REPORT

Initial Gasification Trials

USING A 100 KG/HR DEMONSTRATION PLANT

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A Report on the Initial Gasification Trials Using a 100 kg/hr Demonstration Plant

I. Introduction

The aim of this ARENA project is to scale up an advanced biomass gasification technology to 100 kg/hr biomass processing capacity. A 100 kg/hr biomass gasification demonstration plant has been designed, built and commissioned. Some initial trials have now been carried out using this demonstration plant for the gasification of mallee and other biomasses. The results from these initial trials are highlighted below. These initial results have proved the overall technical feasibility of this advanced gasification technology.

II. A Brief Description of the Technology and the Demonstration Plant

This advanced gasification technology has been developed by the researchers in Fuels and Energy Technology Institute in Curtin University of Technology. Additional intellectual property has been developed in this ARENA project. The technology has many important features, e.g.

- *Use of char as a catalyst* (or char-supported catalyst) to catalytically reform tar residue in the gasification product gas into a clean gas. This eliminates the need to use a liquid (e.g. water or biodiesel) to scrub the gasification product gas for tar removal.
- *Compact design*, making it particularly suitable for combined heat and power generation in distributed mode. It can generate base-load electricity. It can accept a wide range of biomasses as its feedstock.
- *Minimised volatile-char interactions* to achieve rapid gasification even at relatively low temperature and atmospheric pressure, greatly reducing the capital and operating costs.
- *Incorporation of advanced energy recuperation principles* to further increase the energy efficiency. The gas cleaning sub-system also recovers some of the sensible heat of the raw product gas as chemical energy and thermal energy; the latter is then transferred to the gasification system and recuperated into chemical energy.
- *Capability of being operated as a negative carbon emission technology* to sequestrate CO_2 in the atmosphere as biochar in soil, which further enhances the sustainability of biomass as a green energy source by ensuring the long-term fertility of our land.

Figure 1 shows the 100 kg/hr gasification demonstration plant. The demonstration plant includes a number of sub-systems. A dryer is used to reduce the moisture content of feed biomass when necessary although there is no need to dry the biomass completely. The main gasification system converts the biomass into a raw gasification product gas, which is then cleaned using a carbon-based catalyst. As a demonstration unit, the clean gasification

Figure 1. The 100 kg/hr gasification demonstration facility located in the Fuels and Energy Technology Institute, Curtin University, Technology Park, Perth.

Figure 2. Mallee biomass used as feedstock for some of the initial trials.

product gas is finally burned and then released. In the commercial operation in the future, this will be replaced with a gas engine or other power generation devices for combined heat and power generation.

The gasification system minimises the interaction of volatiles and char to achieve rapid gasification at low temperature and close to atmospheric pressure (mostly < 0.2 barg). Air and steam are the main gasifying agents. The consumption of air is minimised to achieve high gasification efficiency.

III. Highlights of Initial Trials

III.1. Biomass Feedstocks

The initial trials have used mallee biomass and wheat straw as feedstocks, both were grown in Western Australia.

Figure 2 shows the mallee biomass feedstock. It is a mixture of all parts of mallee trees, including wood, barks, twigs and leaves. The leaves are under-represented in this particular feedstock because the mallee trees were cut long before the biomass was chipped and thus the dried leaves dropped.

As is shown in Figure 2, the feedstock contained a wide range of particle sizes, ranging from fines (sub-millimetres) to chips (even a few centimetres). It is expected that even larger chips could be used in the commercial operation when the larger feeding system in the commercial system would be able to cope with bigger particles.

III.2. Gas Product Quality

The initial trials included short and long runs. The longest run lasted for about 108 hours (more than 4 days). These runs covered a wide range of experimental conditions including temperature, biomass feeding rate (up to 120-130 kg/hr) and steam/air/biomass ratios.

A key objective of these runs was to demonstrate the ability of our technology to destroy tar residues in the gasification product gas using a carbon-based catalyst without the need to scrub the product gas with water. The tar content (expressed as mg-C/Nm^3) changed significantly with gasification conditions. While the tar content in the raw product gas entering the catalyst bed could be a few hundred mg/Nm^3, the tar content after the char catalyst beds could be as low as <20 mg/Nm^3. This is well below the commonly accepted standard of 100 mg/Nm^3 for the content of tar in the product gas in order for the gas to be used in a gas engine to generate electricity (and heat).

Our gas cleaning system could also drastically reduce the content of fines in the product gas. Further work will be carried out to optimise the conditions to reduce the contents of fines in the product gas.

The main components in the gasification product gas were CO, H_2, CH_4, CO_2 and N_2. N_2 has originated from the air fed into the gasification system as a gasifying agent. As was expected, the gas composition changed widely with experimental conditions as well as biomass feedstock. Typical ranges were:

CO: 14 to 17 vol%

H_2: 16 to 25 vol%

CH_4: 3-6 vol%

CO_2: 12-17 vol%

N_2: being the main balance gas.

The higher heating value of the gasification product gas was calculated based on the gas composition, which varied from about 5.1 to 6.9 MJ/Nm^3 for the conditions tested.

It should be noted that the gas composition and thus heating value can be greatly affected by the heat loss of the whole system. The heat loss would decrease as the technology is further scaled up, resulting in the improvement of gas quality in terms of heating value. Heat integration within the whole gasification-based power generation system could also drastically influence the gas composition and heating value.

It must be emphasised that the above data from the initial trials must be treated as preliminary. However, it is obvious that this technology, without the need to scrub the raw product gas with water (or other liquids) for tar removal and without the need for oxygen production from air separation, has great potential to produce a gasification product gas that is of sufficient quality for use in a gas engine to generate electricity (and heat).

IV. Conclusions

The initial trials have indicated the overall feasibility of our technology for the gasification of biomass. Further trials will aim to further optimise the system and gasification conditions to obtain more detailed data for the design and operation of a commercial scale biomass gasification system using this technology.