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Report

Comparing moisture content results of chips and sawdust determined with Metso MR Moisture analyzer and oven drying

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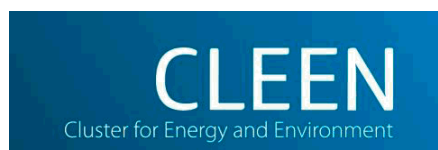




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Abstract

In this study the moisture content results of wood chips and sawdust measured with the Metso MR Moisture analyzer and by the oven drying method (standard EN-14774-1) were compared to each other. The wood chip and sawdust samples were obtained from the Stora Enso mill in Oulu, and the moisture contents were determined in the University of Oulu, Fiber and Particle Engineering Laboratory, in November 2013.

According to the results, the overall standard deviation of moisture measurement was 1.4 % points, which includes the deviation of MR measurement and oven drying measurement. In a controlled test, where moisture content was changed by adding accurately weighed water volumes to dried sawdust, the deviation of MR Moisture analyzer was 1.1 % points. In addition to the deviation, a slight difference in the slope was observed between the moisture analyzer and oven drying method: at low moisture contents the MR Moisture analyzer gives slightly lower readings than oven drying, and at high moisture contents its results were correspondingly a little higher.



1. Introduction

This study was commissioned by Metso Automation and Stora-Enso Oulu mill, and it focused on the reliability of Metso MR Moisture analyzer for wood chip, forest chip and sawdust samples. Two different wood chip samples and one sawdust sample were used in the study. The objective was to find out how moisture content measurement based on the magnetic resonance principle corresponds to moisture content results determined by means of oven drying.

2. Samples and Sample Processing

Moisture contents were determined from wood chip, forest chip and sawdust samples taken on 7. November 2013. About 100 liters of each grade was used as a sample, and this was further divided into smaller partial samples (50 samples/grade). Samples with different moisture contents were prepared by adding tap water to the samples. Figure 1 shows the samples and an example of the smaller partial samples made from the wood chips.



Figure 1. Wood chip, forest chip and sawdust samples, and the wood chip sample after splitting into smaller partial samples.

Processing of Wood Chips and Forest Chips

The wood chips and forest chips were treated in the same way:

1. 30 chip samples were put into Metso MR Moisture analyzer sample cans without any processing, and they were allowed to settle overnight (on average about 20 hours). The moisture contents of the samples were measured with the analyzer, and after this the cans were emptied into foil tins, oven-dried (105 °C, at least overnight) until they were absolutely dry, and weighed.
2. 10 chip samples in foil tins were simultaneously put into the oven to dry at 105 °C. Five of these were removed after half an hour, the other five after one hour. Immediately after removing from the oven the samples were put into plastic bags, closed tightly and allowed to cool overnight to room temperature. The samples were then



put into MR Moisture analyzer sample cans and their moisture contents were measured with the analyzer. After this the samples were emptied into foil tins, oven-dried (105 °C, at least overnight) until they were absolutely dry, and weighed.

3. 10 chip samples were put into plastic bags. Water was added to the bags: 50 g of water to five bags, 100 g of water to the other five bags. The bags were then closed tightly and allowed to stand for 2 days. After this the bags were opened and remaining liquid water was drained out, the samples were put into MR Moisture analyzer sample cans and their moisture contents were measured with the analyzer. After this the samples were emptied into foil tins, oven-dried (105 °C, at least overnight) until they were absolutely dry, and weighed.

Processing of Sawdust

About 10 liters of sawdust was oven-dried until absolutely dry (105 °C, 3 days). The dried sawdust was put MR Moisture analyzer sample cans (18 samples) and the cans were knocked and tapped in order to make the sawdust compact. Samples with different calculated moisture contents (5–90 %) were prepared by adding controlled amounts of water to the cans; the precise water volumes are listed in Table 1. The samples were allowed to settle overnight in the cans, before their moisture contents were measured with the analyzer. After this the samples were emptied into foil tins, oven-dried (105 °C, at least overnight) until they were absolutely dry, and weighed.

3. Measurements

The moisture contents of the chip and sawdust samples were determined with the Metso MR Moisture analyzer and by oven-drying the samples according to standard EN-14774-1. The MR Moisture analyzer was calibrated daily prior to the actual measurements by measuring an empty can and a can filled with water. The device was placed in the laboratory so that no magnetic metals that could disrupt the measurement were in the immediate vicinity (within a radius of about 50 cm). All measurements were made using a 0.8 liter can to hold the samples being measured. Jani Österlund, an experienced laboratory technician from the Fiber and Particle Engineering Laboratory, carried out all the measurements.

4. Results

Figure 2 shows the moisture content results of wood chips, determined by oven drying and with the MR Moisture analyzer (MR vs. oven). A regression line is plotted in the graph to calculate the MR Moisture analyzer results from the moisture content of oven dried wood chips. Within the studied moisture range (~47–66 %) the MR Moisture analyzer gave on average approximately one percent point higher moisture content results than oven drying according to the standard. If we accept the moisture content results obtained with oven drying as the



accurate, true results, the deviation of MR Moisture analyzer results deviate about 0.7 % points from the regression line. The lines on both sides of the regression graph illustrate this deviation from the line.

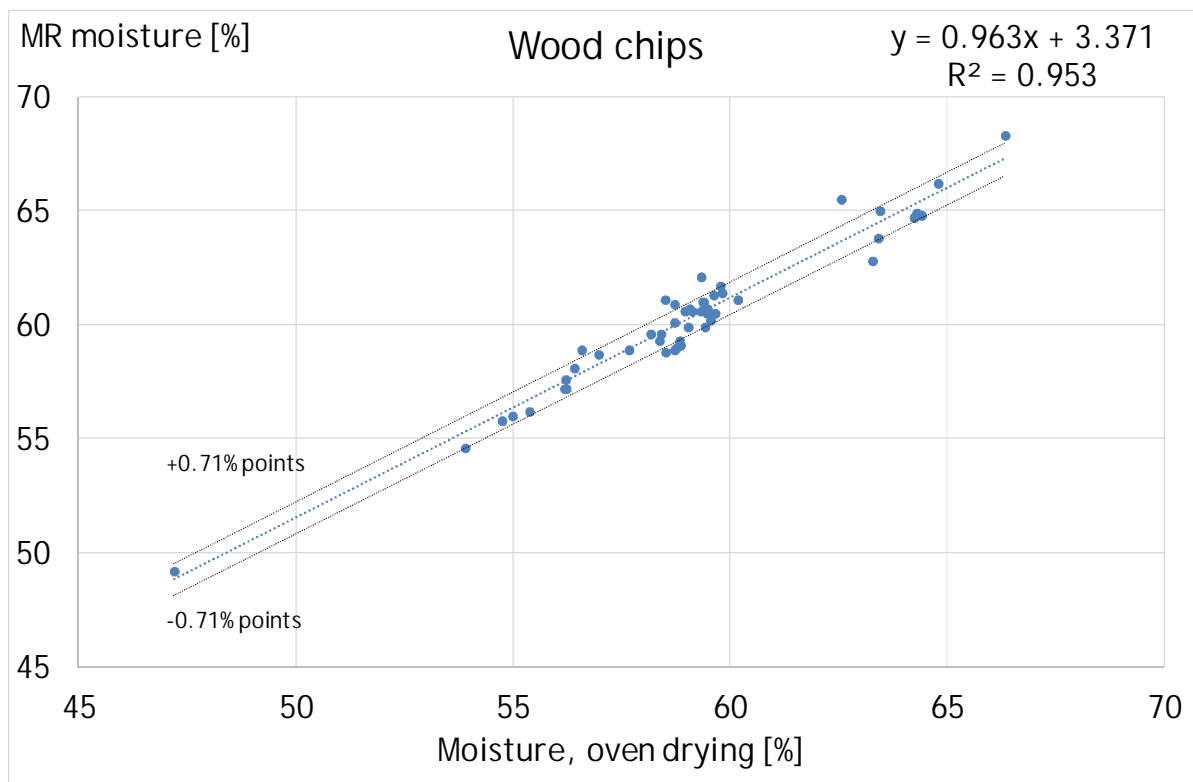


Figure 2. Moisture content of wood chips measured by MR Moisture analyzer as a function of moisture content determined by oven drying. Error limits: standard deviation 0.71 % points.

Figure 3 illustrates the moisture contents of forest chips, determined by oven drying and with the MR Moisture analyzer (MR vs. oven). A regression line is plotted in the graph to calculate the MR Moisture analyzer results from the moisture content of oven dried forest chips. Within the studied moisture range (~22–62 %) the results from MR Moisture analyzer were on average very close to those obtained by oven drying according to the standard. If we accept the moisture content results obtained with oven drying as the accurate, true results, the deviation of MR Moisture analyzer results deviate about 1.7 % points from the regression line. The lines on both sides of the regression graph illustrate the deviation from the regression line. In this case there is clearly more deviation than with wood chips, which is largely due to one clearly deviating point. If this point is rejected as an outlier, the deviation would be around 1.0 % points.



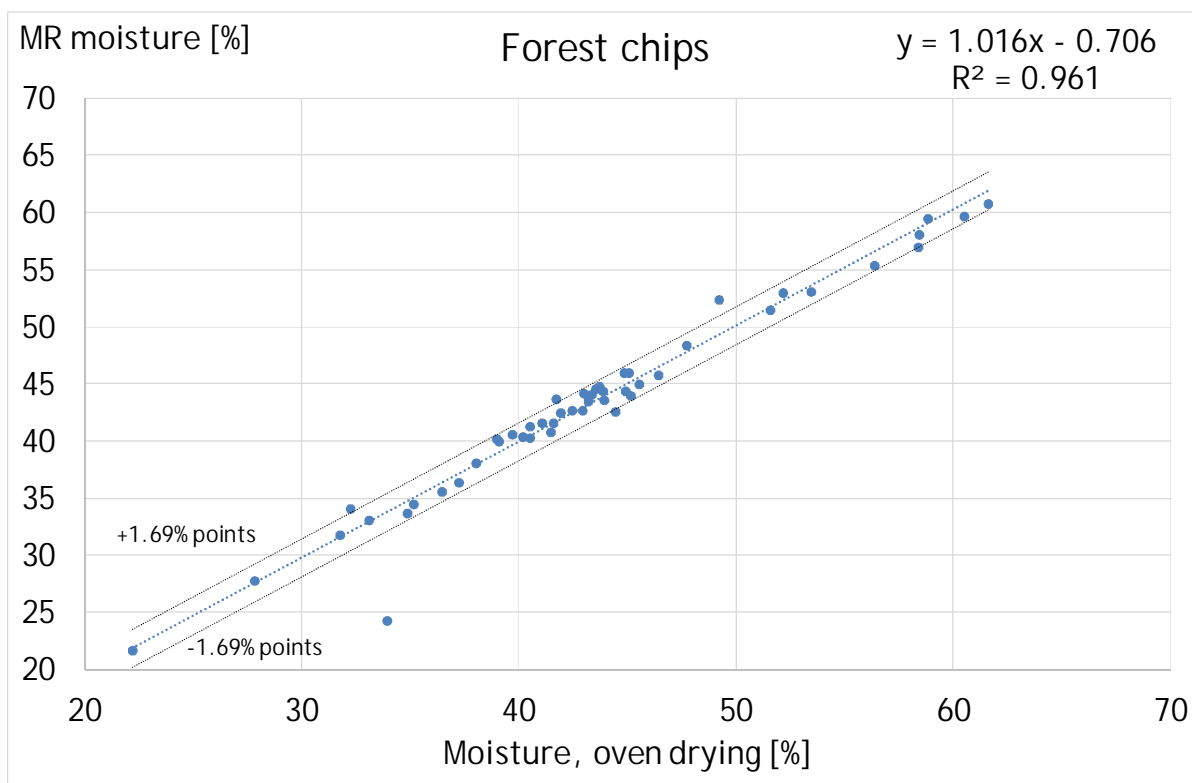


Figure 3. Moisture content of forest chips measured by MR Moisture analyzer as a function of moisture content determined by oven drying. Error limits: standard deviation 1.61 % points.

Figure 4 illustrates the moisture contents of sawdust, determined by oven drying and with the MR Moisture analyzer (MR vs. oven). A regression line is plotted in the graph to calculate the MR Moisture analyzer results from the moisture content of oven dried sawdust. Within the studied low moisture range (~10–40 %) the results from MR Moisture analyzer were on average about 2 % points lower than the results obtained by oven drying according to the standard. In the higher moisture range 70–90 % the results from MR Moisture analyzer were about 1 % point higher than those of oven drying. If we accept the moisture content results obtained with oven drying as the accurate, true results and observe how much the MR Moisture analyzer results deviate from the model line, the moisture result deviation for sawdust is about 1.1 % points. The lines on both sides of the regression graph illustrate the deviation from the regression line. In this case there is clearly more deviation than with wood chips, which is largely due to one clearly deviating point. If this point is rejected as an outlier, the deviation would be around 1.0 % points.



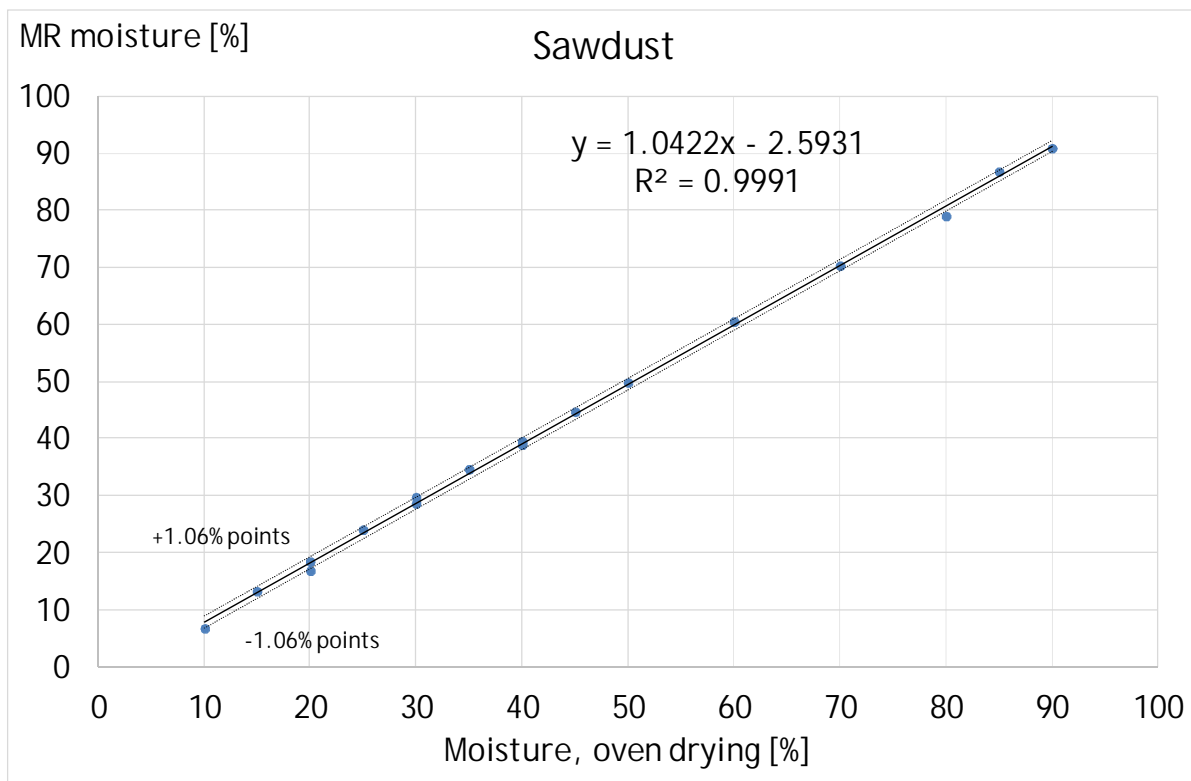


Figure 4. Moisture content of sawdust measured by MR Moisture analyzer as a function of moisture content determined by oven drying. Error limits: standard deviation 1.06 % points.

In the case of sawdust, tests were also made by adding water to absolutely dry sawdust. These results give perhaps the most reliable idea of how accurately oven drying and MR Moisture analyzer are able to determine the moisture content of sawdust. Figure 5 shows the moisture content results of MR Moisture analyzer and the oven drying method as a function of the calculated moisture content of sawdust; the same data is also given in Table 1.

The moisture results obtained by oven drying were on average 0.4 % points above the calculated values over the entire studied moisture range. At moisture content level 20% the results from MR Moisture analyzer were about 1.8 % points below the calculated values; at moisture content level 60% the analyzer readings did not differ significantly from the calculated value. At moisture content level 85% the MR Moisture analyzer readings were on average 1 % point above the calculated moisture of the measured sawdust.



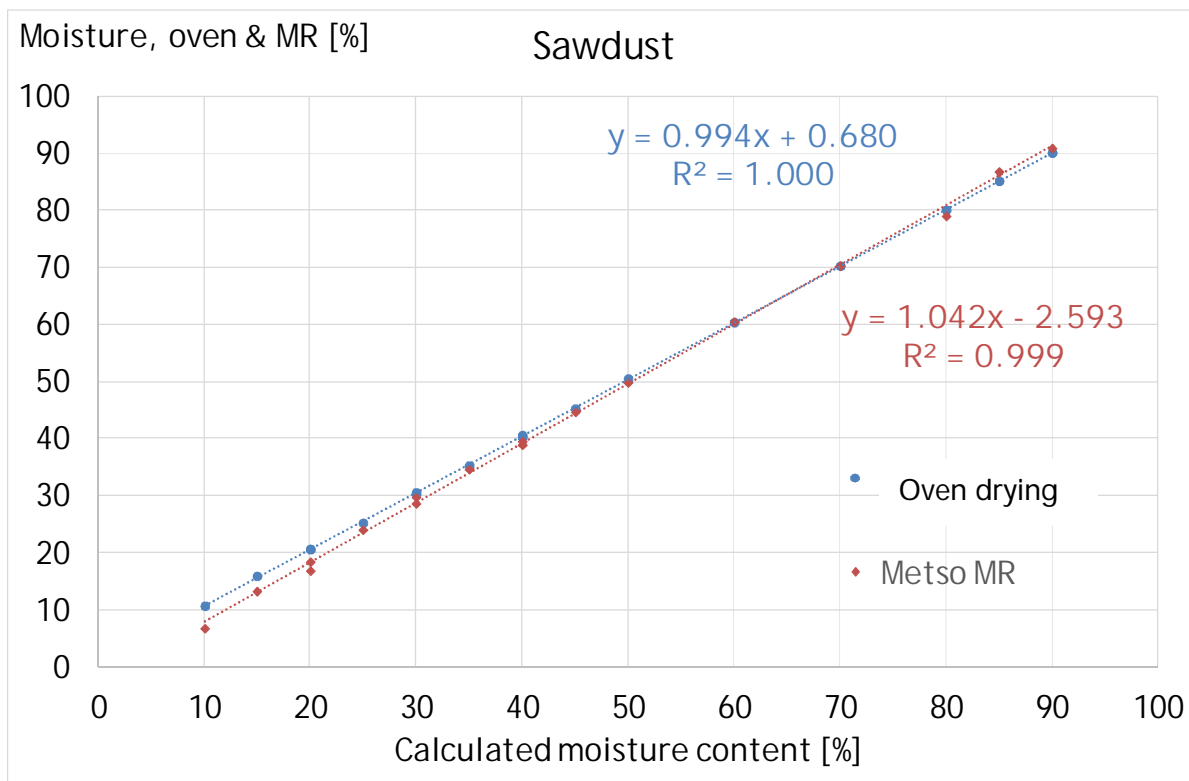


Figure 5. Moisture content of sawdust measured by MR Moisture analyzer (red) and oven drying (blue) as a function of calculated moisture content.

Table 1. Measurements with sawdust (weighed water volumes added to dried sawdust).

Sample ID	Dry sample [g]	Added water [g]	Total mass [g]	Calculated moisture [%]	Moisture (oven drying) [%]	MR moisture [%]
Sawdust 10	133.2	14.9	148.1	10.1	10.7	6.7
Sawdust 20	136.6	34.2	170.8	20.0	20.6	16.8
Sawdust 30	125.6	53.8	179.4	30.0	30.5	29.7
Sawdust 40	145.0	96.7	241.7	40.0	40.6	38.9
Sawdust 50	145.2	145.2	290.4	50.0	50.5	49.8
Sawdust 60	137.1	205.7	342.8	60.0	60.4	60.5
Sawdust 70	117.1	273.3	390.4	70.0	70.3	70.3
Sawdust 80	117.2	468.8	586.0	80.0	80.1	79.0
Sawdust 90	56.5	508.6	565.1	90.0	90.1	90.9
<i>Additional</i>						
Sawdust 15	130.0	22.9	152.9	15.0	15.9	13.2
Sawdust 20	130.0	32.5	162.5	20.0	20.6	18.4
Sawdust 25	130.0	43.3	173.3	25.0	25.2	24.0
Sawdust 30	130.0	55.7	185.7	30.0	30.4	28.6
Sawdust 35	130.0	70.0	200.0	35.0	35.3	34.6
Sawdust 40	130.0	86.7	216.7	40.0	40.2	39.5
Sawdust 45	130.0	106.4	236.4	45.0	45.3	44.7
Sawdust 85	65.0	368.3	433.3	85.0	85.2	86.8



Figure 6 shows the moisture contents for all chip and sawdust samples, determined by oven drying and with the MR Moisture analyzer (MR vs. oven). If we accept the moisture content results obtained with oven drying as the accurate, true results, the results of MR Moisture analyzer deviate about 1.4 % points from the model line. The lines on both sides of the regression graph illustrate the deviation from the regression line.

Within the studied moisture range (10–90 %) the results of MR Moisture analyzer are on average relatively close to those of oven drying according to the standard. When the moisture content of the samples was in the range 40–50 % according to oven drying, the results of MR Moisture analyzer were very similar. The lower the moisture content (< 40 %), the more the results of MR Moisture analyzer deviated negatively from those obtained by oven drying. On the other hand, towards higher moisture contents (> 50 %) the MR Moisture analyzer gave higher readings than oven drying.

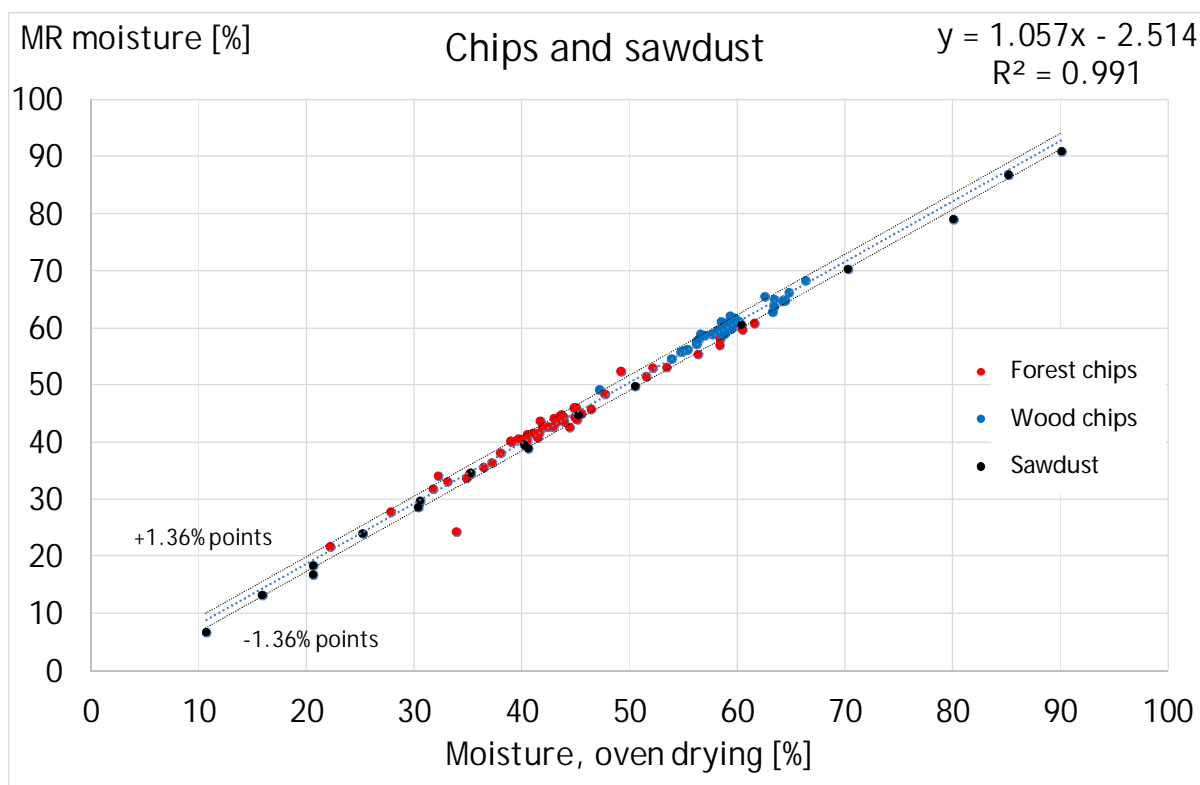


Figure 6. Moisture content of wood chips (blue), forest chips (red) and sawdust (black) measured by MR Moisture analyzer as a function of moisture content determined by oven drying. Error limits: standard deviation 1.36 % points.



5. Conclusion

Based on the results of this study the Metso MR Moisture analyzer is able to rather reliably measure the moisture content of chips and sawdust within the moisture range 10–90 %. In the tests the standard deviation for wood chips was 0.7 % points, for forest chips 1.7 % points and for sawdust 1.1 % points. The overall standard deviation for all test points was 1.4 % points. As the deviation includes the inaccuracies arising both from the MR Moisture measurement and from the oven drying, the most accurate picture of the reliability of the analyzer is given by the sawdust tests where the moisture content of samples was controlled accurately by adding a weighed water volume to dried sawdust. Based on these tests the standard deviation of the MR Moisture measurement is 1.1 % points in the moisture range 10–90 %. There is also a slight difference in the slope between the moisture analyzer and actual moisture content: at low moisture contents the results of the MR Moisture analyzer are somewhat below the actual level, and at high moisture contents the results slightly above it. For example at 15 % moisture the MR Moisture analyzer reading was about 2 % points lower than it should have been according to the added water volume; similarly, at 85 % moisture the analyzer reading was 1 % higher than actual. At 60 % moisture level the difference between calculated moisture and MR Moisture analyzer reading was insignificant.



Appendix 1. Measurement data for wood chips.

Sample ID	Moisture by lab oven [%]	MR moisture [%]	Diff (MR-lab)
wood chips 01	59.48	60.70	1.22
wood chips 02	59.39	61.00	1.61
wood chips 03	58.86	59.10	0.24
wood chips 04	58.84	59.30	0.46
wood chips 05	58.72	58.90	0.18
wood chips 06	59.47	60.50	1.03
wood chips 07	56.58	58.90	2.32
wood chips 08	58.51	58.80	0.29
wood chips 09	59.12	60.60	1.48
wood chips 10	59.03	59.90	0.87
wood chips 11	57.67	58.90	1.23
wood chips 12	59.82	61.40	1.58
wood chips 13	58.41	59.60	1.19
wood chips 14	58.96	60.60	1.64
wood chips 15	59.55	60.20	0.65
wood chips 16	58.76	59.00	0.24
wood chips 17	59.77	61.70	1.93
wood chips 18	59.62	61.30	1.68
wood chips 19	58.72	60.90	2.18
wood chips 20	59.07	60.70	1.63
wood chips 21	59.33	62.10	2.77
wood chips 22	59.37	61.00	1.63
wood chips 23	59.42	59.90	0.48
wood chips 24	58.72	60.10	1.38
wood chips 25	59.33	60.60	1.27
wood chips 26	58.50	61.10	2.60
wood chips 27	58.37	59.30	0.93
wood chips 28	59.65	60.50	0.85
wood chips 29	60.18	61.10	0.92
wood chips 30	58.17	59.60	1.43
wood chips 0.5h 01	56.21	57.60	1.39
wood chips 0.5h 02	56.97	58.70	1.73
wood chips 0.5h 03	56.23	57.20	0.97
wood chips 0.5h 04	56.41	58.10	1.69
wood chips 0.5h 05	56.19	57.20	1.01
wood chips 1h 06	55.38	56.20	0.82
wood chips 1h 07	53.90	54.60	0.70
wood chips 1h 08	54.99	56.00	1.01
wood chips 1h 09	54.75	55.80	1.05
wood chips 1h 10	47.20	49.20	2.00
wood chips 50g 21	63.41	63.80	0.39
wood chips 50g 22	64.30	64.90	0.60
wood chips 50g 23	63.28	62.80	0.48
wood chips 50g 24	63.45	65.00	1.55
wood chips 50g 25	64.41	64.80	0.39
wood chips 100g 26	66.33	68.30	1.97
wood chips 100g 27	64.40	64.80	0.40
wood chips 100g 28	64.23	64.70	0.47
wood chips 100g 29	62.56	65.50	2.94
wood chips 100g 30	64.79	66.20	1.41



Appendix 2. Measurement data for forest chips.

Sample ID	Moisture by lab oven [%]	MR moisture [%]	Diff (MR-lab)
forest chips 01	41.58	41.60	0.02
forest chips 02	40.49	40.30	0.19
forest chips 03	40.50	41.30	0.80
forest chips 04	43.17	44.00	0.83
forest chips 05	40.17	40.40	0.23
forest chips 06	42.92	42.70	0.22
forest chips 07	41.70	43.70	2.00
forest chips 08	39.06	40.00	0.94
forest chips 09	43.91	43.60	0.31
forest chips 10	43.53	44.60	1.07
forest chips 11	44.43	42.60	1.83
forest chips 12	47.71	48.40	0.69
forest chips 13	38.97	40.20	1.23
forest chips 14	42.43	42.70	0.27
forest chips 15	43.34	44.10	0.76
forest chips 16	42.97	44.20	1.23
forest chips 17	43.85	44.40	0.55
forest chips 18	41.45	40.80	0.65
forest chips 19	44.90	44.40	0.50
forest chips 20	41.91	42.50	0.59
forest chips 21	41.05	41.60	0.55
forest chips 22	43.18	43.50	0.32
forest chips 23	39.68	40.60	0.92
forest chips 24	44.83	46.00	1.17
forest chips 25	45.05	46.00	0.95
forest chips 26	45.13	44.00	1.13
forest chips 27	36.44	35.60	0.84
forest chips 28	43.69	44.80	1.11
forest chips 29	46.41	45.80	0.61
forest chips 30	45.52	45.00	0.52
forest chips 0.5h 11	35.14	34.50	0.64
forest chips 0.5h 12	37.22	36.40	0.82
forest chips 0.5h 13	38.02	38.10	0.08
forest chips 0.5h 14	34.85	33.70	1.15
forest chips 0.5h 15	33.92	24.30	9.62
forest chips 1h 16	22.20	21.70	0.50
forest chips 1h 17	32.23	34.10	1.87
forest chips 1h 18	31.75	31.80	0.05
forest chips 1h 19	33.09	33.10	0.01
forest chips 1h 20	27.82	27.80	0.02
forest chips 50g 05	56.35	55.40	0.95
forest chips 50g 10	52.14	53.00	0.86
forest chips 50g 20	53.44	53.10	0.34
forest chips 50g 30	49.20	52.40	3.20
forest chips 50g 40	51.56	51.50	0.06
forest chips 100g 50	58.41	58.10	0.31
forest chips 100g 60	60.48	59.70	0.78
forest chips 100g 70	58.37	57.00	1.37
forest chips 100g 80	58.81	59.50	0.69
forest chips 100g 90	61.59	60.80	0.79



Appendix 3. Measurement data for sawdust.

Sample ID	Moisture by water addition [%]	Moisture by lab oven [%]	MR moisture [%]	Difference (MR-water addition)	Diff (lab oven-water addition)
sawdust05	5.10	5.98	5.60	0.50	0.87
sawdust10	10.06	10.67	6.70	3.36	0.61
sawdust20	20.02	20.61	16.80	3.22	0.59
sawdust30	29.99	30.55	29.70	0.29	0.56
sawdust40	40.01	40.59	38.90	1.11	0.58
sawdust50	50.00	50.52	49.80	0.20	0.52
sawdust60	60.01	60.39	60.50	0.49	0.38
sawdust70	70.01	70.29	70.30	0.29	0.28
sawdust80	80.00	80.09	79.00	1.00	0.09
sawdust90	90.00	90.13	90.90	0.90	0.12
sawdust15	14.98	15.89	13.20	1.78	0.92
sawdust20	20.00	20.62	18.40	1.60	0.62
sawdust25	24.99	25.22	24.00	0.99	0.23
sawdust30	29.99	30.37	28.60	1.39	0.38
sawdust35	35.00	35.25	34.60	0.40	0.25
sawdust40	40.01	40.24	39.50	0.51	0.23
sawdust45	45.01	45.26	44.70	0.31	0.25
sawdust85	85.00	85.18	86.80	1.80	0.18

