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# Logging residue fuel characteristic ash melting temperatures

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**Abstract**

In countries like Latvia, with large forest areas and intensive forestry, large quantities of forest residues are formed. The primary use of forest residues is processing it into forest woodchip fuels. However, it is generally thought that forest woodchips are of poor quality, with one of the main weak spots being low ash melting temperature that accounts for the creation of molten ash in boilers. Molten ash formation in boiler furnaces significantly increases equipment maintenance costs. Thus, this resource is not used to its full potential. The ash melting temperature varies for different materials. The different ash melting properties of different logging residue fuel parts is investigated, highlighting the fractions which contribute to the formation of molten ash in the largest extent. Ash melting properties are evaluated separately for pine and spruce branches and needles. The ash melting properties are evaluated in a mutual relationship as well as in the context of previous research.



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*Keywords:* renewable energy; forestry; biomass; fuel properties; ash melting

## 1. Introduction

One of the main renewables in Latvia is forest resources. Around 41 % of Latvian forests consist of coniferous tree species. There is a tendency that mainly coniferous trees are harvested (more than 50 % from the whole forest yield) in the last decade [1]. During the logging process, logging residues are formed. The logging residues can be used for wood chip production, though it is not always applied [2].

When logging residue wood chips are prepared, the needle content is kept to a minimum, because it is thought that the presence of needles in the wood chip fuel contributes to the overgrowth of the furnace, which is linked to the

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fuel ash melting properties. The ash melting temperature for different fuels varies from about 900 °C to 1500 °C [3]. The ash fusibility is directly linked to the mineral content of the fuel. During the fuel burning, potassium organically binds to the biomass resulting in oxides, hydroxides, chlorides, and sulphates, which are low-melting compounds, and with the fly-ash can develop molten ash build-up on the boiler inside [4, 5]. In the laboratory study by Fang and Jia [6] it is concluded that the biomass ashing temperature does not have a significant effect on the ash melting temperature. Therefore the question about the possibilities of increasing the ash melting point for many types of unconventional biofuels still remains open.

Several studies have been performed in order to determine the deformation and melting temperatures of different biomass fuel ash, including different agriculture and forestry residue ash [7, 8]. The ash melting properties have been studied for specific tree species wood and woody parts such as twigs, sawdust, and pellets. In the scientific literature information on the ash melting temperatures for coniferous tree wood [8–11], twigs [12], bark [8, 10], sawdust [7, 13], and woodchips [4, 14] can be found, the summary of the results can be seen in Table 1.

Table 1. Ash melting properties of different kind of coniferous biomass ash.

| Ash | DT - initial deformation temperature, °C | ST - spherical temperature, °C | HT - hemispherical temperature, °C | FT - fluid temperature, °C | Reference used |
|---|---|---|---|---|---|
| Pine wood | 1410-1640 | - | 1630-1700 | >1700 | [8] |
| | 1190 | 1200 | 1220 | 1280 | [9] |
| Spruce wood | 1110-1340 | 1410-1640 | 1630-1700 | >1700 | [10] |
| | 1250-1390 | 1410-1640 | 1500-1700 | 1550-1750 | [11] |
| Pine bark | 1320-1680 | - | 1340-1700 | >1700 | [8] |
| Spruce bark | 1250-1390 | 1320-1680 | 1340-1700 | >1700 | [10] |
| Pine branches | 1158 | - | 1284 | - | [12] |
| Fir-pine chips | 1236 | 1244 | 1246 | 1249 | [14] |
| Pine chips | 1125 | 1210 | 1250 | 1275 | [7] |
| Spruce sawdust | 1120 | 1150 | 1200 | 1270 | [7] |
| Pine sawdust | 1215 | 1241 | 1252 | 1271 | [13] |
| Forest residue | 1320 | - | 1380 | 1395 | [8] |
| Wood residue chips | 1175 | 1205 | 1320 | 1250 | [7] |

It can be seen in Table 1 that the ash melting properties of different coniferous tree logging residue components varies among different studies. However, it is visible that the virgin coniferous wood is characterised by a higher ash melting temperature, thus making it a higher quality fuel.

The previously conducted studies do not deal with the ash melting properties separately for coniferous tree (pine and spruce) needles. In this study, the ash melting properties of pine and spruce needle and twig ash is tested, the potential influence of the sample torrefaction on the ash melting properties is also analysed. This study includes experimental determination of ash melting temperatures of pine and spruce needles and twigs with different preparation processes – different drying temperatures, and the material torrefaction.

## 2. Materials and methods

A three-factor experimental plan for the needle samples, and a two-factor experimental plan for coniferous branch samples is developed in order to reach the objective of the study. In both of the experiment parts the coniferous tree species, and the presence or absence of torrefaction in the sample preparation were selected as the studied factors. Needle drying temperature (25 °C or 105 °C) was selected as the third factor for the needle sample experimental analysis. Ash initial deformation, hemisphere, and flow temperatures were selected as the response variables in both of the experiment parts.