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PHYSICAL AND CHEMICAL PROPERTIES OF PINE WOOD CHIPS PRODUCED FROM LOGGING RESIDUES

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Abstract. The paper presents research results into quantities of branches and tree tops forming logging residues as well as the calorific value, moisture and ash contents of chips burned in a fluidal boiler. The results showed that logging residues make up 17% of the above ground tree biomass, which gives about 52.8 t/ha. The calorific value of the wood chips was 7.8 MJ/kg for fresh material, 12.9 MJ/kg for chips after 4 month storage time and 16.2 MJ/kg after storing the chips for 8 months. The ash from chips burned in a boiler with a fluidised bed contained 62% of silicon dioxide, resulting from the filling role of sand in the fluidal bed. The share of CaO was 6%, MgO – 2.8% and N_2O – 0.4%.

Key words: logging residues, biomass, calorific value, ash

INTRODUCTION

Logging residues make up the largest potential of energy wood that is available for harvesting in machine technology. Machine technologies are more and more often used for round wood harvesting and they also prove to be viable for producing wood chips from logging residues. Depending on the machine wood harvesting technology used, the fuel material can take the form of chips, whole undivided branches or bundles of various lengths and diameters. In order to produce this fuel material, the machine round wood harvesting technologies must be supplemented with a chipper or a bundler. Scientific literature however, relatively rarely says something about physical and chemical properties of fuels produced from forest biomass, like chips produced from logging residues.

MATERIALS AND METHODS

The field tests were conduced in the Dąbrowa Forest District, in the Regional State Forest Directorate in Toruń. The tree stand was 107 years old, grew on a fresh conifer-

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ous site, its volume was 250 m^3/ha, the average dbh was 28 cm, height – 20 m, and the sample area was 2 ha.

The round wood and chip harvesting technology comprised the following operations:

- felling, delimbing and cross cutting into wood assortments with the use of a Timberjack 1270D one-grip harvester
- extraction of round wood with a Timberjack 1010D forwarder
- pre-concentration of logging residues with a Timberjack 1010D forwarder
- chipping of logging residues with a Bruks 805 chipper on a Timberjack 1010D forwarder chassis
- trucking of wood chips in containers.

Before the process of wood harvesting started the tree biomass was measured in order to figure out the share of branches and tops which form logging residues [Różański et al. 2006]. The measurements of calorific value and moisture were carried out on logging residue samples taken form 8 m long and 4 m high heaps of the residues, before chipping. The first samples were taken when the material was fresh, and then 4 and 8 months later. The chemical contents of the ashes were identified on chips produced from logging residues after 8 month long storing time. The dimensional distribution of the chips was determined according to the SCAN method. The ash samples for chemical analyses were taken from the fluidal bed and they were limited to basic elements present in the fluidal bed ashes.

RESULTS

Results from biomass measurements showed that on average one tree produced 132 kg logging residues, which made 16.6% of the above-ground tree biomass. A simple extrapolation shows that the amount of logging residues amounts to 52.8 t/ha. The residues were chipped and sieved through a set of screens, according to the method SCAN. The distribution of chip fractions was as follows: chips longer than 45 mm – 6.6%, chips 8-45 mm long – 33.3%, chips 7-8 mm long – 46.4%, chips 3-7 mm long – 11.7% and the remaining material – 2%. The calorific and moisture values of the chipped woody fuel is presented in Figure 1. The calorific value of fresh chips was 7.8 MJ/kg, after the storage period of 4 months it increased to 12.9 MJ/kg and after a period of further 4 months it reached 16.2 MJ/kg. The moisture was 51.5%, 26.7% and 18.5%, respectively.

Figure 2 shows the chemical content of the ashes that remained after the logging residues, stored for 8 months, were burned. As the figure shows, silicon dioxide was the most widely represented compound, making 62% of the ash weight. This was due to the fact that the fluidised bed contained sand forming the filling mass. Hence, the chemical content of the ashes is a bit different from the ash left over after burning pure wood in a non-fluidised bed. According to Marutzky and Seeger [1999] the ash from wood contains 28% CaO, 7.6% K_2O, 3.1% MgO, 0.4% Mn_3O_4 and 0.8% P_2O_5. Hartmann et al. [2003] presents a slightly different ash composition: 42% CaO, 6.0% K_2O, 6% MgO, 1% Na_2O, 3% P_2O_5 and traces of manganium and iron.

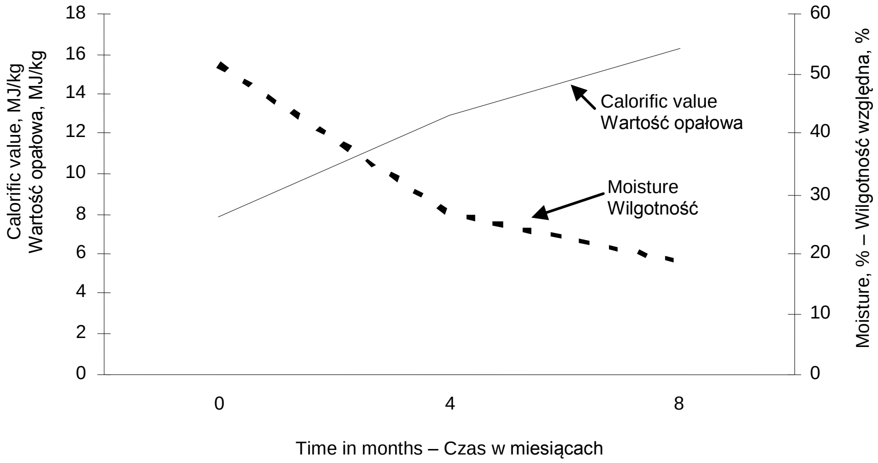

Fig. 1. Changes in the calorific value and moisture of logging residues relative to the storage period
Rys. 1. Zmiany wartości opałowej i wilgotności pozostałości zrębowych w zależności od długości okresu składowania

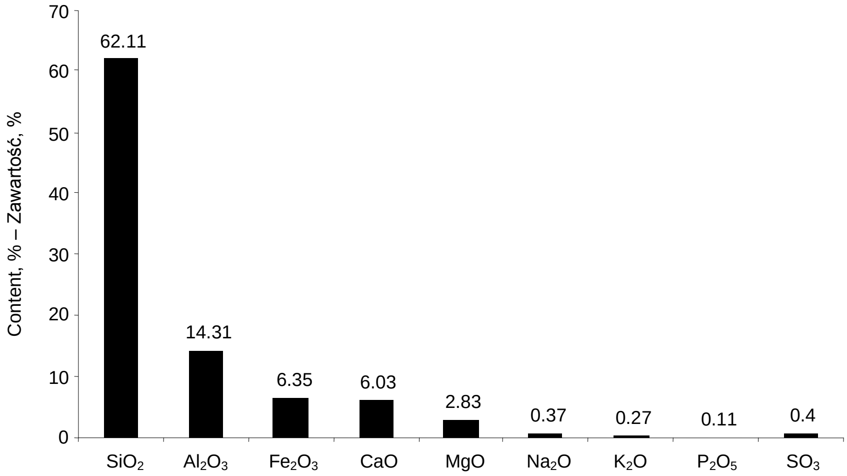

Fig. 2. Chemical composition of ashes from burning logging residues
Rys. 2. Skład chemiczny popiołu ze spalenia zrębków sosnowych

The majority of wood was transformed into gaseous state in course of burning, and only a small part remained in the form of ash. Wood contains about 0.5-1% of substances that form the ash. Among the chemical elements that form the ash in the course of wood burning the most common are calcium, potassium, magnesium, phosphorus and sodium, and they usually occur in the form of oxides.

Another important compound of the ash is silicon dioxide, which is a constituent part of many rocks. It is a result of the process of weathering and, in more or less pure form it is the main constituent of sands. The presence of silicon dioxide in ashes left over after the process of wood burning in a non-fluidised boilers results from mineral contamination of wood. In the case of fluidised beds however, silicon dioxide (as sand) is added during the process of burning as a material in order to stabilize the bed. Hence, the share of silicon dioxide both in the ashes from a fluidized bed or from burning soiled wood is significant. This compound doesn't play any major role in site ecology, but it affects the melting temperature of the ashes and hence the durability and the technical condition of burning installations.

CONCLUSIONS

1. In order to use logging residues for energy purposes, the material should be stored for four to eight months after wood harvesting operations. Such a long storage time causes a drop in moisture to about 20% and an increase in calorific value up to 16 MJ/kg.

2. The share of the mineral substances which form ashes after the burning of chips produced from logging residues amounts to 0.5 to 1% of the original material weight. The most widely represented chemical compounds in the ashes are SiO_2, Al_2O_3, Fe_2O_3 and CaO. Magnesium, sodium, potassium and phosphorus are present in the form of oxides in minor quantities only.

3. The relatively large amount of SiO_2 present in the ashes results from the presence of mineral sand in the fluidised bed, in which the chips were burnt.

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FIZYKOCHEMICZNE WŁAŚCIWOŚCI ZRĘBKÓW SOSNOWYCH WYPRODUKOWANYCH Z POZOSTAŁOŚCI ZRĘBOWYCH

Streszczenie. W pracy przedstawiono wyniki badań nad określeniem ilości biomasy w postaci gałęzi i wierzchołków drzew tworzących pozostałości zrębowe, a następnie nad wartością opałową i wilgotnością uzyskanego surowca, a także składem popiołów uzyskanych ze spalenia zrębków w palenisku fluidalnym. Badania wykazały, że pozostałości zrębowe stanowią około 17% części nadziemnej drzew, co w przeliczeniu na powierzchnie 1 ha daje około 52,8 t/ha. Wartość opałowa uzyskanych zrębków zmniejszała się w miarę wzrostu długości okresu składowania zrębków i wynosiła dla zrębków świeżych – 7,8 MJ/kg, po czterech miesiącach – 12,9 MJ/kg, natomiast po ośmiu miesiącach – 16,2 MJ/kg. Popiół uzyskany ze spalenia zrębków w złożu fluidalnych cechował się znacznym udziałem procentowym krzemionki (62%), wynikającym z obecności piasku jako wypełniacza złoża. Udział CaO wynosił 6%, MgO – 2,8%, a Na_2O – 0,4%.

Słowa kluczowe: pozostałości zrębowe, biomasa, wartość opałowa, popiół

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