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Size range of woodchips

A comparison of determination methods

Two screening systems (horizontal and rotating screens) as well as an image analysis system were compared for efficiency in determining wood chip size range. Compared with rotary screening, horizontal screening on average led to determination of higher proportions of fine particles and material outwith the acceptable range. With the image analysis system, too, a high agreement in measurement value agreement can be achieved, depending on whether classification according to vertical feret diameter or equivalent diameter is involved.

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Keywords

Size classification, screening analysis, image analysis, wood chips

Particle classification often plays a key role in the energy conversion of bio fuels, although the determination of this parameter occurs rarely in that the production of suitable data involves a difficult recording challenge. This is not only due to non-uniform assessment methods but also through the wide choice of different measurement systems and equipment. Additionally, often practical differences occur which can lead to significant influences on results. In the following paper a comparison of the systems is reported upon.

Recording equipment

Whilst horizontal screening equipment is widespread in practice, disadvantages have emerged in its use with biological solid fuel (high time requirement, poor grading, higher labour requirement). Additionally, long thin particles which are especially critical for the handling process can easily fall through one or two screens and thus be falsely graded. Applied in this case was a horizontal sifter (KS1 from Retsch) with round-hole screens (400 mm Ø, 65 mm high) with oscillation frequency of 70 Hertz.

To help solve the problems mentioned with horizontal screening a rotational grader was developed recently at the Danish Centre for Forest, Landscape and Planning (Vejle) with the aim of shortening time requirement and grading accuracy (*fig. 1*). A copy of the prototype tested here featured five consecutive round-hole sieve rings each of 400 mm length giving a screen drum with a total length of 2230 mm and 500 mm Ø. Rotation took place with a 2° fall and at 12 rpm.

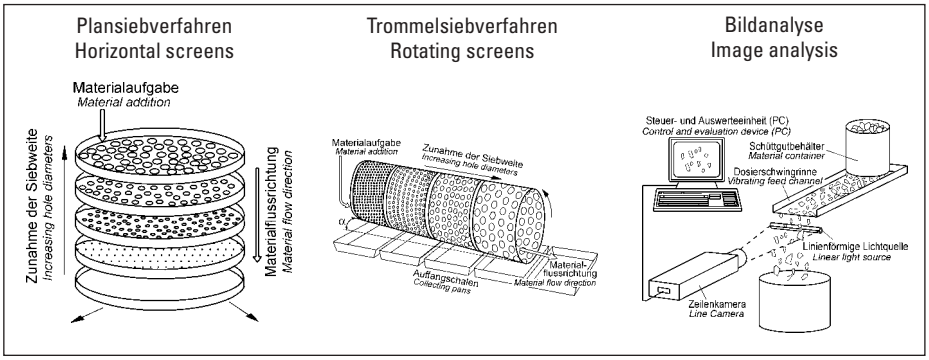
Alongside such screening equipment are also available commercial image analysis systems suitable for laboratory as well as continuous use. In the instrument used here (CPA 4 from Haver & Boecker) individual falling particles pass a linear light source with light interruptions caused by the falling particles recorded by a digital CCD line camera (*fig. 1*). The light reaching the camera lens is interrupted in proportion to the horizontal mass of the particles with area calculation via length of time of the interruption. The camera records 2048 pixels over the full breadth of the material introduction of 240 mm (117 µm per pixel). Classification is according to the vertical Feret Ø, e.g. the longest vertical dimension of the particle as well as according to the projection area-equivalent diameter (the diameter of a to be measured "shadow size" of a same-area circle).

Trials with practical fuels

Mainly used as trial fuels were spruce (9) and beech (5) woodchips. To give material as heterogeneous as possible (fine, medium, large chips) two different choppers were used.

The tested measurement system delivered only partly comparable results. Compared with the other methods, the horizontal screening resulted in the proportion of fine particles being generally higher. This was because some long and thin particles could fall through the sieves, even at loading. This

Fig. 1: Tested screening and image analysis methods measuring size distribution of wood chips



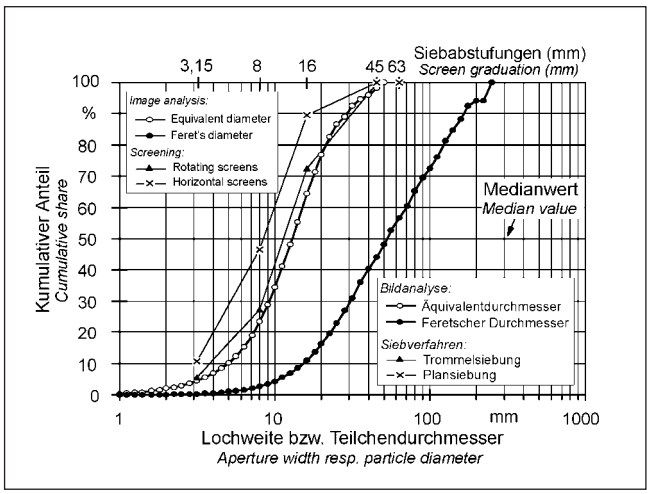


Fig. 2: Cumulative distribution curves; results for various determination methods. Example here: medium spruce chips.

system error was magnified where fine sample material with limited median value was used.

This failure was not so noticeable with drum screening. Through rotation of the drum the particles are repeatedly presented at different holes which lessens the throughflow possibility for long thin particles. Additionally there's more often a horizontal spreading of the particles in the rotating screen floor. This can be seen in the right-directional curve for the drum screen compared with the horizontal one (*fig. 2*).

With the image analysis classification according to feret diameter still greater measurement deviations appeared. Results showed that corn size was strongly underestimated in such cases. Responsible here could be overlapping of particles during their fall through the projection level.

On the other hand a relatively good agreement between results of drum screen and image analysis classifications according to equivalent diameter was able to be determined. With the increase of chip size this agreement, however, decreased while it increased for the horizontal screening.

A further evaluation of the criterion is the repeatability of the system. Here, drum screening showed the least deviations from average median value (on average 0.57%) and even with horizontal screening the values were able to be repeated well (0.78% deviation). The deviations rose moderately in the case of image analysis in the equivalent mode (1.55%) with a strong rise in the ferret mode (3.90%) (*table 1*). The big difference between both image analysis systems is due to the determination of the feret diameter being more strongly dependent on the orientation of the particle during the fall than the determination of the equivalent diameter.

Measurements with a standard sample

Additionally a standard sample with symmetrical and exactly defined measurements and known number of particles was produced so that its "real" corn size distribution compared with fuel used in practice was exactly known. This comprised a total of 18 fractions with round and rectangular cross sections (rectangle and cylinder).

Basically in such cases the similar measurement differences appear as with conventional fuels (*fig. 3*). Here too, the horizontal screen and image analysis results (feret mode) reached both upper and lower ends of the range breadth; the best agreement with the "real" median value was shown with both screen systems. This however, was not the case where average particle size was observed (actual value: 57 mm) instead of median value. The screening systems led then to low particle sizes (44 and 43 mm), whilst best agreement was observed with photo-optical determination of the equivalent diameter (56 mm).

More informative than the average and the median diameter is, on the other hand, available through the measured proportion of material outwith the acceptable grade, either above ("overcorn") or below ("undercorn"). It was shown here that there was 8.3% less over or under corn with drum screening compared with horizontal screening (18.4%) whereby in both cases the exceeding of the range almost always concerned the undercorn particles.

Summary

Compared with horizontal screening, drum screening offers several advantages in size control and improvements in operation which should make this system promising as a standard method for determining quality. On the other hand image analysis currently appears to be a technology for near-time system-optimization and control in continuing production processes.

Table 1: Deviations of median values within different wood chip classes evaluating the repeatability

	Number of recordings				Average relative deviation from its average (%)			
Determination system	Fine	Medium	Large	Σ	Fine	Medium	Large	Ø
Horiz. screening	15	12	6	33	1.20	0.48	0.31	0.78
Rotary screening	22	15	16	53	0.51	0.40	0.80	0.57
Image analysis classification								
Acc. to equivalent-Ø	13	10	9	32	1.22	2.19	1.31	1.55
Acc. to feret Ø	13	10	9	32	2.43	5.07	4.72	3.90

Ø = Average

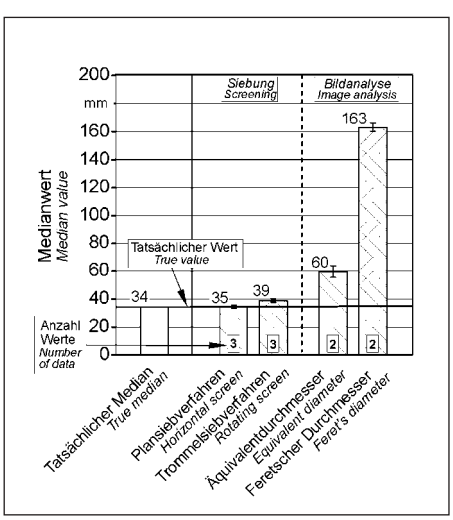


Fig. 3: True and measured median values of the standard sample applying various determination methods.