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

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INTRODUCTION

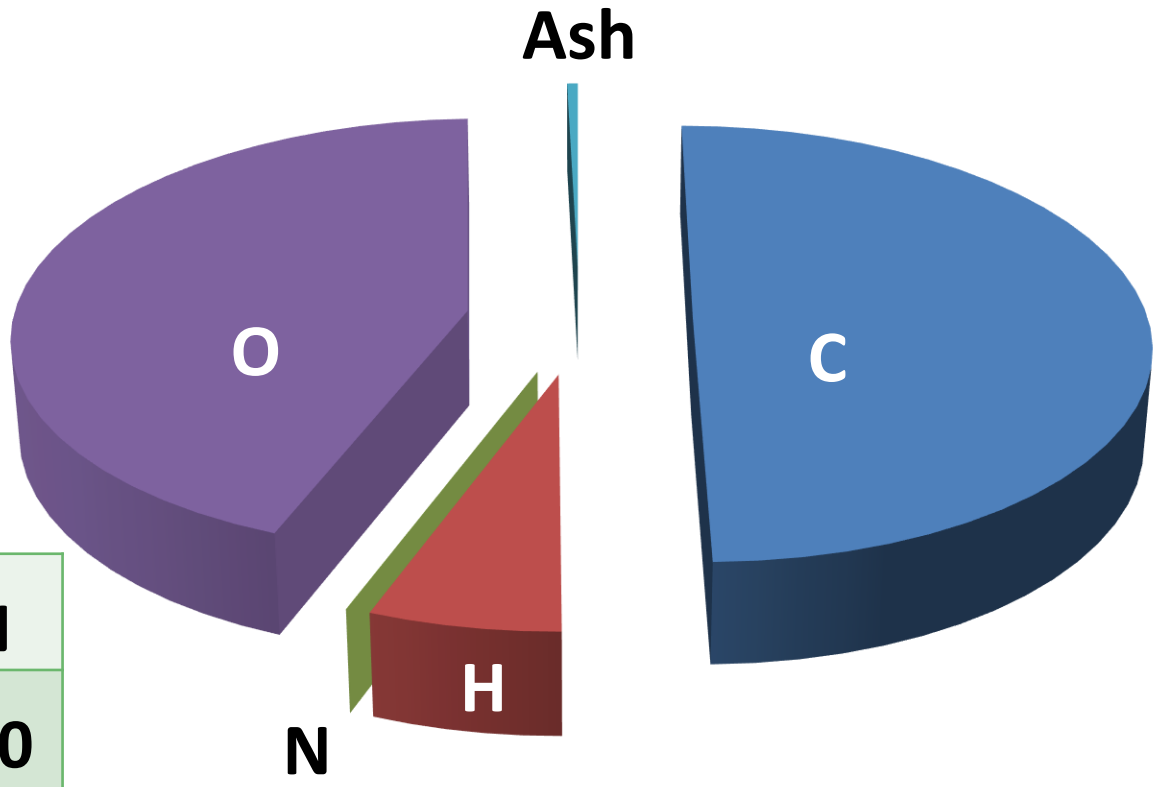
The most common method of utilization of waste from the woodworking industry is its incineration to generate thermal energy and followed by disposal of the resulting ash at a special landfill. The method has serious disadvantages, such as the formation of highly toxic chemical compounds – dioxins, furan 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 ($CO+H_2$), 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.%

Waste from the woodworking industry consists of a mixture of sawdust and wood chips



C	H	O	N
49.88	5.98	43.81	0.10

K_2O	CaO	MgO	Fe_2O_3	SiO_2	MnO	Al_2O	SO_3	P_2O_5	Na_2O
0.01	0.12	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.01

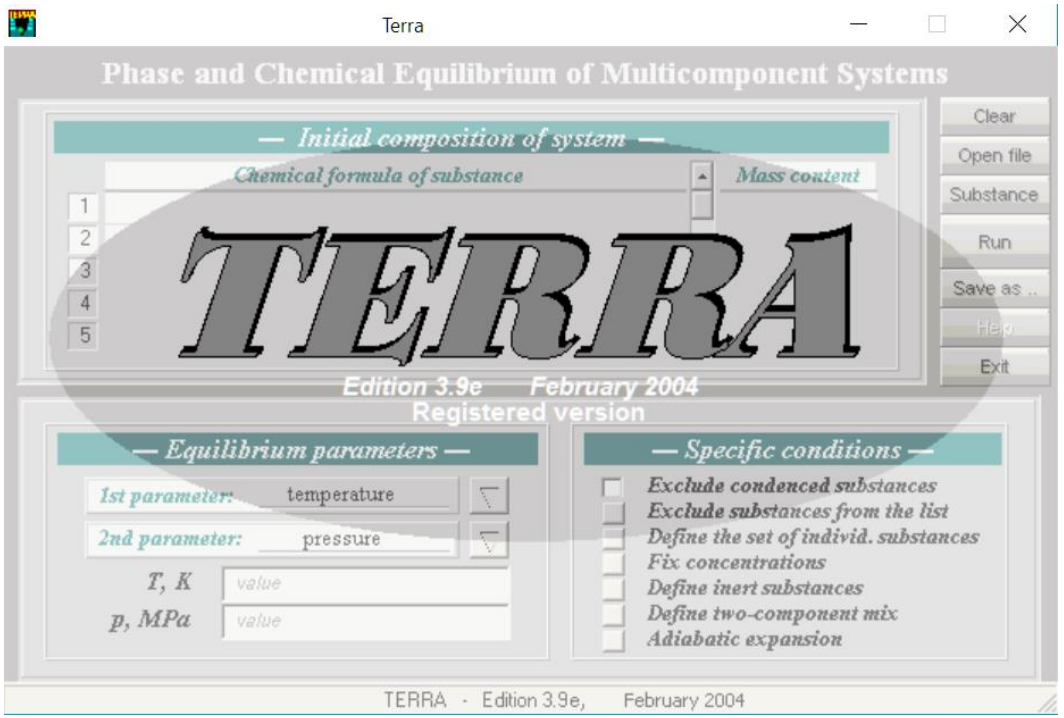
THERMODYNAMIC COMPUTATION

For computation of biomass gasification thermodynamic code TERRA was used.

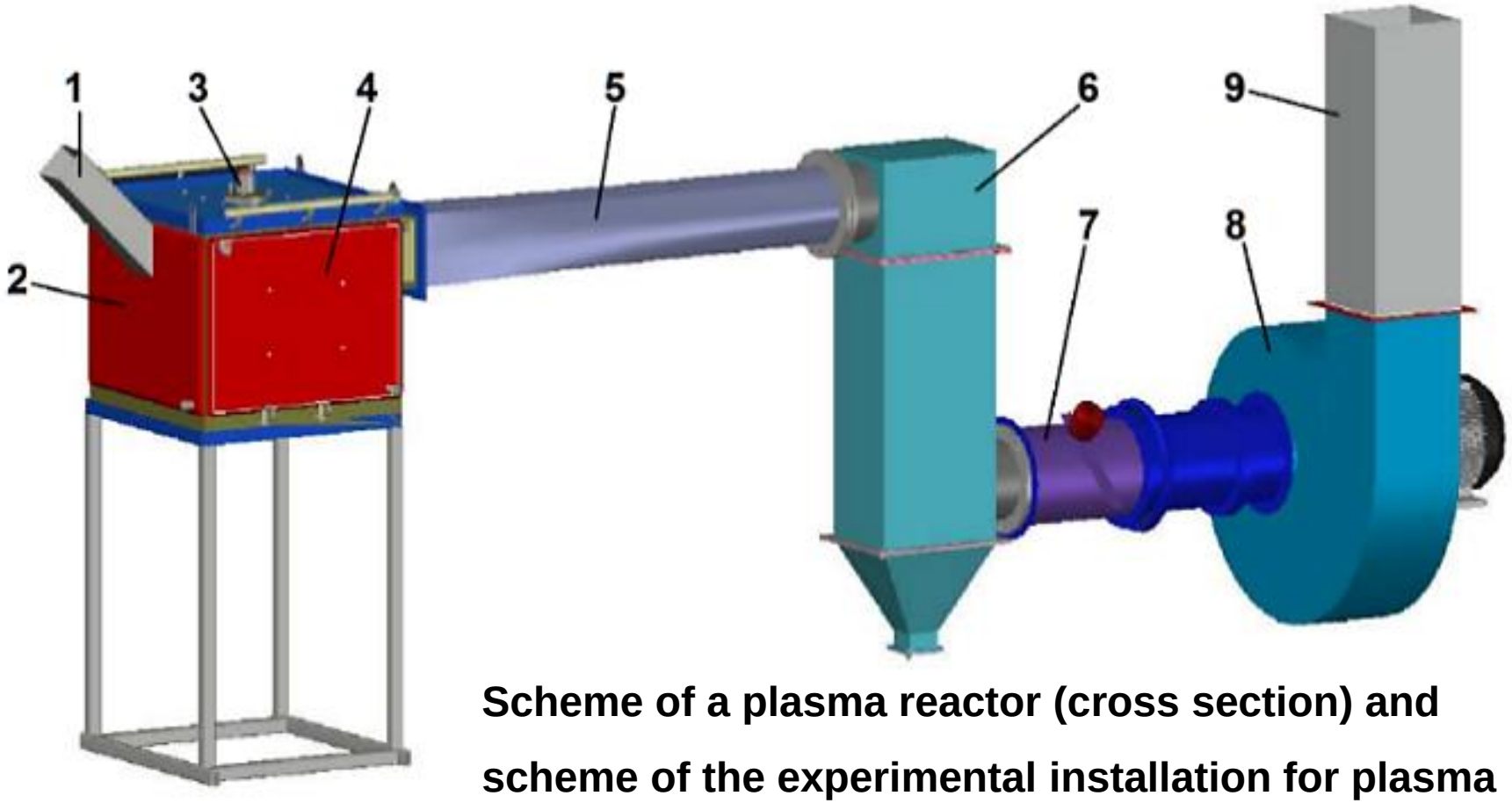
The calculations were performed over a range of temperatures from 300 to 3000 K and pressure 0.1 MPa.

Initial Composition of the System for Computation

1 part of Waste +
1 part of Air

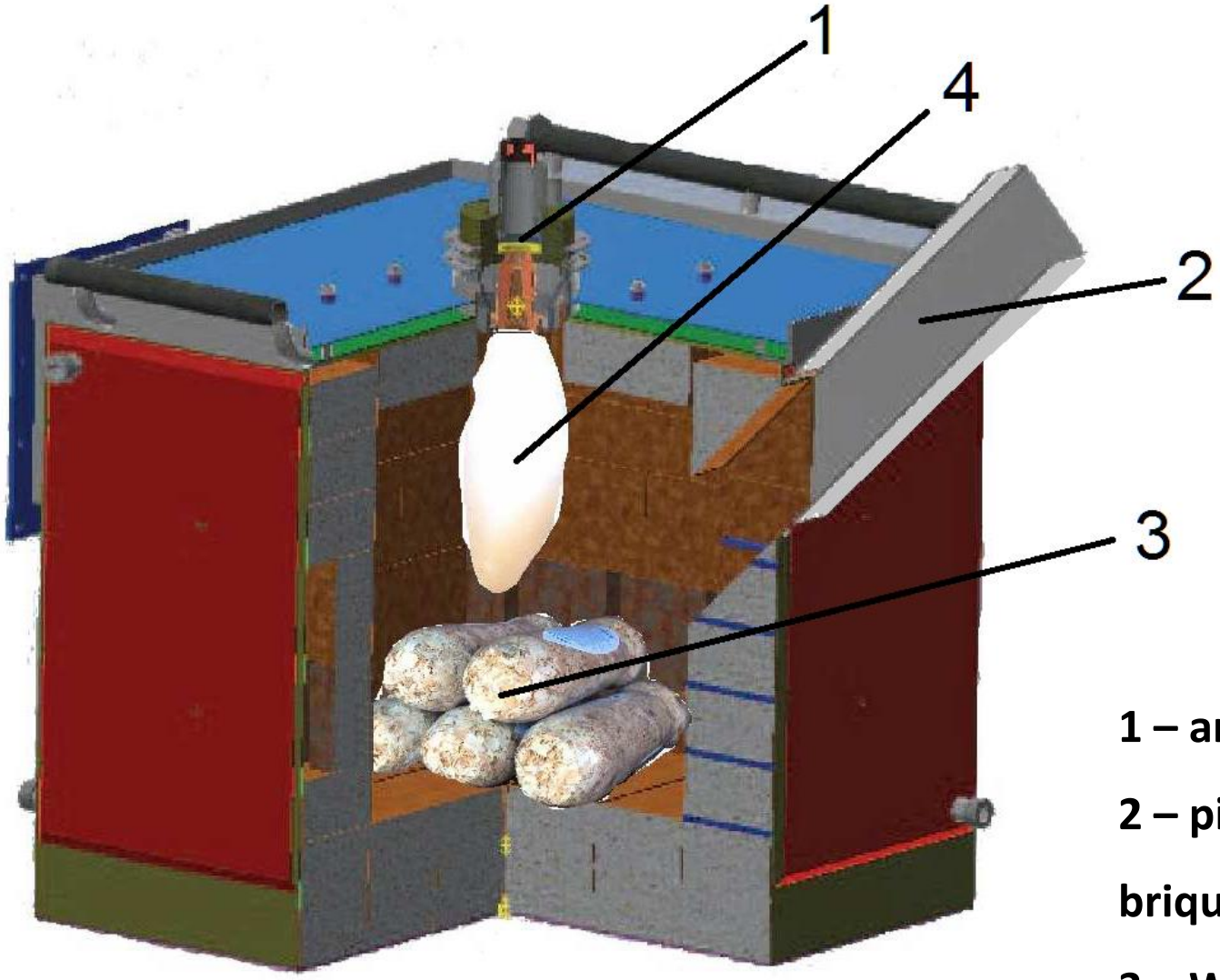


METHODIC OF EXPERIMENT



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, 8 – exhaust fan, 9 – ventilation pipe

Scheme of the plasma reactor



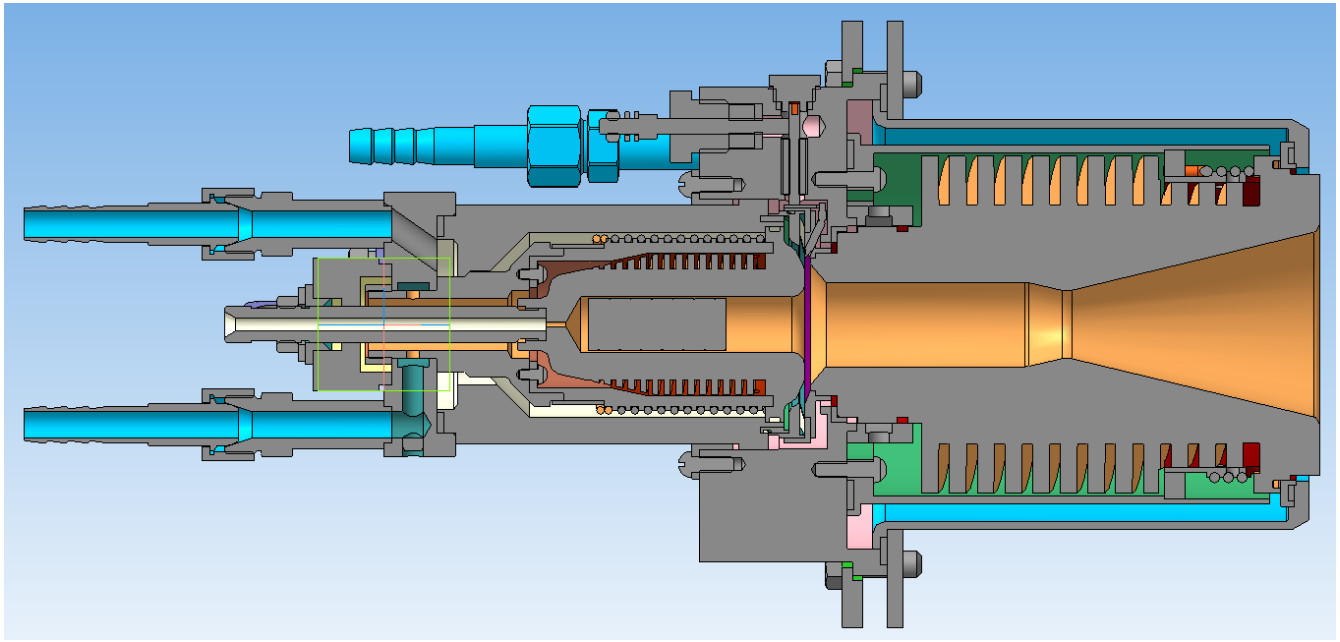
1 – arc plasma torch;

2 – pipe for supplying of briquetted Waste;

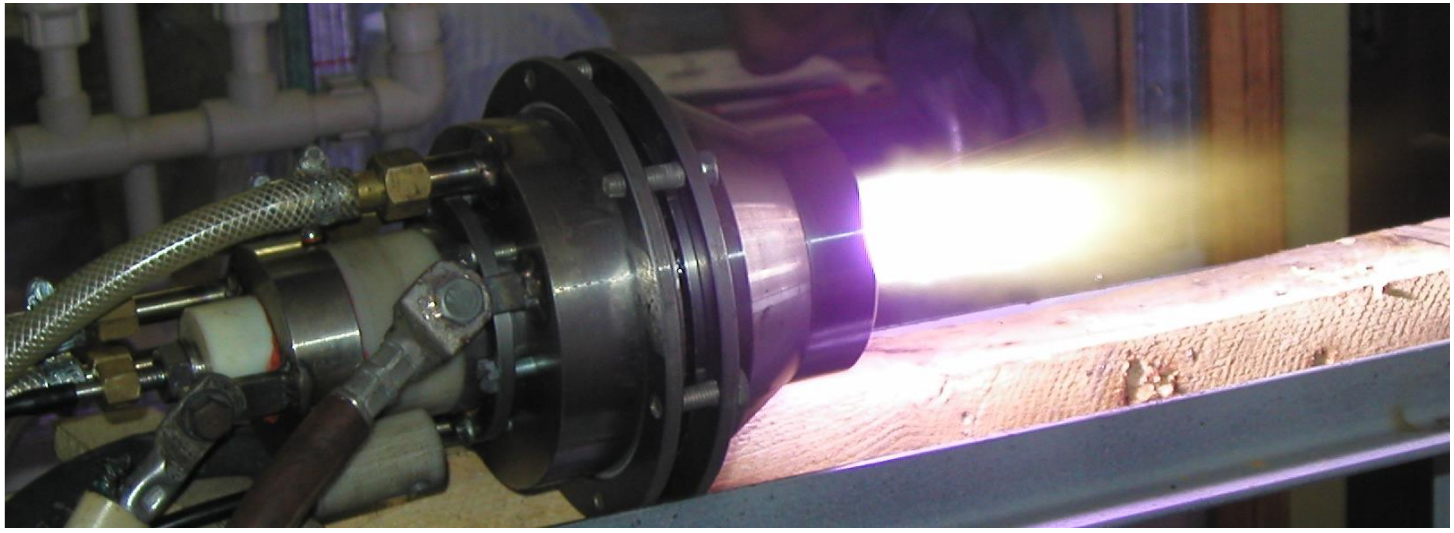
3 – Waste briquettes;

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

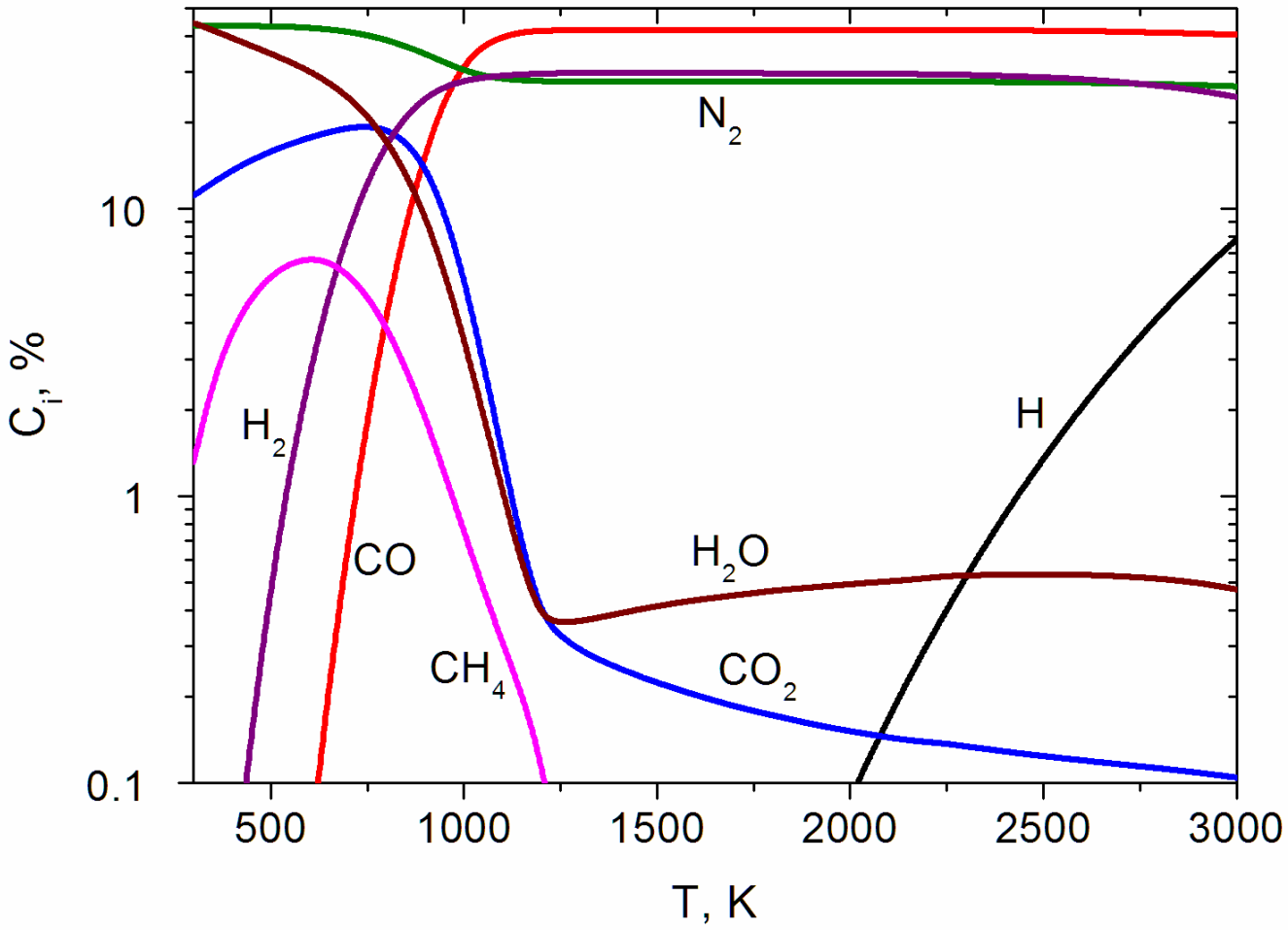


PARAMETERS OF THE PLASMA GASIFIER

- **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**

THERMODYNAMIC COMPUTATION



T = 1600 K:

CO – 41.9%

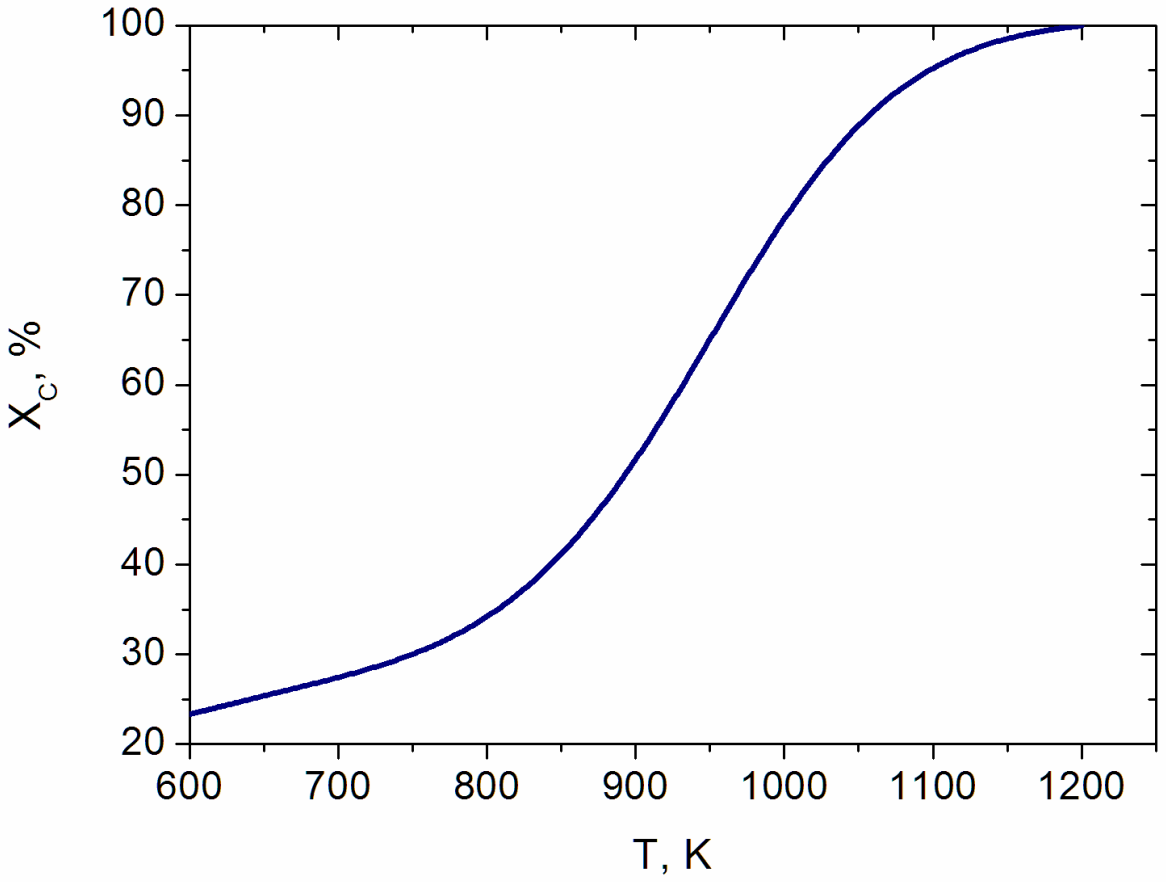
H_2 – 29.7%

N_2 – 27.8%

$CO_2 + H_2O$ – 0.6%

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

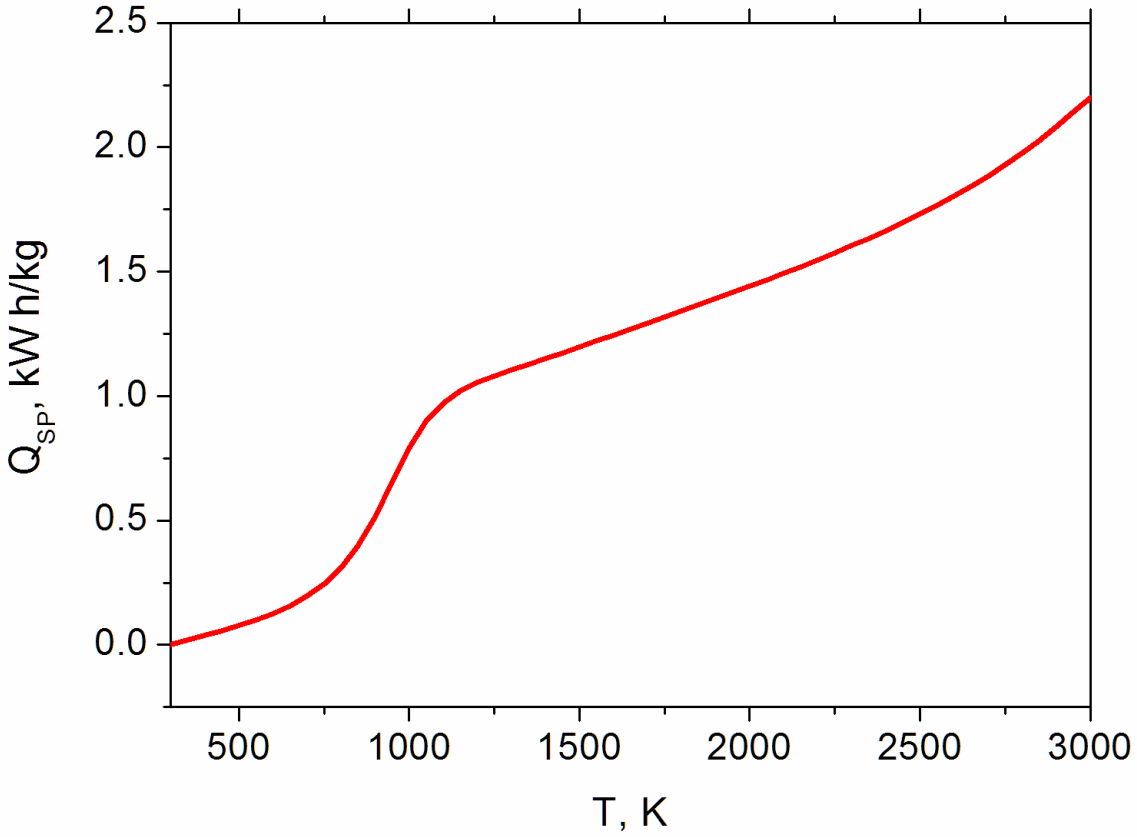
THERMODYNAMIC COMPUTATION



$$X_C = \frac{C_{ini} - C_{fin}}{C_{ini}} \cdot 100\%$$

Carbon gasification degree dependence on temperature of the waste gasification

THERMODYNAMIC COMPUTATION



T = 1600 K:

Q_{sp} – 1.25 kW h/kg

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

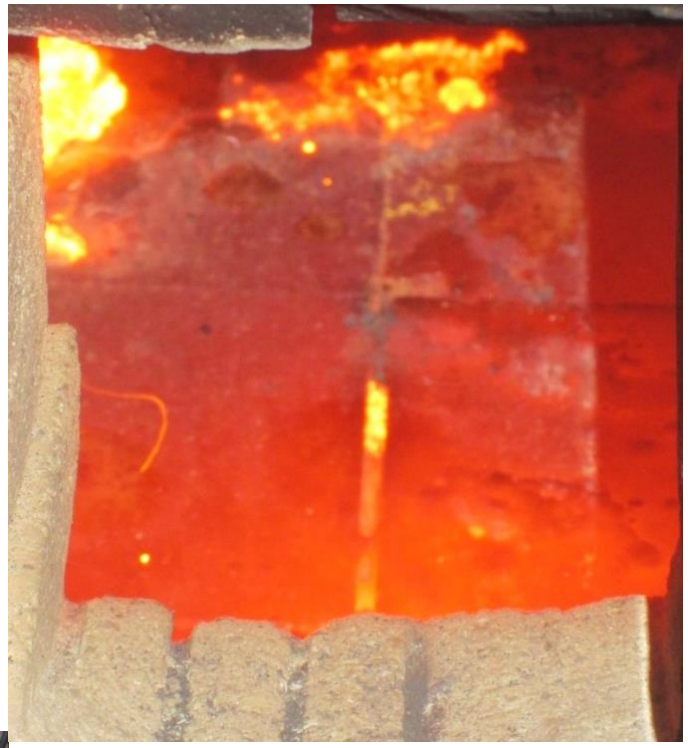
Waste Gasifier with Plasma Torch

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

CO – 42.0%

H_2 – 25.1%

N_2 – 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.**


Thanks !