Aspects Regarding the Use of Sorghum by Gasification

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The paper evidences the efficiency of sorghum using to obtain rich in hydrogen combustible gas. There are presented the experimental results obtained at process gasification of sorghum in fixed bed with reversed flow, using as the gasification agent a mixture of steam and air enriched with oxygen in different quantities. The results obtained are compared with the classical processes in which the raw materials are the conventional solid fuels.

Keywords: sorghum, gasification, reversed fixed bed

Global economic development, especially in the last five decades led to a significant decrease in non-renewable resources of raw materials for technological industries and energetical industry (coal, oil, natural gas, ferrous and nonferrous mineral deposits, salt, etc.) [1]. Besides of resources diminishing, another effect is the environmental pollution (air, water and soil) to a level that seriously affects life on the planet. The use of renewable raw materials and designing processing technologies with minimal or no impact on the environment represents a new way of approaching the green energy.

A major source of renewable raw materials for the energy industry is agriculture, both through its primary products (sorghum, soybeans, canola, etc.) and especially by agricultural waste (peels, straw, stalks, etc.) [2].

This paper intends to show the sorghum energetical capacity through gasification, when the gaseous product obtained has a high content of hydrogen and represents a fuel gas used to produce heat and electricity or, after further processing, it can be raw material for chemical industry (e.g. fertilizers).

Experimental part

Pilot scale laboratory plant, whose scheme is presented in a previous paper [3], is operated at a constant rate of biomass (sorghum): 25 kg/h. It is equipped with a fixed bed gasification bioreactor in reversed flow (upward-moving); as gasification agent is used a mixture of steam - air, air that is enriched in various proportions, with oxygen. The operating conditions were: temperature, 950°C and atmospheric pressure.

Biomass used, sorghum pellets, was characterized by elementary and technique analysis, with the following composition (mass percentage): 16.86% water, 41.80% carbon, 4.70% hydrogen, 0.83 % nitrogen, 33.86% oxygen.

Gasification process is a complex process: the raw material underwent several consecutive reactions: destructive (pyrolysis), oxidation and reduction, with the advantage that can be performed on auto-thermal conditions.

Table 1
COMPOSITIONS OF FUEL GAS FUNCTION OF THE OXYGEN COMPOSITION IN GASIFICATION AGENT

No.	Gasification agent	The combustible gas composition *[%vol.]*						Calorific power *[kmol/Nm^3]*
		CO_2	CO	CH_4	*H_2*	O_2	N_2	
1	***steam-air***	10.57	20.52	1.35	***25.21***	0.16	42.19	1257
2	***steam-air +5% vol. O_2***	11.97	21.42	1.49	***26.01***	0.27	38.84	1312
3	***steam-air +10% vol. O_2***	13.72	21.95	1.53	***27.09***	0.18	35.93	1355
4	***steam-air +20% vol. O_2***	15.74	23.71	1.65	***29.73***	0.28	28.89	1476
5	***steam-air +30% vol. O_2***	17.82	24.88	1.81	***32.10***	0.20	23.19	1578
6	***steam-air +50% vol. O_2***	18.31	28.79	2.21	***37.05***	0.49	13.15	1834

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Table 2
COMPARATIVE DATA FOR DIFFERENT MATERIALS AND PROCESSES OF GASIFICATION

Process	***Reversed fixed bed***	***Fixed bed (Lurgi)***	***Fluidized bed (Winkler)***	***Circulating fluidized bed (Koppers-Totzech)***
Raw material	sorghum	peat, lignite, coal of gas and anthracite	Non-agglomerating coal and brown coal.	lignite, coal and anthracite
Pressure, atm	1	20-30	1	15-28
Temperature, °C	950	1100	1200	1100-1900
Gasification agent	Steam–air +50% vol. O_2	Steam - oxygen	Steam - oxygen	Steam - oxygen
Yield of gasification, %	81.34	76	70-90	-
H_2 conc., %	37.05	39-45	35-45	52-59
CO_2 conc., %	18.31	24-33	13-25	2.5
H_2S conc., %	traces	0.1-1.1	-	0.2-1.8
Calorific power, J/Nm3	7666	10500-12500	2200-3000	3800

Results and discussions

Experimental research aimed to achieving a combustible gas with high hydrogen content and therefore, a high calorific power.

Experimental results regarding the combustible gas composition and calorific power are presented in table 1.

It is found that the most advantageous operating version is 6 (table 1), that with a gasification agent where the air was enriched with oxygen 50%, resulting an increase in the concentration of hydrogen, in fuel gas, from 1.47 times compared to version 1, without added oxygen, and an increase in calorific value of about 1.38 times.

The experimental work follows also the determination of gasification yield and the specific consumption of gasification agent, in all presented version shown in table 1. Comparing the two types of operation (1 with 6) there is evidenced a specific consumption of gasifying agent (kg / kg sorghum pellets) of approximately 1.5 times lower, at the same gasification yield of 81.34% and at a lower concentration of inert (N_2) combustible gases of 1.7 times.

In table 2 are presented the comparison of the gasification process of sorghum in reversed fixed bed, with different coal gasification processes: Lurgi process [4] - in fixed bed, Winkler process [4] - in fluidized bed and the Koppers-Totzech process [4] - in circulating fluidized bed.

It is found that alternative raw material sources (sorghum) have a number of advantages regarding the operating process such as: pressure and temperature, the gasification efficiency, hydrogen content in generated gas and calorific power value.

Conclusions

Recovery sorghum as renewable raw materials, by gasification in fixed bed at atmospheric pressure and at a temperature of 950°C, with a yield of 81.34%, lead to a fuel gas with a hydrogen content of 37.05%, with applications in the energy industry (heat and electricity) and a small effect on air pollution, compared with conventional solid fuels (coal, oil, etc.).

Their application in the thermo-electric plants of small and medium capacity can solve the requirements for urban and rural communities.

References

1. TRIPSA, I., Gazeificarea carbunilor, biomasei si deseurilor, S.C. CHIMFORM DATA S.A., Bucharest, 2004.
2. VAN DER DRIFT, B., Proceedings of the 12th European Biomass Conference, Amsterdam, 2002, p.381.
3.. VLADAN, S., JINESCU, G., Rev. Chim. (Bucharest), **61**, no. 12, 2010, p.1223-1225.
4.. PEEBLES, MALCOLM, W. H., Evolution of the Gas Industry, London and Basingstoke: Macmillan, 1980

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