CHAPTER I

INTRODUCTION

Gasification is a flexible, reliable, and clean technology that can turn a variety of low-value feedstock into high-value products. It helps to reduce our dependence on foreign oil and natural gas, and provides a clean alternative source of base load electricity, fertilizers, fuels, and chemicals. Gasification is a manufacturing process that converts any material such as coal, petroleum coke (petcoke), or biomass into synthesis gas (syngas). The syngas can be burned to produce electricity or further processed to manufacture chemicals, fertilizers, liquid fuels, substitute natural gas (SNG), or hydrogen (National Renewable Energy Laboratory, Department of Energy USA).

Biomass resources are abundant in Thailand and its increasing utilization helps reduce expensive fuel import and enhances local income. Besides, biomass is also environment friendly. It will not cause pollution and green house effect due to the recycling of CO_2. There are 6 types of renewable energy for commercial purposes in Thailand. They are namely, solar, wind, biomass, biogas, ethanol and bio-diesel. There is an gradual increase in the number of biomass plants which utilize agricultural wastes. There are some other interesting technologies for biomass such as pyrolysis and gasification which have been studied and developed by the researchers in Thailand (The Federation of Thai Industries, 2005). The thermo-chemical conversion method of biomass gasification is generating emphatic interest. Not only is this method used for power generation but also it is widely used for gas to liquid (GTL) processes like syntheses of methanol, DME and Fischer-Tropsch syntheses.

In biomass gasification, formation of tar may be unfavorable. Although high temperature gasification decreases tar formation, the process consumes more energy , which leads to high cost. One major issue in biomass gasification is how to deal with the tar formed during the process. Tar is a complex mixture of condensable hydrocarbon which includes single ring to five-ring aromatic compounds along with other oxygen containing hydrocarbons and complex polyaromatic hydrocarbon (PAH).

Tar can be eliminated by thermal cracking or by the use of a catalyst. The catalytic gasification process is an attractive technological alternative to deal with tar and to produce high yield of syn gas (Devi, 2003). Steam is one of the most commonly used gasification agents because a high percentage of hydrogen can be obtained during the process. Steam reforming methods of tar using catalysts are currently being studied. These technologies make use of the sensible heat and steam contained in the gas to convert tar to CO and H_2 in temperature range of approximately 800°C (Aznar et al. 1998).

Many researchers have proved the usefulness and effectiveness of calcined dolomite and nickel based steam reforming catalysts on decreasing tar yield (Sutton, 2001 and Devi, 2003). The catalyst can increase the reaction rate of the steam and can participate in the secondary reactions. Therefore, the catalyst improves the quality of the gas product and reduces tar content in the process (Arouzo et al. 1991). Moreover, adding active bed materials also prevents agglomeration tendencies and subsequent coking of the bed. Nickel and dolomite catalysts have been proven to be very active in terms of tar reduction and it shows excellent catalytic activity, resistance of coking and sulfur poisoning in steam gasification of toluene and naphthalene (Srinakruang et al. 2005).

The application of metal catalysts in biomass gasification is an effective method to reduce tar content. In most cases, commercially available, steam reforming Ni catalysts have been applied and the problem of catalyst deactivation due to coke deposition has been pointed out (Sutton et al. 2001, and Tomishige et al. 2004). Recently, Asadullah et al. (2001) reported the gasification of cellulose and biomass with air using $Rh/CeO_2/SiO_2$. It was found that $Rh/CeO_2/SiO_2$ was much more effective catalyst for gasification of biomass with air than conventional steam reforming that used Ni catalyst and dolomite. It also showed high resistance to coke deposition and high stability. However, the catalyst has problems in high cost and limited availability originated from the usage of Rh. Developments of metal catalysts have also been carried out by the addition of a small amount of noble metal such as Pt, Ru, Rh and Pd (Pompeo et al. 2007). Noble metal are known to form less coke under reforming reactions and the coke formed differs in nature from that found with Ni catalyst. Platinum is an interesting metal to be used as catalyst for syngas obtention due to good availability and its relatively low price with respect to rhodium (Nishikawa et al. 2008). Cobalt catalysts have been reported as an effective catalyst for the steam gasification of wood and biomass, partial oxidation of methane and steam reforming of ethanol (Furusawa et al. 2005).

In summary, the above problems motivated the author to study the catalytic performance of Ni/dolomite for tar removal in biomass gasification and to investigate the catalytic performances of Ni/dolomite catalyst by adding small amounts of noble metal to Ni/dolomite catalyst according to its catalytic reactivity on gas composition, structural stability, and resistance to coking with consideration of the production cost.

This research investigated effects of promoters by using transition metal group VIIIB such as Pt, Co, Fe impregnated on Nickel/dolomite catalyst. The research also studied the efficiency of nickel /dolomite catalyst for tar removal and investigates the suitable operating parameters on product gas compositions.

1.1 Objectives

1. To study effects of promoters on biomass gasification using Nickel/dolomite.
2. To study the efficiency of catalysts for removal tar and find suitable conditions in biomass gasification.

1.2 Scope of research work

1. Literature survey.
2. Experimental design; Gasifier, instrumentation and chemicals.
3. Preparation of 10% Nickel/dolomite catalyst by precipitation method.
4. Investigation of the influence of variables as following:
    - 4.1 The influence of calcination temperature at 500, 750, 950^{o}C.
    - 4.2 The influence of reaction temperature at 600-800^{o}C.
    - 4.3 The influence of steam to carbon ratio in the range of 0.2 – 1.
    - 4.4 The influence of gasifying agent such as oxygen.
    - 4.5 The influence of biomass type: coconut shell, palm.
    - 4.6 The influence of promoters: Fe, Co, Pt.
5. Biomass analysis
    - 5.1 Proximate analysis of biomass: Ash, Moisture, Fixed carbon, Volatile matter.
    - 5.2 Ultimate analysis by CHNS/O Analyzer.
6. Characterization of the catalyst by BET, chemisorptions, X-ray diffraction and SEM.
7. Characterization of the gas products by Gas Chromatography.
8. Results discussions and conclusions.