MODELLING OF GASIFICATION PROCESS IN DEMO CHP PLANT

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1. INTRODUCTION

- Combined heat and power (CHP) production is simultaneous generation of usable heat and electricity in a single process.
- The fuel consumption can be decreased approximately 25.35% with CHP production compared to the power and heat generation in separate processes
- The CO_2 emissions per produced heat and power are reduced and the total efficiency of the generation increases (up to 90%)

2.DEMO CHP PLANT DEVELOPED ON THE PROJECT

- design demo-power plant to 200 kW_{el}, with a capacity of gasification of 150 kg/h
- to work continuously, 365 days a year and 24 hours a day, it is necessary to provide about 1665 t scrap annually
- the amount of scrap is enabled so that the participant in the project, the "Agrosava" from Šimanovci, 1000 t provides of corn cobs per year, and other 665 t should be provided from forest harvesting in the region of the Forest Administration "Kupinovo."

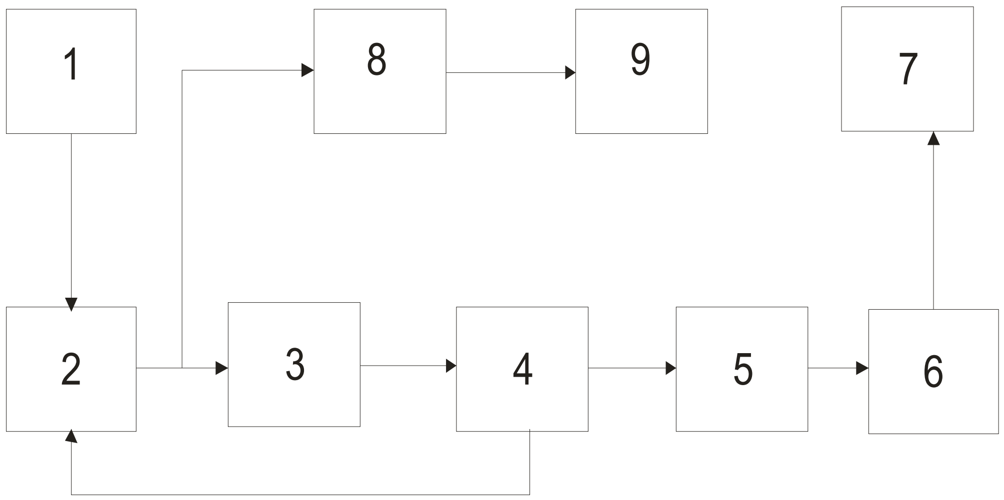

Figure 1: Functional scheme of demo CHP plant:

1. storage of the biomass 2.gasification (gasifier and combustion chamber forces), 3.separation, 4.overheat air and generator cooling gas 5.fine filtration, 6.storage of generator gas for purpose of obtaining electricity 7.obtaining electricity (gas engine with a generator), 8 storage of gas generator for receiving heat, 9.obtaining heat (hot water boiler, power of 880 kW)

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Figure 2 : The concept of demo CHP plant:

- PART 1 – storage and gasification of biomass
- PART 2 – separation and filtration of stack (syn) gas
- PART 3 – boilers and heat exchangers for obtaining heat from stack gas and heat input air in gasificator
- PART4 – modul for obtaining power from stack gas

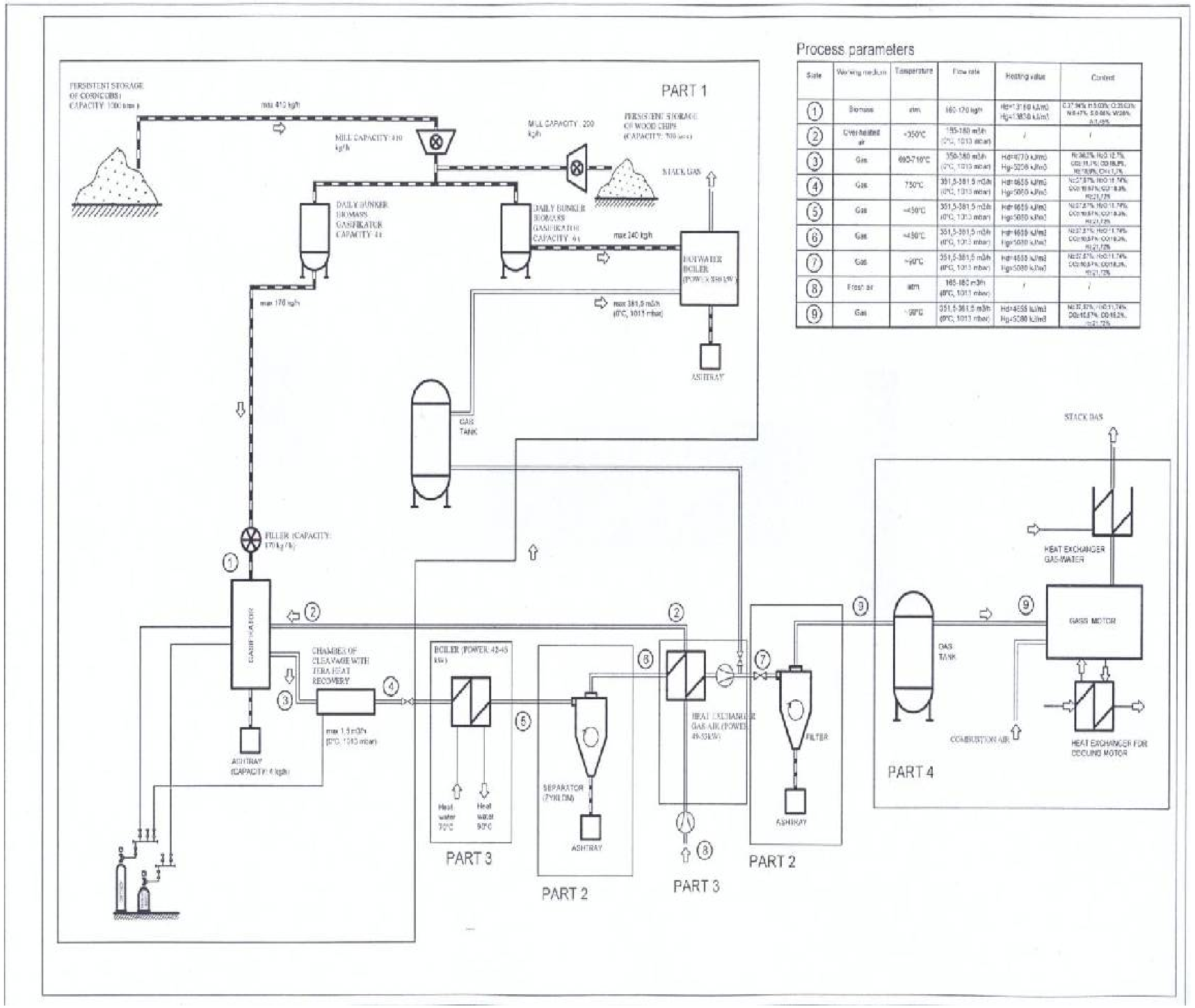
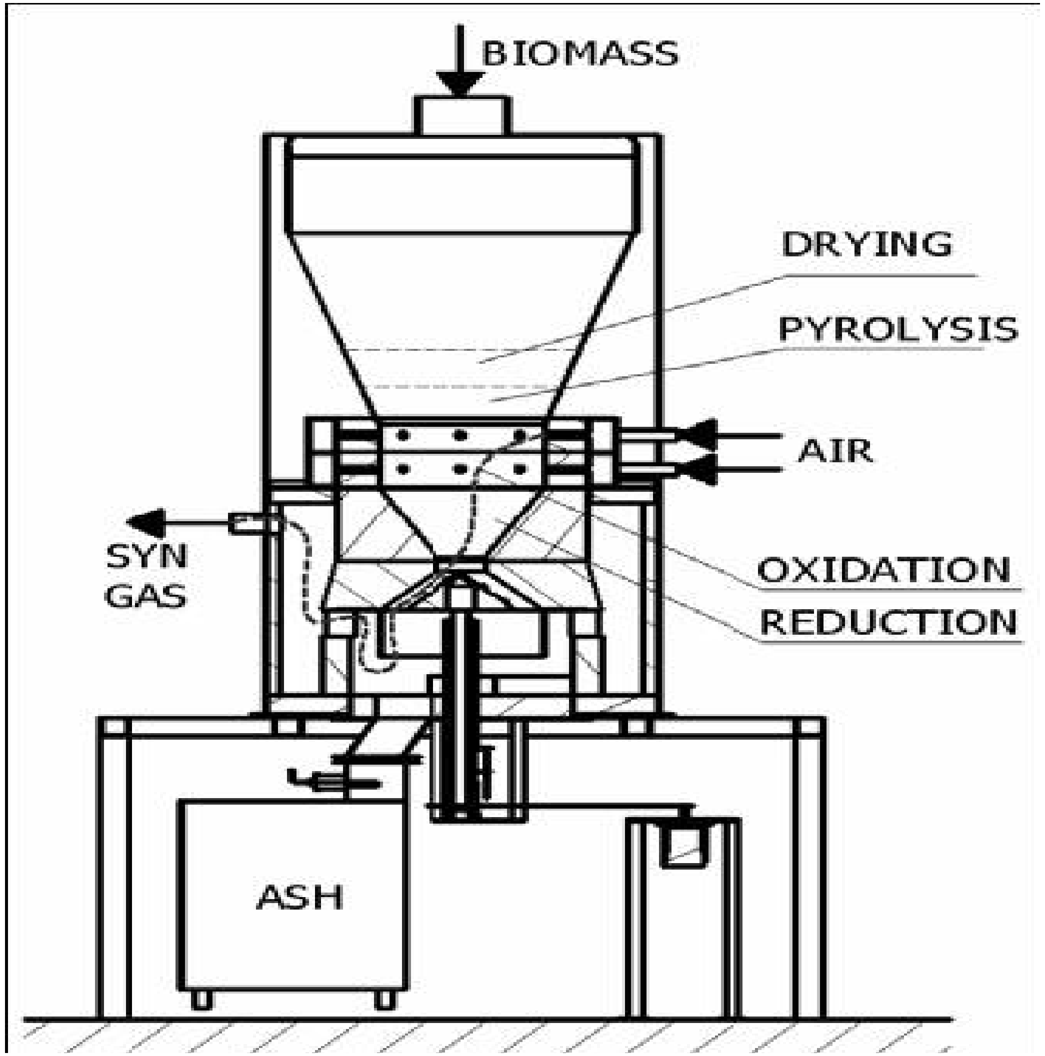


Figure 3: Downdraft gasifier design



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3. THE MODELING

a) Mass balance equations

$$M_C = \dot{m}_g \cdot (k_{CO} + k_{CO_2} + k_{CH_4}) + \dot{m}_c$$

$$M_H = \dot{m}_g \cdot (2 \cdot k_{H_2} + 2 \cdot k_{H_2O} + 4 \cdot k_{CH_4})$$

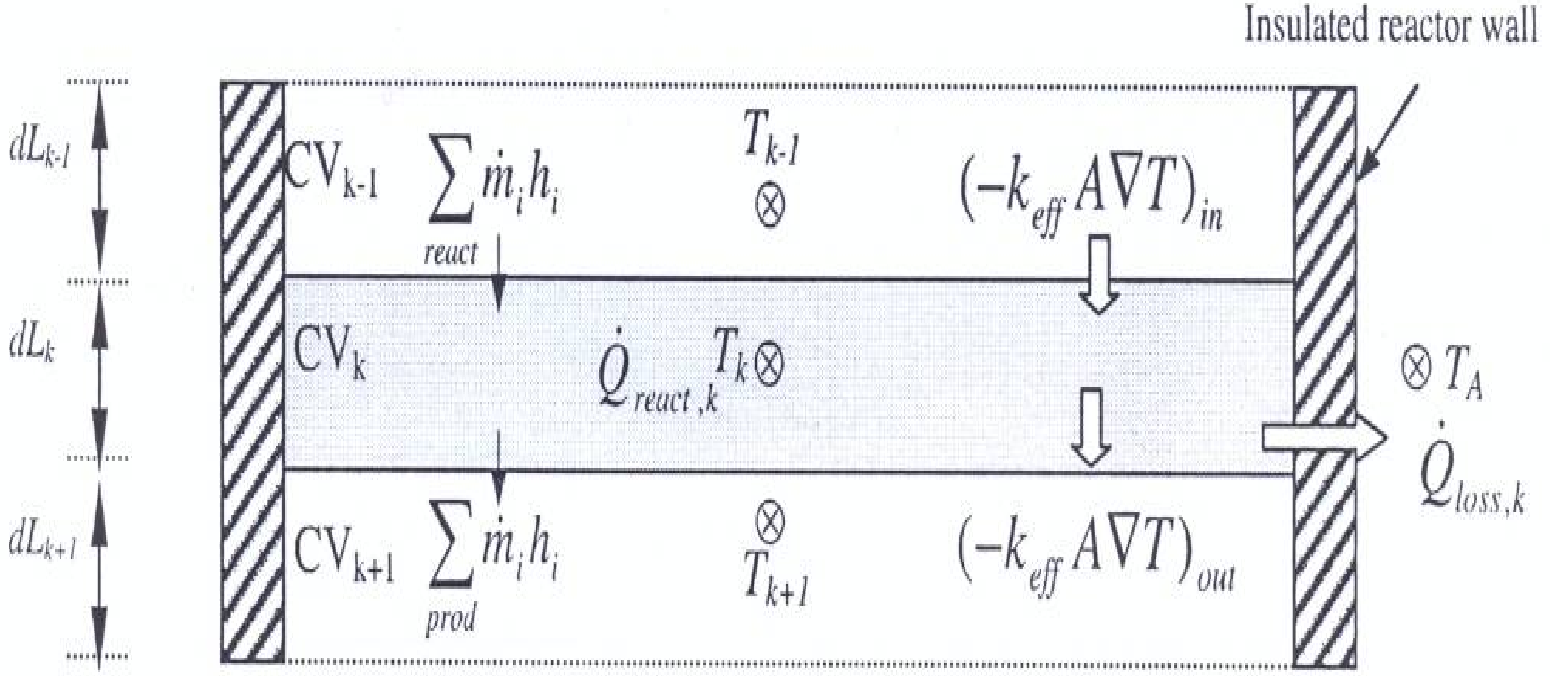
$$M_O = \dot{m}_g \cdot (k_{CO} + 2 \cdot k_{CO_2} + k_{H_2O})$$

$$M_N = 2 \cdot \dot{m}_g \, k_{N_2}$$

$$k_{CO} + k_{CO_2} + k_{H_2} + k_{H_2O} + k_{CH_4} + k_{N_2} = 1$$

b)Energy balance equations

Figure 4: Control volume used for heat transfer analysis



The energy equation can be written as:

$$\sum_{reac} m_i h_i + (-k_{eff} A\nabla T)_{in} - \dot{Q}_{loss,k} - \dot{Q}_{reac,k} = \sum_{prod} m_i h_i + (-k_{eff} A\nabla T)_{out}$$

$Q_{reac;k}$ denotes the endothermic heat absorption rate in k-th control volume of char reduction zone, which can be computed using enthalpy of formation of the reactants and products as given by:

$$\dot{Q}_{reac,k} = \sum_{reac} \dot{m}_i h_i^0 - \sum_{prod} \dot{m}_i h_i^0$$

Analyses and remarks

- Total mass inputs include feedstock (wood chips and corn cobs), air and total water input, while total mass outputs comprise total water output, ash, char, tar, condensate and dry gas outputs.

- The total mass input must be equal to the total mass output.

- The usual method to quantify the discrepancies in the mass balance is the closure of the mass balance which is defined as the percentage ratio of the total output mass to that of the total input mass.

- The average mass balance closure was found to be 95% over 11 runs with chips and corn cobs, for the total fuel input range of 140–170 kg/h.

4. CONCLUSIONS

- Economic effectiveness of cogeneration as well as optimal power of the plant strongly depends on the mode of operation, the total mass input and output,

- The equations representing the equilibrium and kinetic reaction model have been coupled with energy equation to investigate the effect of variation of length of char bed on the following: dry gas composition, heating value of gas, conversion efficiency, endothermic heat absorption rate in the reduction zone, exit gas temperature and gasifier power output,

4. CONCLUSIONS

- Comparison of kinetic and thermodynamic modeling for varying char bed length clearly indicates the coinciding tendencies in their calorific values, conversion efficiencies, exit gas temperatures, gasifier power outputs and endothermic heat absorption rates

- Maximum heat load as well as the shape of the heat load duration curve is important factors for optimization.

- Multi-criteria analysis was done and the endothermic heat absorption rate in control volume of char reduction zone was decreased on 7.3%.

Thank you for your attention