PLASMA PROCESSING OF BIOMASS

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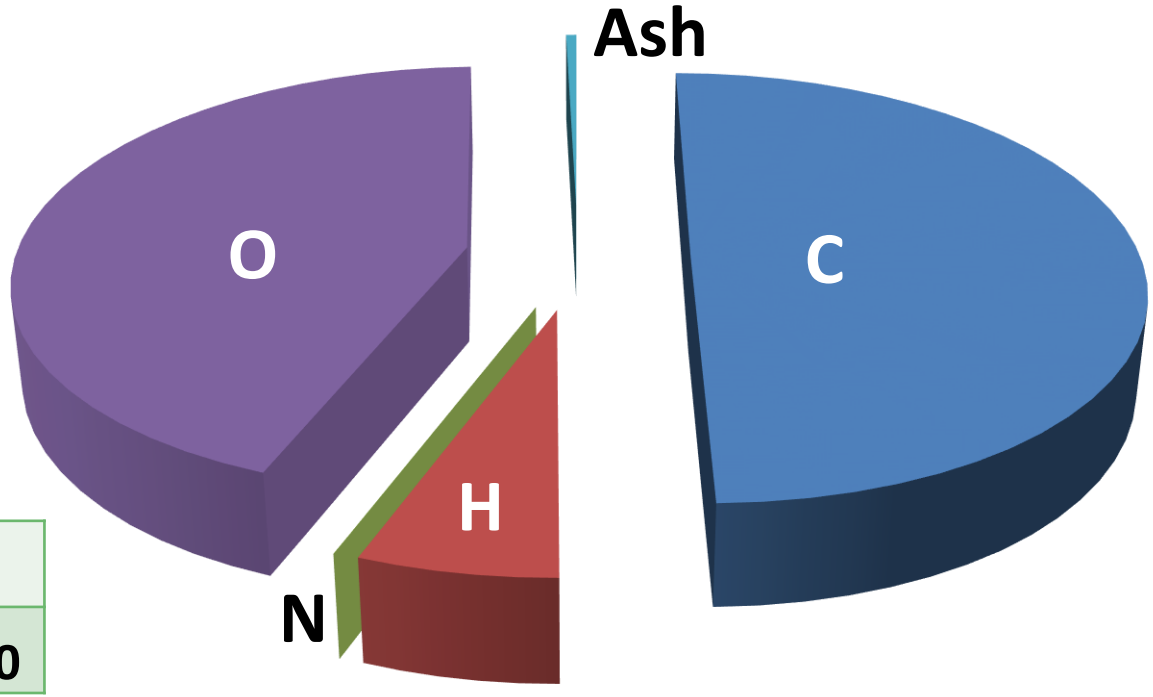
ADVANTAGES OF PLASMA METHODS FOR WASTE PROCESSING

- **Finished decomposition of waste;**
- **Co-processing of different types of waste without pre-sorting;**
- **Decrease in the volume of exhaust gas;**
- **Smaller carryover of dispersed particles;**
- **High performance with small dimensions of equipment;**
- **Creating a desired gaseous atmosphere;**
- **Operative adjustment the process by changing the flow rate of air and power of plasma torches.**

CHEMICAL COMPOSITION OF FUELWOOD, WT.%



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

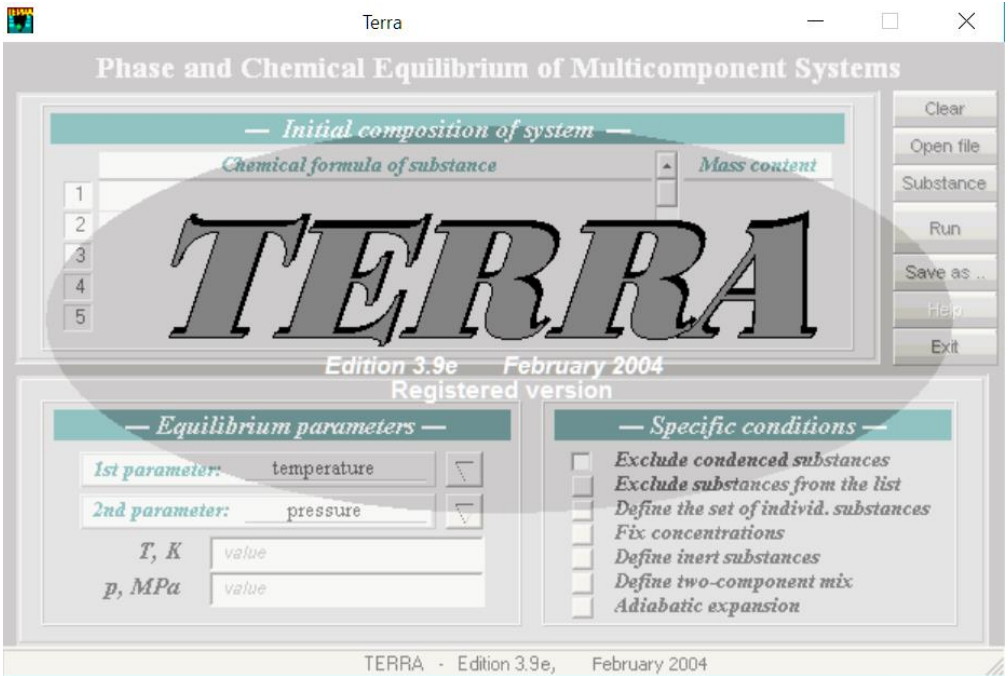
THERMODYNAMIC COMPUTATION

For computation of FW gasification thermodynamic code TERRA was used.

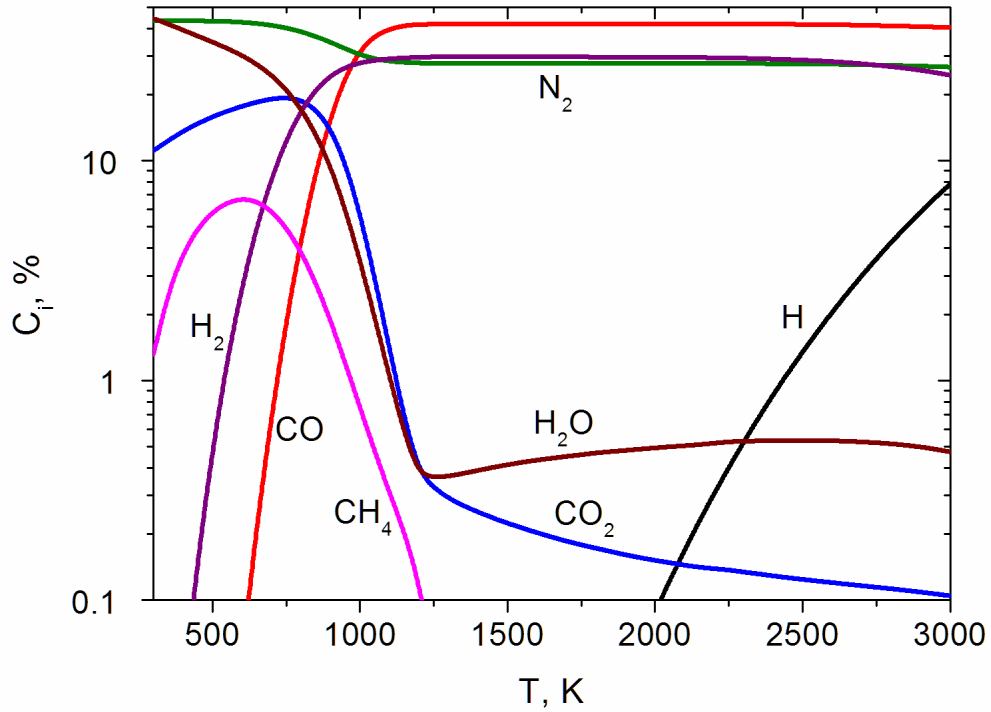
The calculations were performed over a range of temperatures from 300 to 3000 K and pressure 0.1 MPa.

Initial Composition of the System for Computation

10 kg of FW + 10 kg of air



THERMODYNAMIC COMPUTATION



T = 1600 K:

CO – 41.9%

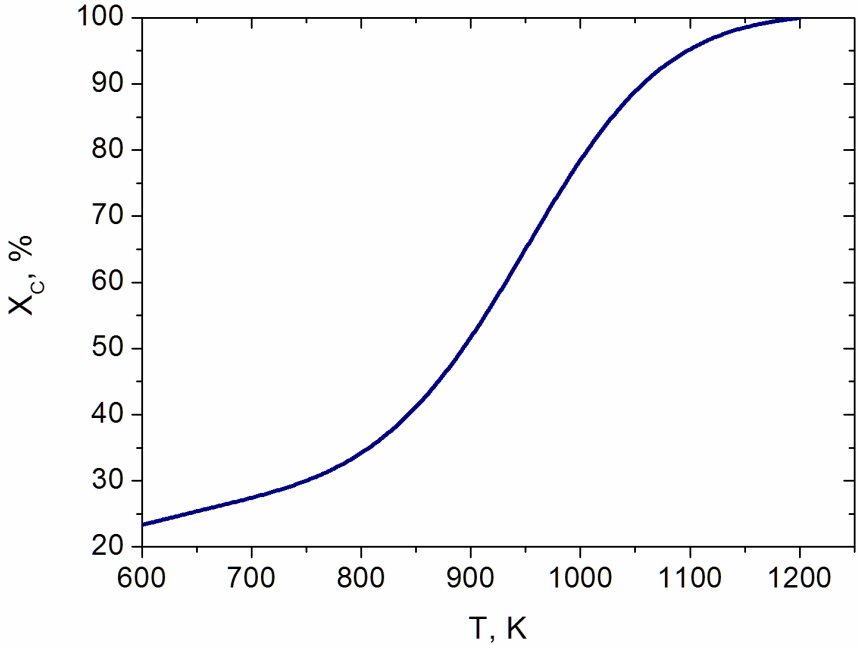
H_2 – 29.7%

N_2 – 27.8%

$CO_2 + HO_2$ – 0.6%

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

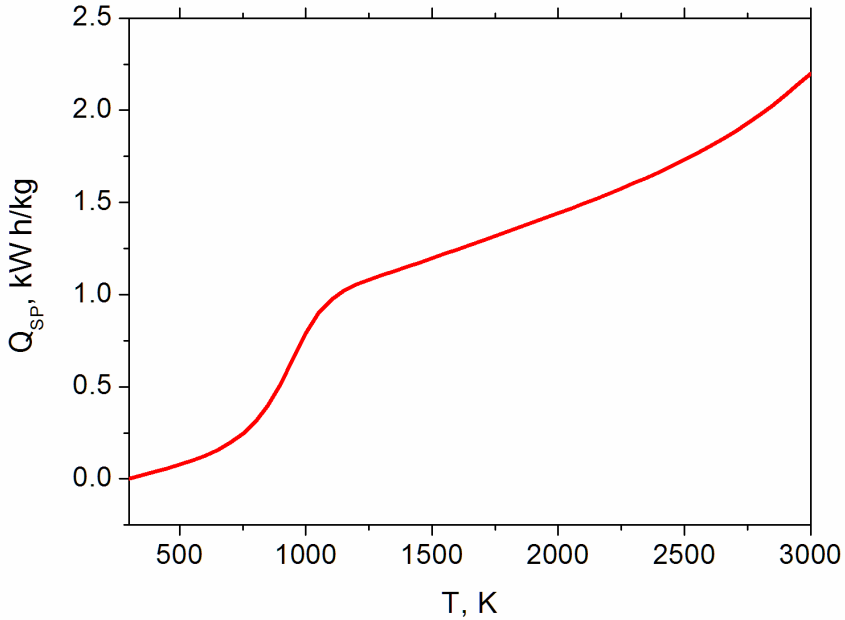
THERMODYNAMIC COMPUTATION



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

Carbon gasification degree dependence on temperature of FW gasification

THERMODYNAMIC COMPUTATION

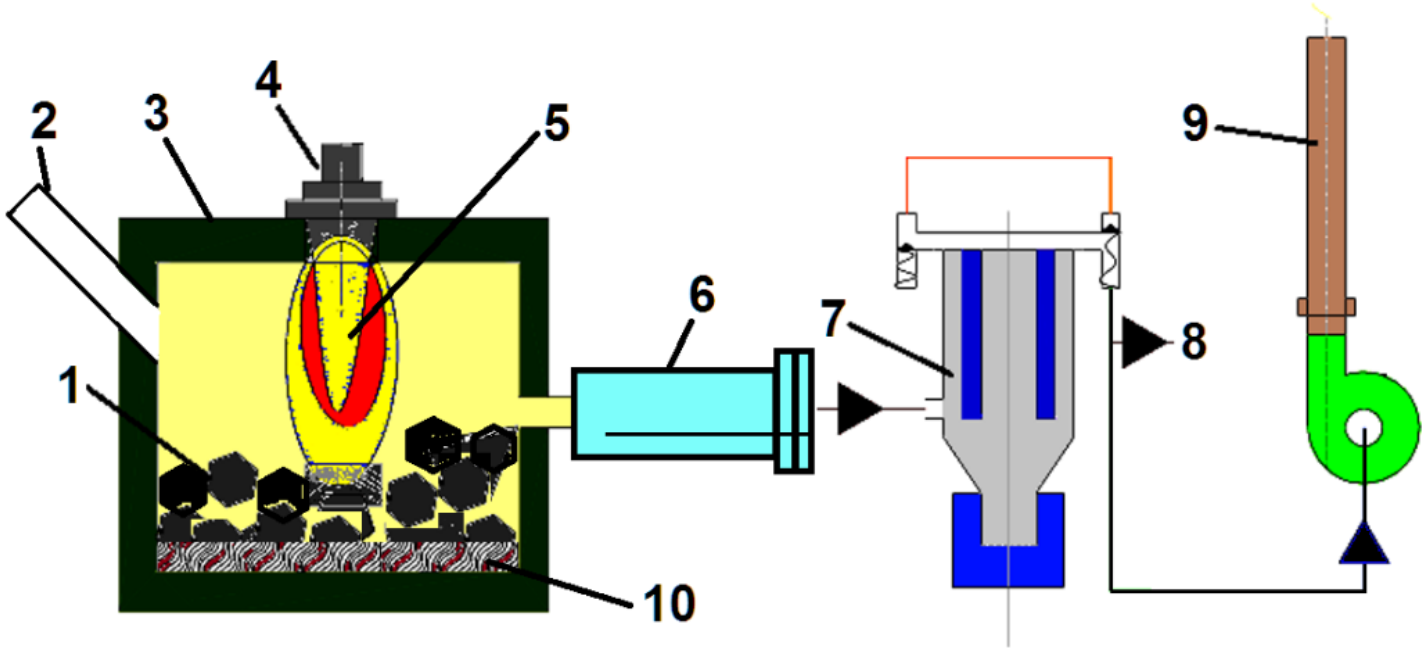


T = 1600 K:

Q_{sp} – 1.25 kW h/kg

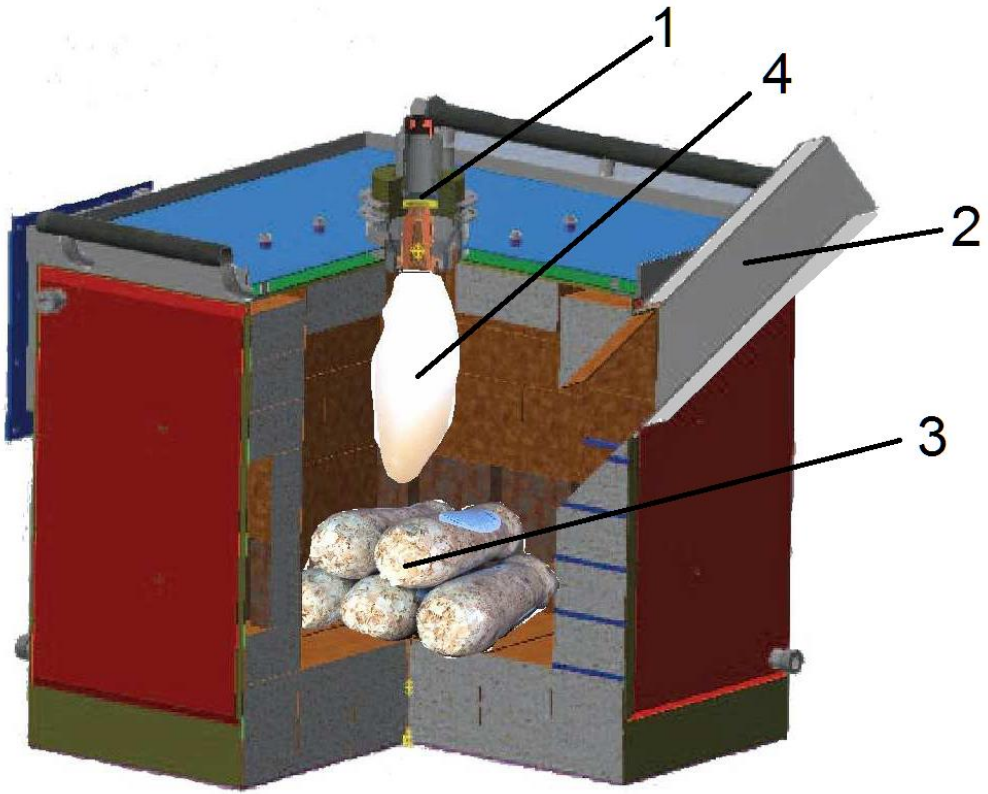
Specific power consumption dependence on temperature of FW plasma gasification

Functional Scheme of the Experimental Installation for Plasma Gasification of Fuelwood



1 – FW gasification zone; 2 – pipe for supplying of briquetted FW; 3 – gasifier; 4 – arc plasma torch; 5 – plasma flame; 6 – flue gas cooling unit; 7 – gas purification unit with a bag filter; 8 – gas sampling system for analysis; 9 – exhaust system; 10 – slag formation zone

Scheme of the plasma reactor



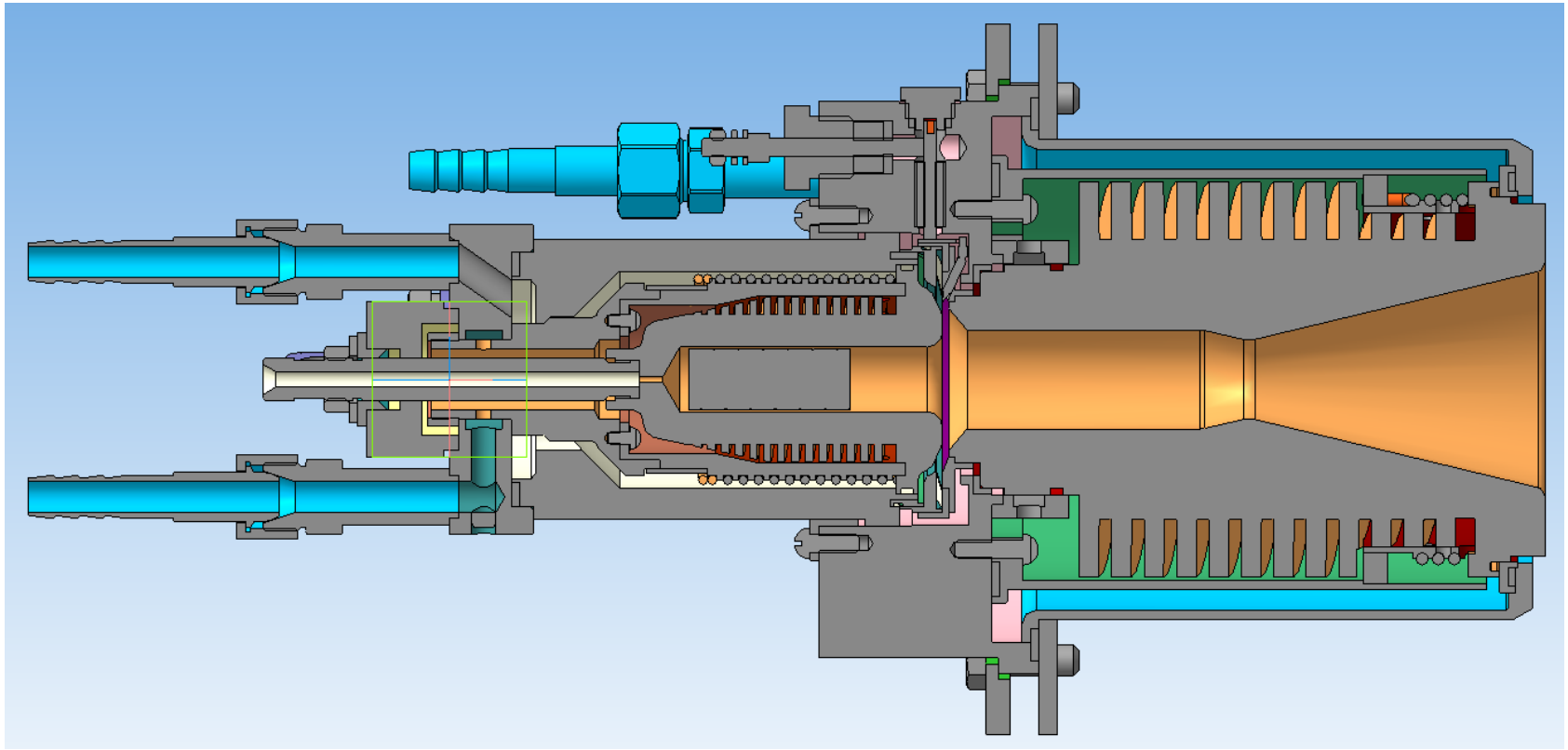
1 – arc plasma torch;

2 – pipe for supplying of briquetted FW;

3 – FW briquettes;

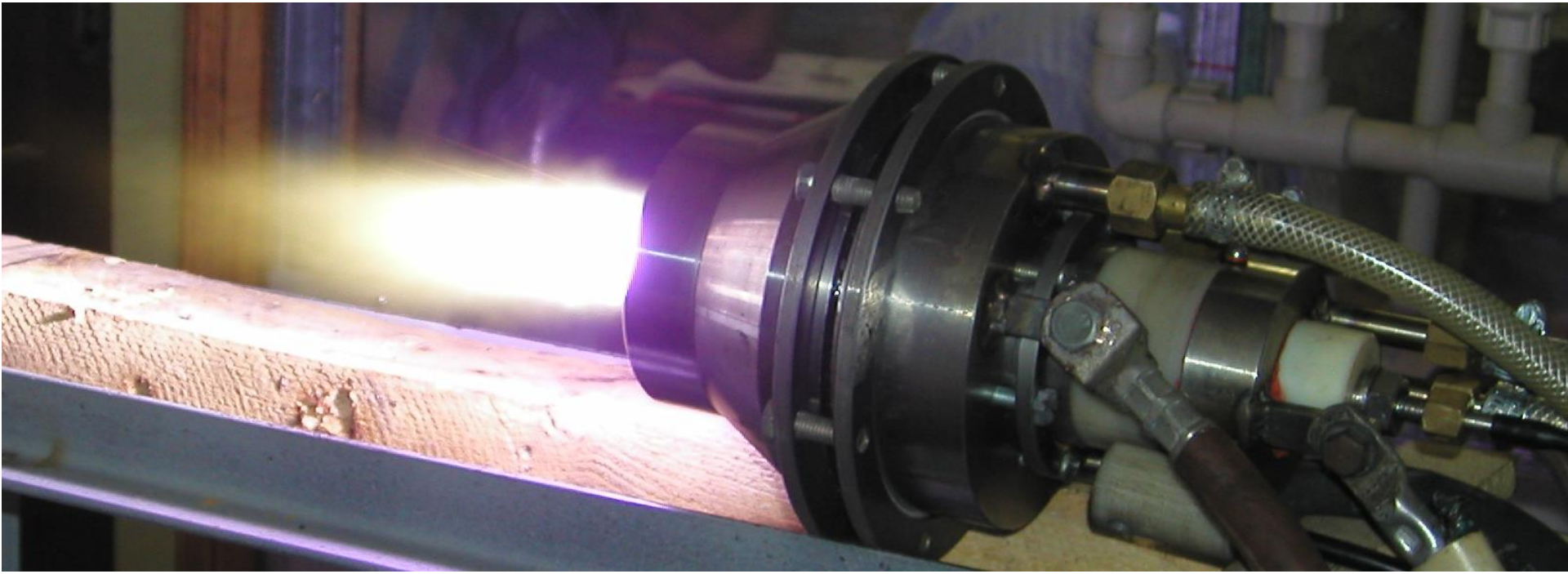
4 – plasma flame

Plasma torch is the main element of the installation



Schematic of a long-service-life plasma torch of 70 kW

Plasma torch is the main element of the installation



**Long-service-life plasma torch of 70 kW in operation:
temperature of the plasma flame is 5000 K**

FW Gasifier with Plasma Torch

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

CO – 42.0%

H_2 – 25.1%

N_2 – 32.9%

As a result of 9.9 kg of FW 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

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 FW is 50.0 kg / h**

COMPOSITION OF THE PRODUCTS AFTER PLASMA GASIFICATION OF FW

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 fuelwood in air medium is achieved at a temperature of 1600K.
- At the air plasma gasification of FW synthesis gas with a concentration of 67.1% (CO – 42.0, H_2 – 25.1) can be obtained. Specific heat of combustion of the synthesis gas produced by air gasification amounts to 9450 kJ/kg.
- At the optimal temperature (1600 K), the specific power consumption for air gasification of FW constitutes 1.53 kW h/kg.
- Found parameters and discovered patterns of the process of plasma gasification of FW have been used to design an experimental plasma installation.
- In the experiments, as well as in thermodynamic calculations, no harmful impurities were found in both gas and condensed products of FW plasma gasification. Utilizable synthesis gas was produced from organic matter of FW and neutral slag from the mineral matter.
- Comparison of experimental results and calculations showed good agreement.