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THE QUALITY OF SYNGAS PRODUCED BY FLUIDISED BED GASIFICATION USING SUNFLOWER HUSK

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ABSTRACT

Gasification systems are successfully applied to the production of energy from biomass. In the present work, the effects of some parameters like excess air ratio and temperature on the quality and the composition of syngas produced in a fluidised bed gasifier using sunflower husks as fuel were investigated. The syngas composition for sunflower husk with an excess air ratio of 0.09 was about 39.62%, 43.39%, 0.3%, 0.5%, 15.41 for H_2, CO, CH_4, CO_2, N_2, respectively, in a moisture free basis. In this paper, the lower heating value of the syngas is reported as an indicator of the gas quality. The lower heating value of the syngas produced by sunflower husk was calculated from the concentration of the combustible components and it ranges from 6.7 MJ/Nm^3 to 9.8 MJ/Nm^3. The LHV of syngas produced decreased with excess air ratio. It has been found that the highest gas quality occurs at the lowest excess air ratio and at operating temperatures around 900°C.

KEYWORDS: syngas quality, sunflower husk, gasification, excess air ratio, LHV

1. INTRODUCTION

Gasification is a thermo-chemical process of gaseous fuel production by partial oxidation of a solid fuel [1]. Coal gasification has been widely used to harness energy from coal in a more environmentally benign fashion. Biomass is indeed nothing but young coal and can be featured as an alternative to coal. Gasification systems are successfully applied to the production of energy from biomass. Renewable energy sources mitigate greenhouse gas emission because CO_2 emitted from thermal conversion is naturally sequestered by photosynthesis. Biomass use as an energy resource relieves municipal and agricultural waste management from the burden of voluminous waste [2].

Thermochemical gasification of biomass is a well-known technology that can be classified depending on the gasifying agent: air, steam, steam–oxygen, air–steam, O2-enriched air [3].

A wide range of biomass sources, such as traditional agricultural crops, dedicated energy crops, residues from agriculture and foresting as well as organic wastes can be gasified [4].

Fluidised bed gasification was originally developed to overcome operational problems of fixed bed gasification related to fuels with high ash content and to increase the efficiency of gasification process [5].

In fluidised bed gasifiers, biomass particles undergo drying, pyrolysis and gasification in a hot, fluidised mixture with inert bed material and air. The fluidised bed process enables good heat transfer between the gas and solid phases [6].

Fluidised bed reactors are gasifiers without different reaction zones. They have an isothermal bed operating at temperatures usually around 700–900°C, lower than maximum fixed bed gasifiers temperatures [7]. There are bubbling fluidised bed (BFB) and circulating fluidised bed (CFB) gasifiers. Circulating fluidised bed gasifiers employ more turbulent mixing than bubbling fluidised bed systems, and use cyclones to separate solid particles from the gas stream before returning them to the bottom of the riser section [6].

The objective of the present paper is to investigate the effects of some parameters like excess air ratio and temperature on the quality and the composition of syngas produced in a fluidised bed gasifier using sunflower husks as fuel. It has been found that the highest gas quality occurs at the lowest excess air ratio and at operating temperatures around 900°C. The syngas composition and heating value were found to be similar to those reported by other researchers [8], [2], [9].

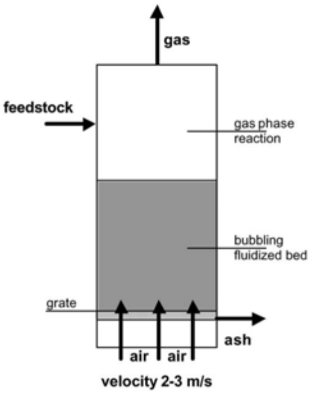

Fig. 1. *Bubbling fluidised bed gasifier [7]*

2. METHODOLOGY

Air gasification experiments were carried out in a fluidised bed gasifier.

The biomass material used in this experiment was sunflower husk. The agent gasification used was air.

The proximate and ultimate analyses of sunflower husk are presented in Table 2.

The gasifying agent utilised in the fluidised bed gasifier has a big influence on the quality of syngas produced. This agent influences the heating value and the composition of syngas (Table 1).

Table 1. *The influence of the gasifying agent on the syngas quality produced by gasification process [10].*

Gasifying agent	Air	H_2O	O_2
Heating value (MJ/Nm^3)	4-6	10-15	8-14

Table 2. *Proximate and ultimate analysis of sunflower husk*

Fuel sample	Sunflower husk
Ultimate analysis (% of dry fuel with ash)	
C	49.11
H	5.9
N	0.70
O	40.57
A	3.71
Proximate analysis (% of fuel with initial moisture)	
Fixed Carbon	17.00
Volatile matter	65.79
Ash	3.71
Moisture	13.50

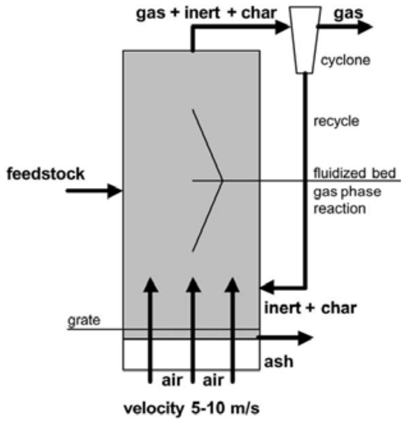

Fig. 2. *Circulating fluidised bed gasifier [7]*

In this paper, the lower heating value of the syngas is reported as an indicator of the gas quality.

The lower heating value of syngas is dependent on the percentage quantities of CO, H_2 and CH_4 in producer gas and can be calculated from the following equation:

$$LHV_g = Y_{CO} LHV_{CO} + Y_{H_2} LHV_{H_2} + Y_{CH_4} LHV_{CH_4}$$

where Y is the mole fraction of each gas species. The lower heating values of the gas species are:

LHV_{CO} = 13.1 MJ/Nm^3,

LHV_{H2} =11.2 MJ/Nm^3,

LHV_{CH4} = 37.1 MJ/Nm^3 [11].

3. RESULTS AND DISCUSSION

The influence of varying excess air ratio on syngas composition and syngas heating value was investigated.

The effects of excess air ratio on product gas composition produced by sunflower husk are illustrated in Table 1 and Fig. 3.

The main components of the syngas produced are CO, H_2, N_2, CO_2, H_2O and CH_4.

The increase of the excess air ratio causes a linearly increase of the N_2 molar fraction due to the greater amount of air fed to the fluidised bed gasifier.

The molar fraction of CH_4 is very low and this increases with the increase of the excess air ratio. The highest concentration of CH_4 was obtained for gasification of sunflower husk at an excess air ratio of 0.23.

It can be observed that the increase in excess air ratio increases the CO_2 content in the syngas. On the other hand, when the excess air ratio is increased, the molar fraction of CO in the syngas decreases. The highest content of CO in the syngas was obtained by gasification of sunflower husk for an excess air ratio of λ=0.09. The molar fraction of CO is the most significant contribution to the syngas heating value.

The highest content of the H_2 in the syngas was obtained by gasification of sunflower husk for an excess air ratio λ=0.09 and the minimum value for an excess air ratio λ=0.23. The molar fraction of H_2 has an important contribution in the calculating of syngas heating content.

Table 1. *The molar composition of syngas produced by gasification of sunflower husk*

temperature	λ	*Syngas composition*, molar fractions							
		CO2	CO	H2	CH4	N2	NH3	H2O	LHV
700	0.22406	0.076	0.276	0.2692	0.0093	0.3223	0.0013	0.0458	6.72087
725	0.18556	0.0582	0.3146	0.2972	0.0086	0.2821	0.0014	0.0378	7.48507
750	0.15535	0.043	0.3479	0.3223	0.0077	0.2472	0.0015	0.0304	8.14393
775	0.13262	0.031	0.3748	0.3435	0.0068	0.2186	0.0015	0.0238	8.67993
800	0.11612	0.0219	0.3953	0.3605	0.0059	0.1965	0.0016	0.0183	9.08985
825	0.10444	0.0153	0.4104	0.3737	0.005	0.1801	0.0016	0.014	9.39061
850	0.09632	0.0106	0.4211	0.3835	0.0042	0.1683	0.0016	0.0106	9.602741
875	0.09073	0.0074	0.4286	0.3908	0.0036	0.1599	0.0016	0.008	9.75467
900	0.08688	0.0052	0.4339	0.3962	0.003	0.1541	0.0016	0.006	9.85833

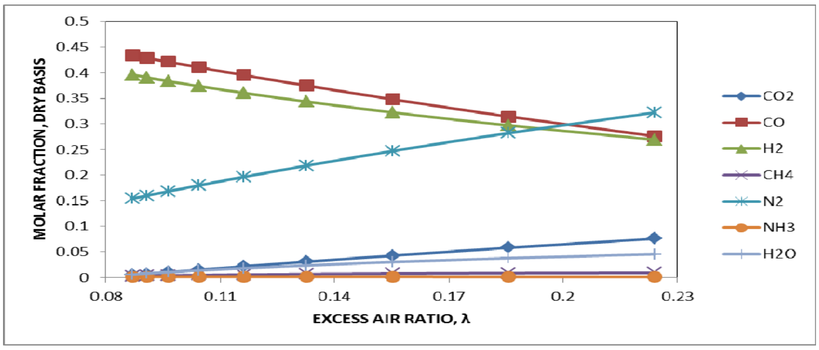

Fig. 3. *The influence of the excess air ratio on the syngas composition for sunflower husk*

It has been found that the syngas composition for sunflower husk with an excess air ratio of 0.09 was about 39.62%, 43.39%, 0.3%, 0.5%, 15.41 for H_2, CO, CH_4, CO_2, N_2, respectively, in a moisture free basis.

The gasification temperature plays an important role in biomass gasification process. In the present work, gasification temperature was varied from 700 to 900°C in 25°C.

The gasification temperature depends on the amount of air fed to the gasifier being controlled by the excess air ratio.

Figure 5 shows that the excess air ratio decreases with the gasification temperature.

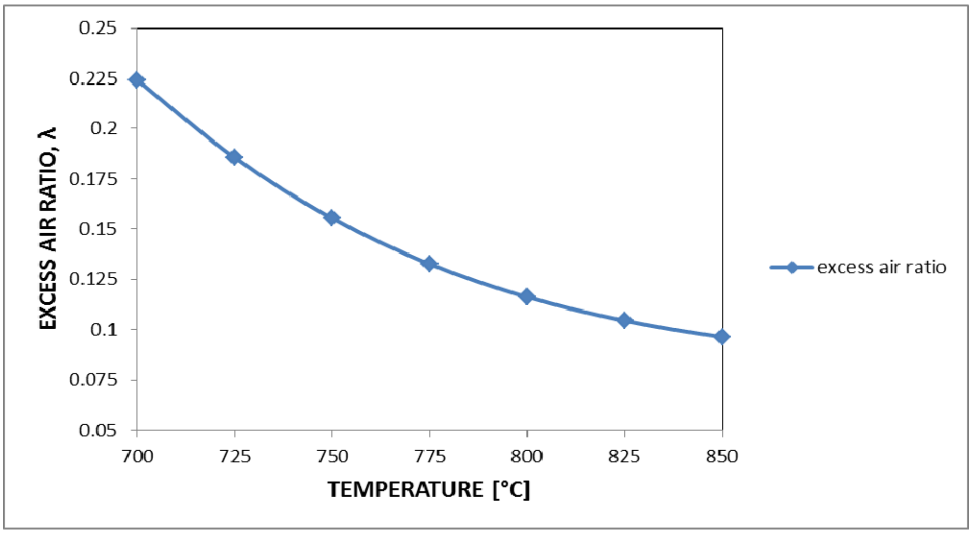

Fig. 4. *The excess air ratio as a function of temperature*

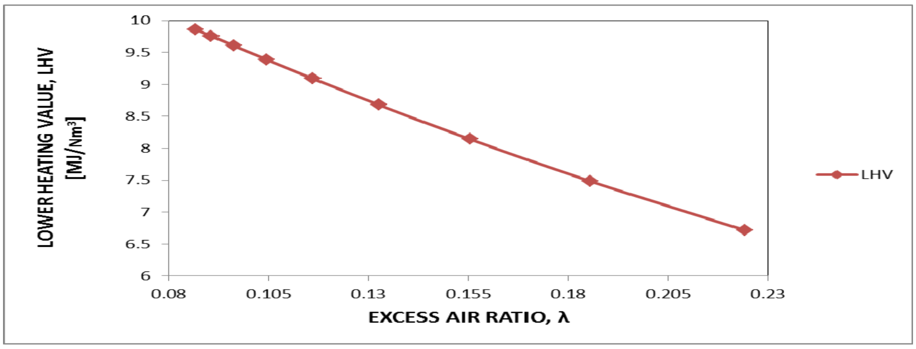

Fig. 5. *The variation of lower heating value of syngas with the excess air ratio*

The useful energy content in the syngas can be quantified by the syngas heating value. Fig. 5 shows the variation of lower heating value against the excess air ratio. It is evident that the lower heating value decreases with the increase in excess air ratio. The lower heating value of the syngas produced by sunflower husk was calculated from the concentration of the combustible components. The LHV of the producer gases ranges from 6.7 MJ/Nm3 to 9.8 MJ/Nm3

The LHV is high for low excess air ratios due to the high H_2 and CO contents.

5. CONCLUSIONS

In the present work, the gasification of sunflower husk in a fluidised bed gasifier was investigated. The air was used as the biomass gasification agent to explore the effects of some critical parameters on gasification performance.

The syngas composition for sunflower husk with an excess air ratio of 0.09 was about 39.62%, 43.39%, 0.3%, 0.5%, 15.41 for H_2, CO, CH_4, CO^2, N_2, respectively, in a moisture free basis.

In this paper, the lower heating value of the syngas is reported as an indicator of the gas quality. The lower heating value of the syngas produced by sunflower husk was calculated from the concentration of the combustible components and it ranges from 6.7 MJ/Nm^3 to 9.8 MJ/Nm^3. It has been found that the highest gas quality occurs at the lowest excess air ratio and at operating temperatures around 900°C.

Acknowledgements

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