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Catalytic Adaro Coal Gasification using Dolomite and Nickel as Catalysts

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Abstract

Integrated Gasification Combined Cycle (IGCC) is an Advanced Clean Coal Technology and can be used as an option for future TNB coal-fired power plant. The implementation of this technology is expected to reduce Green House Gas emissions (eg. CO_2), which caused global warming. However, there are several problems in IGCC system, including low carbon conversion and low efficiency in gasifier. Previous studies had shown that higher carbon conversion and efficiency only can be achieved at higher temperature of 900-1000°C. In this study, we had increased the carbon conversion and gasifier efficiency for Adaro coal gasification process using catalyst as in-bed material at lower operating temperature of 700-800°C. Dolomite and nickel with high catalytic activity are selected as catalysts. These catalysts will enhance tar cracking and production of syngas. Furthermore, dolomite is also cheap and abundantly available in Malaysia. Coal catalytic gasification tests were conducted using TNBR Pilot Scale Gasification Plant (PSGP). Adaro coal (100%), Adaro coal:dolomite (80:20) and Adaro coal:dolomite:nickel (90:9:1) mixtures were gasified using PSGP. The results showed that the presence of dolomite had increased Carbon Conversion (CC) and Gasification Efficiency (GE) about 3.1% and 30.7% respectively, compared to Adaro coal gasification. While, the presence of dolomite and nickel for Adaro coal:dolomite:nickel (90:9:1) gasification, had increased CC and GE about 9.5% and 16.4% compared to Adaro coal gasification. Lower increasing of the GE with the presence of nickel is expected due to the deactivation (poison) effect of H_2S towards nickel during the gasification process.

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Keywords: catalyst; coal; conversion; efficiency; gasification

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1. Introduction

Typical IGCC system is divided into Gasifier Block, Syngas Cleaning System and Power Block (Fig. 1). There are several problems in IGCC system, such as (i) low carbon conversion, low efficiency and ash slagging problem in gasifier; (ii) impurities of the syngas, due to the presence of hydrogen sulphide (H_2S), acid gas and particulates; and (iii) High gas turbine temperature due to the presence of high hydrogen (H_2) content in syngas.

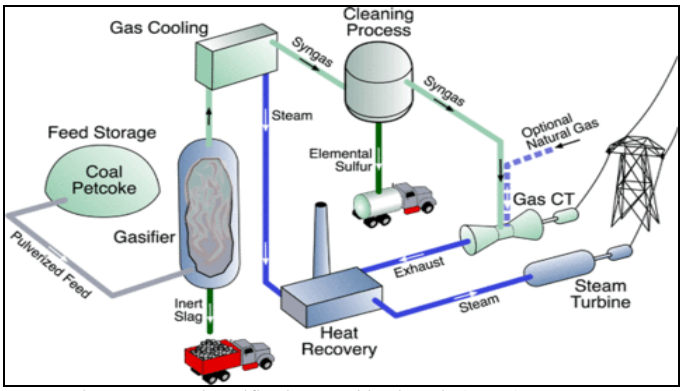

Fig.1. Integrated Gasification Combined Cycle (IGCC) System.

Previous studies [1]-[3] had shown that higher carbon conversion and efficiency only can be achieved at higher temperature of 900-1000°C. In this study, carbon conversion and gasifier efficiency are expected to increase when using catalyst as in-bed material at lower operating temperature of 700-800°C.

2. Methods

Adaro coal from sub-bitumious rank was gasified with and without the presence of dolomite and nickel as catalysts using Pilot Scale Gasification Plant (PSGP) (Fig. 2). Typical characteristics of Adaro coal is shown in Tables 1 and 2. Calorific value, ultimate analysis and proximate analysis were conducted at Fuel Testing Laboratory, TNB Research Sdn Bhd.

Table 1. Calorific Value and Ultimate Analysis of Adaro Coal.

	Ultimate Analysis				
Gross Calorific Value (MJ/kg)	Carbon %	Hydrogen %	Nitrogen %	Sulfur %	Oxygen %
21.0	73.5	5.0	0.9	0.1	20.4

Table 2. Proximate Analysis of Adaro Coal.

Total Moisture %, arb	Ash %, arb	Volatile Matter %, arb	Fixed Carbon %, adb
26.6	1.9	37.1	34.4