Deutsches Biomasseforschungszentrum
gemeinnützige GmbH

DBFZ

Small scale combustion of pelletized low quality wood – impact of the additives on ash characteristics and emission behaviour

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Side Workshop “REDUCING WASTE WOOD ASH RELATED OPERATIONAL PROBLEMS IN USING ADDITIVES”
WORLD SUSTAINABLE ENERGY DAYS in WELS, Austria on 28th of February 2019

Objective

- To determine the influence of recycled gypsum and halloysite on reducing ash related operational problems in combustion of wood waste fuels.
  - ✓ Impact of the used additives on gaseous and particulate matter emission behaviour
  - ✓ Impact of the used additives on bottom ash slagging and emission behaviour

Raw materials

- Residues from wood chip board production, i.e. A II used wood (**WCB**)
  - ✓ particle size: about 60% < 3.15 mm
  - ✓ bulk density: 337 kg/m³
- Wood logging residues (**WLR**)
  - ✓ Wood chip quality: less than class B (ISO 17225-4)
  - ✓ M10
- Gypsum, **G** ($CaSO_4 2H_2O$)
  - ✓ origin: Gips Recycling Nederland BV
  - ✓ bulk density: 700 kg/m³
- Hallosite, **H** ($Al_2(Si_2O_7).2H_2O$)
  - ✓ origin: PTH INTERMARK, poland
  - ✓ bulk density: 1080 kg/m³

Raw materials – additive amounts

- Calculation of Gypsum addition

$$S_{add} = (F_{stoich}((K + Na)/2 + Zn + Pb) - 0.64\ S_{fuel}) / 0.64$$

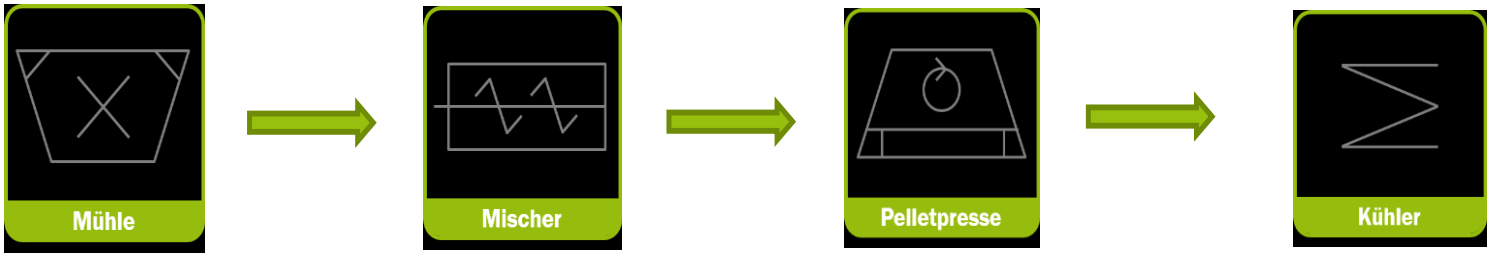
- Calculation of Halloysite addition

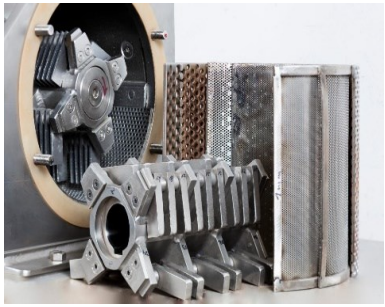
$$Alk_{cap} = Al_{add} - (K_{add} + Na_{add} + 2(Ca_{add} + Mg_{add}))$$

$$Amount_{add} = (K_{fuel} + Na_{fuel}) / Alk_{cap}$$

- WLR (Fstoich=1.5)
  - ✓ Gypsum: 13.4 kg Add / t dry fuel
  - ✓ Halloysite: 31.7 kg Add / t dry fuel
- WCB (Fstoich=1.5)
  - ✓ Gypsum: 4.3 kg Add / t dry fuel
  - ✓ Halloysite: 10.6 kg Add / t dry fuel

Pelleting tests

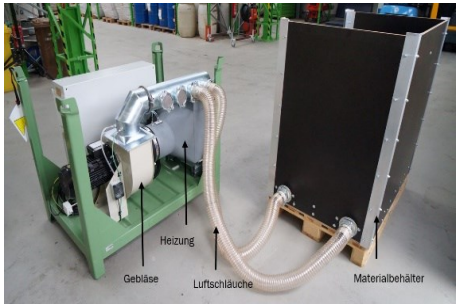




Netzsch ammer mill
type CONDUX-Hammermühle
(CHM 230/200-N3):
- 4 kW
- 3000 U/min

Conditioning
type Chargenmischer
(AT-ENGINEERING, Slowakia):
- capacity 0,3 m³

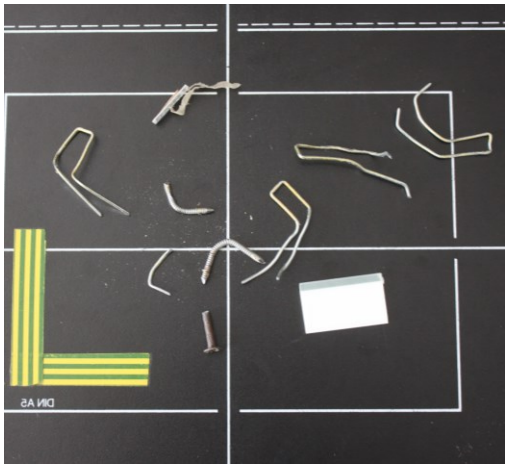
Salmatec pelleting plant
type Maxima 360-40 mini:
- 30 kW
- 3-Koller-System
- integrierted monitoring of temperature and energy consumption



Pellet cooling device
own design (DBFZ):
- heating 18 kW
- ventilation 3 kW
- capacity ca. 1 m³

Pelleting tests

Extraneous material



Wearing of hammer

Fuel	Production related amount of fines [wt%]	Pellet mass flow [kg/h]	Specific energy consumption [kWh/kg]
WLR	25.9	70.5	0.30
WLR+G	15.8	79.4	0.27
WLR+H	11.7	127.5	0.19
WCB	16.4	104.7	0.20
WCB+G	11.3	90.9	0,22
WCB+H	15.1	87.9	0.17

Combustion tests

- Analysis of biomass fuels (major and minor components, physical-mechanical properties, proximate analysis)
- Small-scale heating appliance with moving step grate (nominal heat capacity 30 kW)
- Measurement of gaseous emissions CO, NO_x, SO_2, HCl (Ansyco / FTIR Gasmet CR)
- Measurement of total particulate matter emissions, TPM (VDI 2066-1)
- Sampling and analysis of bottom ash and total particulate matter for analysis (ICP, XRD)

Additive and fuel pellet analysis

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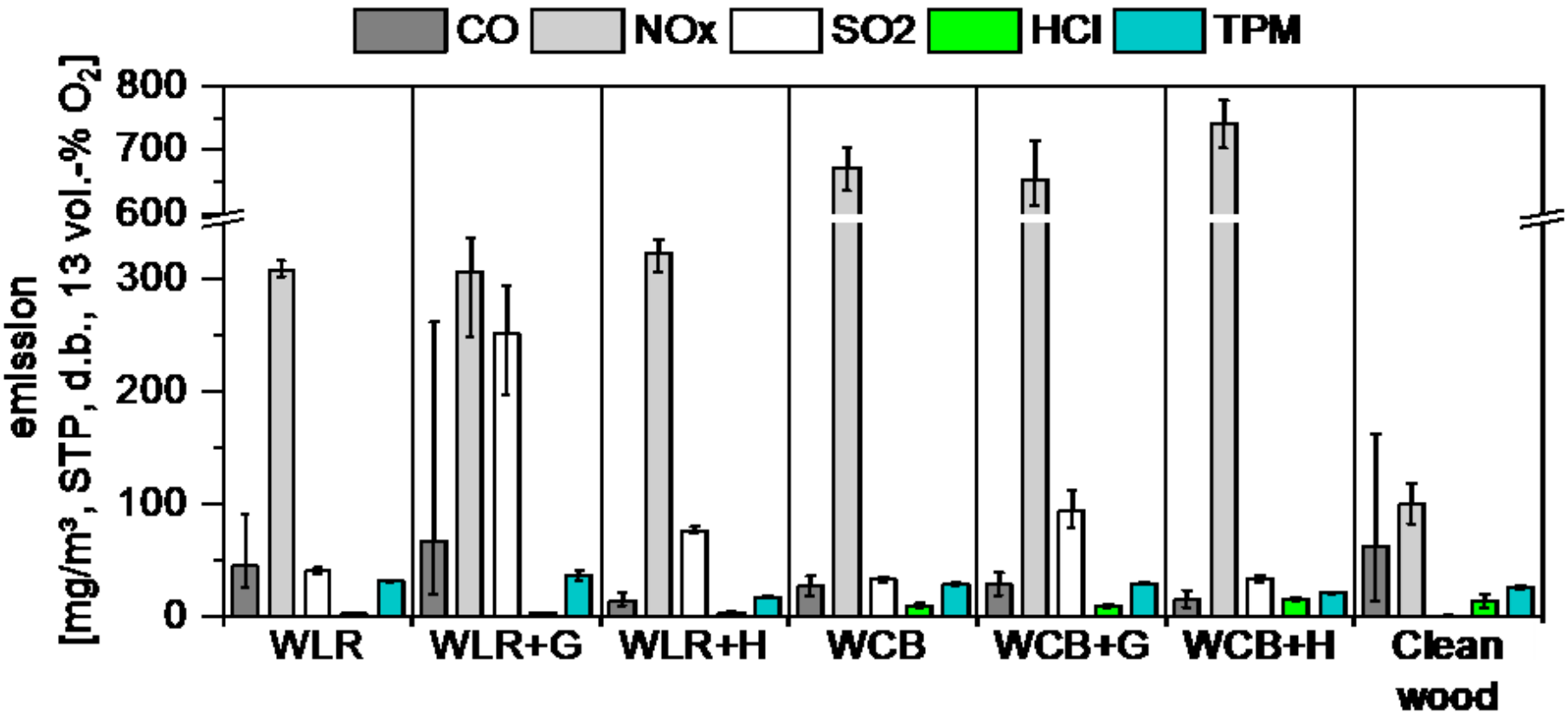
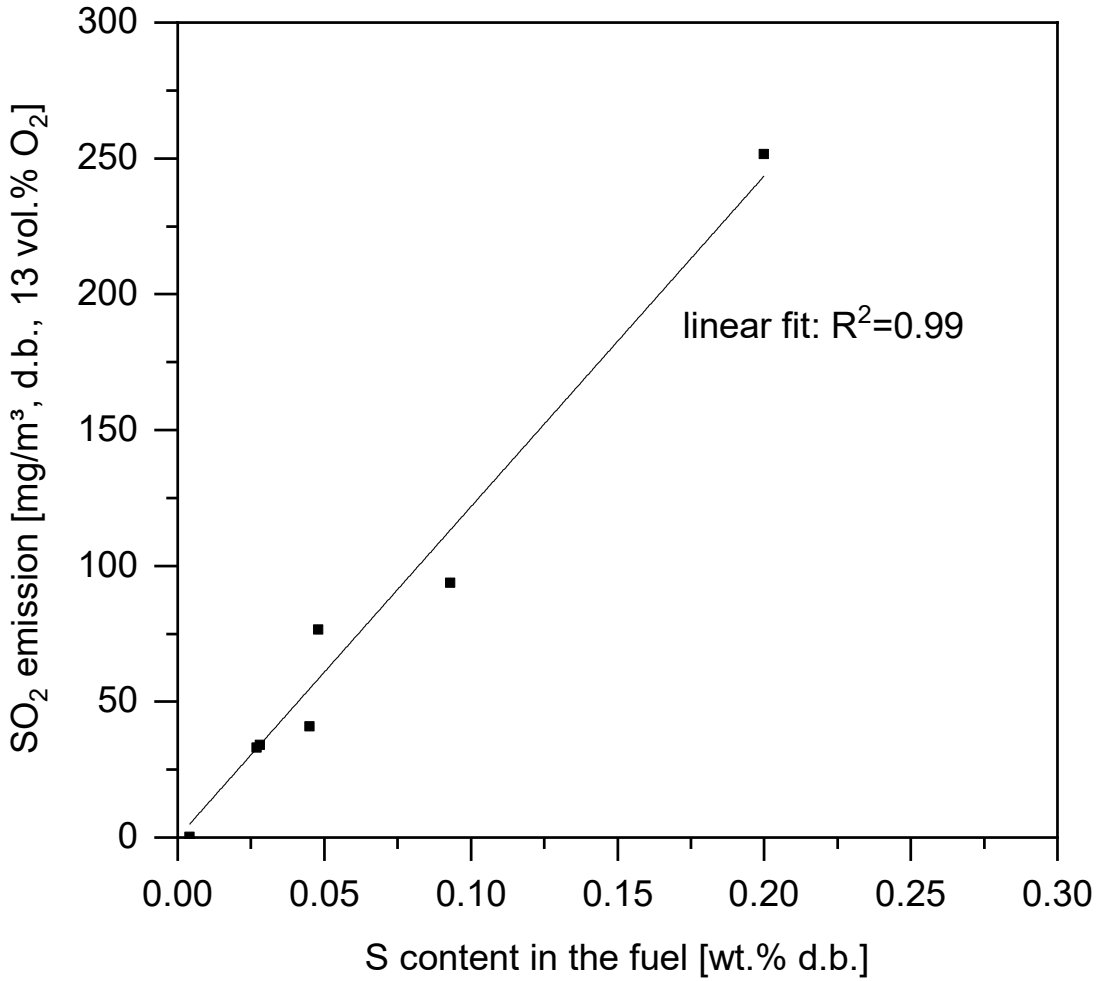
Parameter	Unit	WLR	WLR+G	WLR+H	WCB	WCB+G	WCB+H	Clean wood
Bulk density	kg/m³	661	671	648	569	614	600	633
Mechanical durability	wt%	95.69	94.2	93.9	94.3	96.1	95.2	99.0
Ash content	wt% dry	3.10	4.53	6.15	1.49	1.79	2.26	0.33
Nitrogen	wt% dry	0.50	0.47	0.45	4.33	4.37	4.15	0.21
Chlorine	wt% dry	0.012	0.011	0.012	0.026	0.026	0.028	0.01
Sulfur	wt% dry	0.045	0.200	0.048	0.027	0.093	0.028	0.004
Potassium	mg/kg dry	2310	2330	2400	453	390	295	497
(Si+P+K)/(Ca+Mg)	mol/mol	1.82	1.53	3.43	0.64	0.45	1.18	0.8
Si/K	mol/mol	3.13	4.01	7.25	2.88	309	10.10	0.38
2S/Cl	mol/mol	8.29	40.21	8.85	2.30	7.91	2.21	0.80
K/Cl	mol/mol	17.46	19.21	18.14	1.58	1.36	0.96	4.1

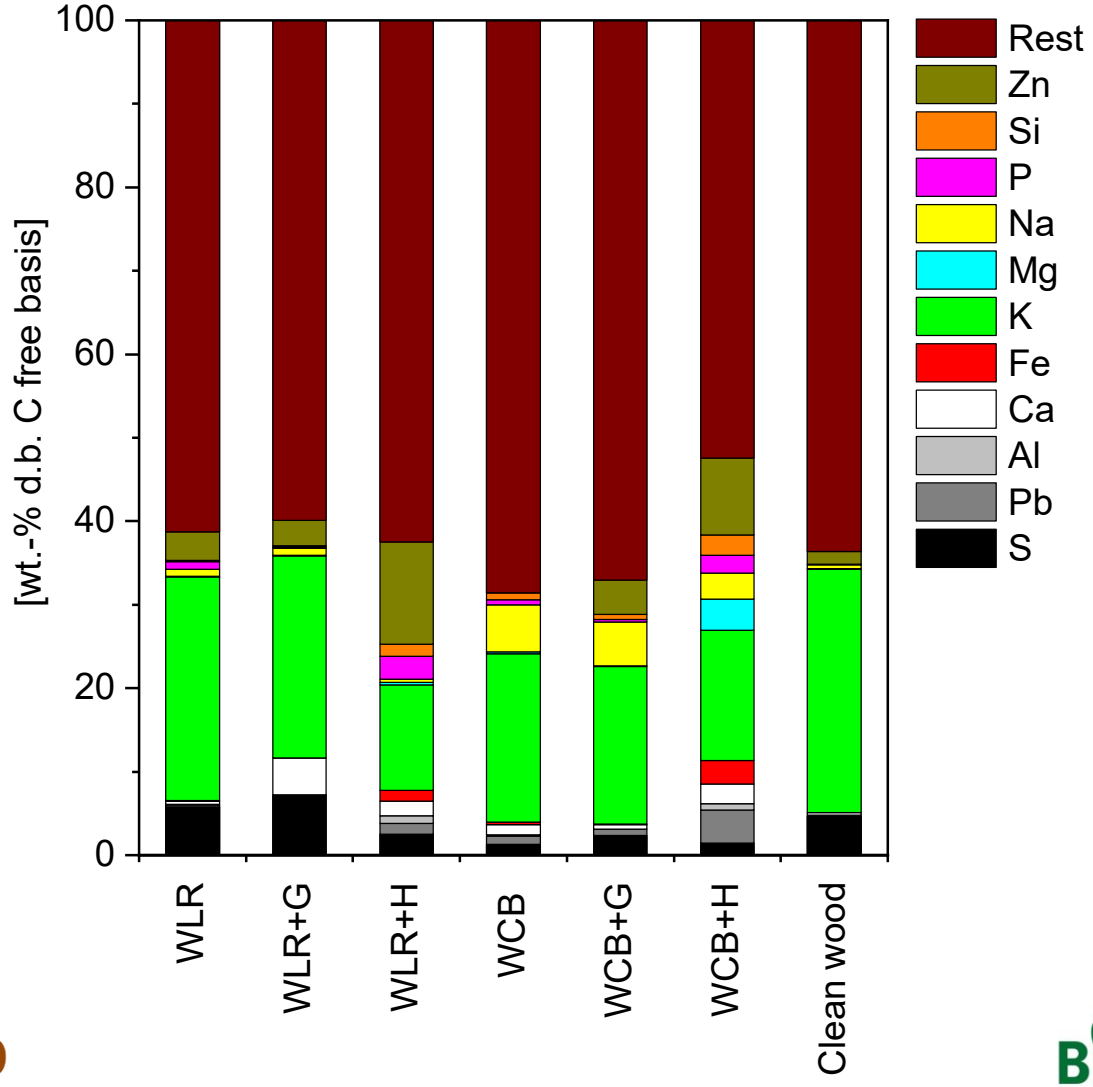
Emissions


CO
NOx
SO2
HCl
TPM
emission
[mg/m³, STP, d.b., 13 vol.-% O2]
800
700
600
300
200
100
0
WLR
WLR+G
WLR+H
WCB
WCB+G
WCB+H
Clean wood

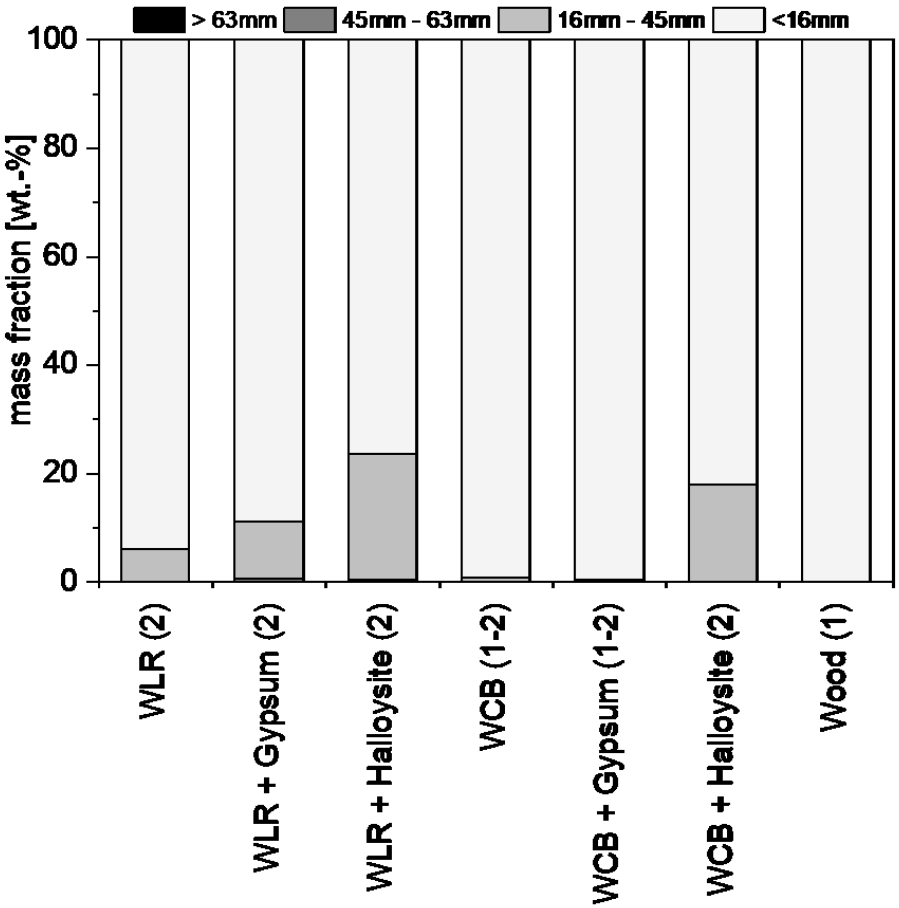
Emissions

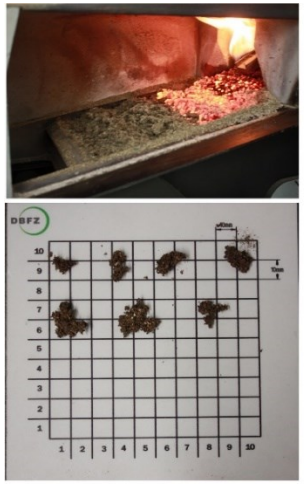

300
250
200
150
100
50
0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
SO2 emission [mg/m³, d.b., 13 vol.% O2]
S content in the fuel [wt.% d.b.]
linear fit: R2=0.99

Analysis of total particulate matter

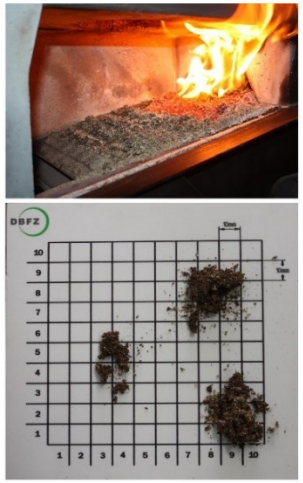


Bottom ash analysis





WCB



WCB + Gypsum

WCB + Halloysite

Conclusions

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Halloysite

- Although the addition of H provides advantages for pelleting and reduction of particulate matter in the flue gas, the increase of ash content and the risk of bottom ash slagging seem to provide serious challenges for waste wood combustion in small scale boilers.

Gypsum

- Although high SO_2 emissions were observed, the reduction potential of Cl containing particles is promising.
- Good prediction of Gypsum amounts is required to minimise potential SO_2 emissions.

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