DEPOSITS AND EMISSIONS DURING THE CO-COMBUSTION OF BIODIESEL RESIDUE WITH COAL AND BIOMASS IN A CFB PILOT

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VTT
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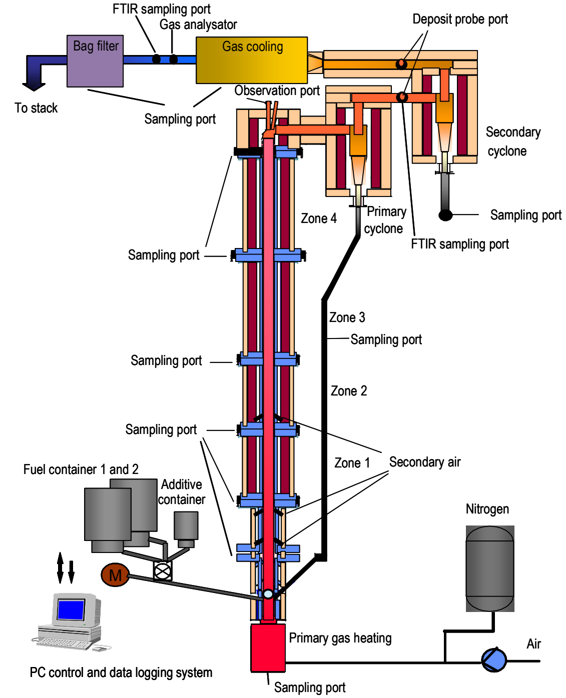


Introduction

- CO_2 reduction

→ Ratio of biomass is increasing in heat and power production

→ Sets challenges for boiler availability, emission performance and efficiency

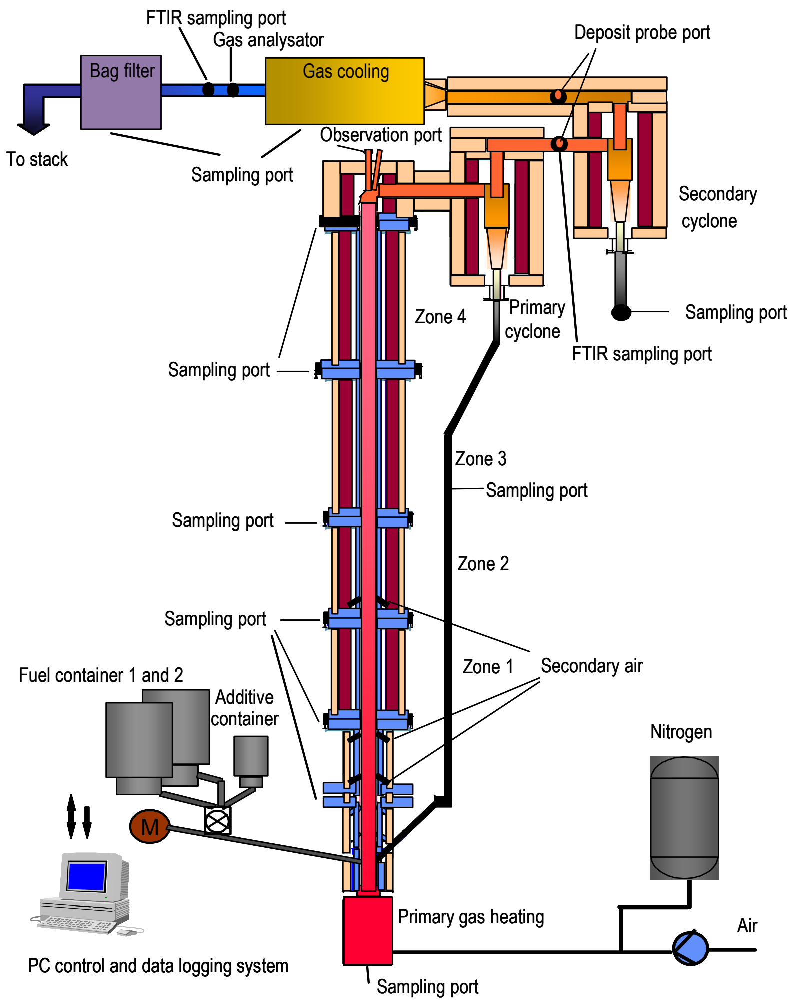
- Production of biodiesel is increasing and use of bio-based residues should be exploited

- E.g. rapeseed expeller from rapeseed biodiesel process

- Combusting rapeseed expeller solves waste problem in biodiesel production through waste-to-energy technology

- Reduces CO_2 emissions of the boiler

Experimental

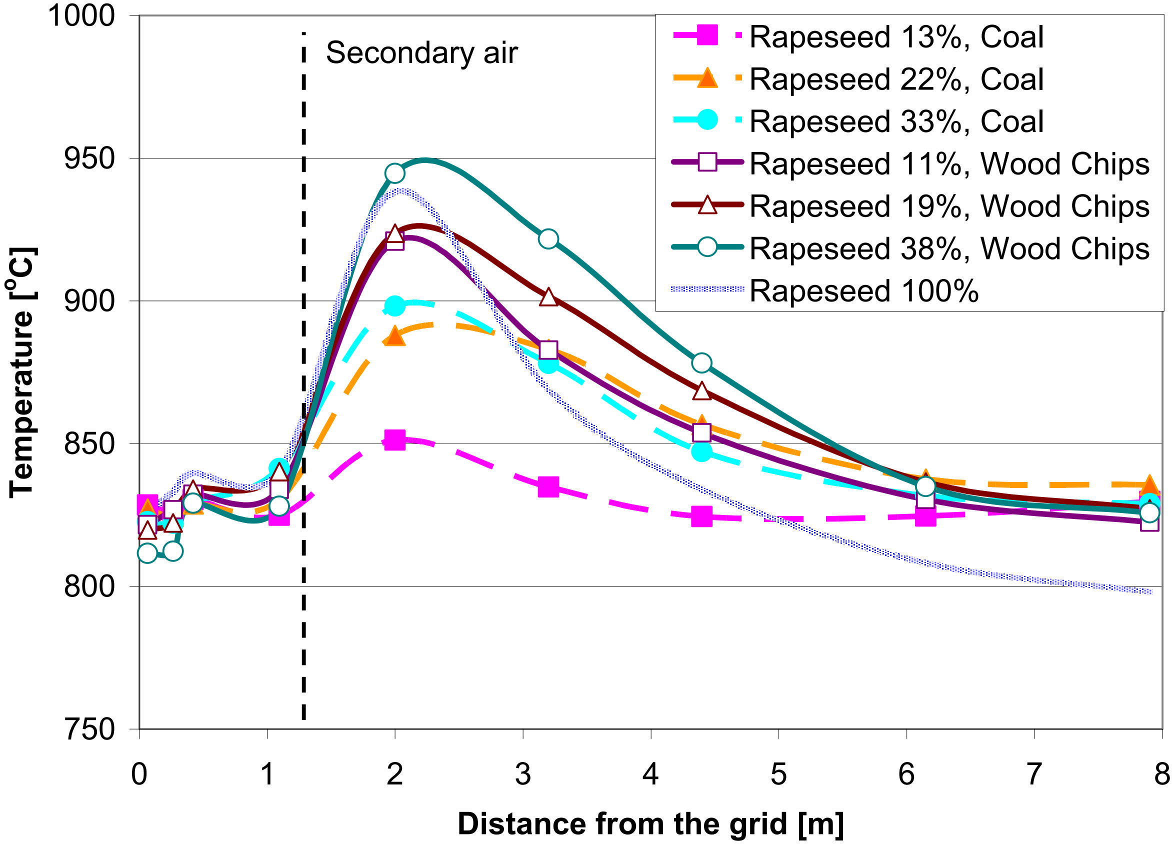


	Rapeseed expeller	*Bituminous coal*	*Wood chips*
Moisture (w-%)	11.1	4.1	34.5
Proximate analysis, w-% on dry basis			
Ash, 815 °C	6.5	12.5	0.8
Volatile content,	75.7	29.7	84.6
Lower heating value, dry (kJ/kg)	19780	27980	18590
Ultimate analysis, w-% on dry basis			
C	49.9	72.4	50.6
H	6.5	4.3	6.1
N	7.15	1.32	0.23
S	0.74	0.75	<0.02
O (calc.)	29.2	8.6	>42.2
Cl	0.020	0.130	0.008

	Fuels	Mixture ratio in energy basis %
1	Rapeseed expeller Polish coal	13 / 87
2	Rapeseed expeller Polish coal	22 / 78
3	Rapeseed expeller Polish coal	33 / 67
4	Rapeseed expeller Wood chips	11 / 89
5	Rapeseed expeller Wood chips	19 / 81
6	Rapeseed expeller Wood chips	38 / 62
7	Rapeseed expeller	100

Temperature profiles

- Bed temperature on the same level with additional cooling
- Increase of biomass assosiated with increase in combustion after sec. air.



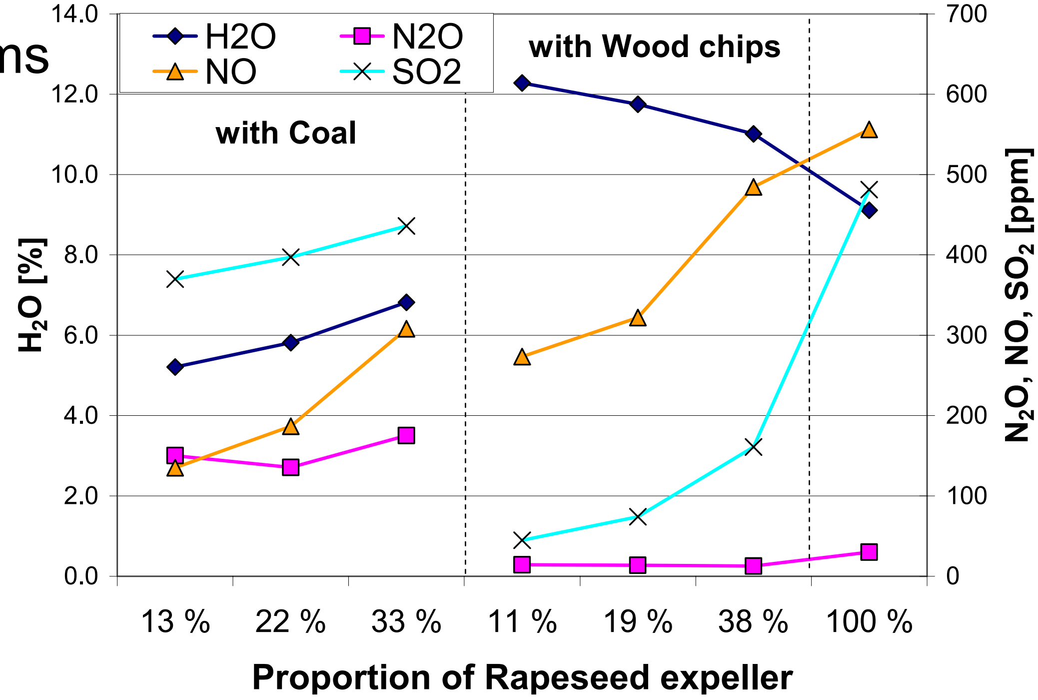
- To avoid ash melting external cooling was used for
  - Expeller 38% + wood
  - Expeller 100%

Emissions

- CO decreased with decreasing ratio of coal
- CO spikes appeared
  - at long intevals in coal - expeller tests
  - continuosly in wood - expeller tests

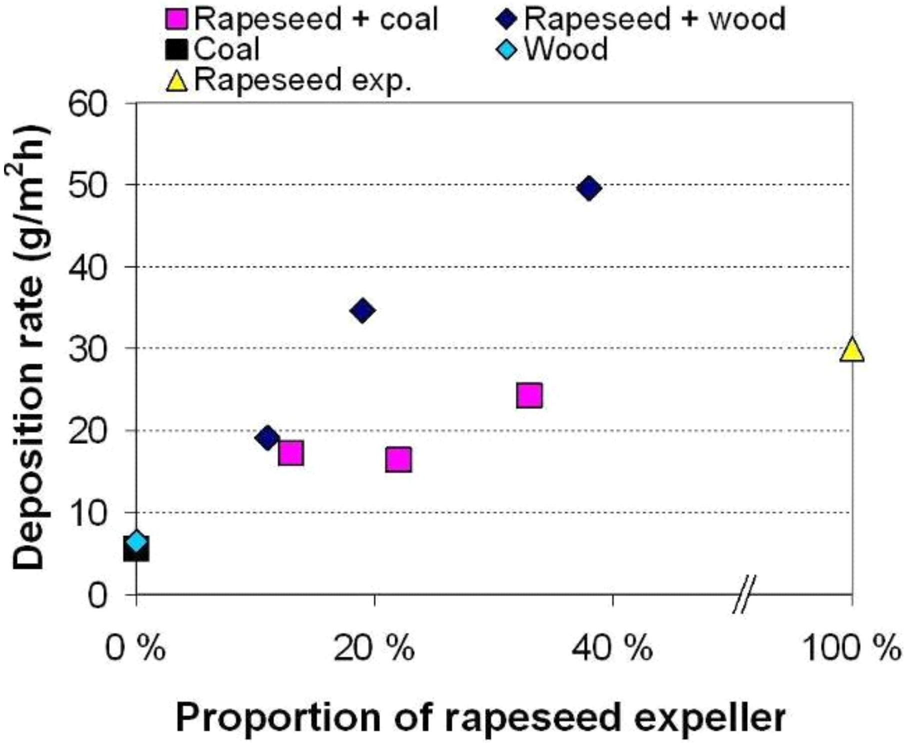
  → possible fuel feed mixing problems

- Used air stagging not optimal in biomass combustion for NO reduction
- Meaurements show effect of
  - large S content of expeller
  - large N content of expeller



Deposit formation

- To simulate the superheater area windward temperature set to 480°C
- Ash appearence
  - -coal + expeller: the gray, loose, easily removable
  - -wood chips + expeller: the ash was compact and close to white
  - -100% expeller: granular and dence
- The deposition rate calculated based on the weights of the deposit sleeves before and after each test.
- With wood deposition rate larger the for 100% expeller eventhough, wood lowers the ash flow in the reactor

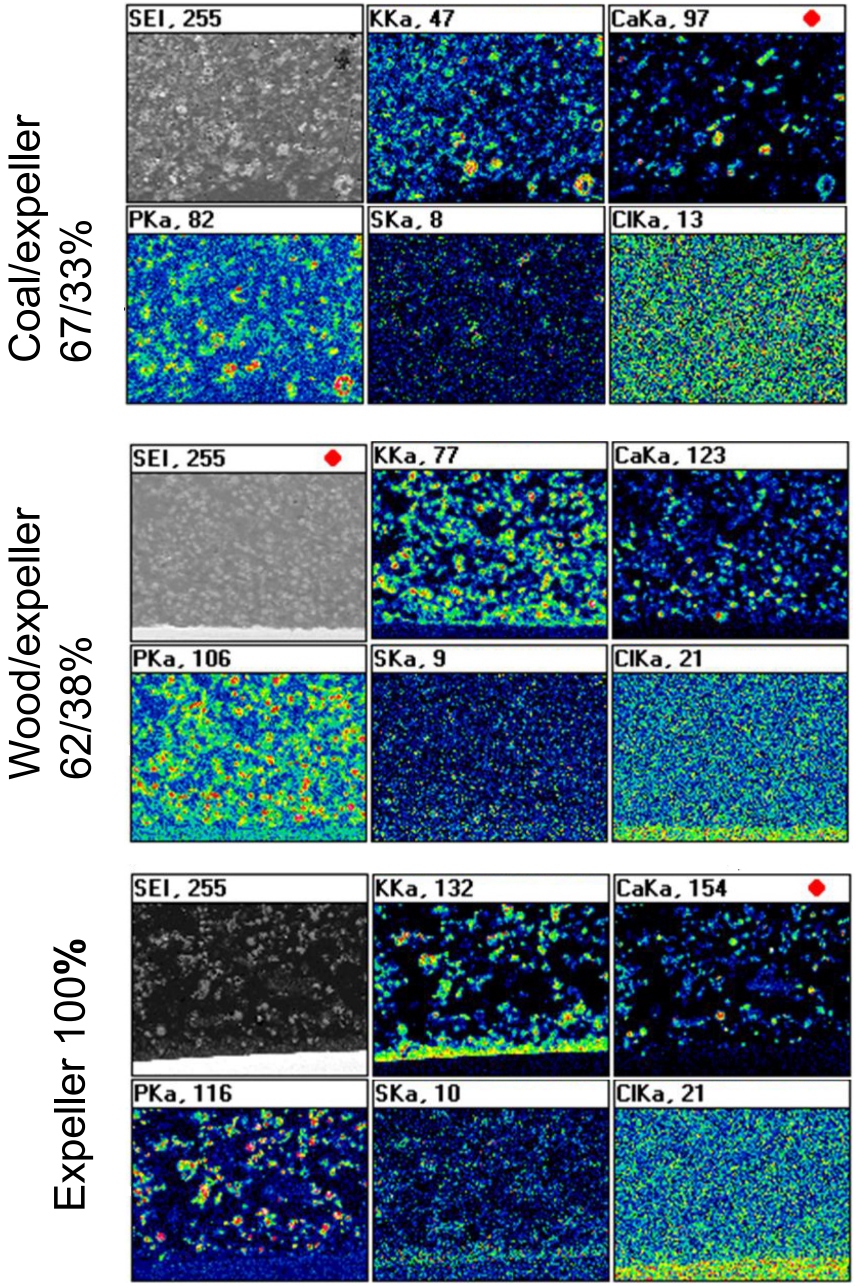


Composition of deposits

- Elemental mapping from SEM-EDX:
  - Potassium and phosphorous similarly distributed
  - Presense of K and P minor in coal co-firing
  - K and P increase with increasing share of expeller in wood co-firing

- Enrichment of clorine in the deposits

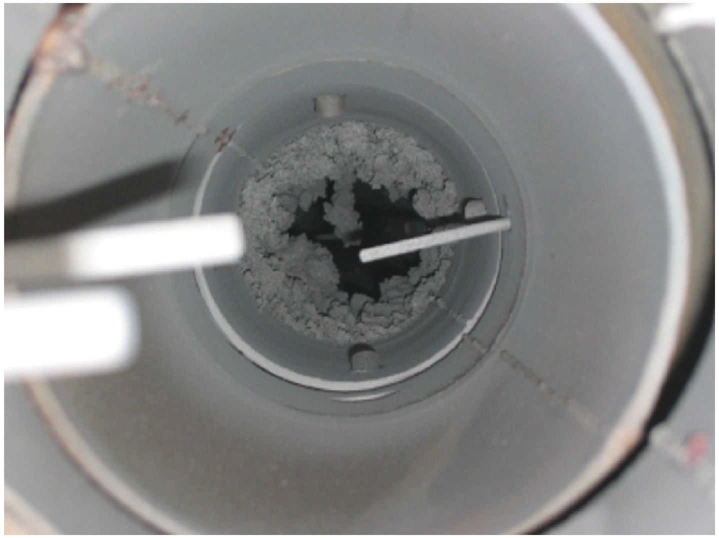
→ indicates increased risk of chlorine induced hot corrosion at least when fired alone or with wood



Slagging

- Reactor was examined after the tests
- Co-firing with coal did not cause problems
- With wood ships severe slagging occured over the sec. air feed
  - -Slag formation started with 38%/62% -mixture but increased significantly with 100% expeller

coal / rapeseed expeller



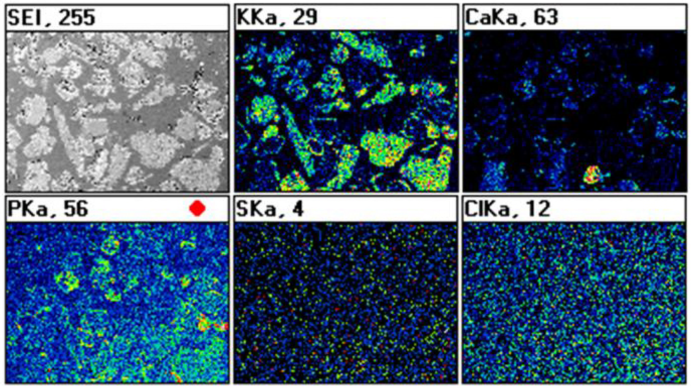
wood / rapeseed expeller

Bed agglomeration

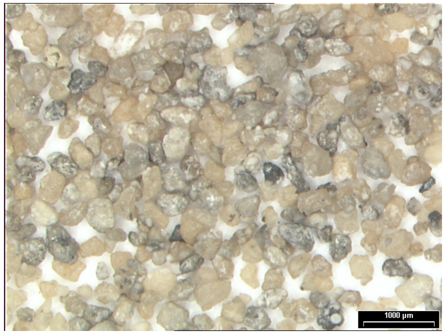
- For expeller clear agglomeration effect with wood and alone
- No signs of agglomeration with coal co-firing

- Elemental mapping by SEM-EDX:
    - Ca, P and S similar distribution
- Low melting point of potassium phosphate could explain observed slagging and bed agglomeration.
- Whether P and K reacted to phosphates, can not be confirmed based on SEM analysis

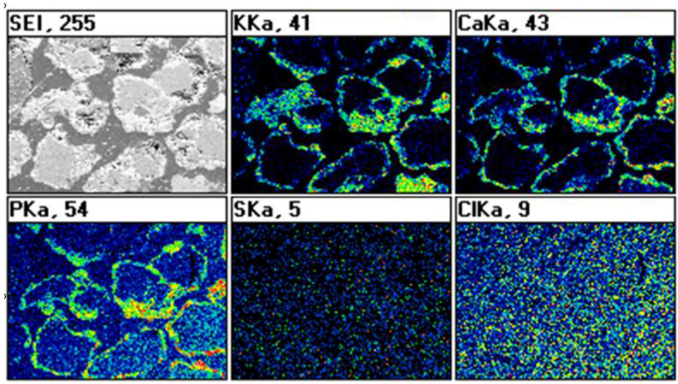
Coal / Expeller 67/33%



Wood / Expeller 62/38%



Expeller 100%



Conclusions 1/2

- Temperature above secondary inlet was more difficult to control in co-combustion with wood chips, due to higher amount of volatiles

- Decrease of CO from coal by rapeseed expeller suggests an effective option to reduce CO from coal

- NOx emissions increase with increasing share of expeller

- In full scale increase on NOx and SOx would likely to be reduced with air stagging (NOx, temperature) and in-furnace capture with limestone (SOx)

Conclusions 2/2

- Increse of rapeseed expeller increased the fouling rate with both coal and wood chips
- The enrichment of the chlorine, typical also for other biomass fuels indicates a slightly inreased risk of chlorine-induced hot corrosion
- Expeller was found to have clear agglomeration effect over the bed material when fired alone or with wood chips, but no agglomeration was found with coal
- Potassium and phosphorous content in the deposit incresed consistently with the ratio of expeller in the biomass co-firing cases

Coal co-firing favourable technology of firing rapeseed residues into energy

Thank you for your attention!

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N	7.15	1.32	0.23
S	0.74	0.75	<0.02
O (calc.)	29.2	8.6	>42.2
Cl	0.020	0.130	0.008
Ash composition, (ashing at 550 °C), w-% in ash			
Na	0	1.1	0.3
K	18.9	2.3	11.1
Ca	10.7	3.8	29.9
Mg	5.4	1.1	3.3
Al	0	13.5	0.2
Fe	0.2	4.5	0.5
Si	0	18.7	0.4
P	17.9	0.5	1.9
Ti	0	0.7	0
S	3	5.1	1.7
Cl	0.3	0	0