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# THE IMPACT OF THE COMPOSITION OF THE WOOD GAS TO EMISSIONS AFTER COMBUSTION OF WOOD GAS

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This paper presents the results of measurements which were carried out on Department of furnaces and thermal technology. Experiments were carried out on a countercurrent gasifier using different fuels, different flow gasification medium and different heights of backfill. In order to obtain values for emissions of the combustion process of producer gas are planned measurements for different composition of produced gas, depending on the type of gasifying medium. In our case, produced gas will be incinerated in the boiler or the cogeneration unit. These measurements are planned for in autumn 2014. The obtained data can serve as a basis for the use of produced gas in industrial practice.
**Key words:** wood chips, wood pellets, wood gas, combustion of wood gas, emission.

**Utjecaj sastava drvnog plina na emisije njegovim izgaranjem.** Ovaj rad prikazuje rezultate mjerenja koji su obavljeni u Zavodu za peći i toplinsku tehnologiju. Eksperimenti su provedeni na protustrujnom rasplinjaču korištenjem različitih goriva, različitih protoka rasplinjavajućeg medija i različitih visina zasipa. Da bi se dobile vrijednosti emisija za procese izgaranja plina planirana su mjerenja za različite sastave proizvedenog plina ovisno o vrsti rasplinjavajućeg medija. U ovom će se slučaju proizvedeni plin spaljivati u kotlu ili kogeneracijskom uređaju. Ova mjerenja su planirana za proljeće 2014. Dobiveni rezultati mogu poslužiti kao osnova za uporabu proizvedenog plina u industrijskoj praksi.
**Ključne riječi:** drvna strugotina, drvni peleti, drvni plin, izgaranje drvnog plina, emisija.

## INTRODUCTION

The notion of air protection means the set of administrative and technical measures that lead directly or indirectly to the alleviation of their growth or even a reduction in air pollution. To the most important technical measures include reducing emissions from sources. Therefore, tracking or reducing emissions from the combustion of producer gas is a current topic [1].

### The gasification of wood biomass

The gasification is considerably complicated thermochemical conversion of fuel in the deficiency of oxygen, in which arises gas low calorific in the range of 4-10 MJ.m$^{-3}$. By the instrumentality of thermal to the wood biomass occurs at temperature range of approximately 500 - 600 °C to gradual release of gaseous substances. This phenomenon, known as pyrolysis is used for gasification biofuels in order to obtain energetically exploitable gas. The degassed residue is charcoal, semi coke. There is thermal equilibrium between the reactions that consume heat and the reactions producing heat. State when these two heats are in equilibrium balance and when the temperature doesn't change in the reactor is called autothermal. The objective is to achieve this autothermal status. The product of the wood biomass gasification is raw wood gas containing mainly of CO, $CO_2$, $H_2$, $CH_4$, $N_2$. In addition to the above mentioned constituents, the product also contains other undesirable constituents; in particular, dust, tars, alkalis, and nitrogen compounds. Wood gas can be defined as a combination of the foregoing constituents (desirable and undesirable). It is flammable and malodorous after the tar. Wood gas is explosive when in mixture with air [2].

The resulting gas can be incinerated in a gas turbine or piston combustion engines of cogeneration units. The gasification takes place in order to the greatest proportion of energy from the fuel is transformed into the energy content of gas. The gasification process can be executed with greater efficiency and achieving lower level of emissions when compared to the direct combustion process [3].

## Cleaning of wood gas

Cleaning of the wood gas is necessary in order to meet the specifications laid down by the engine suppliers that usually specify very particular operational conditions, e.g. the level of the gas flow, specific composition of the wood gas and the level of allowable contamination. The main contaminants of raw wood gas are the particulate matter (soot, dust) and tar. Wood gas may also contain other impurities, namely ammonia (which is converted to NOx during combustion engine), HCl, $H_2S$, alkalis and acids. If the gasification takes place in the countercurrent gasifier is high level of tar in wood gas (150 $g.m^{-3}$). Therefore, counter-current gasifier are not suitable for engines and gas turbines without complete gas cleaning [4]. Table 1 describes the interval of impurities in the product gas and the maximum upper limit of allowable impurities in energetic equipment that use producer gas. Demand on cleanness of gas rising in the line of internal combustion engines through turbines up to extremely low values required for the trouble-free operation of fuel cells.

**Table 1.** Typical composition of impurities producer gas and emission limits for various energy equipment
**Tablica 1.** Tipični sastav nečistoća proizvedenog plina i granična emisijska vrijednost za različita energetska postrojenja

| **Emission** | **Raw gas** ($mg.m^{-3}$) | **Combustion engines** ($mg.m^{-3}$) | **Gas turbines** ($mg.m^{-3}$) | **Fuel cell** ($mg.m^{-3}$) |
|---|---|---|---|---|
| $NH_3$ | 600-6000 | <50 | n.f. | <1 |
| SP* | 1000-10000 | <50 | <1 | <10 |
| $H_2S$ | 20-200 | <700 | <1 | <0,1 |
| HCl | <100 | <100 | <0,5 | <0,1 |
| Tars | 100-10000 | <100 | <5 | <0,1 |
| Na,K,Li | 30-100 | n.f. | <0,2 | <0,1 |

Dust particles must be thoroughly removed from the gas prior to its use in combustion devices (e.g. in the gas turbine) [5].

**Utilization of wood gas**

The usability of produced gas depends primarily on its quality that is usually expressed by the calorific value, content of usable components and the level of purity. In term of the energy content, produced gas can be divided in the low-energy and in the medium-energy gas. Low-energy gas has the calorific value in the range of approximately 2.5 to 8.0 ($MJ.m^{-3}$) of autothermic gasification with air is combusted together in order to combined heat and power [6]. In studied case, wood gas will be combusted in a cogeneration unit [10].

## MATERIALS AND METHODS

The basis for calculating the stoichiometry of fuel is to analyse the of elements fuel. Elements composition of the fuel affects all stochiometric calculations, thermal efficiency and losses of the devices and greatly influences the thermal working of the device itself.

Elemental composition analysis was used in the case of solid fuels. Results of the analysis are shown in percentage (by weight). In particular, the content of carbon, hydrogen, oxygen, sulphur, nitrogen, and water is measured in the original fuel. Properties of the wood pellets can be improved by using additives [11]. The results of the elemental analysis are shown in Table 2.

**Table 2.** Technical and elemental analysis of biomass used for gasification on Department of furnaces and thermal technology [7,8]

**Tablica 2.** Tehnička i elementarna analiza biomase korištena za rasplinjavanje u Zavodu za peći i toplinsku tehnologiju

| Parameters | Moisture (%) | Ash (%) | Carbon (%) | Hydrogen (%) | Oxygen (%) | Nitrogen (%) | Sulphur (%) | LHV ($MJ.kg^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| wood chips | 8 | 0,67 | 46 | 5,56 | 39,5 | 0,27 | 0 | 16,84 |
| pellets | 10 | 0,7 | 50,3 | 5,7 | 33,05 | 0,22 | 0,03 | 17,5 |

The measurements were carried out on an experimental countercurrent gasifier reactor with an expected output of the gas 15 kW. The gasification agent is used air at atmospheric pressure. The measurements were focused on the fuel consumption, air consumption, influence of the backfill height (level of fuel layer in the reactor) and on the composition of the produced gas. Each measurement consisted of several stages: equipment preparation, start-up, stabilization, and the measurement termination. Management of the start-up required to track the volume of the flow gasification air for relevant fuel mass flow, temperature in the reactor and the height of backfill. After temperature stabilization occurs sample of offtake. Offtake point for taking a sample produced gas for subsequent analysis of the gas composition is placed in the outlet pipe of producer gas 20 cm at output from the reactor.

## ANALYSIS OF RESULTS

The chemical analysis of prepared samples was performed on device ORSAT, that works on the absorption principle. The concentration levels of different components were gradually analyzed, in particular level of $CO_2$, $O_2$, CO, by combusting and re-absorption of $CO_2$ and $CH_4$. Subsequently the concentration of $H_2$ was also determined. The residual gas was contemplated as pure $N_2$. It was also contemplated that all hydrocarbons that were present in the gaseous phase were in the form of $CH_4$. Table 3 shows the composition of the wood gas produced during the wood chips and pellets gasification as measured at the Department of furnaces and thermal technology.

**Table 3.** The composition of wood gas present during the wood chip and pellets gasification, Department of furnaces and thermal technology [7,8]
**Tablica 3.** Sastav drvnog plina za vrijeme rasplinjavanja drvnih strugotina i peleta, Zavod za peći i toplinsku tehnologiju

| **Gas composition** | **Wood chips (vol.%)** | **Pellets (vol.%)** |
|---|---|---|
| Carbon monoxide (CO) | 17 | 15,3 |
| Carbon dioxide ($CO_2$) | 11,2 | 10,8 |
| Nitrogen ($N_2$) | 66,47 | 67,51 |
| Hyrdogen ($H_2$) | 3,33 | 3,57 |
| Methane ($CH_4$) | 2 | 2,82 |

Figure 1 show that negligible differences exist between wood gas compositions that were produced during the wood chips and pellets gasification process. The main reason for behind this similarity is the same level of backfill feedstock measured, in particular the level of 0.3 m. However, it is proved that difference of height backfill has impacts on the composition of the produced wood gas. In addition, is proven that variations in gas composition give rise to a variation in the emission of unburned fuel from the engine.

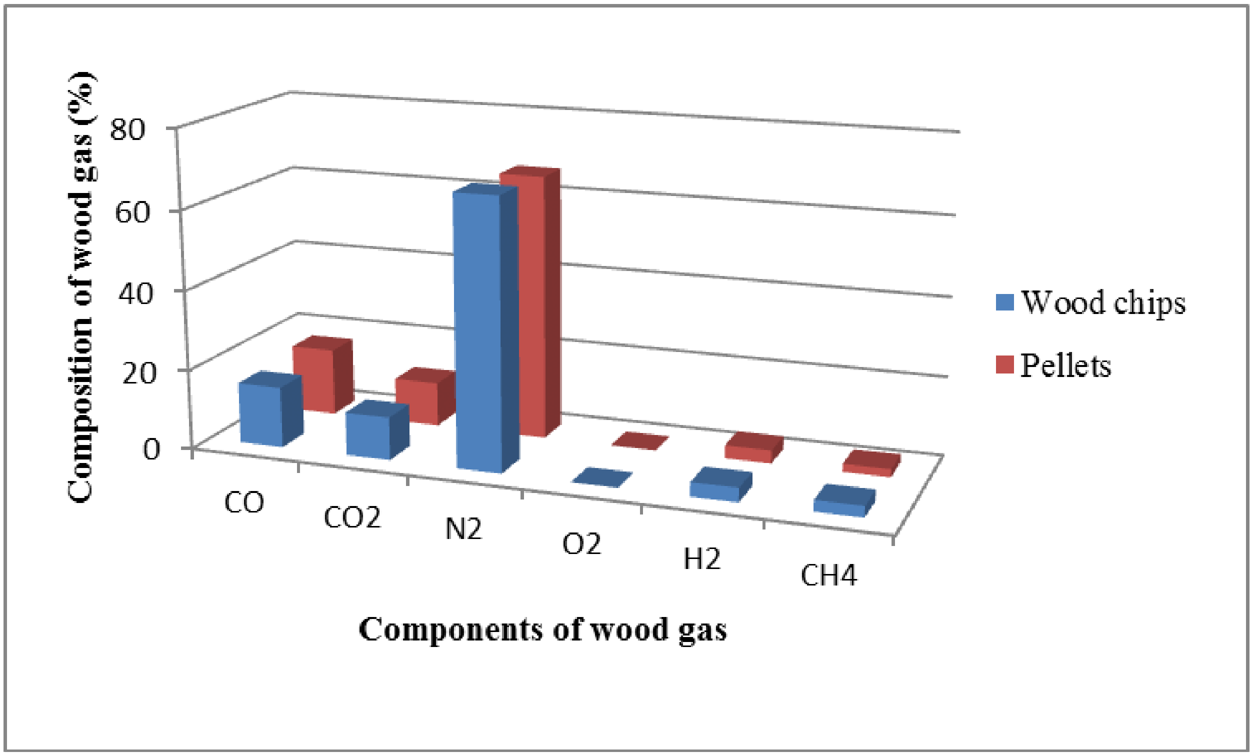


**Figure 1.** The wood gas composition from gasification wood chips and pellets
**Slika 1.** Sastav drvnog plina proizveden rasplinjavanjem drvnih strugotina i peleta

## EXPERIMENTAL MEASUREMENTS FOR COMBUSTION OF WOOD GAS

The planned experiment aims to show the impact of the composition of the wood gas to emissions after combustion of wood gas in the cogeneration unit or in boiler. Wood gas is produced in the countercurrent gasifier. The wood gas produced in the reactor is carried to the cyclone, in which the dust particles are filtered away from the gas. Cleaned gas further proceeds into the filter and cooler.

Produced gas will be used in cogeneration units with an electrical capacity of 75 kW. The aim is to optimise incineration of wood gas in mentioned device while observing the emission characteristics and thus achieve successful utilization of wood gas produced from alternative fuels (in this case wood biomass). The measurement will be carried out for different wood gas composition, depending on the type of gasification fuel (wood chips, pellets) and function as a gasifying agent. Scheme of the device is shown in Figure 2.

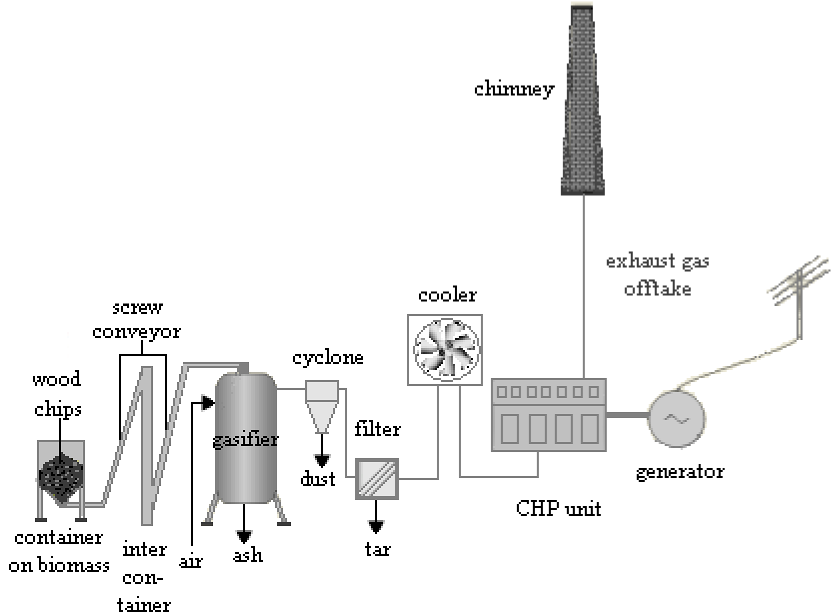


**Figure 2.** The scheme cogeneration device low-power to gasification of wood biomass
**Slika 2.** Shema kogeneracijskog uređaja male snage na bazi rasplinjavanja drvne biomase

The aim will thus be:

- At the experimental equipment monitor the impact of quality wood gas on formation emission (CO, $CO_2$ and $NO_x$) in the process of combustion.
- Proposal of measures focused on reduce emissions in the combustion process of wood gas.

## CONCLUSION

At the Department of furnaces and thermal technology, measurements were carried out focusing on the quality of wood gas. Planned measurements will be focused on the concentration of emissions from combustion of wood gas in CHP unit or in the boiler and will be implemented in autumn 2014. The type of the feedstock during the gasification woody biomass has an impact on composition of wood gas and therefore we can assume that the combusting of wood gas will be different emission values. Will be ascertained carbon oxides (carbon dioxide $CO_2$, carbon monoxide CO), nitrogen oxides (nitric oxide NO and nitrogen dioxide $NO_2$). Emission concentrations will be as measured by TESTO 350 XL. One of the other objectives will be verify compliance with emission limits. The proposal to reduce the $NO_x$ is flue gas recirculation [9].

During the measurement can expect a certain complications related with the character of incinerated media. Can also expect a significant influence of combustion process with impurities (dust and tar) contained in the combustion of wood gas.

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