Physical-mechanical fuel properties – Significance and standard determination methods

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   - Moisture content
   - Ash content
   - Bulk density
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Quality characteristics in standardisation

a) **Combustion related properties**
   - moisture content
   - calorific value
   - volatile matter
   - ash content
   - ash melting behaviour
   CEN/TS 14774
   CEN/TS 14918
   CEN/TS 15148
   CEN/TS 14775
   CEN/TS 15370

b) **Mechanical properties**
   - bulk density / particle density
   - particle size distribution
   - durability (compressed fuels)
   CEN/TS 15103/15150
   CEN/TS 15149
   CEN/TS 15210
Moisture content

Effects of moisture

- Calorific value (by mass) and energy content (by volume)
- Fungy growth and spores emissions (health hazards)
- Suitability for combustion (domestic furnaces)
- Risk of self-ignition
- Effect on bulk density
Storage of "green" wood chips: Danger of self-ignition
Determination of moisture content

Standard Method CEN/TS 14774:

"Solid Biofuels – Methods for the determination of moisture content – Oven dry method,"

- Part 1: Total moisture – Reference method
- Part 2: Total moisture – Simplified method
- Part 3: Moisture in general analysis sample

Method characteristics:
- Oven drying method
- Sample mass >300 g (part 1&2)
- Drying temperature: 105 ± 2 °C
- Drying time: until constant mass (16 – 24 h)
- Balance resolution: 0,1 g
Ash content

Effects of ash content

- Ash disposal efforts
- Boiler design
- Particle emissions in flue gases
- Calorific value (d.b.)
Ash content

Influence of the ash content on dust emissions
(49 kW wood chip boiler)

Regression for wood fuels:
\[ y = 13.3 + 22.7 A \]
\[ R^2 = 0.67 \quad (N = 79) \]
Determination of ash content

Standard Method CEN/TS 14775:
"Solid Biofuels – Methods for the determination of ash content"

Method characteristics:
- Calculation from the mass of the residue remaining after the sample is heated.
- Sample mass > 1 g
- Defined temperature raise (5°/min)
  (RT -> 250 °C in 50 min, maintain for 60 min,
   250 °C -> 550°C in 60 min, maintain for 120 min)
- Furnace temperature: 550 ± 10 °C
- Cooling in desiccator
- Balance resolution: 0,1 mg = 0,0001 g
Determination of ash content
**Determination of bulk density**

**Standard Method CEN/TS 15103:**
"Solid Biofuels – Methods for the determination of bulk density"

**Method characteristics:**
- The volume of the test sample is determined in defined round containers after shock impact
- Shock impact by dropping the container freely from 150 mm height onto a wooden board (3 times + refilling)
- Balance resolution: 1 g / 10 g

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Durability of pellets & briquettes

Effects of insufficient durability

- Release of fine particles or dust emissions during transport or storage (health hazard/consumer harassment)
- Risk of dust explosions
- Disturbance of conveying process (broken pellets)
Determination of durability of pellets & briquettes

**Standard Method CEN/TS 15210:**
"Solid Biofuels – **Method for determination of mechanical durability of pellets and briquettes**"  
- Part 1: Pellets – Part 2: Briquettes

**Method characteristics (pellets):**
- The test sample is tumbled in a defined rotating test chamber, the mass of abraded fine material is then determined
- Screening before tumbling: 3,15 mm
- Sample mass. 500 g
- Rotating time 10 min / 500 rotations
- Screening after tumbling: 3,15 mm round holes
Equipment for determining mechanical durability
Particle size & distribution

Mechanical effects of unfavourable particle size distribution

- Clogging or system damages in conveying and transportation
- Disturb a continuous material flow
- Bridging in storage or conveying systems
- Increasing resistance to air flow in aeration or drying
- Inhibition of particle spreading on fire beds
- Dust formation during transportation

Length is not determined by screening!
Bridging

Bridging summarizes several phenomena:
- Building of a stable bridge over an opening
- Inhomogeneous horizontal distribution or vertical flow
- Clogging hazards during conveying

Influences on bridging properties:
- Particle size distribution
- Maximum particle length
- Mean size/length ratio
- Particle shape (sphericity)
- Moisture
- Density
Determination of particle size distribution

Standard Method CEN/TS 15149:
"Solid Biofuels – Methods for the determination of particle size distribution,”

- Part 1: Oscillating screen method using sieve apertures of 3,15 mm and above
- Part 2: Vibrating screen method using sieve apertures of 3,15 mm and below
- Part 3: Rotary screen method
Determination of particle size distribution

Method characteristics (horiz. screening)
- Particle separation is achieved by screening, share of size class is determined by weight
- Min. sample size: 8 l (Part 1) or 50 g (Part 2)
- Sample moisture: < 20 %
- Min. screen sizes: 1200 cm² / 250 cm²
- Hole geometry: round (Part 1) or square & round (Part 2)
- Hole sizes: 3,15/8/16/45/63 mm (Part 1); 0,25/0,5/1/1,4/2/2,8/3,15 mm (Part 2)
- Time: 15 min or to be tested in advance
Interdependency among physical/mechanical properties

- Bridging properties
- Calorific value (w.b.)
- Ash content
- Moisture content
- Impurities
- Ash softening behaviour

- Size distribution
- Durability (of pellets)
- Bulk density
- Particle density

Summary and conclusions (1)
Moisture is the parameter with the largest influence on other physical properties.

Measures which aim at manipulating a physical-mechanical property will always affect other parameters.

Most of the required methods for physical fuel characterisation are standardised. Standards are currently under revision. But still there is only little experience with their application in general practice.

The list of standardised test methods is still incomplete. Further fuel parameters should be introduced to gain information on fuel mechanical behaviour (e.g. particle shape factors).
Thank you for your attention!