ISSN 1848-0071
66.022+536.46=111
Recieved: 2014-02-18
Accepted: 2014-06-13
Original scientific paper

PRODUCTION OF EMISSIONS DURING COMBUSTION OF DENDROMASS WITH DIFFERENT TYPES OF ADDITIVES

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Dendromass remains the largest biomass energy source today. Dendromass has a lot of advantages in comparison with fossil fuels. One important benefit is reduced SO_2 and NOx formation through a decrease in fuel bound sulfur and nitrogen respectively. One of applications of dendromass are wood pellets. Using of additives can affect some properties of wood pellets include combustion and production of emissions. In this work were produced wood pellets with additives (kaolin, talc, lime, limestone, dolomite) in 2 % amount in comparison with pellets which are free of additive (reference sample). The effect of various additives to formation of emissions was observed. Experimental measurements have been performed in domestic boiler for combustion of wood pellets with rated power 18 kW. During the measurements were recorded concentrations of following emissions: CO, SO_2, NO_x, OGC and particulate matters (PM) in the flue gas. The lowest concentrations of CO were recorded in the sample with 2% of kaolin in comparison with reference sample. The highest concentrations of carbon monoxide have been reported in sample with addition of lime. The results of SO_2, NO_x and OGC production indicate negligible difference, when comparing the reference sample to samples with additives. The highest amount of particulate matter was observed in measurements of lime and limestone. The sample with dolomite has lower concentration of total particulate matter in comparison to reference sample. The results of measurements indicate that the type of additive has a considerable effect on the combustion process and formation of emissions.
Key words: additive, emissions, biomass, wood pellets.

Tvorba emisije onečišćujućih tvari izgaranjem dendromase s različitim vrstama aditiva. Dendromasa ostaje najveći izvor energije iz biomase danas. Dendromasa ima puno prednosti u odnosu na fosilna goriva. Jedna važna prednost je smanjeno stvaranje SO_2 i NOx povezano kroz smanjenje sumpora i dušika u gorivu. Jedna od primjena dendromase su drvne pelete. Korištenje aditiva može utjecati na neka svojstva drvnih peleta uključujući izgaranje i tvorbu emisija onečišćujućih tvari. U ovom radu proizvedene su drvne palete s aditivima (kaolin, talk, vapno, vapnenac, dolomit) u 2%-tnom iznosu u odnosu na pelete koje su bezaditiva (referentni uzorak). Razmatran je učinak različitih aditiva na stvaranje emisije onečišćujućih tvari. Eksperimentalna mjerenja su provedena u domaćem kotlu za izgaranje drvnih peleta s nazivnom snagom od 18 kW. Tijekom mjerenja su zabilježene koncentracije sljedećih emisija onečišćujućih tvari: CO, SO_2, NO_x, OGC i čestica (PM) u dimnim plinovima. Najniže koncentracije CO zabilježene su na uzorcima s 2% kaolina u usporedbi s referentnim uzorkom. Najviše koncentracije ugljičnog monoksida su zabilježene u uzorcima s dodatkom vapna. Rezultati proizvodnje SO_2, NO_x i OGC ukazuju na neznatnu razliku kada se uspoređuju referentni uzorci s uzorcima s aditivima. Najviši iznos čestica zabilježen je u mjerenjima vapna i vapnenca. Uzorak s dolomitom ima manju koncentraciju ukupnih čestica u usporedbi s referentnim uzorkom. Rezultati mjerenja pokazuju da vrsta aditiva ima značajan utjecaj na proces izgaranja i nastajanja emisije onečišćujućih tvari.
Ključne riječi: aditivi, emisija, biomasa, drvne pelete.

INTRODUCTION

Dendromass remains the largest biomass energy source today; examples include forest residues (such as dead trees, branches and tree stumps), yard clippings, wood chips and even municipal solid waste [1-3]. In the second sense, biomass includes plant or animal matter that can be converted into fibers or other industrial chemicals, including biofuels. Industrial biomass can be grown from numerous types of plants, including miscanthus, switchgrass, hemp, corn, poplar, willow, sorghum, sugarcane, bamboo and a variety of tree species, ranging from eucalyptus to oil palm (palm oil). [4-5]

Dendromass has a lot of advantages in comparison with fossil fuels [6-7]. One important benefit is reduced SO_2 and NO_x formation through a decrease in fuel bound sulfur and nitrogen respectively. [8] The incomplete combustion of biomass however is a significant source of several other potential pollutants such as CO and particulate matter (PM). [9-10]

One of applications of dendromassare wood pellets. Pellets are a form of wood fuel. They are cylinders with a diameter of 6-10 mm and a length of 10-50 mm manufactured from raw wood (chips, sawdust) made by compression, called pelletizing, usually with no chemical additives [11-13]. It is a modern form of compaction of biomass, which offers interesting possibilities for the development of renewable energy worldwide. In the use of compacting biomass is dominated by wood residues, which are otherwise not processed and still contain large amounts of energy. Trees are not only intentionally harvested for their manufacture. [14-15]

Additives can be added to biomass during production of wood pellets for many reasons, for improving of some parameters, like increasing of ash melting temperature, improving of resistance of wood pellets and others [16-17]. Paper presents result of emission measurement of wood pellets combustion with different additives.

MATERIALS AND EXPERIMENTAL METHODS

The effect of specific additives in the wood pellets before the experiment can only be assumed. Additives affect the pelleting process, the properties of pellets and combustion of wood pellets. [18-19]

In this work were produced wood pellets with additives in 2 % amount in comparison with pellets which are free of additive (reference sample), see table 1.

Table 1. Amount of used additives
Tablica 1. Iznos korištenih aditiva

Woodpellets	***Amountofadditives [%]***
Referencesample	Without
Kaolin	2
Talc	2
Lime	2
Limestone	2
Dolomite	2

The effect of various additives to formation of emissions in small heat source is evaluated as well. Experimental measurements have been performed in domestic boiler for combustion of wood pellets with rated power 18 kW connected to experimental device for boiler measurements, which can be seen in fig.1. The boiler is designed to burn wood pellets with a diameter of 6-10 mm. Pellets were automatically transported from the reservoir to the burner.

During the measurements were recorded concentrations of following emissions: CO, SO_2, NO_x, OGC and particulate matters (PM) in the flue gas. Methods for measurement of pollutant emissions can be carried out for particulate matters and gaseous substances, which were recorded by analyser. Solid emissions were measured with gravimetric method.

Gravimetric method is the manual single method with sampling of the flow gas by probe. It is based on determination of the median concentrations by sampling from multiple points of measurements cross-section and their subsequent gravimetric assessment. Solid contaminants are usually separated by an external filter.

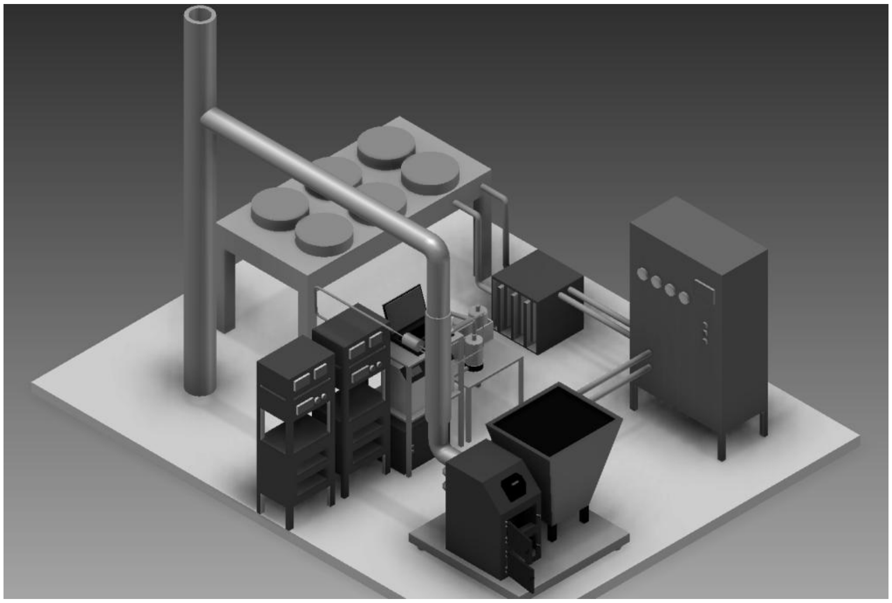

Figure 1. Scheme of experimental device for boiler measurements
Slika 1. Shema eksperimentalnog uređaja za kotlovska mjerenja

Representative sampling is performed by sampling probe suitable shape and the correct speed under isokinetic condition.

The cumulative collection can provide in the cross section average concentration but not concentration profile. Flow velocity, or flow of the sample gas is measured by ensuring of isokinetic, for example by aperture track and a total collected amount of gas by gas meter. The principal scheme of a gravimetric method is shown in fig. 2.

The advantage of the gravimetric method is its simplicity. In particular, mutual reproducibility and comparability of measurement results regardless of the type of device, the air flow, type of filter material, the suction speed etc.

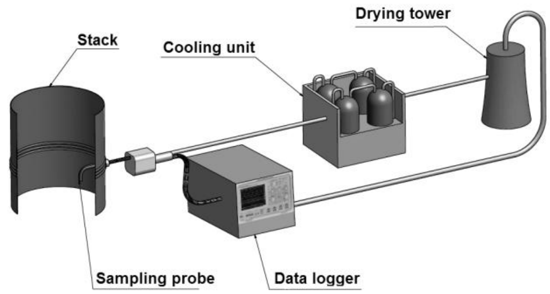

Figure 2. Scheme of gravimetric method
Slika 2. Shema gravimetrijske metode

RESULTS AND DISCUSSION

On figure 3 are shown concentrations of measured emissions CO and NOx according to the time. The measured concentration of emissions were recalculated to the reference oxygen (O_{2ref}=10%) [20].

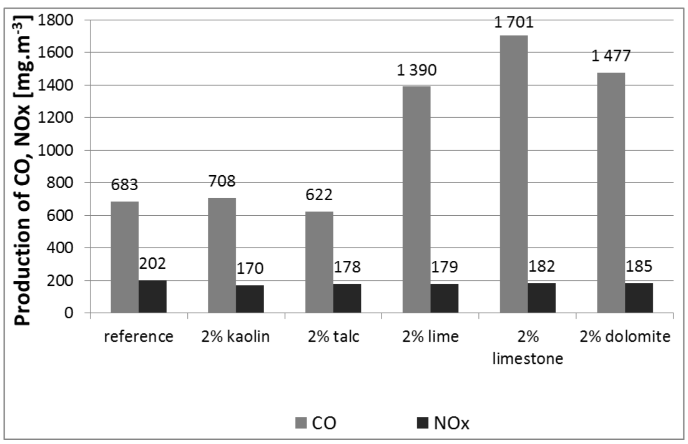

Figure 3. Concentrations of measured emissions CO and Nox
Slika 3. Koncentracije izmjerene emisije CO i NOx

It is noticeable that the lowest concentrations of CO were recorded in the sample with 2% of talc and kaolin in comparison with reference sample. The highest concentrations of carbon monoxide have been reported in sample with addition of limestone.All measured values comply with the emission limit for CO production (3000 mg.m^{-3}) of Class 3 for automatic heat sources with a rated heat output up to 50 kW for biogenic fuels in accordance with STN EN 303 – 5 [21].

Additives had no influence to production of NO_x, because combustion temperatures were very similar [21].

During the measurements were recorded low concentrations of SO_2 and OGC. The measured concentrations of SO_2 and OGC are presented in fig. 4.

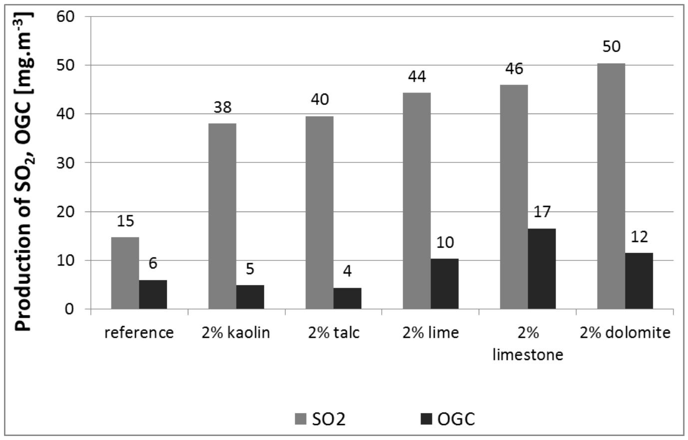

Figure 4. Concentrations of measured SO_2 and OGC
Slika 4. Koncentracije izmjerene SO_2i OGC

The results indicate negligible difference, when comparing the reference sample to samples with additives. The highest concentration of $SO_2$was achieved during combustion of sample with addition of limestone. All measured values comply with the emission limit for OGC production (20 $mg.m^{-3}$) of Class 5 for automatic heat sources with a rated heat output up to 50 kW for biogenic fuels in accordance with STN EN 303 – 5 [20].

Particulate measurements were conducted on all samples for 30 minutes. During this time, the individual samples collected PM that was captured by the filters. These were subsequently stripped of moisture and weighed. Concentrations of particulate matter were determined by difference weight of the filter before and after the measurement. The highest amount of particulate matter was observed in measurements of lime and limestone, see fig. 5. The sample with dolomite has lower concentration of total particulate matter in comparison to reference sample.

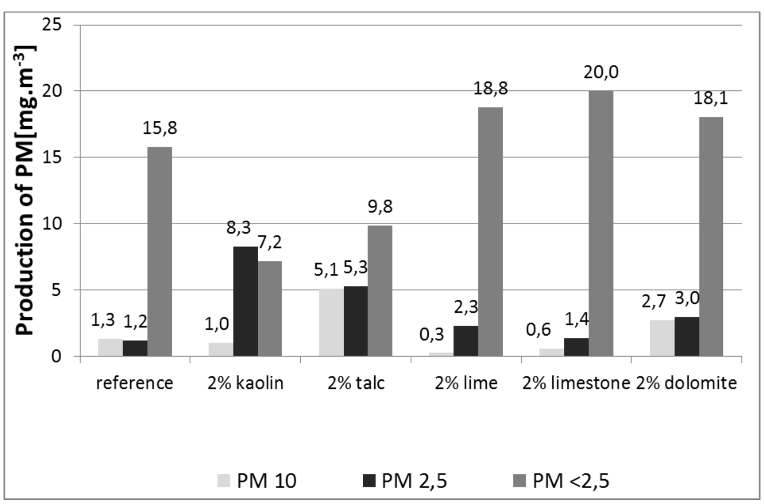

Figure 5. Concentrations of measured PM
Slika 5. Koncentracije izmjerene PM

CONCLUSION

In this research work was examined the influence of various additives to formation of emissions and particulate matters during the combustion process. The results of measurements indicate that the type of additive has a considerable effect on the combustion process and formation of emissions.

The measured data show that pellets with addition of lime and limestone have higher concentrations of CO and total particulate matter in comparison with reference sample. Addition of kaolin has relatively high impact on combustion process of pellets. From the experimental work it was found out that using 2 percent of kaolin during production of wood pellets markedly decreases concentrations of carbon monoxide. Addition of dolomite can be recommended for reduction of particulate matter from combustion of wood pellets.

Application of additives during production of pellets requires a lot of experiences and work. Therefore is necessary to carry out further experiments and find a suitable additive.

Acknowledgement

The authors would like to express gratitude for financial support in the frame of the project “Modern heat sources for heating” KEGA 070ŽU-4/2013.

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