Arbetsrapport

Från Skogforsk nr. 839–2014

Evaluation of the METSO MR Moisture Analyser

Utvärdering av fukthaltsmätare METSO MR Moisture Analyzer

Lars Fridh

SKOGFORSK

Arbetsrapport

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The Arbetsrapport series comprises background material, descriptions ofmethods, results, analyses and conclusions relating to both current and completed research.

Titel:
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METSO MR Moisture Analyzer.

Bildtext:
Metso MR Moisture Analyzer.

Ämnesord:

Moisture meter, forest fuel, wood chip, timber measurement.

Fukthaltsmätare, skogsbränsle, flis, virkesmätning.

Redigering och formgivning:

Ingegerd Hallberg

ISSN 1404-305X

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Abstract

Moisture content (MC) is an important quality parameter of wood chips, strongly influencing heating value and consequently the price of fuel chips. The oven method, the current standard for determining MC, is slow and may sometimes not be concluded before the sampled lot is combusted, increasing the risk of poor combustion and reducing the value of MC determination. A fast and reliable method for MC determination would therefore be valuable.

Skogforsk compared the Metso MR Moisture Analyser (Metso), which uses magnetic resonance to measure MC, with the oven drying method. MC measurements were carried out on stem wood and logging residue chips, and wet basis MC ranged from 17% to 65%.

On average the Metso overestimated the MC by 0.15 percentage points for wood chips and 0.11 percentage points for residue chips. A linear regression with reference MC as dependent variable and Metso MC as independent explained 98.8% of the variation for stem wood chips and 99.1% for residue chips. In both cases a 95% confidence interval covered less than ±2.5 percentage units. The standard deviation of repeated measurements on a sample with the Metso was 1.0 percentage points for wood and 0.6 for residue chips. MC was measured in standardised 0.8-litre containers, which limits the length of the wood chips that can be measured without further sample preparation.

The Metso is easy to use and a single measurement requires 120 seconds, allowing quick MC measurement, even if multiple samples are needed.

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Sammanfattning

Fukthalten är en av de viktigaste kvalitetsparametrarna för skogsflis, och den har en stor påverkan på priset per ton bränsle. I dagsläget är ugnsmetoden standard för att mäta fukthalt. Problemet för många värmeverk är att det tar ett dygn att bestämma fukthalten, så bränslet kan vara på väg in i pannan långt innan mätresultatet fastställts. Fukthaltsmätare som snabbt och precist kan bestämma fukthalten är av stort värde.

Skogforsk har jämfört Metso MR Moisture Analyzer, som mäter fukten med hjälp av magnetisk resonans, med ugnsmetoden. Fukthaltsmätningar har gjorts på både stamvedsflis och grotflis. Flisen höll en fukthalt i intervallet från 17 % till 65 %. För stamvedsflis var den genomsnittliga avvikelsen mellan METSO och referensen 0,15 %-enheter, och för grotflis var avvikelsen 0,11 %-enheter. En linjär regression med referensfukthalten som beroende och mätarens fukthalt som oberoende variabel förklarar 98,8 % av variationen för stamvedsflisen. Motsvarande regression för grotflis förklarar 99,1 % av variationen.

Standardavvikelsen för upprepade mätningar på samma prov var 1,0 respektive 0,6 %-enheter för stamvedsflis respektive grotflis. Mätningen sker i standardiserade behållare som är på 0,8 liter, vilket begränsar längden på den flis som kan mätas. Mätaren är enkel att använda och en enskild mätning tar 120 sekunder. Detta gör att värmeverken snabbt kan få en skattning av fukthalten, även om man tar flera prover per lass.

Summary

Moisture content is one of the most important quality parameters of wood chips, strongly influencing the price per ton of fuel. Oven-drying is currently the standard method for measuring moisture content. The problem for many heating plants is that the method takes 24 hours to determine moisture content, so the fuel can be on its way into the boiler long before the results are known. A device that can determine moisture content quickly and accurately would be very valuable.

Skogforsk has compared the Metso MR Moisture Analyzer, which measures moisture content using magnetic resonance, with the oven-drying method. Moisture content was measured in chips of both stemwood and logging residue. The moisture content of the chips was in the interval 17–65%. For stemwood chips, the average deviation between the Metso MR and the reference was 0.15 percentage points, and for logging residue chips the deviation was 0.11 percentage points. A linear regression, with reference moisture content as dependent variable and moisture content measured with the Metso MR as independent variable, explained 98.8% of the variation for stemwood chips. The corresponding regression for logging residue chips explained 99.1% of the variation.

Standard deviation for repeated measurements of the same sample was 1.0 percentage points for stemwood chips and 0.6% percentage points for logging residue chips. Moisture content is measured in standardised containers of 0.8 litres, which limits the length of chips that can be measured. The device is simple to use, and an individual measurement takes only 120 seconds, so the heating plant can quickly obtain an estimate of the moisture content even if several samples are taken per load.

Introduction

Moisture content is one of the most important quality parameters of wood chips. It strongly influences the net calorific value of the delivered fuels, and consequently the price per ton of fuel chips. The standard method currently used to determine moisture content, oven-drying, involves drying the material at 105 °C until a constant weight is obtained (SS-EN 14774-1:2009, SS-EN 14774-2:2009). A disadvantage of this method is that it takes at least 24 hours before the moisture content of the delivery can be determined, which is a problem for many heating plants. The fuel can be on its way into the boiler long before the results are known, increasing the risk of inoptimal combustion and reducing the value of knowing the moisture content. The oven-drying method is too slow and/or cumbersome for measurement at small terminals or if knowing the moisture content is desirable before transport and delivery to the customer.

A device that can determine moisture content quickly and accurately would therefore be very valuable. A number of moisture content devices are available on the market, some hand-held (Fridh 2012; Volpé, 2011) and some that are larger machines for use at measurement stations and in laboratories. Metso Automation Inc. has developed a meter for use at stations and in laboratories that uses magnetic resonance to measure the moisture content of a sample in two minutes.

The method of determining moisture content by nuclear magnetic resonance is based on the principle that a spinning hydrogen atom makes it a magnetic dipole, a small magnet. If the hydrogen atom is exposed to an external magnetic field, it settles in the field direction with a rotating motion that depends on the strength of the field (Sjöström, 2011). Exposing a sample that is already in a magnetic field to a short but powerful electromagnetic field perpendicular to the first field temporarily generates an induced electric field that can drive a current in the coil wound around the sample. A higher moisture content in the sample increases the induced voltage in the coil, often called FID (Free Induction Decay), which has been shown to increase linearly with moisture content.

In addition to the nuclei of hydrogen atoms in water, protons in the wood also induce a voltage by this method. However, the time taken for the various particles to induce a voltage varies. Hydrogen nuclei in water have a relatively long relaxation time of more than 300 μs, while the relaxation time for wood is approximately 15 μs. Measuring the voltage at a carefully chosen time interval after the sample has been exposed to the pulse will screen out the effect of the wood. However, one drawback is that the technique cannot be used to measure moisture content in frozen material (Sjöström, 2011).

Aim

The aim of the study was to evaluate measurement accuracy and user-friendliness of the Metso MR Moisture Analyzer for determining moisture content in wood chips. The device was evaluated within a broad interval of moisture content (20–60%), which corresponds to the normal interval for forest chips.

Materials and methods

Before the tests were started, the instruction book and manual were carefully studied and a number of practice measurements were carried out to ensure correct procedures during the actual measurement tests.

The oven-drying method according to Swedish Standard SS-EN 14774-2 *Total Moisture – Simplified Method* was used as reference method for determining moisture content. A laboratory balance with accuracy down to 0.01 grams was used to weigh samples.

Moisture content was measured in two different types of forest fuel, chips from stemwood and logging residue. The stemwood chips comprised five main samples, each of 20 litres. From each main sample, five sub-samples were taken, each of 0.8 litres, making a total of 25 sub-samples. The logging residue chips comprised five main samples, each of 20 litres. From each main sample, nine sub-samples were taken, each of 0.8 litres, making a total of 36 sub-samples.

Each sub-sample was placed in the standardised plastic container, and measured five times with the Metso MR. Between each measurement, the container was lifted out, shaken and rotated one-fifth of a turn, before being re-inserted in the meter. Finally, each sub-sample was dried in an oven to determine the reference moisture content.

Statistical analyses were carried out using ANCOVA models.

Results

For all measurements of stemwood chips, average deviation between the moisture content determined by the meter and the reference method was 0.15 percentage points, with a standard deviation of 1.32 percentage points.

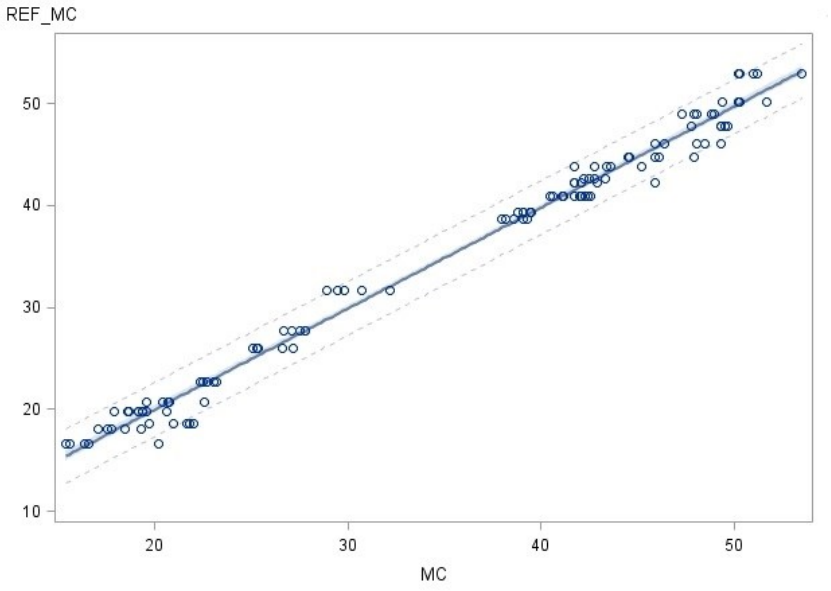

Figure 1.
Relationship between measured moisture content (MC) and reference moisture content (REF_MC) for stemwood chips.

Covariance analysis, with reference moisture content as response and the moisture content measured with the meter as covariate, explained 98.8% of the variation for stemwood chips, and resulted in the following function for estimating the reference moisture content:

$$REF\_MC = 0.18 + 0.99 \times MC$$

For all measurements, the average deviation for five repeated measurements on the same sample was 0.15 percentage points, with a standard deviation of 1.01 percentage points.

For all measurements of logging residue chips, average deviation between the moisture content determined by the meter and the reference method was 0.11 percentage points, with a standard deviation of 1.57 percentage points.

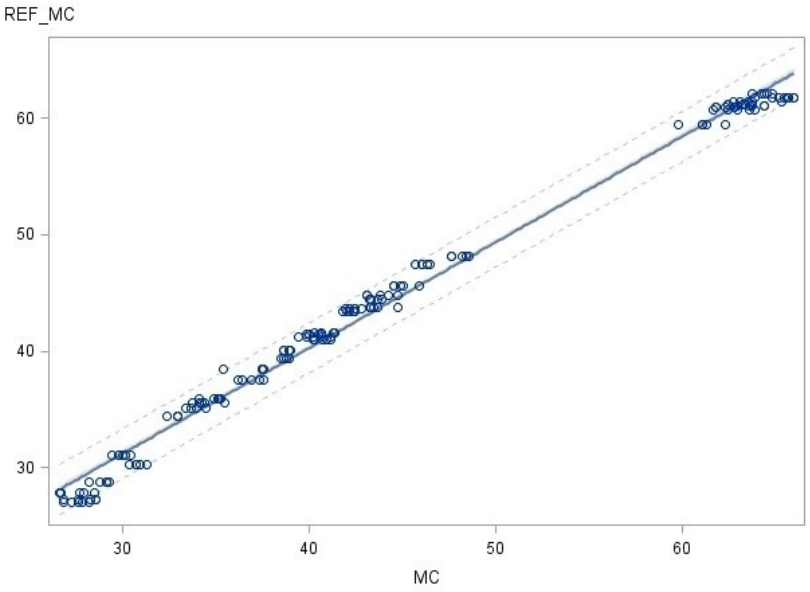

Figure 2.
Relationship between measured moisture content (MC) and reference moisture content (REF_MC) for logging residue chips.

Covariance analysis, with reference moisture content as response and the moisture content measured with the meter as covariate, explained 99.1% of the variation for logging residue chips, and resulted in the following function for estimating the reference moisture content:

$$REF\_MC = 3.91+0.91*MC$$

For all measurements, average deviation for five repeated measurements on the same sample was 0.09 percentage points, with a standard deviation of 0.58 percentage points.

Discussion

The results show that the Metso MR Moisture Analyzer can measure moisture content with a high degree of precision and accuracy. Average deviations in moisture content as measured by the meter and the oven-drying method were between 0.1 and 0.2 percentage points, which must be regarded as very low. Standard deviations were between 1.3 and 1.6 percentage points, which gave a 95% confidence interval within ±2.5 percentage points.

The precision in the moisture content measurement was so high that the variation in the reference method could affect the comparisons just as much as the variation between repeated measurements by the Metso device. One of the major causes of the variation between repeated measurements of the logging residue chips was that one individual measurement deviated from the other four measurements on the sample. This occurred for 7 of 58 samples.

Since the device measures electromagnetic fields around the hydrogen atom nuclei in water, the meter is calibrated using ordinary tap water. This means that no special calibration is needed for each of the different materials for which moisture content is being measured. Once the machine is calibrated, moisture content in all types of material can be measured, such as bark, sawdust, wood pulp, and logging residue chips. Calibration requires one empty container and one container filled with tap water, and the entire calibration procedure takes about five minutes. If the temperature of the measuring equipment varies by ±3.0 °C from the previous calibration point, the machine requests a new calibration, and no measurements can be taken before this is done

If the meter is to measure accurately, the total weight of water in the container must exceed 20 grams. This can entail problems in certain cases. When a sample of stemwood chips with a moisture content of 17% was measured, the deviations between the reference method and the machine were found to be great. Closer analysis revealed a limitation in that the container was too small in relation to the size and length of the chips. When the chips were thick and quite long, the container could not be filled with sufficient chips to ensure a sufficiently high water weight. If, in the future, the chip fractions were to be increased in size, i.e. larger and longer, the lower limit of moisture content that can be measured without processing the sample will be higher. This problem can be resolved by either grinding the chips to a smaller fraction, or making the containers bigger. However, if the containers were made bigger, this would make the machine considerably larger and heavier.

One of the limitations of the meter is that the magnetic resonance technique does not allow measurement of frozen material. The plastic containers in which the chip samples are placed before being lowered into the meter have a lid that is airtight and waterproof. A possible solution for handling frozen material is to use a microwave oven to thaw the chips, but the method must be quality assured and correct power and time must be defined for various materials and moisture contents. If the power is too high, and the time too long, the chips could start to carbonise and, if the water evaporates, an overpressure can be created in the sealed container, with a risk of explosion.

Conclusion

The Metso MR Moisture Analyzer measures a sample of 0.8 litres in two minutes with such high precision that the variations in the reference method of oven-drying can affect the comparison just as much as the variations in the instrument.

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