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Moisture content of wood chips

A comparison of test methods

Different methods for determining the moisture content of wood chips were investigated and compared. The main point was identifying the speed of tests. The systems depending on drying effect showed the least deviations to the reference system (drying cabinet at 105 C). Capacitive systems or those following the principal of infrared reflection (for flowing material) gave, after appropriate calibration, in part very promising results – also for stationary use. The last-mentioned system also worked independently of the density of the material pile.

The moisture content is one of the most important quality characteristics of solid bio fuel. Energy exploitation, storage suitability and delivery price all depend on it so that in practice an as precise as possible determination of this parameter in desirable. Testing moisture content by the drying cabinet method [1] is widely used but is too time-consuming for many practical applications. Because of this, many promising rapid test methods have been developed (in some cases for biomass too) and have been brought- up to operating standards in laboratories and for on-site tests. The following report describes a comparison of the systems.

Taking measurements

Were taken from different plantations at various stages of moisture content and chopped with different machines in order to achieve a great scatter with regard to the characteristics moisture content, chip size, chip size variation, brushwood and needle proportions. Some rapid-testing equipment (IR drying, microwave drying, Pandis, Schaller) were able to be used immediately, i.e., moisture content could be directly – or with the help from tables – read off. Other systems (microwave, TDR and IR reflections, reflection capacitive Arnold/Liebherr systems) required a calibration for which at first a simple linear regression of the measurement values with the reference values (drying at 105 C) had to be carried out (*fig. 2*). Because of the physical measurement principles there was in some cases a significant dependence on the density of the heap so that these parallel determined values must also be considered in the establishment of the calibrating function (for HF-sensor, Imko, Liebherr and Arnold) in that a two-dimensional analysis with the reading value and the dry matter density are carried-through as parameters.

Results

The absolute maximum of the average deviation with the different drying systems compared with the reference method (105 C) is relatively small in comparison to the breadth of scatter most rapid reading systems (*fig. 3*). As expected, with 80 C drying temperature, and with freeze drying, measured moisture content was only minimally reduced. Surprisingly, downward deviations in the median also took place with microwave and infrared drying. Possibly with these systems, too, a heightened release of mobile components out of the wood dry matter is not to be expected in that the period of higher temperature influence is limited. However, scatter breadth is substantially increased, especially with the IR drying, which can also be traced back to the minimal, and therefore less representative, sample size of maximum

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Keywords
Wood chips, determining moisture, measuring techniques

Literature details are available from the publishers under LT 00416 or via Internet at http://www.landwirtschaftsverlag.com/landtech/local/fliteratur.htm.

Table 1: Statistical key figures from the regression analysis carried out

Measuring system	Measuring-range {%}b	Determination mass	Standard-error	Ordinate-intersection point	Direct-gradient
Drying cabinet 80 C	0-100	0,998	0,59	-0,62	1,01
Freeze-drying	0-100	1,000	0,22	-0,70	1,01
Microwave drying – CEM	0-100	0,999	0,63	-1,43	1,02
IR drying – Sartorius	0-100	0,990	1,46	-0,14	0,99
IR drying – Ultra-X	0-100	0,992	1,28	-0,86	0,98
Surrounding moisture – Schaller	2-14	0,883	0,66	5,13	0,45
Microwave – hi-Sensor3	0-100	0,873	4,86	3,83	0,87
TDR – Imko	2- ~45	0,751	4,85	5,95	0,75
Capacitive – Pandis	0-55	0,921	4,43	-2,66	1,19
Capacitive – Liebherr3	0-100	0,904	4,34	2,91	0,90
Capacitive – Arnold	0-90	0,952	3,11	1,43	0,95
IR-reflection – Mesa	0-100	0,971	2,43	0,86	0,97
IR reflection – Pier	o- ~50	0,826	5,30	5,42	0,83

[a]3 Calibration under influence of the water-free material pile density (significant influence proved) Contribution of the material pile density to total distribution: HF-sensor 3.8%, TDR 6.8%, Liebherr 4.6%, Arnold 4.2%. b Moisture content calculated from the total mass

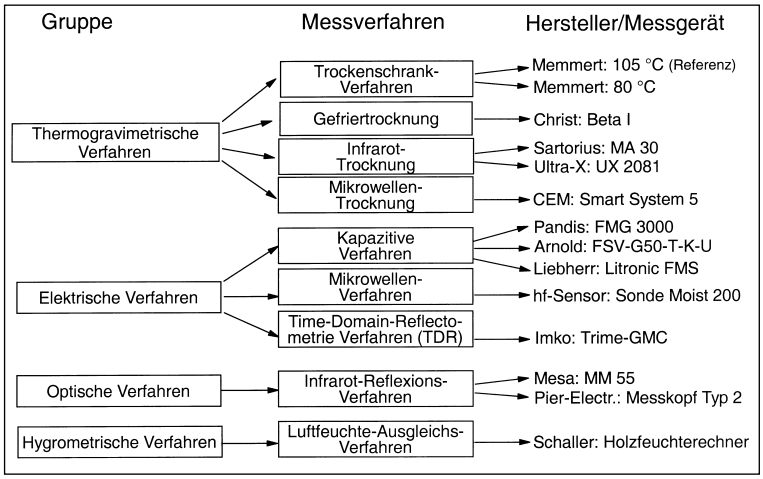

Fig. 1: Tested methods - manufacturers and instrument names

12g (Sartorius) or 60 g (Ultra-X).

Substantially greater deviations were, however, noted in the case of the "interference-free" rapid test systems – although the absolute deviation for the median lay only by -2.3 to +1.4 percent. Notably good results were delivered by the infrared reflection system (MESA) although probably it also depends here on the technique and equipment (for instance the number and type of wavelengths used, the detector sensitivity, the use of comparison rays, the calculated number of measurement values per second). Something the same applies to the capacitive method (Arnold).The comparison to other capacitive methods such as the Pandis measuring container is, however, problematic as these were pre-calibrated by the manufacturers especially for wood chips and thus could not be adjusted to the fuel basis present during the running of the trials. Also the results from the rest of the capacitive and IR reflectrometric working equipment must be interpreted with caution in that these were developed for a continuous material flow which could be simulated here only through an appropriate development of the trial (swinging the chip samples over or under the measurement head). Stationary laboratory or on-site rapid tests are also possible, however.

Contrary to the previously mentioned equipment, the ambient moisture measuring system for wood chips was not able to be tested. The equipment is only suitable for the measuring range up to 14% moisture content, and therefore only the testing of pellets in this case come in question.

To get further evaluation criteria alongside the deviations shown in *fig. 3*, linear regression analyses for the correlation between measurement values (after calibration) and reference measurements were carried out. From this, the statistical data shown in table 1 were produced. Alongside the determination mass and the standard error, the distance of the ordinate intersection point to the zero point, and the deviation of the direct gradient 1 can now be used as evaluation criteria. These calculations show repeated advantages of precision for the dry measuring system, but also for the above-mentioned continuous measurement systems. A continuing observation of the individual results shows, additionally, that the precision of the measurements (in absolute size units) reduced with increasing moisture content. The extreme values displayed in *fig. 3* where, above all, measured in the high moisture range from 35%; on the other hand the values often did not move over (2 percentage points in the low moisture range (to 20%). In the case of relative errors there was, however, no clear trend to identify.

For the systems with density influence, there is the difficulty in practice that the density value has to be first estimated. From this there results further causes of scatter, causes which were not yet taken account of in the present results because here, the actual measured densities were used. However, density influence, which anyway only explains around 5% of the total scatter (*table 1*), is relatively small, so that a poor estimation of this has little effect.

Literatur

Bücher sind mit • gekennzeichnet

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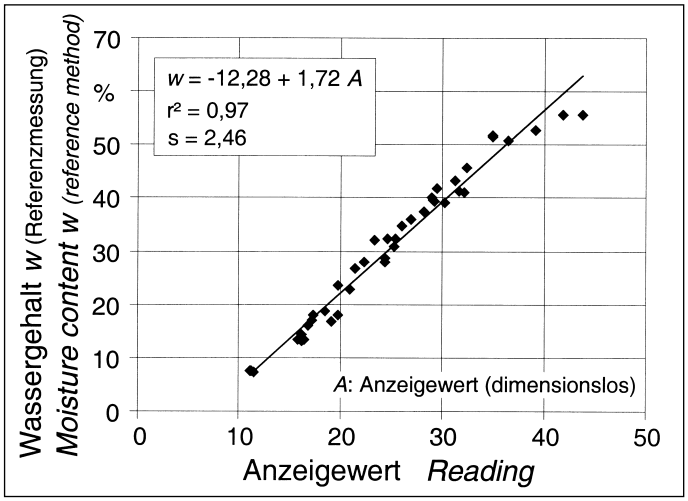

Fig. 2: One-dimensional calibration function (here: Mesa) with coefficient of determination r^2 and standard error s

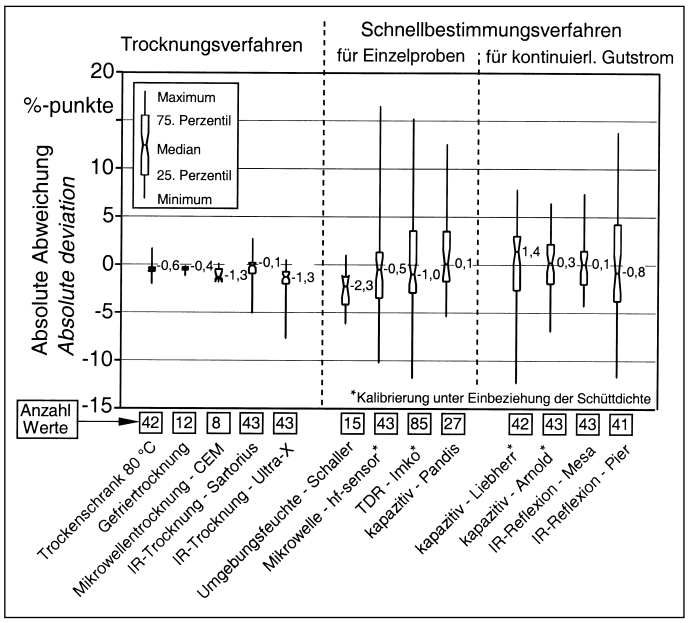

Fig. 3: Deviations of individual measurements for moisture content (wet basis) from the reference method results (drying oven method 105 ° C)