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The utilization of biomass at TUKE

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Technologies for energetic utilizing of biomass

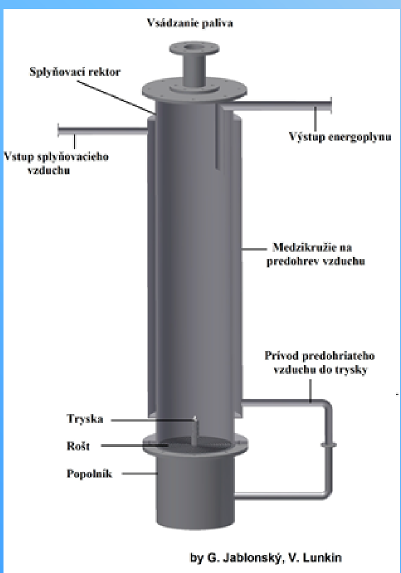
Activity 1.1 of project VUKONZE at TUKE is devoted to biomass utilization
(Research centre for performance of the renewable energy resources integration)

Data were provided by referee of activity 1.1: doc. Ing. Ladislav Lukáč, PhD. (HF, TUKE)

Objectives of the activity

- **design, construct and build experimental generator for gasification of wood biomass and device for combustion of produced generator gas for heat and electricity,**
- **mathematical modeling of gas flow through the layer with specific material inserted in generator,**
- **optimization of generator operation (influence of consumption of gasificated air, backfill height, feeding, fuel moisture) with a focus on produced gas, temperature field and reactor power.**

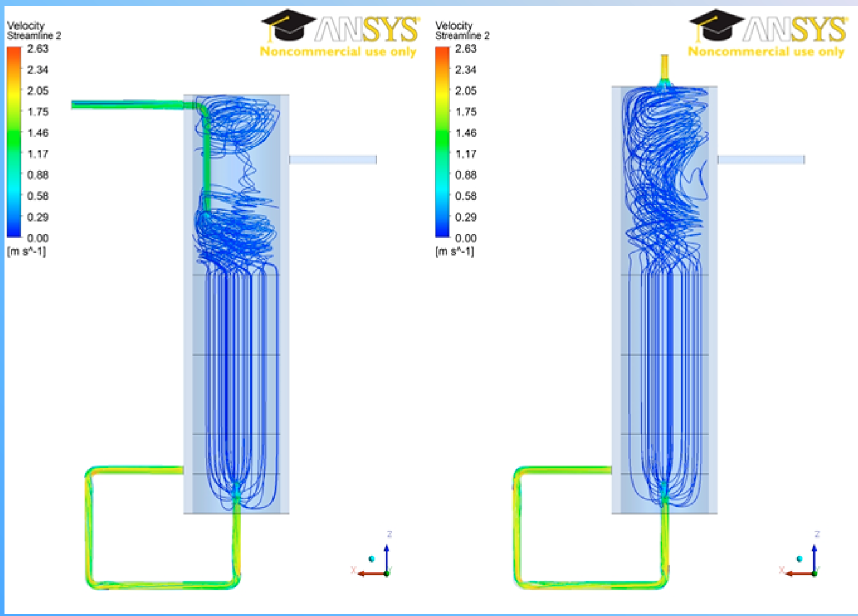
Experimental gasification reactor



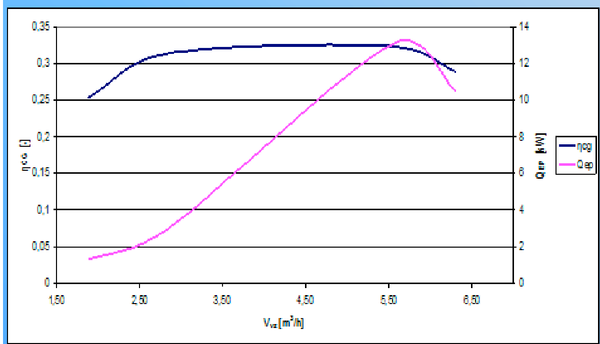
Designed and constructed reactor:

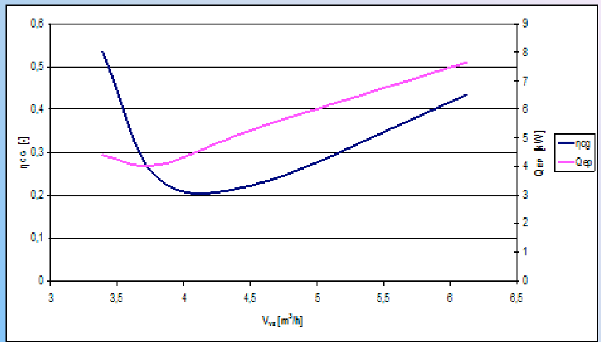
Estimated power: 15 kW
Fuel: wood biomass
Grain size: 10-20 mm
Bulk density: 220 kg/m^3

Modeling of flow - velocity of the gaseous medium



Optimization of gasification reactor

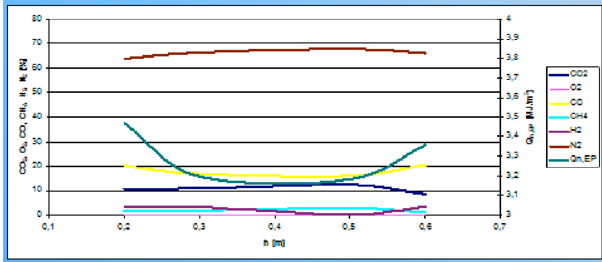




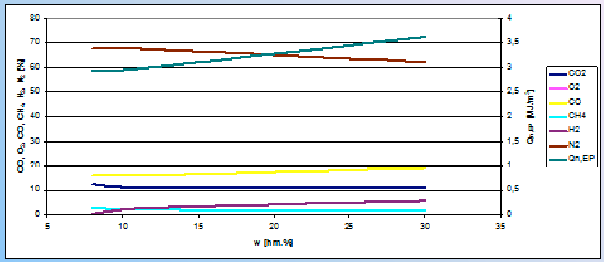
Graph 1. The effectiveness of cold gas and max. performance in gas achieved by various consumption of gasification air for layer height of 0,5 m.

Graph 2. Max. effectiveness of cold gas and power in the gas achieved by various consumption of gasification air for layer height of 0,7 m.

Influence of filling height and biomass moisture in generator on the composition and calorific value of the produced gas



Graph 3. Composition of generator gas and its calorific value for different levels of filling in the gasification air consumption of 2,9 m³/h.



Graph 4. Composition of generator gas and its calorific value for different fuel moisture content in the gasification air consumption of 2,9 m³/h and filling level of 0,5 m.

Measure the temperature along the height of the reactor

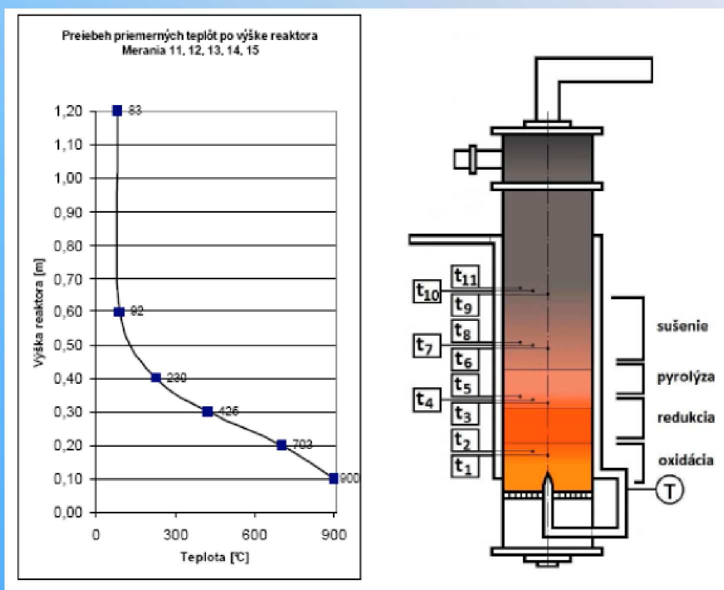


Fig. 1 Characteristics of average temperatures in the height of the reactor during the measurements

Influence of filling height on the formation of tar and cleaning efficiency of filtration device

There was investigated:

- **formation of tar,**
- **efficiency of impurities reduction from produced gas on an experimental filtration equipment.**

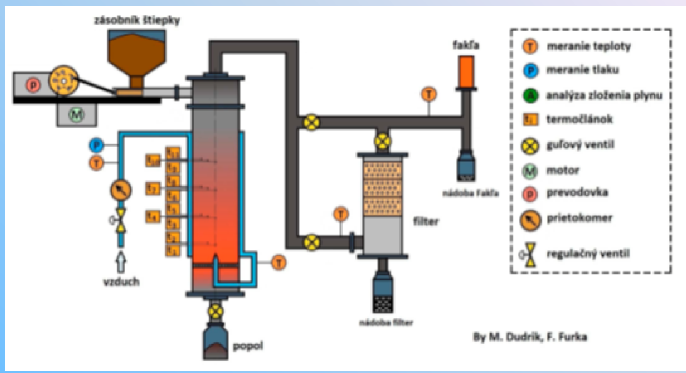
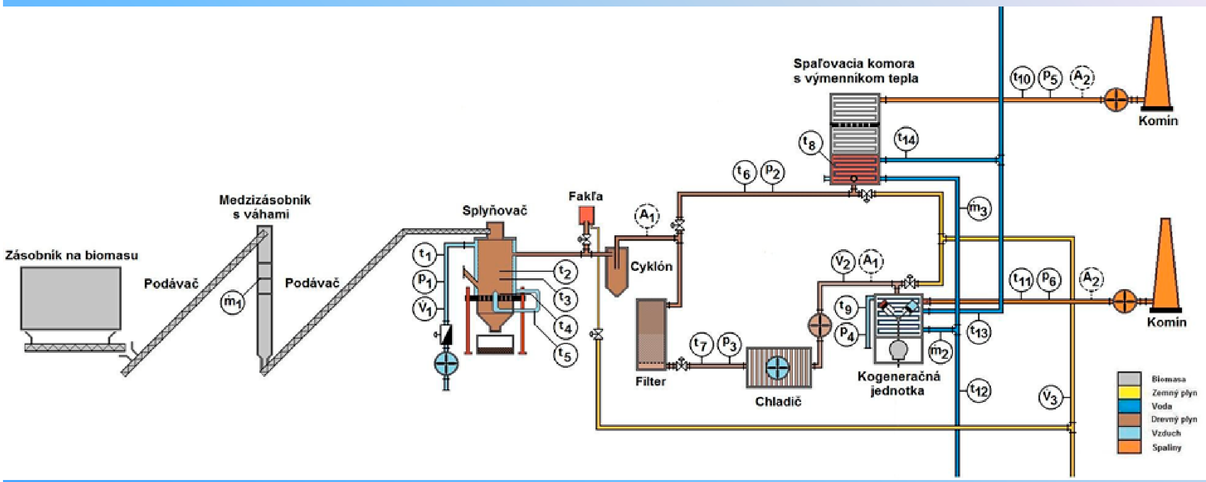


Fig. 2 Schematic diagram of filtration equipment behind the biomass gasification generator

Utilizing of obtained results for the project VUKONZE (Activity 1.1)

- **nozzle for air supply,**
- **system for removal of wood gas from the gasifier (side and ceiling outlet),**
- **system of biomass feeding – uniform wood biomass feeding.**

Scheme of the cogeneration device of low power combusting solid biomass



Future and sustainability

- Enhancement of knowledge in the field of:
  - combined production of electricity and heat using low-power biomass via gasification resp. combustion,
  - gasification method and type of gasification media on the quality of the produced gas.
- Solving of the reduction system of tar from contraflow gasification generator.
- Use of cogeneration units with external combustion can help to bypass the problem of impurities presence in the gas and adjust its quality.

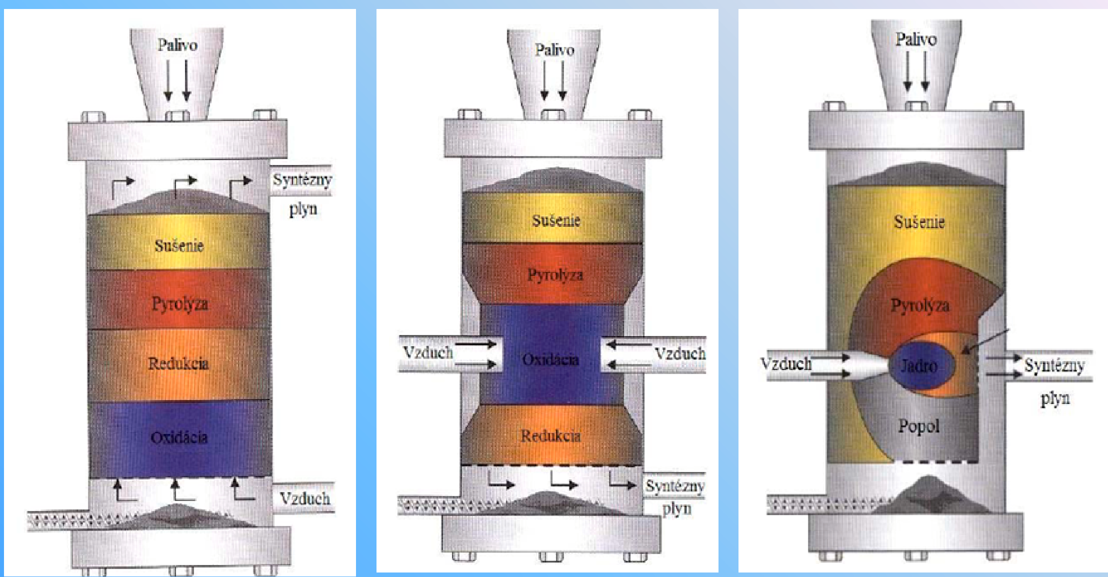
Contribution to the central laboratory

Heat source from biomass will provide heat to a central laboratory for research of combination of efficiently utilized renewable energy sources.

Primary denitrification of combustion gas with woodgas

The work complementary add the knowledge and ideas about the method of reburning realized at TUKE.

Data were provided by doc. Ing. Ladislav Lukáč, PhD. (HF, TUKE)



countercurrent gasifier   uniform gasifier   cross-flow gasifier

Figure 1: Diagram of gasifiers with a fixed bearing

Tab. 1: Overview and characteristics of ideal generator gases

Gas composition	Countersurrent reactor	Uniform reactor	Fluid reactor
H_2 [volume %]	10-15	15 - 20	10-15
CO_2 [volume %]	15 - 20	8 - 15	15 - 20
CO [volume %]	15 - 20	25 - 30	15 - 20
CH_4 [volume %]	2 - 5	1 – 1,5	1 – 3
C_2+ [volume %]	5	< 1	2 - 3
N_2 [volume %]	43- 47	45 - 50	45 - 55
Outlet temperature [°C]	150 - 300	750 - 850	600 - 750
Dust [$g.m^{-3}$]	1 - 20	1 - 20	5 - 50
Tar [$g.m^{-3}$]	> 100	0,1 - 1	1 - 20
Type of tar	primary	secondary	secondary
Q [$MJ.m^{-3}$]	5,5 - 7	5 – 5,5	4,5 – 6,5

Utilizing of wood gas in the Reburning process

Stepped combustion of fuel and combustion air – Reburning + OFA (afterburning air) comprises from forming a number of combustion zones in the combustion chamber, namely:

- primary combustion zone
- reduction - reburning zone
- afterburning zone with afterburner air

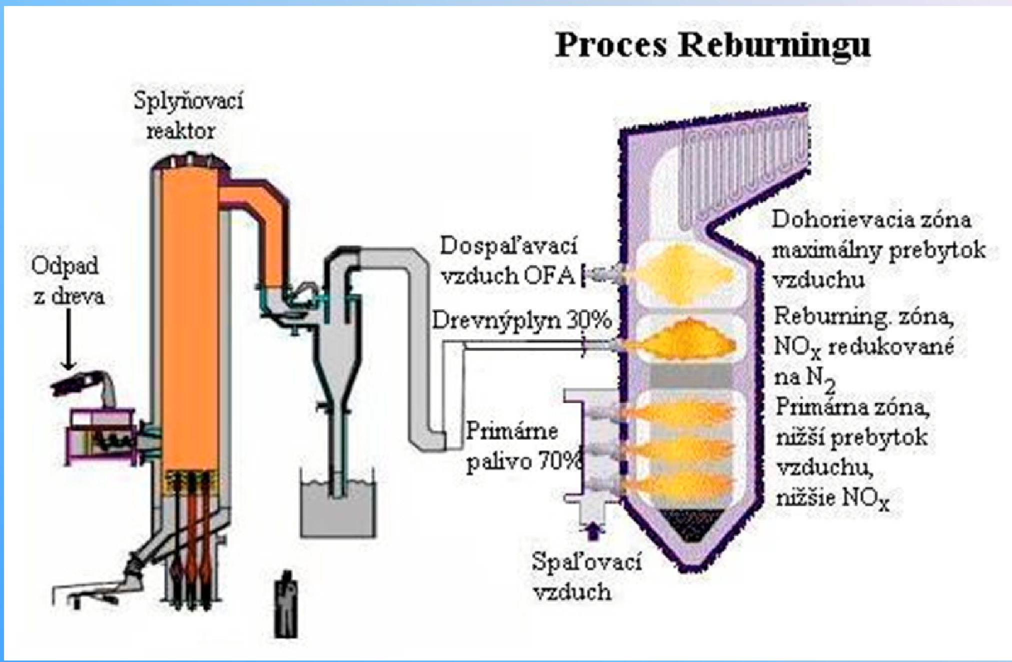


Fig. 2 The combination of gasification and reburning

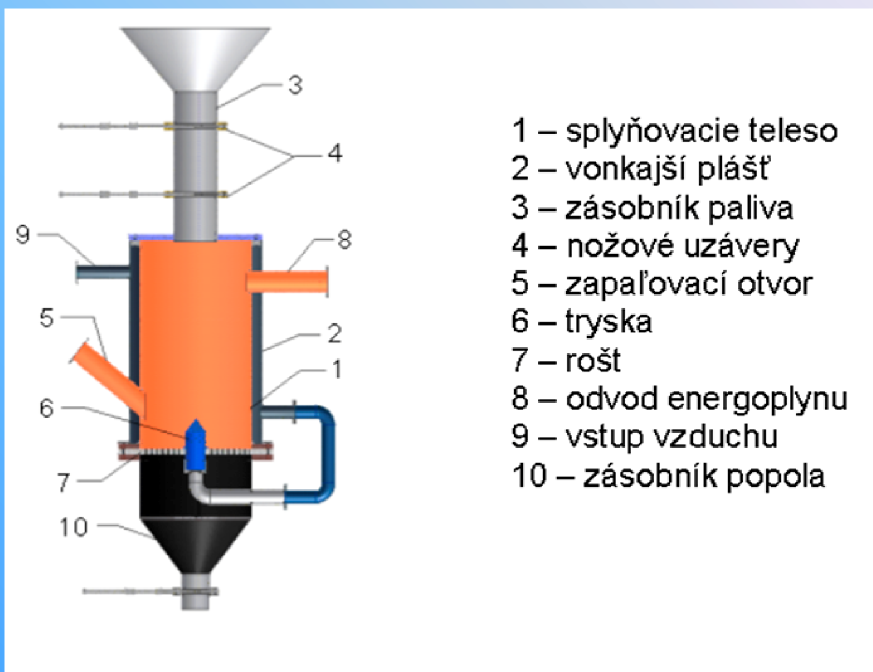


Fig. 3 Gasification device S & H

Fig. 4 Gasification device S & H

Tab. 2 Composition of energogas

Gas composition	
H_2 [volume %]	10,6
CO_2 [volume %]	12
CO [volume %]	23
CH_4 [volume %]	3,33
O_2 [volume %]	0,52
N_2 [volume %]	48,9
Outlet temperature [°C]	200 - 350
Q [$MJ.m^{-3}$]	4,7
Amount of gas [$m^3.h^{-1}$]	120 - 150

Fig. 5 Gasification device and reburning device

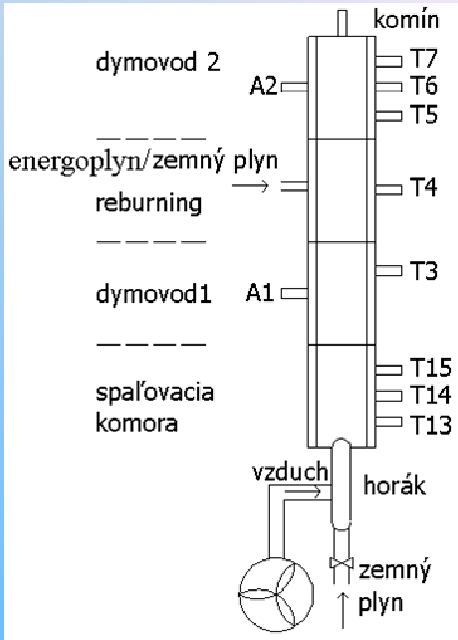


Fig. 6 Schematic of experimental device for reburning with biomass

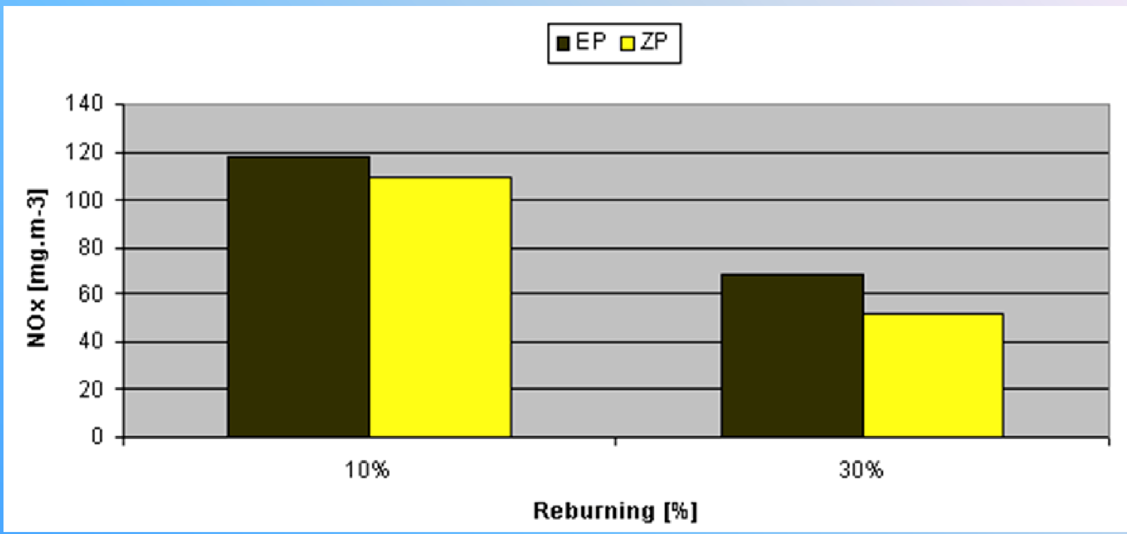


Fig. 7 Comparison of NO_x formation during the combustion of energogas and natural gas as reburning fuel in air excess of 1,1 and for total gas flow of 1,6 m^3/hour

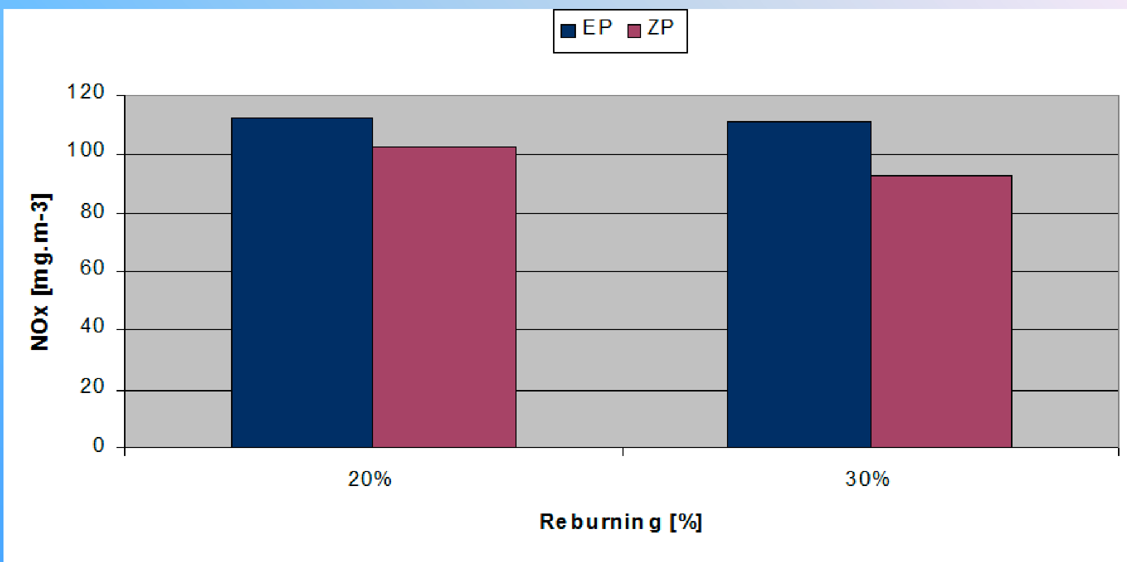


Fig. 8 Comparison of NOx formation during the combustion of energogas and natural gas as reburning fuel in air excess of 1,1 and for total gas flow of 2,0 m^3/hour

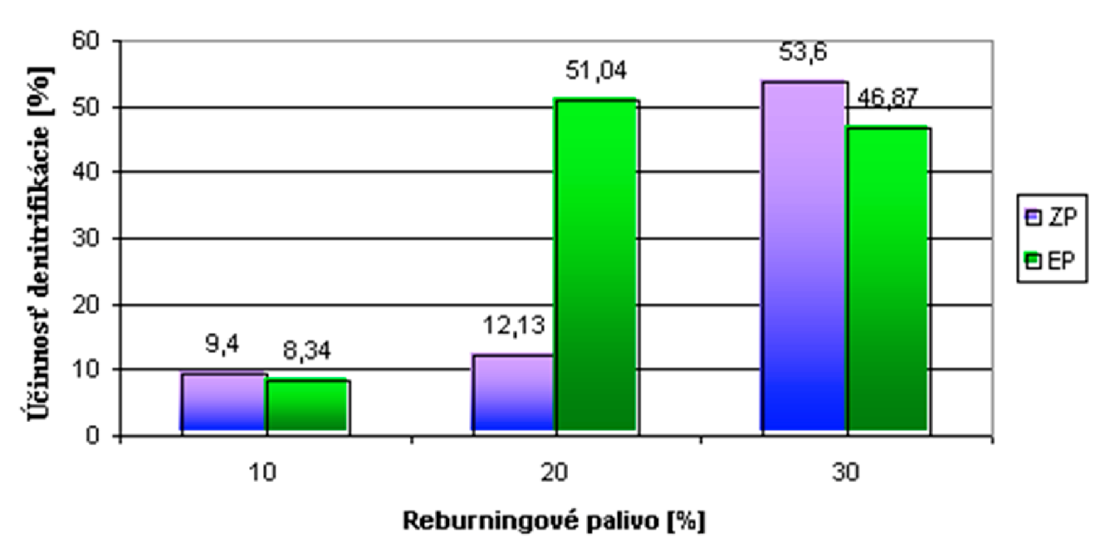


Fig. 9 Comparison of the effectiveness of denitrification ZP and EP at a flow rate of

Q = 1,6 $m^3 \cdot h^{-1}$ and excess of m = 1,1

Conclusion

- Experimental device in Figures 5, 6 was used to monitor the effectiveness of reduction of NO_x by reburning method depending on the excess amount of combustion air and reburning gas (energogas). The highest efficiency of denitrification 53,6% was achieved at 30% of reburning ZP and the lowest at 10% of reburning EP, i.e. 8,34%.
- Using the reburning by coal there can be achieved 50-55% reduction in NO_x emissions for cyclone boiler with melting (slag-tap) fireplace. Using reburning by natural gas (NGR) in coal-fired boilers there can achieve 45-65% reduction of NO_x. Using the gas from gasification process of reburning there can achieve up to 70% NO_x reduction.
- Energetic utilizing of biomass in Slovakia, but also in some countries in the EU is one of the most promising renewable energy source.