ASSESSMENT OF ASH MELTING TEMPERATURE OF BIRCH AND GRASS BIOMASS PELLET MIXTURES

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Abstract. Birch is a sturdy tree andoften the first to be found in untouched, uncultivated lands. Dry birch wood gives off 25 % more heat than aspen and 15 % more heat than pine wood. Pellet fuel is an improved alternative fuel made of compressed hardwood (birch) and perennial grass biomass. The aim of the study: to evaluate the ash melting temperature of birch and grass mixture pellets for production of fuel. The pellets produced of birch and tall fescue, festulolium and timothy biomass in various mixture proportions were used in the present research.The lowest ash melting temperature at all four ash melting phases was identified in the pellets made of birch in proportion 1/3 with tall fescue, festulolium and timothy biomass, but the pellets made of birch in proportion 3/1 with tall fescue, festulolium and timothy biomass had the highest ash melting temperature. Therefore, the most appropriate recommended proportion for pellets is 3/1 (3 birch + 1 perennial grass biomass). Ash melting temperature of birch biomass at all four melting phases ranged from 1460 to 1500 ºC, while grass biomass reached 1020-1200 ºC.

Keywords: birch, grasses, biomass, pellets, ash melting temperature.

Introduction

The transition to wood-grass pellets in heating is defined as the use of renewable energy sources [1]. As forest is a market product, it is a valuable immovable property and a component of the ecosystem. The latter criterion matters the most, raising the value of forests. It includes such indicators as the climate regulation function, oxygen production, water regulation, water supply, erosion control, soil formation, nutrient circulation, genetic resources, recreation function, and culture function [2].

The most part, i. e. 54 % of Latvian forests, are occupied by deciduous trees, and the rest 46 % are occupied by coniferous trees, specifically, birch covers 27.9 %, pine – 28.9 %, and white alder – 9.8 % [3]. In Latvia, the popularity of the birch as a tree species increases, what is outlined in Table 1.

Table 1

Afforested birch forest areas in Latvia, ha

Years	2013	2014	2015
In total in Latvia	521	545	1264
of which national forests	107	64	68
of which other forests	414	481	1196

Source: Central Statistical Bureau of Latvia.

Perspective direction is the production of pellet fuel from biomass of energy crops (wood, straw, reed canary grass), as the combustion of these pellets in furnaces is more efficient and they have low moisture content (7-9 %) with enhanced combustion energy [4].

Ash melting temperature is a significant indicator of solid biofuels. The higher the ash melting temperature of biofuel, the more suitable it is for automatic furnaces, as the melting temperature must be higher than the temperature in a furnace in order to avoid the formation of melts and melted mineral residues [5; 6].

Several indicators affect the ash melting temperature: nitrogen fertilizer used on biomass grasses [7], meteorological conditions and chemical composition [8; 9], while, regarding wood, precipitation is considered as uncertainty that cannot be forecasted precisely [10].

The aim of the study was to assess the ash melting temperature of birch and perennial grass biomass mixture pellets.

Materials and methods

Research objects: festulolium (×*Festulolium* Asch. &Graebn.), tall fescue (*Festucaarundinacea*Schreb.), and timothy (*Phleumpratense* L.) grown at the Research and Study farm "Pēterlauki" (56 º53'N, 23 º71'E) of the Latvia University of Agriculture (LLU).

Birch (*Betula pendula*Roth.) from naturally renewed birch coppice of hylocomiosa type in Baldone site of Zemgale forestry, produced in a form of dry wood powder at the Latvian State Forest Research Institute "Silava" in Salaspils.

Ash melting temperature was identified in the Waste and Fuel Research and Testing Laboratory "Virsma" Ltd. using the methods of the standard ISO 540 LVS NE 15370-1. During the pellet manufacturing process, grass biomass was ground to fine powder with the electric mill ЭМ-3А УХЛ 4.2 in a laboratory of the LLU. The obtained grass and wood powder was formed into pellets using a hand press "IKA WERKE".

Pellet types:

- 100 % birch biomass or grass (tall fescue or festulolium, or timothy) biomass,
- 3 parts of birch wood and 1 part of grass (tall fescue or festulolium, or timothy) biomass (3/1),
- 1 part of birch and 1 part of grass (tall fescue or festulolium, or timothy) biomass (1/1),
- 1 part of birch and 3 parts of grass (tall fescue or festulolium, or timothy) biomass (1/3).

Results

Wood pellets are a biofuel, which in its very nature is concentrated solar energy accumulated over a longer period of time. Biomass – grasses, plants, trees, and shrubs – is unique, as during the growth it attracts large amounts of CO_2 – carbon dioxide, not to mention the enormous amounts of oxygen produced during the photosynthesis process. The use of wood pellets ensures the use of automatic boilers. In order to ensure automaticity, the ash melting temperature must be at least 1100 ºC.

Ash melting temperature has four phases: DT – initial point of deformation when the sharp peak is rounding; ST – softening temperature when the ash cone deforms to such extent that the height of the structure reduces to the size of its diameter; HT – point of the formation of hemisphere, or the cone collapses and becomes dome-shaped; FT – flow temperature, the liquid ash dissipates along the surface [8]. The most important phase is DT, as it is usually the shortest phase and more affected by different conditions: chemical composition, applied fertiliser, precipitation and air temperature during the period of vegetation [7-9].

In comparison with coal, the ash melting temperature of which exceeds 1000ºC [11] or 1150-1500 ºC [12], biomass has a comparatively low ash melting temperature (usually between 750 and 1000 ºC), as it has a very different ash chemical and mineralogical composition [9]. Straw ash melting temperature is 850-1100 ºC [13].

When burning biomass pellets with low ash melting temperature (<1000 ºC), special attention should be paid to a correct combustion regime. The presence of alkali metals, phosphorus, silicon and calcium is a key determinant of ash melting temperature [9; 13; 14]; therefore, the grass (tall fescue, festulolium and timothy) biomass ash melting temperature is lower – 1020-1270 ºC – at all phases (Fig. 1-4), whereas the birch biomass temperature is higher and reaches 1460-1500 ºC.

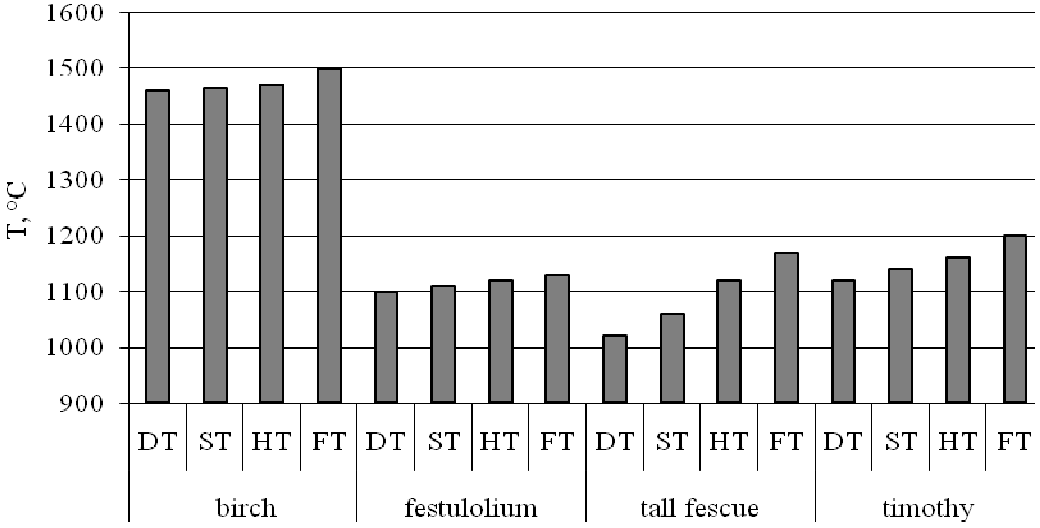

Fig. 1. **Ash melting temperature of birch and tall fescue, festulolium and timothy biomass pellets**

In Fig. 1, it is seen that the ash melting temperature of the grass biomass pellets is almost 200 ºC lower than that of the birch pellets.

Comparison of the pellets of birch and tall fescue, festulolium and timothy biomass in proportion 3/1 demonstrated that the pellets produced of birch and timothy biomass had the highest ash melting temperature at all four phases, ranging from 1180 to 1270 ºC (Fig. 2).

Analysis of the pellet biomass mixture (1/1) showed that birch and festulolium biomass had the lowest ash melting indicators, but birch with timothy had the highest ash melting indicators– 1125-1210 ºC (Fig. 3).

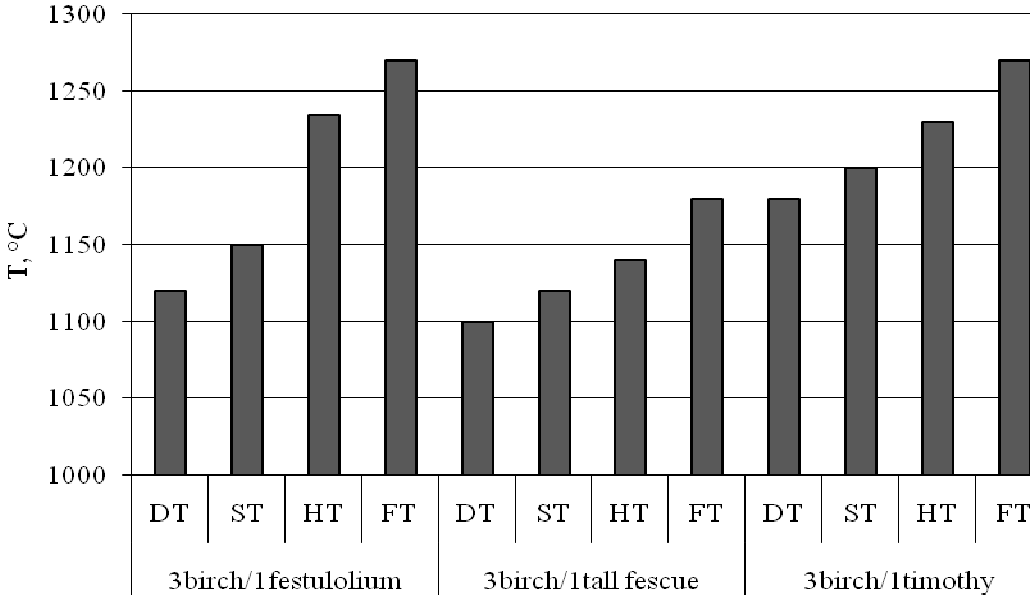

Fig. 2. **Comparison of the ash melting temperature of birch and tall fescue, festulolium and timothy biomass pellets (3/1)**

The pellets made of birch and tall fescue, festulolium and timothy biomass in proportion 1/3 were observed to have the lowest ash melting temperature at all four ash melting phases (Fig. 4). The study showed that a higher ash melting temperature at all ash melting phases was achieved when the pellet mixture was made of birch and timothy in different proportions, whereas the tall fescue and festulolium pellet mixture exhibited a lower melting temperature.

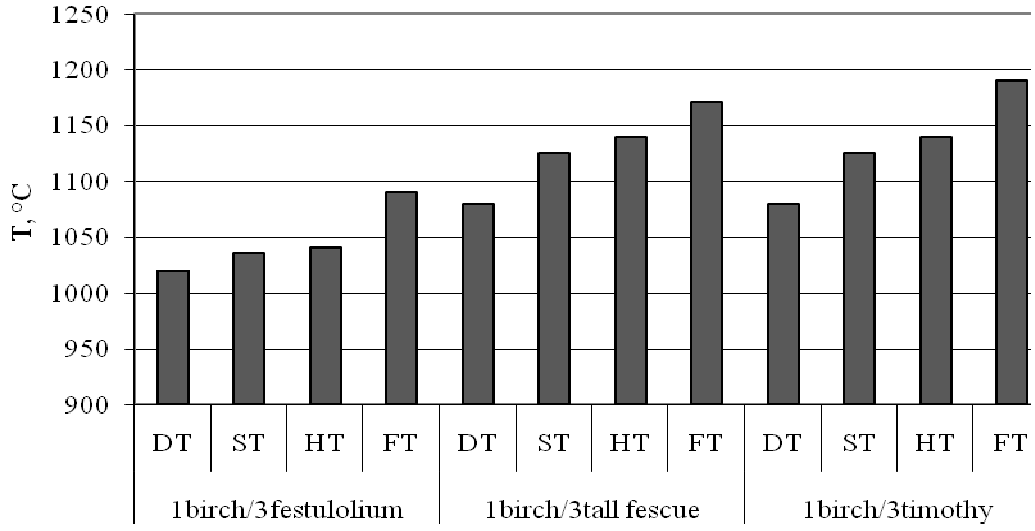

Fig. 3. **Comparison of the ash melting temperature of birch and tall fescue, festulolium and timothy biomass pellets (1/1)**

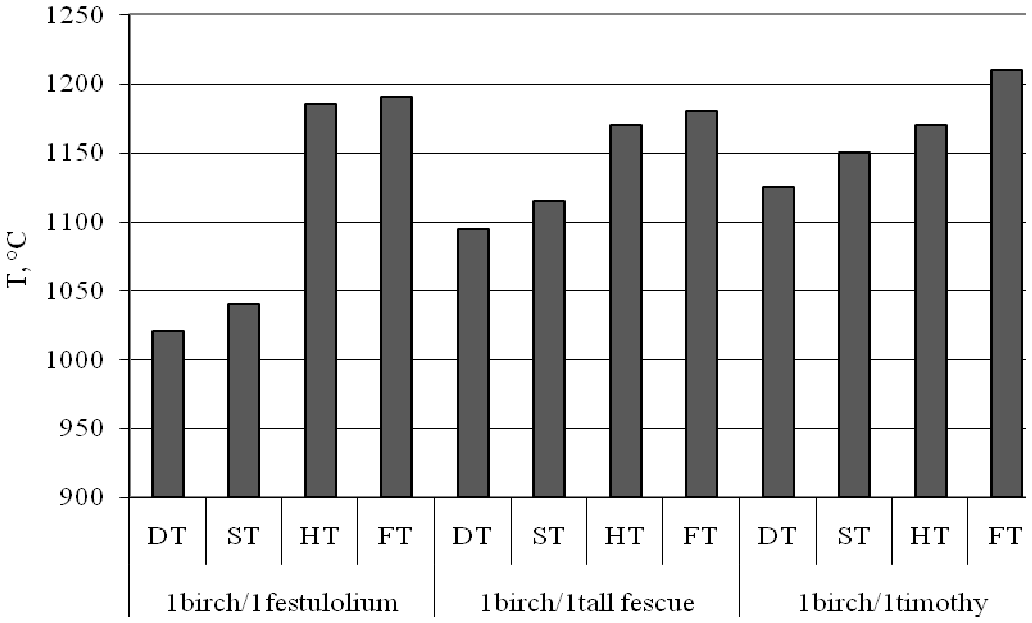

Fig. 4. **Comparison of the ash melting temperature of birch and tall fescue, festulolium and timothy biomass pellets (1/3)**

Conclusions

1. The pellets made of birch in proportion 1/3 with tall fescue, festulolium and timothy biomass had the lowest ash melting temperature at all four ash melting phases, but the pellets made of birch in proportion 3/1 with tall fescue, festulolium and timothy biomass had the highest ash melting temperature.
2. At all four ash melting phases, the birch biomass pellets had the temperature above 1400 ºC, but the temperature of the grass biomass pellets variet within1020–1200 ºC.
3. When producing fuels, it is recommended to make the pellets of birch and grass biomass mixture in proportion 3/1, because in this case the ash melting temperature is closer to the optimal temperature.
4. If grass biomass is mixed with birch in proportion 1/3, the ash melting temperature increases by 24 %, the mixture of grass and birch biomass in proportion 1/1 increases the ash melting temperature by 22 %, but in proportion 3/1 the ash melting temperature increases by 19 %.

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