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ASH CONTENT FIREWOOD DETERMINED IN ACCORDANCE WITH ISO 1171:2003 AND EN 14775:2010

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Abstract

In this paper there are presented the results of works realized to quantify the ash content from annealing wood according to EN 14775:(2010) and ISO 1171:(2003). The analysis shows that the average ash share set according to the norm EN 14775: (2010) is higher than according to the Norm ISO 1171: (2003). The reason of this fact is a different temperature of biofuel samples annealing in a muffle furnace as well as an influence of temperature on the thermal decomposition of minerals forming inorganic portion of firewood.

The objectification information on the proportion of the ash formed in the combustion process of firewood should take into account the use of the same standards to determine the proportion of ash, depending on the temperature of the wood burning furnace power equipment. Failure to respect that fact can be a source of errors in the energy, environmental and ecological analysis and the balance of woody biomass production aspects ashes.

Key words: *firewood, inorganic proportion of wood, ash, standards EN 14775: 2010, standards ISO 1171: 2003*

INTRODUCTION

Ash is the inorganic residue after combustion of fuel in solid forms. Inorganic proportion of wood is formed by minerals which trees gain during growth from the soil through the root system. These are mainly carbonates, sulfates, calcium, magnesium, potassium, and substantially in less amount, phosphates, chlorides and silicates as well as other elements.

The content and concentration of individual elements of mineral substances, as stated by the authors (*Blažej et al. 1975, Simanov 1995, Zevenhoven 2001, Pitman 2002, Zule – Dolenc 2012, Dzurenda et al.2013, Hytönen – Nurmi 2015, Pérez et al. 2015, Dzurenda-Banski 2015, Pňakovič – Dzurenda 2015)* differ between individual wood species as well as within one wood species, and also markedly depends upon the place of growth and ecological factors. Needles, leaves, bark, wood of branches and roots contain a higher concentration of inorganic substances than the wood of the tree stem. There are also differences related to the age of the tree; young individuals contain a higher concentration of mineral substances than older individuals and, additionally, the wood of deciduous wood species is richer in minerals than the wood of coniferous wood species.

Data on the amount of inorganic substances in dendromass is mainly obtained from indirect determination, i.e. from ash (residue after burning dendromass). In terms of ash

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production from the combustion process, dendromass ranks amongst fuels with a low ash content with values for dry wood of A^d = 0.21–0.67 % and bark of A^d = 1.80–5.55 %. According to works by (*Nikitin 1956, Buchanan 1963, Blažej et al. 1975, Misra et al. 1994, Dzurenda – Jandačka 2010, Zevenhoven et al. 2010)*, ash from burning wood is a mixture of oxides: K_2O, Na_2O, CaO, MgO, Fe_2O_3, Al_2O_3, SiO_2, and P_2O_5. Although the amount and content of ash from dendromass depends upon the wood species and the abovementioned factors, for quantitative representation of individual oxides in ash from wood and bark, BLAŽEJ *et al*. (1975) state the following ranges: CaO = 40–70 %, K_2O = 10–30 %, MgO = 0.5–10 % and Fe_2O_3 = 0.5–2 %. The inorganic proportion in wood matter determined in ash, according to the works of *(Misra et al. 1994, Malaťak – Vaculík 2008, Zevenhoven et al. 2010, Fernandes et al. 2013, Dzurenda – Pňakovič 2014, 2016)* also depends upon the combustion conditions and combustion temperature, biofuel. The proportion of ash decreases with a growth in the combustion temperature of the dendromass. Ash from the combustion process of dendromass below 750 ºC also contains thermally undecomposed carbonates, sulphates and silicates.

Determination of the ratio of ash from the combustion of fuels for the energy needs is performed in accordance with *ISO 1171 Solid mineral fuels Determination of ash*. In 2009, the European Committee for Standardization adopted for biofuels the standard *EN 14775 Solid biofuels. Determination of ash content*, which in comparison with the standard *ISO 1171 Solid mineral fuels. Determination of ash* differs so in the thermal decomposition temperature of the fuel, and also the annealing temperature of the non-volatile combustibles fuel.

In this paper there are presented the results of experimental works carried out to assess the standards *EN 14775:(2010)* and *ISO 1171:(2003)* content via quantification of the ratio of ash from biofuel – wood species: Norway spruce, Aspen poplar, White birch, European beech, English oak and Black locust.

MATERIALS AND METHODS

Samples of fuel wood of wood species: Norway spruce, Aspen poplar, White birch, European beech, English oak and Black locust for analysing the influence of the burning temperature of non-volatile combustible matter upon the production and properties of ash were taken from the logs of fuel wood in the dispatch stores of Gabčíkovo and Žarnovica Forest Management.

Combustion of wood samples in a muffle furnace LAC LMH 04/12 (Fig. 1) was carried out in accordance with the two existing standards *ISO 1171 Solid mineral fuels - Determination of ash* and *EN 14775 Solid biofuels - Determination of ash content* and was realized in the laboratories of the Department of Woodworking, Faculty of Wood Sciences and Technology, Technical University in Zvolen (Slovakia).

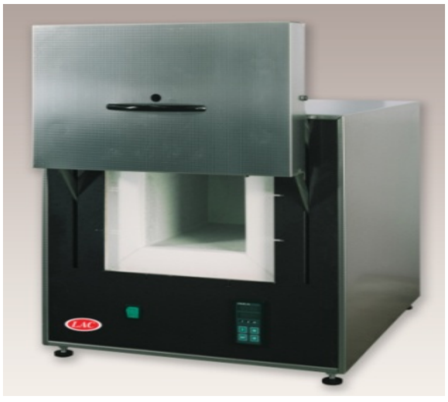

Fig. 1. Muffle furnace LAC LMH 04/12

A sample of biofuel with a weight of approximately 10 grams, during the works in the laboratory according to *EN 14775:(2010) - Solid biofuels - Determination of ash content*, was heated at a rate of 4.5 °C/min. i. e. in 50 min. it was heated to a temperature of 250 °C and maintained this temperature for 60 min., due to the release of volatiles substances from the sample. Subsequently the temperature increased to t =550 ± 10 °C and annealing was carried out at this temperature for 360 min. After cooling it to the room temperature t = 25 °C the ash dish was weighed with the accuracy of 0.1 mg.

In laboratory testing, according to *ISO 1171:(2003) Solid mineral fuels - Determination of ash*, the sample of biofuel with weight of approximately 10 grams was heated to a temperature t = 500 ° C and annealed for 60 min. Then the temperature was increased to t = 815 ± 10 °C and on this temperature continued annealing for 360 min. After cooling it to the room temperature t = 25 ° C the ash dish was weighed with the accuracy of 0.1 mg.

The heating temperature of the samples in a muffle furnace in determining the proportion of the ash in the combustion of Wood according to ISO 1171: 2003 and EN 14775: 2010 in Fig. 2

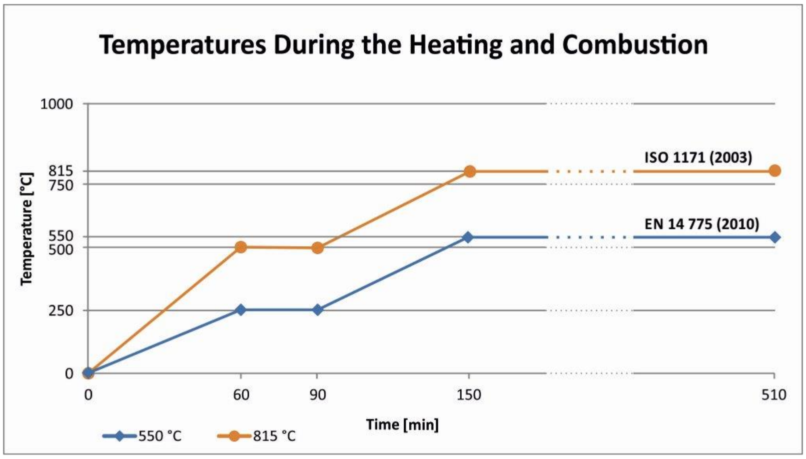

Fig. 2 The development of the heating temperature and burning of a sample of biofuel in a muffle furnace LAC LMH 04/12.

The ash content attributable to the dry matter of wood A^d of analyzed sample, expressed as a percentage by mass, is then calculated according to equation no. 3:

$$A^d = \frac{(m_3 - m_1)}{(m_2 - m_1)} * 100 \ [\%] \qquad (3)$$

where: A_d – the ratio of ash [%]
m_1 – the weight of the empty dish [g]
m_2 – the weight of the dish with the test sample [g]
m_3 – the weight of the dish with ash [g]

A comparison of the proportion of ash firewood by species specified in accordance with standards ISO 1171: 2003 and EN 14775: 2010 is, as an absolute value share ash from samples of firewood, as well as through the relative rate of increase in the proportion of ash from the process of annealing the samples firewood at t = 550 ± 10 ° C (EN 14775: 2010) and on the annealing temperature T = 815 ± 10 ° C (ISO 1171: 203) according to equation (4).

$$\Delta A^d = \frac{A^d_{t=550} - A^d_{t=815}}{A^d_{t=550}} \cdot 100 \qquad [\%] \qquad (4)$$

where: $A^d_{t=550}$ – the ash content from annealing wood at a temperature t = 550±10 °C [%]
$A^d_{t=815}$ – the ash content from annealing wood at a temperature t = 815±10 °C [%]

RESULTS

The ash content of the samples analyzed firewood trees set the standards: EN14775 (2010) and ISO1171 (2003) are given in Table 1. A ash content are given an entry of $x_i = \bar{x}_i \pm u_{Ci}$ e.g. the average reading and the combined standard measurement uncertainty.

Tab. 1 The ash content from tree species sample analysed determined according to the standards *EN14775:(2010) and ISO1171:(2003).*

Tree species	Number of samples	Method for determining the ash content	
		ISO 1171:2003	EN 14 775: 2010
Norway spruce	12	A^d = 0,16 ± 0,01	A^d = 0,29 ± 0,01
Aspen poplar	12	A^d = 0,41 ± 0,03	A^d = 0,57 ± 0,03
White birch	12	A^d = 0,27 ± 0,02	A^d = 0,42 ± 0,03
European beech	12	A^d = 0,32 ± 0,03	A^d = 0,44 ± 0,03
English oak	12	A^d = 0,35 ± 0,04	A^d = 0,49 ± 0,04
Black locust	12	A^d = 0,52 ± 0,02	A^d = 0,68 ± 0,05

Difference in the formation of ash from annealing process of wood at a temperature t = 550 ± 10 °C and annealing temperature t = 815 ± 10 °C of the analyzed tree species is displayed in the diagram in Fig. 3.

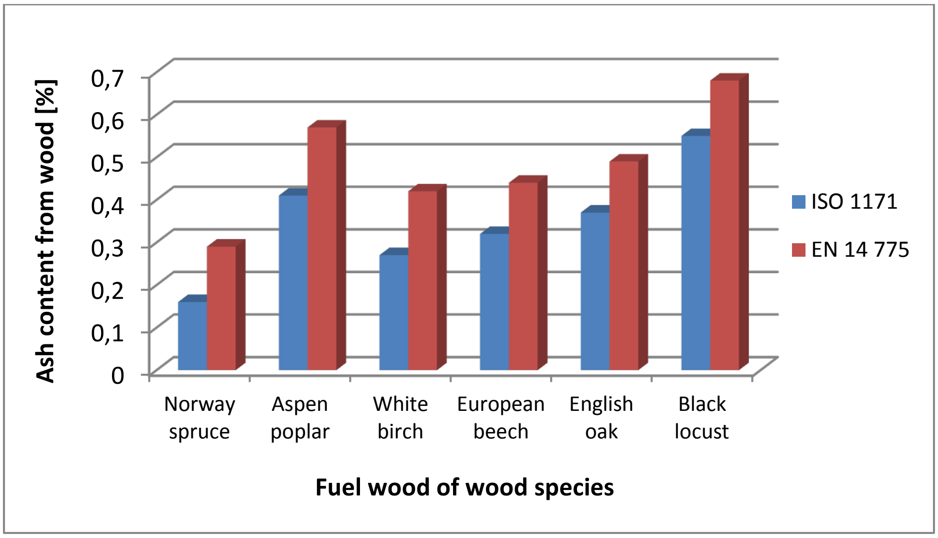

Fig.3. The ash content from annealing process of wood analyzed tree species at a temperature t = 550 ± 10 °C (*EN 14775:2010*) and temperature t = 815 ± 10 °C (*ISO 1171:2003*)

Relative rate of increase of the ash content from annealing process of the firewood at a temperature t = 550 ± 10 °C and annealing temperature t = 815 ± 10 °C of the analyzed tree species, determined according to equation (4), is stated by the Tab 2.

Tab. 2 Relative rate of increase of the ash content determined according to *EN 14775:(2010)* and *ISO 1171:(2003)*

Tree species	Relative rate of increase of the ash content ΔA^d[%] determined according to *EN 14775:(2010)* and *ISO 1171:(2003)*
Norway spruce	48,82
Aspen poplar	28,07
White birch	35,71
European beech	27,27
English oak	24,48
Black locust	19,11

DISCUSION

The results of analyses stating the proportion of ash from burning the non-volatile combustible matter of the analysed wood species have been confirmed by current knowledge of the low proportion of ash from wood presented in the works of *(Simanov 1995, Vesterinen 2003, Jandačka et al. 2007, Malatak – Vaculik 2008, Dzurenda – Pňakovič 2016)* and at the same time, they show a certain dispersity of values of inorganic residue within a wood species, induced by its thermal decomposition. The inorganic proportion of wood is highly heterogenic and mainly formed of carbonates and sulphates, $CaCO_3$, $MgCO_3$, $FeCO_3$, $CaSO_4$, $MgSO_4$, which, at individual temperatures, decompose with varying intensity into carbon dioxide CO_2 and the appropriate metal oxides. This is also confirmed by our analysis of the proportion of calcium carbonate $CaCO_3$ in ash from black locust wood, according to which, at combustion temperature of t = 500 ºC, the ash contained 78 % calcium carbonate $CaCO_3$, at combustion portion of calcium carbonate $CaCO_3$ in the ash decreased to 13 %. Another thermal process contributing to a decrease in the proportion of ash, according to the works: *(Sippula et al. 2007, Tissari 2008),* is the evaporation of potassium during thermal decomposition of K_2CO_3, KCl and K_2SO_4.

Based on analyzes it can be stated that the objectification of information on the proportion of ash generated in the combustion process biofuels should take into account the use of standards for determining which ash productions depending on the temperature in the furnace energy installation. Failure to respect that fact can be a source of considerable error as proof tab. 2 for energy, environmental and ecological analysis of balance sheets and wood - biofuels dependent on the production of ash.

CONCLUSION

From the realized experimental measurements aimed to establish the ash content from wood according to *EN 14775*, respectively *ISO 1171* there can be stated the differences in production of ash. The production of ash at the annealing temperature of wood t = 550 ± 10 °C (*EN 14775: 2010*) is higher than the annealing temperature of the wood of the same tree species at t = 815 ± 10 °C (*ISO 1171: 2003*).

The objectification information on the proportion of the ash formed in the combustion process of firewood should take into account the use of the same standards to determine the proportion of ash, depending on the temperature of the wood burning furnace power equipment. Failure to respect that fact can be a source of errors in the energy, environmental and ecological analysis and the balance of woody biomass production aspects ashes.

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