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The Effect of Different Operational Parameters on Biomass(The Pine Wood) Gasification

Fen-xia Huang[1,2],Shi-ping Jin[1,*],Yi-xin Lin[1], Zhao-hui Shu[1], and Sheng Li[1]

[1]Huangzhong University of Science and Technology, School of Energy and Power Eingineering, Wuhan, Hubei, China
[2]Yangtze University, Department of Petroleum Eingineering, Wuhan, Hubei, China

Abstract. Biomass gasification gains additional significance each year. For the pursuit of the H_2 content of product gas, selecting air-dried pine wood chips as gasification feedstock, a lot of experimental work is completed in gasifier by altering the operation parameters such as particle size(60mesh,80mesh,100mesh),temperature (700℃,750℃,800℃,850℃,900℃) and steam mass to biomass mass ratio(S/B)(0.7,1.4,2.1,2.8).The effects of operation parameters on the ingredients of product gas are analyzed, which predicts the optional operation parameters for other biomass gasification.

1 Introduction

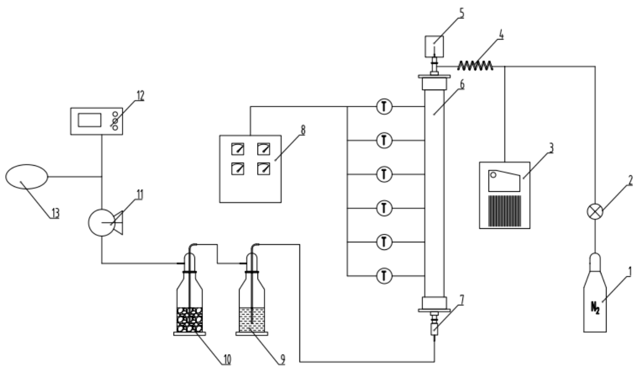
The traditional energy competition is becoming incre-asingly acute, the development of renewable energy sources as supplementary to petroleum products attra-cts the world's attention. Biomass is defined as rene-wable green energy for its cyclic nature. Biomass re-sources are widely distributed in nature, which can b e used directly or indirectly by converting it into ga seous or liquid fuel[1].Biomass products have a varie ty of uses depending on its characteristics and the te chnological process.

In the present study, the gasification using steam as gasification agent has caught an enormous amou n-t of attention for hig-her ratio of H_2/CO and hydr o-gen yield. Reams of experimental work is done usi n-g a downdraft gasifier with steam[2][3][4][5][6].A l ot of numerical work are compared with experimen-t al work[4][7][8][9][10][11][12],however, there is no u nitive conclusion. In this study, the experiments mad -e on pipe wood chips gasification with steam in ga -sifier are carried out, adding its conclusions to previ -ous studies.

2 Methods

2.1 Experimental set-up

The overall experiment setup appears in the Fig.1,w-hich contains five equipments:inert atmosphere syste-m,steam generator, biomass gasifier, gas purification system, gas collecting and analyzing device. The iner t atmosphere system consists of Ni-trogen tank and vavle.The steam generator includes steam generator a nd electric heater. The biomass gasifier is made up of feeder device, Quartz tube,filter cartridge and PID temperature control system. The washing bottle and drying bottle make up gas purification system. The gas collecting and analyzing system consists of sucti-on pump, infrared gas analyzer and airbag. The resis t-ance wire heating keeps the gasifier at a specific c onstant temperature, which provides external heat so-urce needed.



1-Nitrogen tank 2-Valve 3-Steam generator 4-Electric heate rs 5-Feeder 6-Quartz tube gasifier 7-Filter cartridge 8-PI-D temperature control cabinet 9-Washing bottle 10-Dryingbot tle 11-Suction pump 12-Infrared gas analyzer 13-Airbag
Fig.1. Experiment set-up of gasification of biomass

2.2 Parameters and testing methods

The pine wood chips is chosen as the gasification feed stock, are broken into the biomass micron using a small blade mill.By the sieves,60 mesh,80 mesh and 100 mesh pine wood chips are sieved out.

The property of the biomass influences the qua-lit y of product gas. Proximate analysis and Ultimate a nalysis are completed by automatic analyzer MAC-30 00A and Vario Micro cube ultimate analyzer. TheInf rared gas analyzer(Gasboard-3100) is used for pro-du ct gas analysis.

*Corresponding author: jinshiping@hust.edu.cn

2.3 Index parameters

Product gas mainly contains H_2, CO, CO_2, CH_4, N_2, H_2O. Gas production and calorific value of gas production are opposite index parameters;CO_2 has no contribution to the calorific value of gas;CH_4 has little contribution to gas production; N_2 is inert gas;H_2O is removed during the purification phase, so the main consideration is the content of H_2 and CO. Compared with the property of CO,H_2 has its environmental advantages as a clean fuel and high calorific value which makes it more energy efficient, the ratio of H_2/CO is the most suitable index parameter[2][7]13], which not only reflects the changes of volume, but also reflects the changes of the quality of product gas .

3 Results and discussion

3.1 Proximate analysis and Ultimate analysis

Table 1 Proximate analysis and Ultimate analysis

Proximate analysis (wt %,ad)				Ultimate analysis (wt %,ad)				
FC	A	V	M	C	H	O	N	S
12	12	74	12	43.5	4	39	1	0.5

3.2 The effect of temperature on product gas

In this experiment, the pine wood chips with a particle size of 60 mesh have been selected as the gasification feed stock. The feeding rate maintains at 3g/min, some experiments are completed at temperatures of 700℃, 750℃,800℃,850℃ and 900℃ respectively,the results are shown in Fig.2 and Fig.3

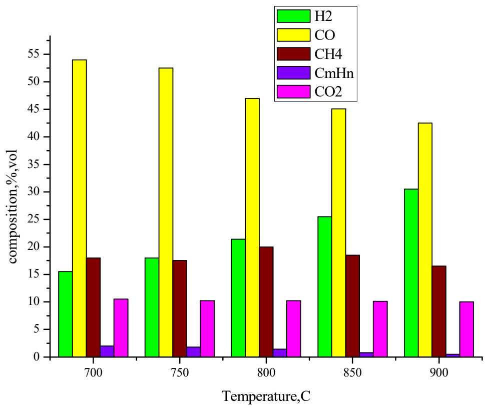


Fig.2. Gas composition at different temperature

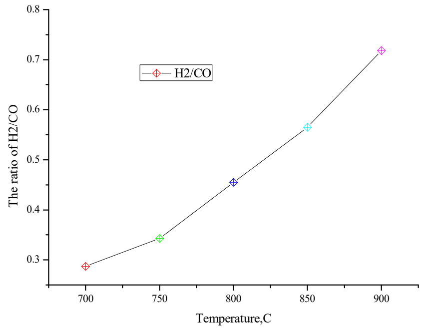


Fig.3 The ratio of H_2/CO at different temperature

Fig.2 shows that the temperature changes have a great difference to the ingredients of gasification gas. With the increase of temperature, the proportion of H_2 is leaping growth from 15.5% to 30.5%;the prop ortion of CO shows a decreasing mode from 54% to 42.5%, the content of CH_4 increases first and then decreases, When the temperature is 800℃, the conte nt of CH_4 is at the highest point, the proportion of C_mH_n and CO_2 have decreased with temperature incr easing.

Fig.3 reveals that the ratio of H_2/CO has been gr owing from 700 to 900℃,however, the increase in e ach temperature section is not the same, ,the higher the temperature, the greater the ratio of H_2/CO.

3.3 The effect of particle size on product gas

In this experiment, without gasification agent, some eperiments are carried out ,maintaining the temperature of the gasifier at 900℃ and feeding rate of 3g/min, taking 60 mesh, 80 mesh and 100 mesh pine wood chips as the gasification feed stock. The results are shown in Fig.4 and Fig.5.

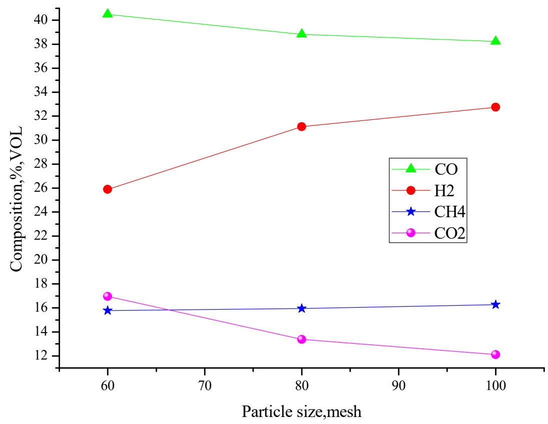


Fig.4 Gas composition of different particle size

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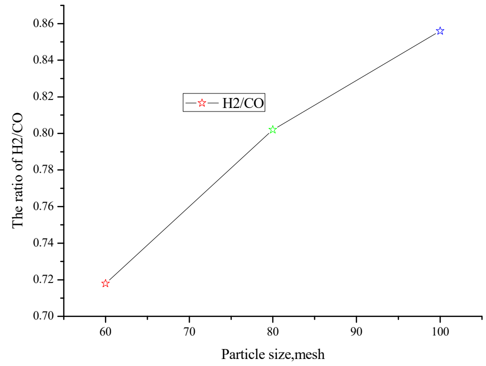

Fig.5 The ratio of H_2/CO at different particle size

Fig.4 points out that the proportion of CO decreases from 40% to 38%, but the decrease is small as the particle size becomes smaller. The proportion of H_2 have increased obviously from 26% to 33%;The proportion of CH_4 changes insignificantly. The proportion of CO_2 decreases.

After the crushing of the pine wood chips, the cellulose structure is effectively destroyed at the microcosmic level. As the crystallinity decreased, the porosity of the particles is increased. On the macroscopic level, the reduction of the particle diameter causes the specific surface area of the biomass particles to react with the surrounding atmasosphere increasing, which is also helpful for the heat exchange between the raw material and the surrounding atmosphere, so that the yield of H_2 increases.

According to the Fig.5, the H_2/CO increases almost linearly as the particle size becomes smaller, which appears inflection point when the particle size is 80 mesh. when the paticle size is between 60 mesh and 80mesh, the growth rate the H_2/CO is greater, compared to that the paticle size is between 80 mesh and 100 mesh. Considering the cost of broken pine wood chips, the 80 mesh may be the optimal particle size for the gasificatio-n of pine wood chips.

3.4 The effect of gasification dose on product gas

In this experiment, steam is picked as gasification agent. Taking 80 mesh pine wood chips as the gasification feed stock, keeping the gasifier temperature 900 ℃ and feedin-g rate of 3g/min, the S/B (the ratio of steam mass to biomass mass) are 0.7,1.4,2.1,2.8 respectively. The results are shown in Fig.6 and Fig.7.

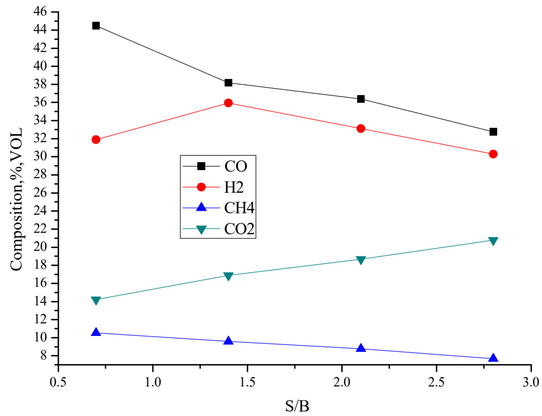

Fig.6 Gas composition of different S/B

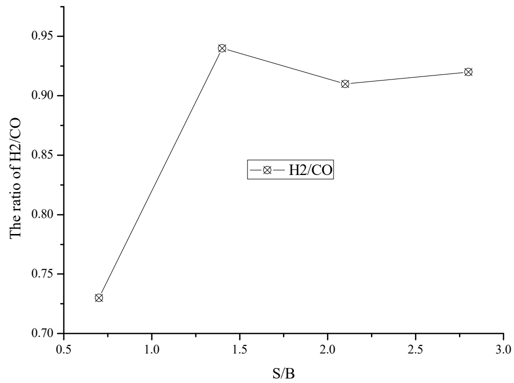

Fig.7 The ratio of H_2/CO at different particle size

Fig.6 suggests that the content of CO drops by 11.72% from 0.7 to 2.8 of S/B, the content of H_2 grows by 1.61%. The proportion of CH_4 decreases, the proportion of CO_2 increases.

The introduction of steam is conducive to the formation of H_2, but the steam temperature is lower than the ambient temperature, resulting in heat loss, having an impact on heat and mass transfer, Excess steam inhibits the generation of H_2.

Fig.7 domenstrates that the S/B is 1.4, the content of H_2 is highest at 35.94%.Although the sum of the two is highest as S/B is 0.7,which is not much more than it as S/B is 1.4.this experiment shows that the optimal S/B is 1.4.

4 Conclusions

In this study, the focused inspection are the effects of temperature, particle size, and S/B on the composition of product gas. The three parameters have a great difference to gas composition, maybe they are the most important influence factors. Based on the obtained results come from experiments, following conclusions are draw: for the pine wood gasification, the higher the temperature, the better the quality of the product gas, the optional particle size of pipe wood gasification is 80 mesh or 0.17mm, the optional S/B is 1.4.

Acknowledgement

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