FEEDSTOCK ADAPTABILITY TO PRESSURIZED FIXED BED GASIFICATION

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Abstract

In order to produce synthesis gas for BTL (biomass to liquid) process, pressurized gasification is an option. Pressurized updraft fixed bed gasifier was chosen and an experimental setup was made. Whole apparatus including gasifier, feedstock hopper, feeder, etc. were put inside a pressure vessel. Wood chip or PKS (Palm kernel Shell) are adoptable feedstock for updraft fixed bed gasifier. In considering the use of waste polymeric materials for gasifier, their adaptability is a matter. Pressurized fixed bed gasification of PKS and wood pellet, which is not the same as wood chip, was carried out. As a result, the difference between PKS and wood pellet was seen in adaptability. Gasification reaction was achieved well in the experiment for PKS while the problem such as channeling of the gas flow was caused using wood pellet. Such problem for wood pellet was reduced by lowering the bed height of the materials inside the gasifier, and outlet gas temperature increased by bed height lowering.

Keywords: biomass, gasification, pressure, BTL, DME

1. Introduction

Liquid fuels for transportation vehicles have been derived from petroleum. It is expected to obtain a part of fuels from wastes or sustainable materials in the future. BTL (biomass to liquid) process supplies fuels, especially used for diesel engine, from biomasses. BTL process consists of biomass gasification and fuel synthesis. DME is one of the most applicable fuels for diesel engine, and DME can be obtained from synthesis-gas (CO and H_2). DME is synthesized usually at around 2MPa with catalyst.

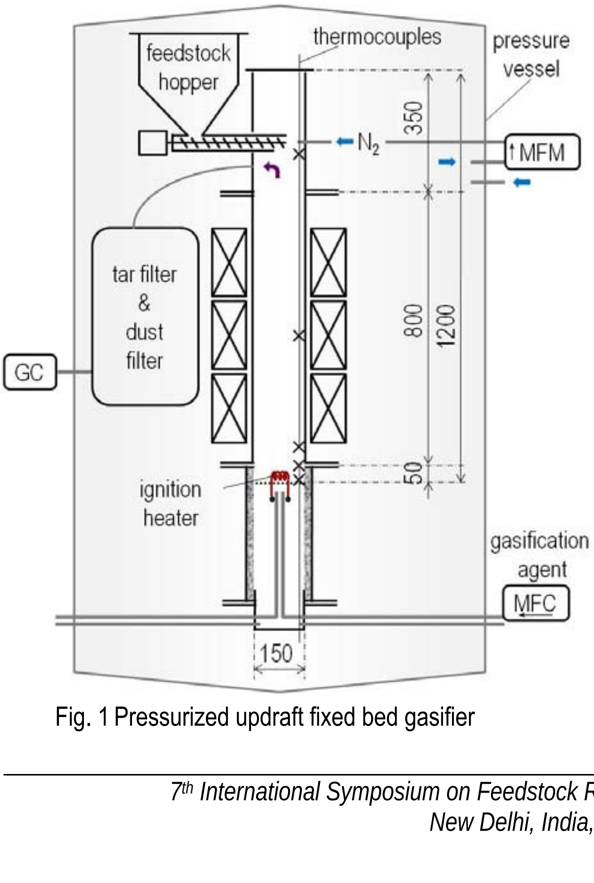

Fig. 1 Pressurized updraft fixed bed gasifier

Recently, such lower pressure condition as less than 1MPa was tried to apply DME catalytic synthesis. In the BTL process, syngas has to be increased in pressure by a booster machine. Because biomass is gasified at atmospheric pressure by ordinary, syngas is usually obtained as in atmospheric pressure. Meanwhile, power for syngas compressing can be reduced when biomass is gasified at pressurized condition.

Pressurized fixed bed gasifier was chosen as relative high conversion efficiency in smaller scale. Wood chip is adoptable feedstock for updraft fixed bed gasifier. Considering using waste polymeric materials, adaptability to gasifier is a matter. Powders or fibrous materials, for example, are anticipated to cause some problems.

In this study, the experimental setup for pressurized fixed bed gasification was used. Wood pellet, which is made from wood powder, was used as gasification feedstock to compare PKS, which is as suitable feedstock as wood chip for fixed bed gasifier.

2. Materials and Methods

2-1. Apparatus

Pressurized updraft fixed bed gasifier which is operated at below 1MPa (gauge pressure) was used. Whole apparatus including gasifier, feedstock hopper, feeder, etc. were put inside a pressure vessel as shown in Fig. 1. Feedstock was supplied continuously (10-80g/min) from the hopper by the screw feeder. Air as the gasification agent was supplied from the bottom of the gasifier with 10-100L/min. Temperature of 5 points inside gasifier was monitored by K-type thermocouples (TC) during each experiment. The distances from each TC to the bottom inside gasifier are 10mm (TC1), 50mm (TC2), 115mm (TC3), 460mm (TC4), and 1008mm (TC5), respectively. Product gas concentration was detected by GC-TCD and GC-FID, liquid products (tar and water solution) and residual solid products (char) were collected and weighed after experiments.

2-2. Feedstock

PKS (Palm kernel Shell), 3-25mm and wood pellet (Japanese softwood), φ6mm × 10-25mm were used. Maximum amount was 20kg for an experiment,

3. Results and Discussion

3-1. PKS

Temperatures at the lower part inside the gasifier, TC1-3, were raised to around 500°C at about 20min after ignition and kept over 500°C using PKS with controlling to keep the bed height of the materials from the bottom inside the gasifier around 300-600mm. At the same time, TC4 and TC5 which reflect the outlet gas temperature kept below 200°C. Product distribution showed mostly constant after 60min, CO: 50%, CO_2: 20%, H_2: 10%, CH_4: 5%, approximately. Similar tendencies of changes in temperature and product distribution were shown and stable operations were kept with changing experimental conditions such as pressure, bed height (100-600mm), while absolute values of the temperature and concentration were varied. There are not observed notable heterogeneity in planar direction of the residual solids, no such large hole as exceeding 10mm or pulverization, opening the gasifier after experiments of PKS.

3-2. Wood pellet

Temperatures change inside the gasifier during wood pellet gasification at 0.3MPa is shown in Fig. 2. The bed height was tried to control keeping relatively low around 100-150mm. TC1 reached around 600°C at 20min after ignition and kept 600-800°C. TC2 reached around 600°C at 60min. Meanwhile, TC3 reached around 800°C at 10min and continued to rise toward 1100°C at 120min, it tuned to drop to around 300°C after 130min, because TC3 placed near the top of the material bed. The bed height seemed to fluctuate depending on the consumption rate of the feedstock. However combustion was major reaction in the early stage of the experiment, gasification became major in the latter half leading the top of the bed could shift under TC3. Gasification with same rate of air supply conduce higher consumption rate than combustion. TC4 exceeded 200°C in 30min, continued to rise toward 400°C at 200min. The outlet gas temperature reached higher (>400°C) when bed height is lower (<150mm) comparing with the result in 3-1, which temperature was low (<200°C) at higher bed thickness (300-600mm).

Change in major product gas distribution is shown in Fig. 3. CO_2 was continued to major product with leading by combustion until 40min. After the product gases

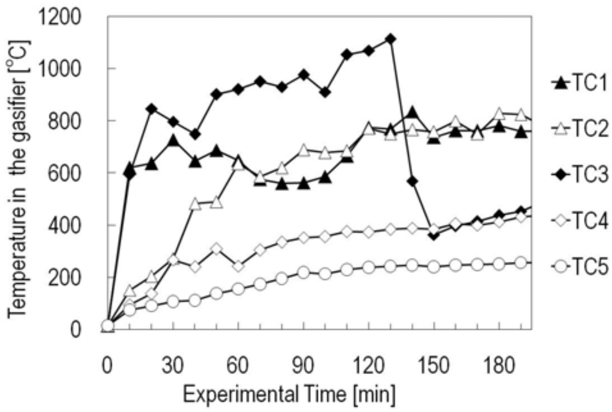

Fig. 2 Temperature change inside gasifier during wood pellet gasification at 0.3MPa

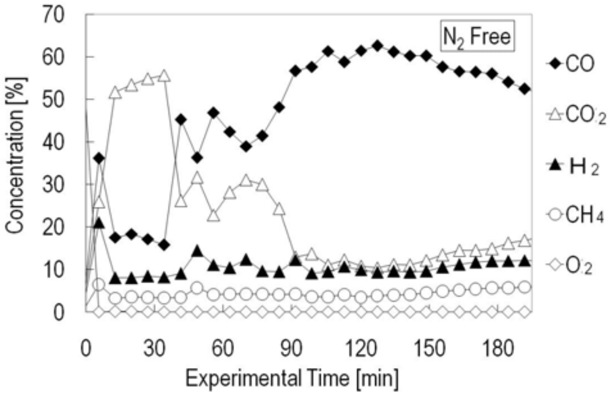

Fig. 3 Change in product gas distribution during wood pellet gasification at 0.3MPa

fluctuated up-and-down around 40-90min, CO exceeded 50% after 90min migrating to gasification as the major reaction and continued until 200min.

On the other hand, with regular bed height as 300-600mm for wood pellet, CO_2 was inevitably continued to high as 40-60% and CO did not exceed 20-30%. There were hole inside the material bed to gas to sweep (channeling) causing accumulation of the materials, feedstock and partial reacted char, by the observation after the experiments. Basically, several layers, which are combustion zone, gasification zone, pyrolysis zone, and drying zone, are formed from bottom up in the updraft gasifier, but their layers are hard to form with arising a hole. This is an explanation of why problem in gas stream was caused is that wood pellet was pulverized and swollen by exposing under vapors for tens of minutes at 100-300°C, the formed powdery substance inhibited to uniform gas flow.

4. Conclusions

The difference between PKS and wood pellet was seen in adaptability for pressurized fixed bed gasification. Gasification reaction was achieved well in the experiment for PKS while the problem such as the channeling of the gas flow was caused using wood pellet. Such problem was reduced by lowering the bed height of the materials inside the gasifier, even though outlet gas temperature increased by bed height lowering.