INTRODUCTION

1.1 Motivation, problem statement and brief review

Energy is an essential source for application in domestic and industrial activities. However, the energy production and usage can lead to environmental, economic and social impacts. The production of energy through combustion of fuel like coals normally lead to the problem of global warming caused by the rapidly increasing emissions of greenhouse gases such as carbon dioxide (CO$_2$) and methane.

Previously, one of the approaches to produce energy is by burning coals through combustion or gasification processes (Boqiang and Ouyang, 2014). The combustion and gasification processes utilizing coal leads to the increased carbon dioxide emissions and over ash accumulation which leads to the greenhouse effect (Salleh et al., 2009). The coal is one of the types of fossil fuels which is non-renewable type of fuels. Therefore, the coal can be short-run sometimes in the future and also affecting the environment through the mass production of carbon dioxide. Since some of the electric utilities are consumed of fossil fuels from the coal, therefore an alternative for the energy production is then necessary (Patrik, 2001).

Increasing of global concern on the environmental issues and decreasing the dependence to the fossil fuels leads to the use of renewable energy (Galindo et al., 2014). Renewable energy becomes an alternative energy technologies which use feed stocks like biomass, biogas or, solar to meet the future energy demand (Galindo et al., 2014). It will not give adverse effect on the environment when compare to the fossil fuels (Canbing et al., 2014).

Currently, enormous efforts have been done to recycle waste materials to produce energy where the major proportions of waste materials are the biomass materials. Gasification process is not a new technology but it is quite new technology for most of the peoples and thus, the introduction of the technology requires research to identify the potential benefits, and the potential risks to convince people to use this type of technology. For the analysis, there is a need to consider a detail characteristics and potential of the technology which may include the amount of energy can be produced
from the production and the effect of any condition change on the energy production rate.

Biomass becomes one of the most promising renewable energy sources due to its abundance, energy content, and the low emissions of carbon dioxide to the atmosphere (Gao et al., 2008). Usually, the energy from biomass materials may come from plant sources, such as wood from natural forests, waste from agricultural, forestry processes and industrial or human and animal wastes (Twidell, 1998). Biomass gasification produces syngas through thermo chemical conversion of biomass, usually involving partial oxidation of feedstock in the presence of air, oxygen or steam (Li et al., 2004). In Malaysia particularly, the biomass materials such as wood, rice husk, empty fruit bunch and sawdust are cheap abundant resources and therefore can be utilized for energy production using biomass gasification process. Here, the biomass gasification is one of the approaches to convert these biomass materials to energy where it is an attractive solution to solve both waste disposal and energy problems by producing fuel gas like hydrogen (Karmakar and Datta, 2011). Hydrogen is one of the clean energy sources and a potential alternative fuel. The combustion of hydrogen does not negatively affect the environment.

Nowadays, many gasification technologies to exploit biomass abundances such as downdraft and fluidized bed gasifier are used to produce of electricity, heat, chemicals and liquid fuels. Technically, there are two groups of biomass gasification models to represent downdraft or fluidized bed gasifications which are equilibrium approach and kinetic approach. Kinetic models predict the progress and product composition at different positions along a reactor, whereas equilibrium model predicts the maximum achievable yield of a desired product from a reacting system (Li et al., 2004).

Kinetic models concern on the chemical kinetics of the main reactions and the transfer phenomena among phases, estimating the composition of each species on any point of space and time of a system. The kinetics models are specified in general for each process by providing important considerations on the chemical mechanisms and to increase the reaction rates and the overall process performance. However, the kinetic models always contain parameters which make them hardly applicable to different plants (Schuster et al., 2001). An accurate description of the chemical kinetic rate
expression is a key issue. The choice of chemical kinetic laws is difficult because there are as many kinetic laws as kinetic studies. A large discrepancy can be observed between them and it is highly hazardous to extrapolate literature results obtained under different operating conditions (Avdhesh, 2008). For example, the steam and carbon dioxide reforming reactions of char are kinetically limited at temperatures lower than 1000°C (Koroneos and Lykidou, 2011).

Although kinetic models provide essential information on mechanisms and rates, equilibrium models are more suitable as it can predict thermodynamic limits to design, evaluation and improve a process. Equilibrium model also provides a useful design aid in evaluating the limiting possible behaviour of a complex reacting system which is difficult or unsafe to reproduce experimentally or in commercial operation. It provides the greatest possible conversion of each species regardless the system size and the time needed to reach equilibrium. These models do not require details of system geometry neither estimate the necessary time to reach that equilibrium (Karmakar and Datta, 2011).

The increase of global concern on environmental issues had led to the finding of alternative ways to produce energy. One of the most promising ways of energy production is through the use of renewable energy like biomass gasification process. Since the gasification models can be divided into two groups that are equilibrium approach and kinetic approach, the comparison between both types of model had been done. Among them the most effective and applicable model is the equilibrium model due to its behaviour and operation system.

1.2 Objectives

The following are the objectives of this research:

i) To investigate and analyse the performance of downdraft biomass gasification using thermodynamic equilibrium model using wood, rice husk, empty fruit bunch and sawdust.

ii) To investigate and analyse the performance of fluidized bed biomass gasification using thermodynamic equilibrium model using wood, rice husk, empty fruit bunch and sawdust.