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Using of Mg – containing additives in wood biomass

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Abstract: *Using of Mg – containing additives in wood biomass.* Biomass combustion is not as easy as it may seem. During biomass combustion can be observed some problems like problems with low ash melting temperature. It causes a lot of problems that reduce efficiency of combustion process. It is due to the formation of sinters, slags and ash agglomerations. Using of additives is one of ways to solving problems with low ash melting temperature of biomass, but it is very important find out effect of additives on fuel properties. In this paper are used Mg – containing additives – talc and dolomite. They were added in amount 1 % and 2 % to spruce wood and wood pellets with additives were made. These samples were tested and compared with reference sample without additive. Samples were tested on abrasion resistance of wood pellets, disintegration time of wood pellets in water test and total heating value of wood pellets. Talc and dolomite had an impact on wood pellets properties.

Keywords: additive, wood pellets, biomass, magnesium, talc, dolomite

INTRODUCTION

During biomass combustion, especially during phytomass, the may occur some problems like low ash melting temperature. Because of it they can be formatted ash slags, sinters and agglomerations (Buczyński et al. 2013). They can reduce efficiency of combustion process, prevent of heat transfer in heat exchangers, contribute to corrosion formation and cause more problems. Low ash melting temperature is caused by problematic chemical composition of biomass. (Holubčík, 2013)

Minerals and other different substances which form ash got into biomass during growth. Ash is solid residue resulted from the perfect laboratory combustion of fuel. It is composed of minerals that are present in the fuel. The published work of Pedersen (2003) and Zevenhoven (2001, 2003), it was found that the highest concentration of diversity to make up the ash biomass reaches silicon, aluminium and iron. Chemically, the ash from biomass is mainly composed of a mixture of oxides of inorganic elements K_2O, Na_2O, CaO, MgO, Fe_2O_3, Al_2O_3, SiO_2, P_2O_5. Amount of ash depends on the combustion conditions. (Nosek et al., 2010, Jandačka et al., 2011, Holubčík et. al, 2012) For biofuels is monitored in potassium, sodium, sulfur, chlorine and the various compounds, as the burning they comprise a molten phase in which the particles become sticky ash, thereby adhering to the heat exchange surface. (Werkelin et al., 2005) For certain types of plant biomass, such as straw, whole plant cereals and hay combustion chamber temperature is higher than 800 to 900 ° C. Therefore, they must be regarded as technically complicated combustible fuels (Kizek and Zsigraiová, 1999). Maintaining the temperature in the combustion chamber in temperature under ash melting temperature and avoid creating of sinter deposits and slags are quite complex, but it is possible to control the combustion temperature at least within certain limits, so that the formation of sediments and sinters is significantly limited. (Jandačka et al., 2011, Tarasov et al. 2013)

Possible solution problems of low ash melting temperature of biomass may be the addition of additives to the fuel during its production or addition of additives just before combustion of fuel. From our other researches (Holubčík, 2013, Holubčík and Jandačka, 2013) can be said that the higher proportion of magnesium (Mg) respectively magnesium oxide (MgO) in biomass ash, the higher ash melting temperature is. Mg – containing additives can increase ash melting temperature. But with one positive effect can be observed some new problems like problems of fuel quality.

The paper presents the results of using Mg – containing additives – talc and dolomite in biomass. These samples were tested and compared with reference sample without additive. Samples were tested on abrasion resistance of wood pellets, disintegration time of wood pellets in water test and total heating value of wood pellets.

MATERIALS AND METHODS

Mg – containing additives – talc and dolomite were added to spruce wood in amount 1 % and 2 %.

Dolomite is a carbonate mineral composed of calcium magnesium carbonate $CaMg(CO_3)_2$. The term is also used to describe the sedimentary carbonate rock dolostone. In used material was 53 - 57 % $CaCO_3$, 42 - 46 % $MgCO_3$, 1,0 % SiO_2, 0,5 % Al_2O_3 and 0,4 % Fe_2O_3.

Talc is a mineral composed of hydrated magnesium silicate with the chemical formula $H_2Mg_3(SiO_3)_4$. In used material was 60,9 % SiO_2, 2,0 % Al_2O_3, 31,2 % MgO, 0,8 % Fe_2O_3 and 5,0 % H_2O^+.

Spruce wood was in crushed to wood sawdust with size of fractions up to 4 mm. Relative humidity of used material was about 10 %. Calorific value of used spruce wood was 18 $MJ.kg^{-1}$. Chemical composition was 49,8 % C, 6,3 % H_2, 43,2 % O_2, 0,13 % N_2, 0,01 % S, 0,005 % Cl.

In the laboratory of University of Zilina has been designed and implemented an experimental device for pelletizing. It consists of input material tank (in which is delivered biomass for production of pellets), crusher (which crush material to fractions of size max. 6 mm), crushed material tank (where the crushed material is temporarily stored), dryer (where is possibly wet material dried for optimal humidity), mixing machine with capacity of 50 dm^3 (where is dried material mixed with water and additive), pellet mill with capacity of 70 – 100 $kg.h^{-1}$ (where is prepared biomass material pressed to pellets), cooler and duster with fan (final product - pellets are cooled to room temperature and dusted) and produced pellets tank (where are pellets temporarily stored before packing). This experimental device for pelletizing was used for production of experimental samples of wood pellets. For producing of experimental samples was used dendromass - spruce sawdust. Spruce sawdust was delivered by external company and their moisture content was about 8 - 9%. It was necessary to moisten it to the ideal moisture content about 15 to 20 % due to making the process of pelletization uniform. (Dzurenda and Slovák, 2001) Increasing moisture was carried out in mixing machine, which was also used for mixing the input material with additional additives. About 15 kg of sawdust was milled and compressed into pellets for all samples of wood pellets with addition of dolomite and talc.

There were produced one reference sample without additive and samples with 1 and 2 per cent addition of dolomite and talc.

There were 4 properties measured on the produces samples:

- Abrasion resistance of wood pellets - it was determined as quality parameter according to STN EN 15210 by using of special device – LignoTester (figure 1). There were samples placed in stream of air for 30 s or 60 s by used program with pressure of air 30 mbar, respectively 70 mbar.

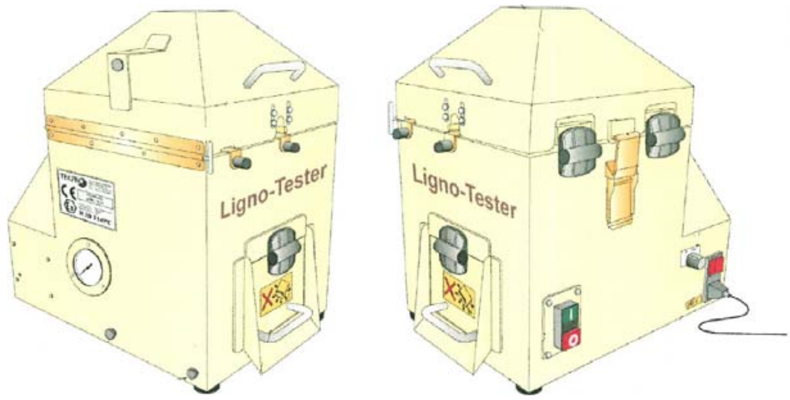

Fig. 1 Lignotester

- Disintegration time of wood pellets in water test - it second quality parameter. This method of determining the quality of pellets is unconventional and it is only approximate and serves only to compare different samples of wood pellets. From each sample of the produced pellets were selected two large pellets at the same size. Sample was placed in a glass container filled with water of about 0,2 dm^3. Consequently, time is measured until the pellets disintegrate completely. The longer the disintegration time of pellets means higher quality of pellets.
- Total heating value - it was determined according to STN EN 14918 by using of calorimeter LECO AC 500. A sample of wood pellet with weight about 1,0 g was burned in combustion vessel filled with oxygen to a pressure 31,0 bar. Combustion vessel was immersed in 2,0 dm^3 of distilled water. During burning of sample was measured temperature increase of water.

RESEARCH RESULTS

On figure 2 are average values of abrasion resistance of produced wood pellets. Addition of talc had negative effect on abrasion resistance of wood pellets. 2 % addition of talc decreased 60 s abrasion resistance from 88,3 % to 86,5 %. Addition of dolomite had opposite effect. 1 % addition of dolomite increased 60 s abrasion resistance from 88,3 % to 93,9 % in comparison with reference sample. Larger amount of dolomite (2 % addition) decreased abrasion resistance of wood pellets.

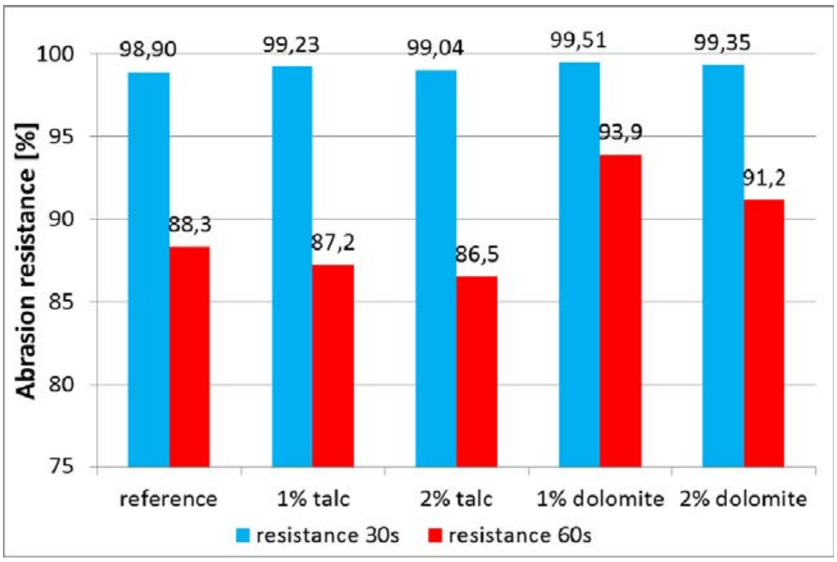

Fig. 2 Effect of additives on abrasion resistance of produced wood pellets

On figure 3 are average values of disintegration time of wood pellets in water test. There is visible that addition of talc has very positive effect on disintegration time of wood pellets. Disintegration time of wood pellets increased up to three times. Dolomite had lower positive effect. 2 % addition of dolomite increased disintegration time of wood pellets in water test about 30 per cent.

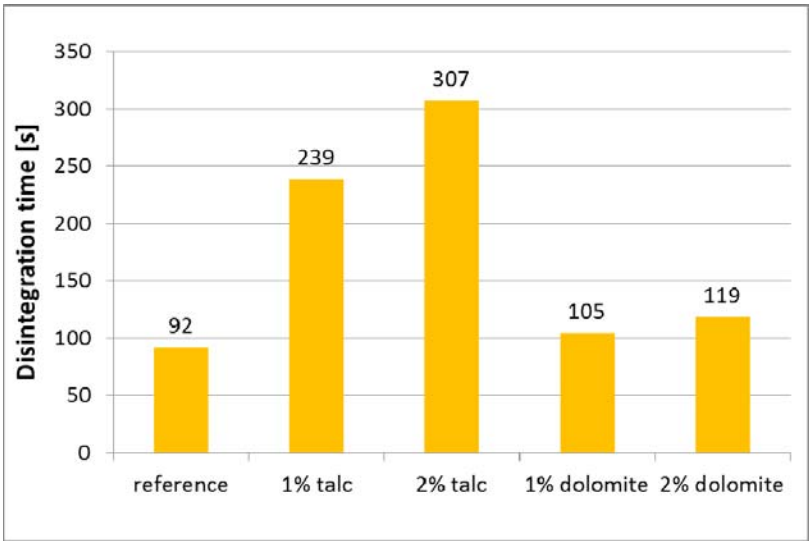

Fig. 3 Effect of additives on disintegration time of produced wood pellets in water test

On figure 4 are average values of total heating value of produced wood pellets. Addition of both additives had negative effect on total heating value because they reduce the proportion of combustible in wood pellets. Total heating value reduction was lower with using dolomite as additive. 2% addition of talc decreased total heating value from 20,5 $MJ.kg^{-1}$ to 19,7 $MJ.kg^{-1}$.

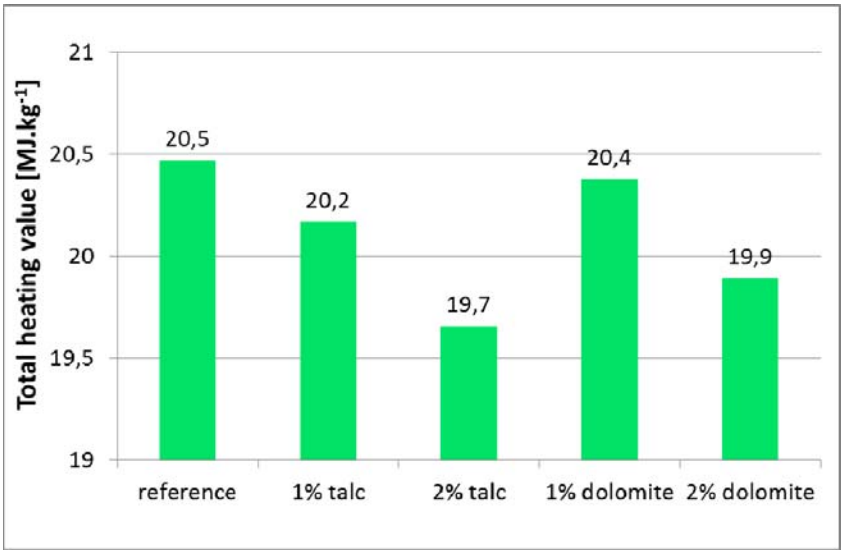

Fig. 4 Effect of additives on total heating value of produced wood pellets

CONCLUSIONS

Addition of Mg – containing additives, talc and dolomite had strong effect on various properties of biofuel – wood pellets.

Addition of talc decreased abrasion resistance of wood pellets, strongly increased disintegration time of wood pellets in water test and had negative effect on total heating value of wood pellets.

Addition of dolomite increased abrasion resistance of wood pellets, lightly increased disintegration time of wood pellets in water test and had lightly negative effect on total heating value of wood pellets.

Using of additives can be very beneficial, for example for increasing of ash melting temperature (Holubčík and Jandačka, 2013), but it can cause some problems like decreasing of fuel quality or increasing of emission production during combustion (Jandačka et al., 2013). Because of this it is necessary do a lot of experiments before using of concrete additive in technical practice.

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Streszczenie: *Zastosowanie dodatków opartych na magnezie w biomasie drzewnej*. Spalanie biomas jest bardziej skomplikowane niż mogłoby się wydawać. Jednym z wielu problemów jest niska temperatura topnienia popiołów, stwarzająca dużo problemów i obniżająca sprawność procesu, np. poprzez formację szlaki czy spieków. Zastosowanie dodatków jest jednym z rozwiązań problemu niskiej temperatury topnienia popiołów, należy jednak zbadać ich oddziaływanie na własności samego paliwa. W tej pracy opisano dodatki zawierające magnez, talk oraz dolomit. Były one domieszane w proporcjach 1 do 2% do peletów świerkowych. Wyniki porównywano do próbek referencyjnych bez żadnych dodatków. Testowano odporność na ścieranie, czas rozpadu w wodzie oraz wartość opałową. Talk oraz dolomit miały wpływ na własności peletu.

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