

Chapter 1

1. INTRODUCTION

1.1. Background and Problem Statement

According to the BP (2007) statistical review of world energy, coal is, in terms of consumption, the fastest growing primary energy resource in the world. Coal is also the most abundant and reliable fossil fuel world wide. Of the remaining world proven coal reserves, about 50% is lignite (BP, 2007).

The growth in coal consumption worldwide as well as the high oil price in the recent past has led to the current increased interest in the application of coal gasification technologies. Indeed, in 2006/2007 Sasol-Lurgi Technology Company (Pty) Ltd (SLTC), a sole licensor of the Sasol Lurgi Fixed Bed Dry Bottom (S-L FBDB) gasification technology received about 60 enquiries per week from the potential customers of their technology around the world. Of the coals evaluated by SLTC for gasifiability since January 2006, about 70% of them were lignite. Sasol has however limited experience in the gasification of lignite, although it participated in the full scale testing of lignite in Sasolburg and the commissioning of Dakota Gasification Company's Great Plains Synfuels plant (DGC) in the early 1980's (Roeger and Jones Jr., 1983).

Sasol, through its subsidiary Sasol Synfuels International (Pty) Ltd has embarked on a globalization strategy for deploying its Coal to Liquids (CTL) technology. In this technology, gasification is the core process from which synthetic gas is produced and converted to liquid fuels and chemicals via the Fischer-Tropsch (FT) process. Although there are other gasification technologies that can be used for the international CTL ventures, the S-L FBDB gasification technology offers various advantages. Amongst others, the advantages include the H_2/CO ratio of 1.6 – 2.0 which is, without any modifications/adjustments, directly suitable for the FT technology (Assberg-Petersen *et al.*, 2004).

There is therefore a need for the understanding of the behaviour of foreign coals in the S-L FBDB gasifiers. This will enhance the opportunities for the confident deployment of both the Sasol CTL and S-L FBDB gasification technologies to the countries that have “stranded” coal and lignite reserves. As an example, understanding of the reaction zones in the S-L FBDB gasifiers operating on coals of different types and ranks may assist in determining the optimal height of the gasifiers required for gasification of these particular foreign coals.

As one of the licensees of the S-L FBDB gasification technology, DGC, through the Great Plains Synfuels Plant gasifies about 18 000 tons of North Dakota lignite from the Freedom Mine (located near Beulah, North Dakota (ND)) daily to produce about 4 500 km³N (about 160 million cubic feet) of Synthetic Natural Gas (SNG) and other by-products (Fagerstrom, 2007). Sampling and analysis of the gasifier bed material at the Great Plains Synfuels Plant therefore offers a very good opportunity for understanding the behaviour of lignite in the S-L FBDB gasifiers.

1.2. Hypothesis

It is hypothesised in this study that using the FBDB gasifier sampling methodologies available in the literature, with some modifications to suit the context of this study, can help to explain the fuel bed behaviour as well as the coal properties transformation behaviour during gasification of lignite in the S-L FBDB process. The information and knowledge gained in this type of a study may enhance the understanding of the process and hence contribute towards improvement in operations, modelling and design of the S-L FBDB gasifiers.

1.3. Objectives and Scope of the Study

The main objective of this study was to investigate the fuel bed behaviour as well as coal properties transformational behaviour in a S-L FBDB gasifier that gasifies ND lignite. The following were the sub-objectives of the study:-

- a) Determine and understand the reaction zones for lignite in a commercial scale S-L FBDB gasifier.
- b) Develop profiles of the coal property transformational behaviour (chemical, physical, petrographic and mineralogical properties) in the various reaction zones of the gasifier.
- c) Compare the reaction zones as well as some of the ND lignite coal properties transformation profiles with Medium Rank C, bituminous coal from the Highveld Coalfield in Secunda South Africa.
- d) Discuss the engineering or design implications from the information obtained and also identify the optimization opportunities for the DGC operations.
- e) Identify fundamental research opportunities with regard to lignite coal gasification using the S-L FBDB gasification process.

To achieve these objectives, two MK IV Sasol-Lurgi Fixed Bed Dry Bottom gasifiers (i.e. "Albert" and "Bernice") were sampled using the Turn-Out method developed by Bunt (2006) and modified in this study to suit lignite. The samples were characterised for their chemical, physical, petrographic and mineralogical properties which were then interpreted in terms of their transformation in the various reaction zones of the gasifiers. It is envisaged that the results obtained in this study will not only benefit Sasol or SLTC with regard to the understanding of the reactors and improvement in modelling and design, but will also assist DGC in further optimising their lignite gasification process.