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WOOD FUEL CHIP QUALITY
PROPERTIES OF FUEL WOOD CHIPS IN NORWAY

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Summary: In a market for solid biofuels, it is necessary to know different characteristics of wood chips as fuel. The CEN and ISO standards describe the methods of sampling, measurements and calculations.

In this study NFLI has analysed 116 samples of wood chips for particle size, moisture content, bulk density, ash content, calorific value and energy density. These factors are important for the individual fuel plant, for transportation, for the size of stock, for the combustion and for the purchase and sale of biofuel. The study has measured wood chips from logging residues, whole trees, stemwood, stumps and bark.

The raw material decides the particle size distribution, moisture content, bulk density, ash content, calorific value and energy density. Different chippers, different sieve size, number of knives and sharpness of knives are also important factors that influences chip size. The median particle size (d50) for logging residues was calculated to approximately 8.9 mm. The median particle size for whole tree and stem wood chips were around 12.5 mm.

The variations in chip quality are a challenge for fuel plants, since they affect the efficiency of the boiler. Boilers could be utilized better if the right fuel wood quality had been provided. This could be achieved through analysis and control of the parameters measured in this paper.

Keywords: Biomass, fuel, wood chip, quality, measurements, standards.

1 Introduction

Wood chips are currently used as fuel in many heat and power plants and small chip boilers. The international standards describes methods of sampling, measurements and calculations of moisture content, bulk density, chip size, calorific value and energy density. These are variables that are important for the individual fuel plants, for transportation, for the size of stock, for the combustion and for the purchase and sale of biofuel.

This study by NLFI has looked at the chips from logging residues, whole trees, stemwood, stumps and bark. There are differences between the assortments of biofuel and the assumption is that this is mainly because of the raw material but also chipping, handling, chipper type, knife maintenance and storage of the chip can cause variation in the chip material.

Different types of combustion require fuel of different quality (Bäfver and Renström 2013) and optimal quality for a combustion facility varies according to boiler type, fuel handling, storage and mixing, and operating strategy. There is a need for the facilities to consider the fuel deliveries together with the supplier. The aim of the study was therefore to quantify specific quality parameters on chipped energy wood from forest.

2 Material and Methods

The measurements and calculations were made according to the current standards for solid biofuels. Bulk density was measured in a bucket with known weight and volume (EN 15103:2009) he chip particle size distributions were analyzed using an oscillating screen. The definition of the median particle size (d50) of a sample is 50 % of the particle mass is below and 50 % is over the calculated particle size (EN 15419-1:2010).

Gross calorific value ($q_{V,gr,d}$) was measured in a bomb calorimeter (EN 14918:2009). Gross calorific value is the basis for calculations of net calorific value in dry and ash-free basis ($q_{p,net,daf}$). The ash content was determined using an oven with the temperature of 590 °C. The standard says 550 °C following a certain heating routine (EN 14775:2009). The ash content was taken into account when calculating the net calorific value as received ($q_{p,net,ar}$).

Determination of moisture content was done by the oven dry method (EN 14474-2:2009). Energy density was calculated using the net calorific value as received ($q_{p,net,ar}$) and the bulk density (BD_{ar}) (EN 14961-1:2010). Together with the samples and analysis information about the chipper, raw material and weather conditions was also noted.

3 Results

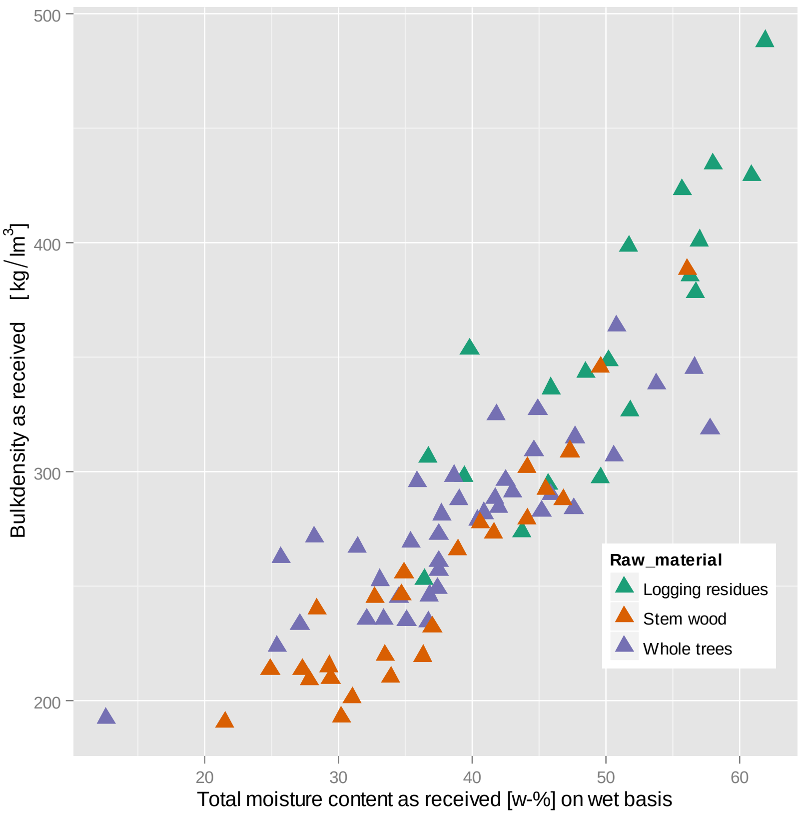
3.1 Moisture content

Moisture content is essential for energy content and storage capabilities. Moisture content for the entire chip material (n=116) averaged 41.7 w-% (s= 10.1 w-%). Moisture content for logging residues averaged 49.8 % (s=8.0 %). Whole trees averaged 39.9 w-% (s=9.5 %) and stem wood chips 39.8 w-% (s=8.9 %). The highest moisture content was measured on logging residues (69.9 %).

3.2 Bulk density

Bulk density is the volume weight of the biofuel as received, in kilogram per cubic metre (kg/m^3) of bulk volume. Bulk density for logging residues (n=19) averaged 356 kg/lm^3 (s=63 kg/m^3), whole trees (n=46) weighed 278 kg/m^3 (s=36 kg/m^3) and stem wood weighed 251 kg/m^3 (s=49 kg/m^3). The lowest bulk density was measured on stem wood (191 kg/m^3) and the highest in logging residue (488 kg/m^3). The bulk density is highly dependent of the moisture content.

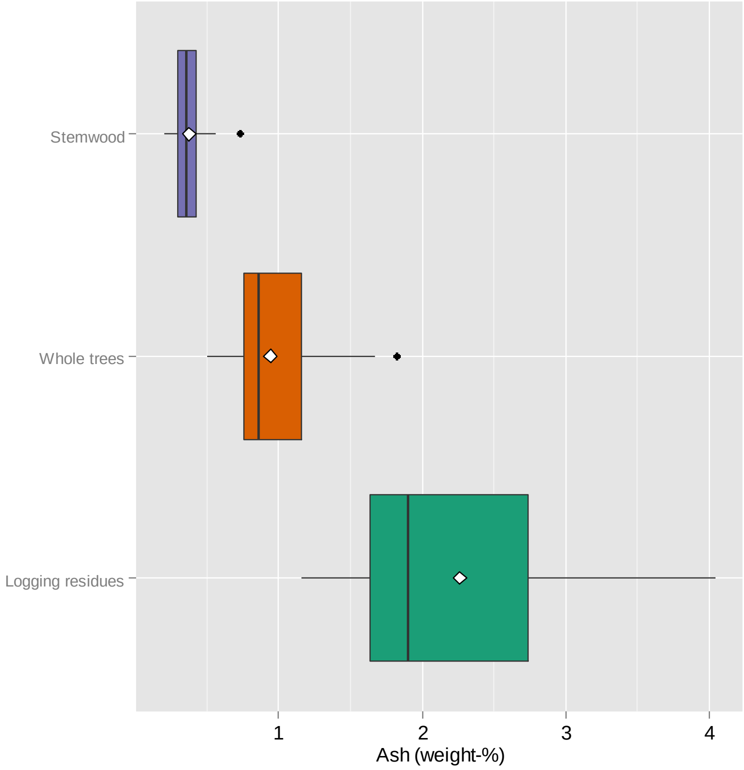
Bulk density and moisture content for logging residues, whole tree and stem wood chips.



3.3 Ash

The ash content in logging residues (n=15) averaged 2.26 % (s=0.95 %) of dry weight. Whole trees (n=40) contained on average 0.94 % (s=0.30 %) ash; stem wood (n=25) contained on average 0.37 % (s=0.12 %) of ash.

Ash content in logging residues, whole tree and stem wood chips



3.4 Net calorific value in dry and ash-free basis

The net calorific value in dry and ash-free basis ($q_{p,net,daf}$) for logging residues (n=15) averaged 5.47 (s=0.10) kWh/kg, for whole trees (n=43) was the average 5.25 (s=0.09) kWh/kg and for stem wood (n=26) to 5.25 (s=0.04) kWh/kg and bark (n=1) to 5.50 kWh/kg.

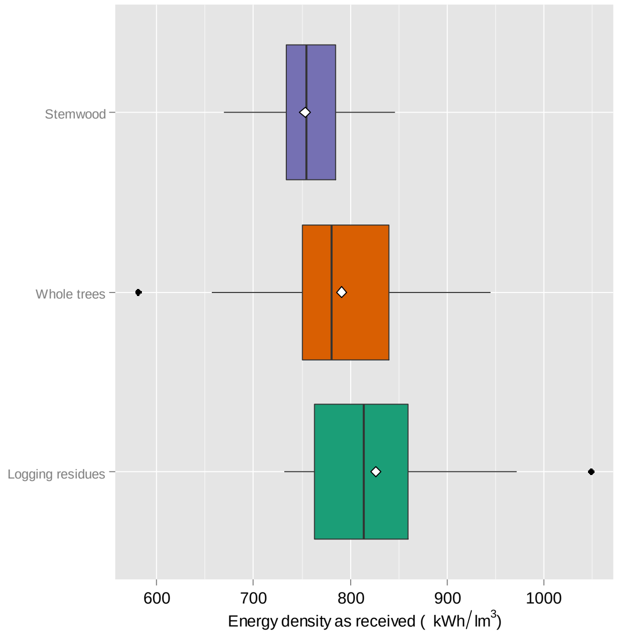
3.5 Net calorific value as received

Net calorific value as received ($q_{p,net,ar}$) for logging residues (n=15) was calculated to 2.40 (s=0.49) kWh/kg , for whole trees (n=43) to 2.92 (s=0.50) kWh/kg and stem wood (n=26) to 3.02 (s=0.56) kWh/kg. The lowest $q_{p,net,ar}$ was calculated on the bark (1.13 kWh/kg) and the highest in a sample of whole tree (4.44 kWh/kg) .

3.6 Energy density

Energy density is the ratio of energy output and volume, or kilowatt hours per bulk volume. Logging residues (n=15) averaged 826 (s=89) kWh/m^3, whole tree (n=40) averaged 791 (s=77) kWh/m^3 and stem wood (n=25) averaged 753 (s=47) kWh/m^3. The lowest energy density in bark was calculated (490 kWh/m^3) and the highest in logging residues chips (1048 kWh/m^3).

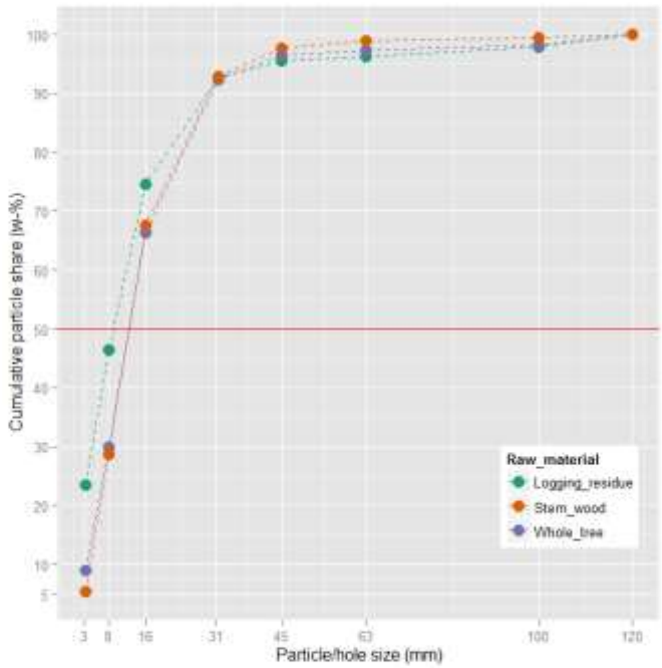
Energy density for logging residues, whole tree and stem wood chips



3.7 Particle size

The median cumulative particle size (d50) distribution for logging residue was 8.9 mm, for whole tree and stem wood the median particle size were 12.5 mm. For stem wood there was a difference in particle size (d50) for disk chipper (16 mm) and drum chipper (12 mm).

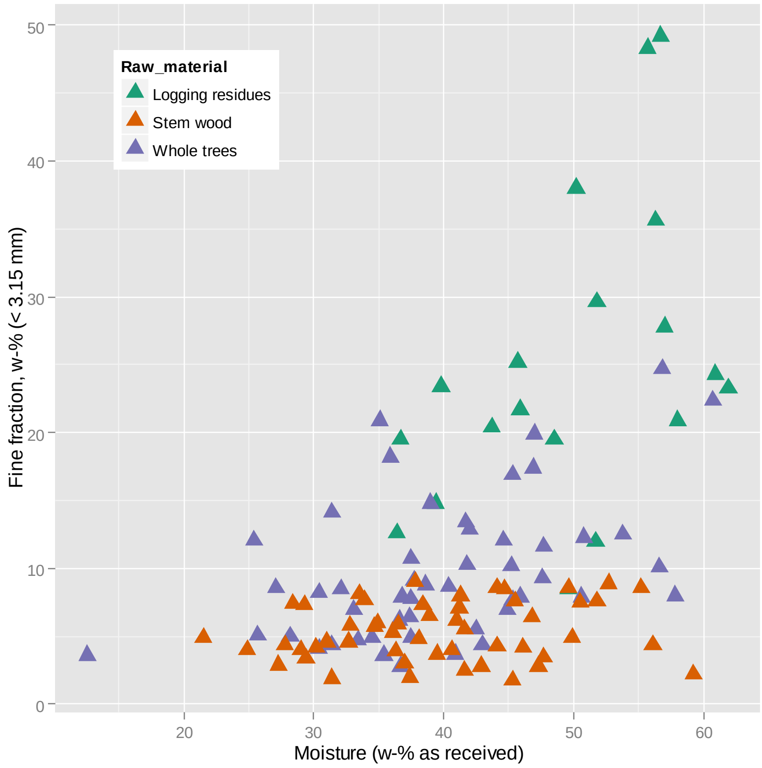
Cumulative particle size and distribution for logging residues, whole tree and stem wood chips.



3.8 Fine fraction (<3.15 mm)

Fines are defined as particles less than 3.15 mm. The total amount of fines (w-%) for logging residues (n=19) averaged 25.0 % (s=11.2 %), for whole trees (n=49), the average was 8.8 % (s= 4.9 %) and for stem wood (n=46) the average was 5.3 % (s=2.1 %) fines. The lowest fine fraction measured was on stem wood (2.2 %) and the highest in logging residues (49.2 %). All the logging residues chip were produced by drum chippers.

Moisture content and fine fraction for logging residues, whole tree and stem wood chips.



3.9 Coarse fraction

Coarse fraction is defined as the length and cross sectional area (cm^2) of chip particles. 61 of 85 chip samples contained twigs, branches or sticks longer than 120 mm. LR (n=19) averaged 2.1 w-% (s=1.5 w-%), WT (n=49) 1.6 w-% (s=1.4 w-%), while the SW (n=46) averaged 0.6 % (s= 0.7 w-%). For LR chip length up to 350 mm is tolerated.

4 Discussions

This study shows that the moisture content in chips will vary. For heating plants it is important to have control of the moister content (Bäfver and Renström 2013). The standard method or the manual oven dry test was used for finding the total moisture content. The oven method takes normally 24 hours. Accurate real-time knowledge about moisture content is preferable (Leblon, Adedipe et al. 2013).

Bulk density varies with moisture content. For logging residues the weight can reach 450 kg/m^3 bulk volume and more. A typical chip truck can load 30–32 tons i.e. 115 cubic meters of chips. If the woodchips weighs more than about 280 kg/m^3 it would be difficult to utilize the load volume of the truck (Belbo and Gjølsjø 2008). One way to measure bulk density is to weigh the whole load, but bulk density can easily be measured with a bucket with known weight and volume.

Net calorific value in dry and ash-free basis ($q_{p,net,daf}$) is higher for logging residues than for whole trees and stemwood. This is mainly because of the high ash content and a higher content of extractives and lignin in bark, branches and needles (Nurmi 1997). If the ash content varies quite a lot (or is high) for the specific biofuel i.e. logging residues then using the equation for dry and ash free basis with typical value of $q_{p,net,daf}$ is preferable (EN 14961-1:2010). If wood fuels for small-scale heating plants and households are traded on volume basis it would be useful to know the energy content or the energy density of the biofuel received. This can done by multiplying bulk density with the net calorific value as received ($q_{p,net,ar}$). The study showed that logging residues has on average a higher energy density than whole tree and stem wood chips. Logging residues are denser; it weighs more per loose cubic meter than i.e. stemwood chips. One sample of chip from logging residue was measured to more than 1 MWh of energy per cubic meter bulk volume.

In operations of heating plants it would be important to consider the boilers tolerance for fines (< 3.15 mm) (Bäfver and Renström 2013). Chip size is highly dependent of type of raw material. Stemwood chips contains low amount of ash and fines. Whole tree chips contain more fines and coarse fraction than stem wood; this is mainly due to small branches, bark and crushed leaves. Chipper type, number of knives and sieve size will also influence the chip size. For logging residues there is a tendency that the amount of fine particles will increase with increasing moisture content. It is important that the logging residues can dry on the logging site so that needles can drop of the branches before it is stacked in piles and chipped. It is also important not to contaminate the raw material with soil or sand when harvesting, collecting and chipping. Contaminated chip will increase the amount of ash.

There are quality variations in chips for fuel. Boilers could probably been utilized better if a more optimal fraction or chip type was used in combustion. This could be achieved trough control of the purchased fuel.

Bulk density can be measured with a bucket with known weight and volume.

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