THE RESULTS OF THE MEASUREMENTS BIOMASS GASIFICATION IN A FLUIDIZET BED REAKTOR

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VÝSLEDKY MERANÍ ZO SPLYŇOVANIA BIOMASY VO FLUIDNOM REAKTORE

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Abstrakt

V priemyselne vyspelých krajinách neustále rastie záujem o využívanie alternatívnych zdrojov energie – vietor, voda, geotermálna energia, biomasa. V stredoeurópskych štátoch EÚ patrí k perspektívnemu využitiu alternatívnych energetických zdrojov práve biomasa. Hlavné výhody energetického využitia biomasy sú obnoviteľnosť, skutočnosť, že biomasa je neutrálnym palivom, zanedbateľný obsah síry, nezávislosť na dovoze primárnych energetických zdrojov.

Cieľom práce bolo popísať možnosť využitie biomasy ako alternatívneho energetického zdroja splyňovaním vo fluidnom reaktore v kombinácii s prídavkom konkrétneho percentuálneho množstva drevného uhlia za účelom zvýšenia výhrevnosti generovaného drevného plynu a účinnosti splyňovacieho reaktora. Splyňovanie patrí medzi termochemické premeny biomasy, medzi ktoré sa radí aj spaľovanie a pyrolýza. Výhodami splyňovania biomasy oproti jej spaľovaniu je pretransformovanie pevného paliva na plynné, s možnosťou následného spaľovania v tepelných agregátoch, možnosť využitia rôznych druhov biomasy.

Teoretická časť práce je zameraná na popis princípu splyňovacieho procesu, technológie fluidných reaktorov.

Druhá časť je zameraná na výskum a vyhodnotenie samotného priebehu splyňovacieho procesu s použitím konkrétneho alternatívneho paliva v závislosti od prebytku splyňovacieho vzduchu, so zameraním na splyňovací proces s ohľadom na koncentráciu horľavých zložiek drevného plynu, teplotný priebeh procesu a výhrevnosť analyzovaného plynu. Experimentálne merania boli realizované na experimentálnom splyňovacom zariadení, ktoré bolo skonštruované na Katedre pecí a teplotechniky, HF TU Košice, za účelom výskumu splyňovania alternatívnych palív .

Abstract

There is a continuously increasing interest in the exploitation of alternative sources of energy (wind, water, geothermal energy and biomass) especially in the industrially developed countries. The most perspective exploitation of them in central-European European union countries has biomass. The main advantages of the energetic exploitation of biomass are the facts that biomass is a renewable natural resource, it is neutral fuel concerning production of air pollutant emissions, it has negligible content of sulphur and it is independent from import of primary energetic sources of power.

The purpose of the thesis is to describe the exploitation of biomass as an alternative source of power by the gasification process in the fluid reactor and in combination with the

addition of the concrete percent amount of charcoal for the purpose of the increase of fuel value of the generated syn gas as well as for the purpose of the efficiency of the gasifying reactor. The gasification is a thermo-chemical transformation of biomass as well as the combustion and the pyrolysis. The gasification of biomass has in comparison with its combustion these advantages: transformation of solid fuel into gas fuel, possibility of the consecutive combustion and the possibility to use different types of biomass.

The theoretical part of the thesis is focused on the description of principles of the following: the gasification process, the technologies of the fluid reactors.

The second part is focused on the research and the evaluation of the very progression of the gasification process by using concrete alternative fuel depending on the excess of the gasifying air, with the focus on the gasification process with the reference to the concentration of the combustive compounds of the syn gas, to the thermal progression of this process and to the heat value of the analysed gas.

All the experimental measures were performed on the experimental gasification device constructed at The Department of Furnaces and Thermal Technology, Faculty of Metallurgy, The Technical University of Košice, for the purpose of the gasification of the alternative fuels.

Key words : biomass, gasification, syngas, fluid reaktor

1. The principle of gasification of biomass

The gasification of biomass is thermochemical transformation of carbon material into combustible gases. This is possible by action of high temperatures and combustion mediums.

Final syn gas contains CO, CO_2, CH_4, H_2O, H_2, N_2, saturated and unsaturated hydrocarbons and the products of pyrolysis – tar, solid leftover – ash, dust and others compounds.

Acquired gas is possible to use for combustion in standard combustion burner, and after abstertion also in combustion turbines and in modified combustion engines. It is possible to use chemically free or fixed oxygen (CO_2, vapour) and hydrogen.

In general it is possible to divide every gas producer into four basic sectors, where chemical process of transformation of biomass into the combustion gas can be in progress. These sectors are not divided what` s concerning their construction and the bounds between them blend together and move according to temperature in given room.

There are following physical-chemical processes in typical gas producers at these temperatures:

1. Drainage > 150 °C
2. Pyrolysis 150 - 700°C
3. Oxidation 400 - 1500°C
4. Reduction 800 - 1100°C

Processes 1, 2, 4 absorb the heat generated by exothermical oxidation process. [1,2]

2. Gasifying of biomass

Gasifying of biomass at higher temperatures

Gasifying of biomass at higher temperatures - 1200 ºC is performed in gas producers with solid bed of fuel. According to the direction of flow of acquired syn gas and according to fuel input it is possible to divide them into: ascending, descending and crosswise.

Gasifying of biomass at lower temperatures

Gasifying of biomass at lower temperatures - 850-900 ºC - is performed in gas producers with solid bed of fuel. Solid particles react like a liquid as a result of being contacted with the gas. It is possible to divide fluid gas producers into stationary and rotary.

The advantage of fluid gas producers is compact construction, which allows gasifying of biomass also at low temperature of fuel meltdown. Also it is possible to use very different types of fuels and without any intervention to the device. [3]

3. Experimental gasifying device

Experimental gasifying device was constructed at The Department of Furnaces and Thermal Technology, Faculty of Metallurgy, The Technical University of Košice, for the purpose of research of the gasification of the biomass. The device is displayed at figure 1. It is fluid gasifying device with stationary bed which works at atmospheric pressure. The main part of device is fluid gasifying gas producer (1), where the fuel is fluidized and gasifyied. The fuel is put into the gas producer by feeding machine (2). Air, the gasifying medium as well as the fluidization medium, is piped into bottom part of gas producer (3) by blower (4). There is additional gas producers for natural gas (5) located at the bottom part of gas producer. The syn gas is piped into the cyclone (6) where are segregated fuel particles which were not gasifyied. These consequently fall into the bulk tank (7). The syn gas is piped from the cyclone and is fired by safety combustion burner (8). The auxiliary natural-gas burner (9). There is an additional burner (10) attached to natural gas for the purpose of the initial ignition. The device includes the exhauster of combustion gases (11). The syn gas for the purpose of analysis is sampled from the sample area behind the cyclone.

Fig.1 Experimental gasifying device

There was performed a research of gasifying process by using a biomass and a biomass with addition 10% of charcoal. There are presented the results of gasifying process by using a fuel - a biomass with addition 10% of charcoal in the contribution.

4. Results of gasifying process

There was used a biomass with addition of 10% of charcoal as a fuel, the gasifying medium as well as the fluidization medium was used air. There were taken three samples 1, 2 and 3 during the measurement, which were analyzed by accredited Testing laboratory Koksovne, U. S. Steel Košice – Labortest, s.r.o. The structure, fuel value, and density of syn gas samples 1, 2, 3 at particular surplus products are presented in table1.

Table 1 The structure, fuel value, and density of syn gas samples

		1	2	3
Surplus product	[-]	**0,18**	**0,26**	**0,29**
CH_4	[%]	2,190	2,260	3,370
H_2	[%]	3,910	3,960	3,810
O_2	[%]	0,500	0,190	0,050
N_2	[%]	62,000	61,500	56,100
CO_2	[%]	14,200	14,100	13,900
CO	[%]	16,100	16,700	20,600
C_2H_4	[%]	0,500	0,710	1,070
C_2H_6	[%]	0,173	0,180	0,280
C_2H_2	[%]	0,052	0,070	0,100
$C_3 – C_8$	[%]	0,416	0,400	0,724
Q_n	($MJ.m^{-3}$)	**4,162**	**4,390**	**5,990**
Density	($kg.Nm^{-3}$)	1,302	1,299	1,299

There is relatively linear increase resulting from the running of fuel value of particular analysed samples towards to the syn gas surplus to the value 0,3. The highest syn gas fuel value was detected with usage of syn gas 3 – 5,99 ($MJ.m^{-3}$), at gasifying process with surplus of air 0,29.

There was done energetic balance for sample 3 in order to find out effectivity assessment of experimental gasifying device by using gasifyied fuel SP2 (10% charcoal - 90% biomass). There are energetic balance results presented in table 2 for 3 syn gas sample

Table 2 Energetic balance results for DP6 syn gas sample

Output of energetic balance		
Syn gas output	Q_{sg}	13,25 (kW)
Total heat loss	Q_{hl}	2,39 (kW)
Heat loss by reactor walls	Q_{rw}	0,54 (kW)
Heat loss by syn gas heat	$Q_{h,sg}$	1,85 (kW)
Heat loss in solid leftover, by production and tar condensation	$Q_{sl} + Q_{tar}$	6,25 (kW)

The effectivity of gasifying device was calculated as ratio of energy contained in syn gas to the energy given to the reactor in fuel. The heat energy of syn gas is also included in the calculation and it is ideally possible to use it too.

$$\eta = \frac{Q_{sg} + Q_{h,sg}}{Q_{fuel}} = \frac{13{,}25kW + 1{,}85kW}{21{,}89kW}.100 = 69\%$$

During experimental measurements which were done with fuel – biomass, was achieved fuel value of syn gas 3,60 ($MJ.m^{-3}$) and was achieved effectivity of gasifying process 47%.

There is resulting 22% increase of effectivity by using biomass with an addition of charcoal as a fuel in comparison with using only biomass as a fuel.

5. Conclusion

The main advantages of the energetic exploitation of biomass are the facts that biomass is a renewable natural resource, it is neutral fuel concerning production of air pollutant emissions, it has negligible content of sulphur and it is independent from import of primary energetic sources of power. The gasifying process is one of the possibilities of energetic utilization of biomass. Gasifying technology, when biomass transforms itself into the hydrogen and carbon dioxide, becoming more and more important nowadays, as it allows combined production of electricity and heat.

The goal of the contribution was to point to the possibility to increase the fuel value of syn gas generated by gasifying by adding concrete amounts of charcoal to alternative fuel biomass in gasifying process.

Acknowledgement

The contribution is a part of the VEGA 1/4147/07 project solution

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