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PLASMA PROCESSING OF WASTE FROM THE WOODWORKING INDUSTRY: NUMERICAL ANALYSIS AND EXPERIMENT

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INTRODUCTION

The most common method of utilization of waste from the woodworking industry is its incineration to generate thermal energy and followed by disposal of the resulting ash at a special landfill. The method has serious disadvantages, such as the formation of highly toxic chemical compounds – dioxins, furan and benzo(a)pyrene.

An alternative method is the plasma gasification of this waste with the production of a combustible gas. Plasma gasification of waste allows to intensify the process of obtaining combustible gas, consisting mainly of synthesis gas (CO+H₂), which can be used as a working fluid of highly efficient electric generators.

This paper presents the results of thermodynamic analysis and experimental study on plasma gasification for the utilization of the woodworking industry waste.

CHEMICAL COMPOSITION OF THE WASTE, WT.%

Ash Waste from the woodworking industry consists of a mixture of sawdust and wood chips \bigcap С Η 0 Ν Η 49.88 5.98 43.81 0.10 Ν MgO Fe₂O₃ SiO₂ MnO Al₂O K₂O CaO SO₃ P_2O_5 Na₂O 0.02 0.02 0.01 0.01 0.01 0.01 0.01 0.01 0.12 0.01

For computation of biomass gasification thermodynamic code TERRA was used.

The calculations were performed over a range of temperatures from 300 to 3000 K and pressure 0.1 MPa.

Initial Composition of the System for Computation

1 part of Waste + 1 part of Air



METHODIC OF EXPERIMENT



Scheme of a plasma reactor (cross section) and scheme of the experimental installation for plasma gasification of waste: 1 – pipe for loading briquetted

waste into the reactor, 2 – plasma reactor, 3 – DC electric arc plasma torch, 4 – waste gasification zone, 5 – exhaust gas cooling unit, 6 – gas cleaning unit with bag filter, 7 – section with gas sampling and temperature measurement system, 5 8 – exhaust fan, 9 – ventilation pipe

Scheme of the plasma reactor



- 1 arc plasma torch;
- 2 pipe for supplying of

briquetted Waste;

- 3 Waste briquettes;
- 4 plasma flame

Plasma torch is the main element of the installation



Schematic of a long-service-life plasma torch of 70 kW and plasma torch in operation: temperature of the plasma flame is 5000 K



PARAMETERS OF THE PLASMA GASIFIER

- DC plasma torch output power of 70 kW.
- Plasma forming gas air, flow 3.3 g/s (12 kg/h).
- Geometric dimensions of the reactor:
 height 0.45 m, side 0.45 m, lining 65 mm.
- Amount of processed waste is 50.0 kg / h



Concentration of the gas components dependence on temperature of the waste plasma gasification



Carbon gasification degree dependence on temperature of the waste gasification



Specific energy consumption for plasma-air gasification of the waste depending on temperature

Waste Gasifier with Plasma Torch





Photo of the combustible gas control flame from the pipe for supplying of briquetted waste

- **CO 42.0%**
- $H_2 25.1\%$
- N₂ 32.9%



As a result of 9.9 kg of the waste gasification 0.013 kg of ash was collected from the bottom of the reactor.



Photo of hot ash on the bottom of the reactor after plasma torch turn off

COMPOSITION OF THE PRODUCTS AFTER WASTE PLASMA GASIFICATION

Products components	Percentage	
	Experiment	Computation
Carbon monoxide (CO), Vol. %	42.0	41.9
Hydrogen (H ₂), Vol. %	25.1	29.7
Nitrogen (N ₂), Vol. %	32.9	27.8
Total, Vol. %:	100	99,4
Carbon (C), Wt. %	1.13	0
X _c , %	96.6	100
Specific power consumption Q _{sp} , kW h/kg	1.53	1.25

Conclusions

- Thermodynamic calculations showed that the maximum yield of the synthesis gas at plasma gasification of woodworking industry waste in air is achieved at a temperature of 1600K.
- At the air plasma gasification of the waste synthesis gas with a concentration of 67.1% (CO 42.0, H_2 25.1) is obtained. Specific heat of combustion of the synthesis gas amounts to 9450 kJ/kg.
- At the optimal temperature (1600 K), the specific power consumption for air gasification of the waste constitutes 1.53 kW h/kg.
- Comparison of experimental results and calculations showed good agreement.
- Both in calculations and in experiments, no harmful impurities were found in the products of plasma-air gasification of the studied wastes, which confirms the environmental efficiency of the plasma waste processing technology.

