

Rice husk as the feedstock for gasification purpose

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Rice husk was used as the feedstock for gasification purpose due to its significant abundance and suitable caloric value. First, the biomass sample was dried at 90 °C for 2 h and then, it was shredded into five different biomass particle size (db) ranges, namely <1.5 mm, 1.5-2.0 mm, 2.0-2.5 mm, 2.5-3.0 mm and > 3.0 mm. The ultimate and elemental analysis of biomass sample was respectively done through a CHNS analyzer and a Vario MACRO cube elemental analyzer. The higher heating value of rice husk was calculated through Channiwala-Parikh (Eq. 1) based on biomass elemental composition.

Apparatus

The gasification of rice husk was done by a bubbling fluidized bed (height 600 mm with an OD of 205 mm). The gasifier which is created by 1Cr18Ni9Ti stainless steel was covered by an insulation layer to minimize the heat loss. The gasifier temperature was measured by three k-type thermocouples and recorded in a monitoring system. The gasifier tube was heater with two electric heaters at a heating rate of 15 °C/min to the desired temperature and then kept constant. The gasification experiments were carried out at atmospheric pressure with air as a gasification agent.

At first, the electric heaters were turned on, and when the reaction temperature reached the desired final temperature, the screw feeder on top of the gasifier was turned on and biomass particles were fed into the gasifier with a desired rotation speed. The produced gas was initially transferred into a condenser to separate the tar content from the producer gas through a cooling process. The tars were collected at the bottom of the condenser and the syngas was transferred into a cyclone to remove the remaining aerosol

and tars. To insure the reliability of the test data, the condenser, cyclone and interface pipelines were washed with tetrahydrofuran (THF). The char was collected in the char collector and its quantity was measured by the weight difference of the collector before and after each test.

To minimize the possibility of dolomite erosion and catalyst deactivation, calcined dolomite was mixed well with the biomass samples by a mixer before each test. The produced gas was finally transferred into a capsule to be analyzed with a gas chromatograph (GC-1790 Agilent) equipped with a flame ionization detector (FID) and a thermal conductivity detector (TCD). The obtained data were recorded by an N2000 chromatograph data workstation and the concentration of gaseous products was determined. A GC-MS, which is composed of a gas chromatograph (GC-7890B Agilent) and a mass spectrum (MS-5975E Agilent), was used to analyze the tar.

The operating conditions are: Column: 112DB Agilent; Carrier gas: helium with a flow rate of 1.5 ml/min; Temperature: 1 min at 50 °C then 5 °C/min to 290 °C then 1 min at 290 °C. MS parameters were: Ionization voltage: 70 eV; Filament emission current: 80 amps; Sampling frequency: 24000 kHz; Electron multiplier voltage: 1200 V, Scan delay: 2.7 min; Scan rate: 10 scan per second; Scan range: 14-600 amu. Natural dolomite (Shijiazhuang, China) was shredded into particles of sizes of approximately 1.5 mm and then calcined in air at 830 °C for 3.5 h to improve catalytic activity. Chemical composition of uncalcined dolomite was presented in Table 2. To ensure the accuracy of results, each test was repeated three times and the results had

only a slight deviation. The results presented here are the average values of the three times.

Results and discussion

ER is defined as the ratio of virtual air to stoichiometric air. The ER was varied from 0.1 to 0.18, while other parameters were hold constant. In the absence of catalyst, CO₂ was increased from 34.5 vol% to 40.8 vol%, while CH₄ and C₂H₄ were decreased from 6.9 vol% to 4.2 vol% and 4.4 vol% to 2.8 vol% by increasing ER from 0.1 to 0.18, respectively. CO and H₂ were initially increased from 32.9 vol% to 33.3 vol% and 30.3 vol% to 31.1 vol% as ER increased to 0.14, then they decreased to 29.7 vol% and 27.5 vol%, respectively. As the ER was increased, more oxygen entered the gasification system which led to the enhancement of the oxidation reactions of combustible product gases and production of more CO₂ instead of H₂, CO, CH₄ and C₂H₄.

When the ER was increased from 0.1 to 0.18, the gas yield continuously increased from 73.3 wt% to 83.5 wt%, while the yields of tar and char decreased from 12.2 wt% to 8.1 wt% and 14.5 wt% to 10.4 wt%, respectively. Although the gas yield increased and the yields of tar and char decreased as ER increased from 0.1 to 0.18, CO and H₂ showed a non-linear trend, which is in agreement with the study conducted by Raheem et al. As observed, the addition of calcined dolomite offers more promising conditions for syngas production, tar reduction and steam reforming of light hydrocarbons. In the presence of calcined dolomite, the volume of light hydrocarbons (CH₄+C₂H₄) and the tar yield reduced by a factor of 3.0 and

2. 0, respectively. ER also indicated a great effect on gas LHV. LHV is calculated based on the energetic components as follows.