and condensable vapours (various tar compounds) and the residuum from this process will be mainly activated carbon.