FULL-SCALE INVESTIGATIONS ON CO-FIRING OF STRAW

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Outline of presentation

- Background
- The Studstrup straw co-firing concept
- Experiences from straw co-firing at Studstrup
  - Fly ash properties
  - Deposit formation and corrosion
  - SCR catalyst deactivation
- Conclusions and further work

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Background

- Straw is the main biomass ressource for CHP in Denmark
- High investment costs for grate-fired stand alone boilers
- Co-firing is an interesting option due to low investment costs, high efficiency and low emissions
- 1996-1998: Successful demonstration of straw co-firing at the 150 MWe coal-fired Studstrup unit 1 (20% on energy basis)
- 1998-2001: No commercial use of co-firing technology due to problems with industrial use of fly ash
- 2001: Revised requirements for fly ash in cement production
- 2002: Start up of commercial operation of straw co-firing at the 350 MWe coal-fired Studstrup Unit 4 (10% on energy basis)

Plant description
Co-firing of straw at Studstrup unit 4

Year of commissioning	1985
Type	Opposed wall fired Benson boiler
Unit & electric capacity	824 MW / 350 MW
Coal burners	24 (in 4 rows of 6 pcs.)
Modified coal and straw burners	4 in top row
HP – Steam data	286 kg/s, 240 bar, 540°C
RH – Steam data	256 kg/s, 45 bar, 540°C
Straw input	20 t/h (10% straw share at full load)
Straw consumption	>100,000 t/year
Desulphurisation	Semi-dry FGD plant

Straw shredder

Straw hammer mill

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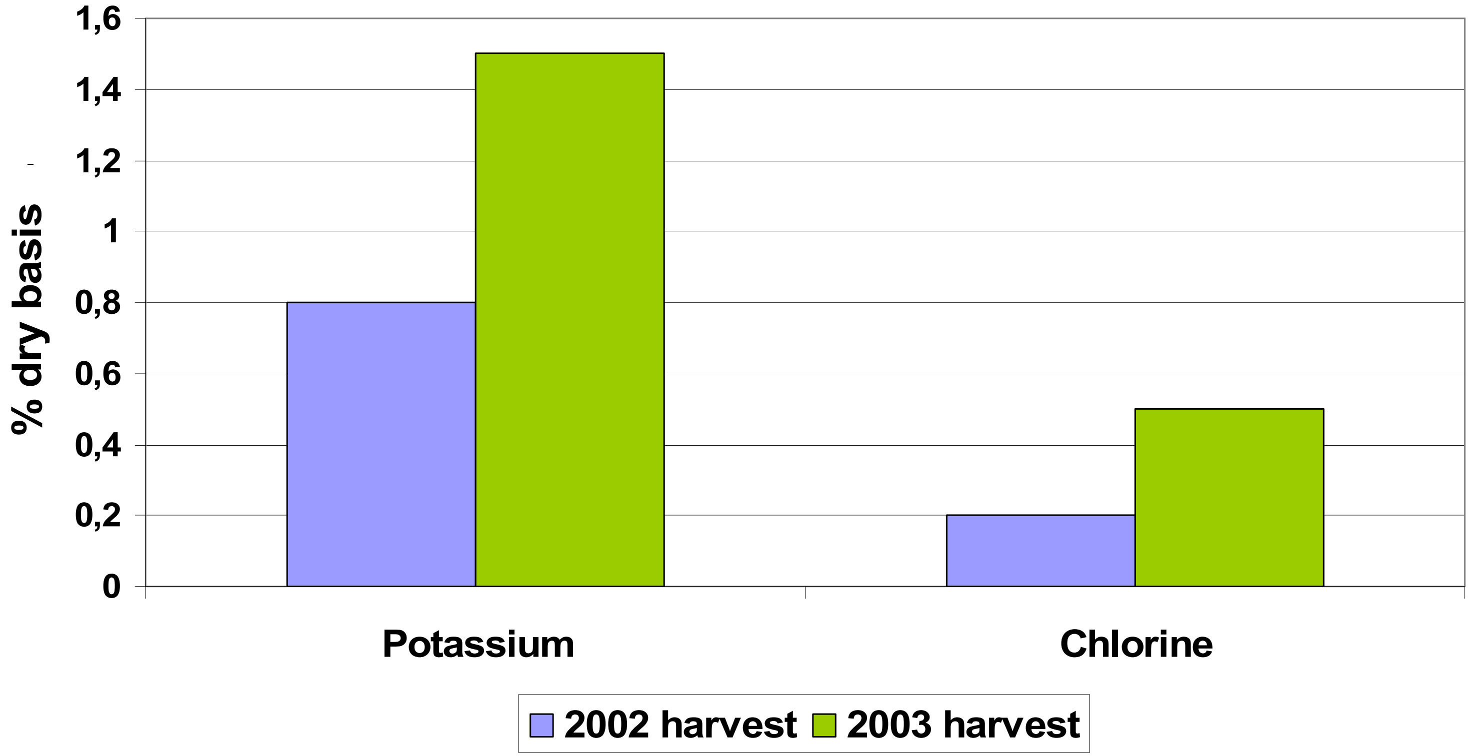
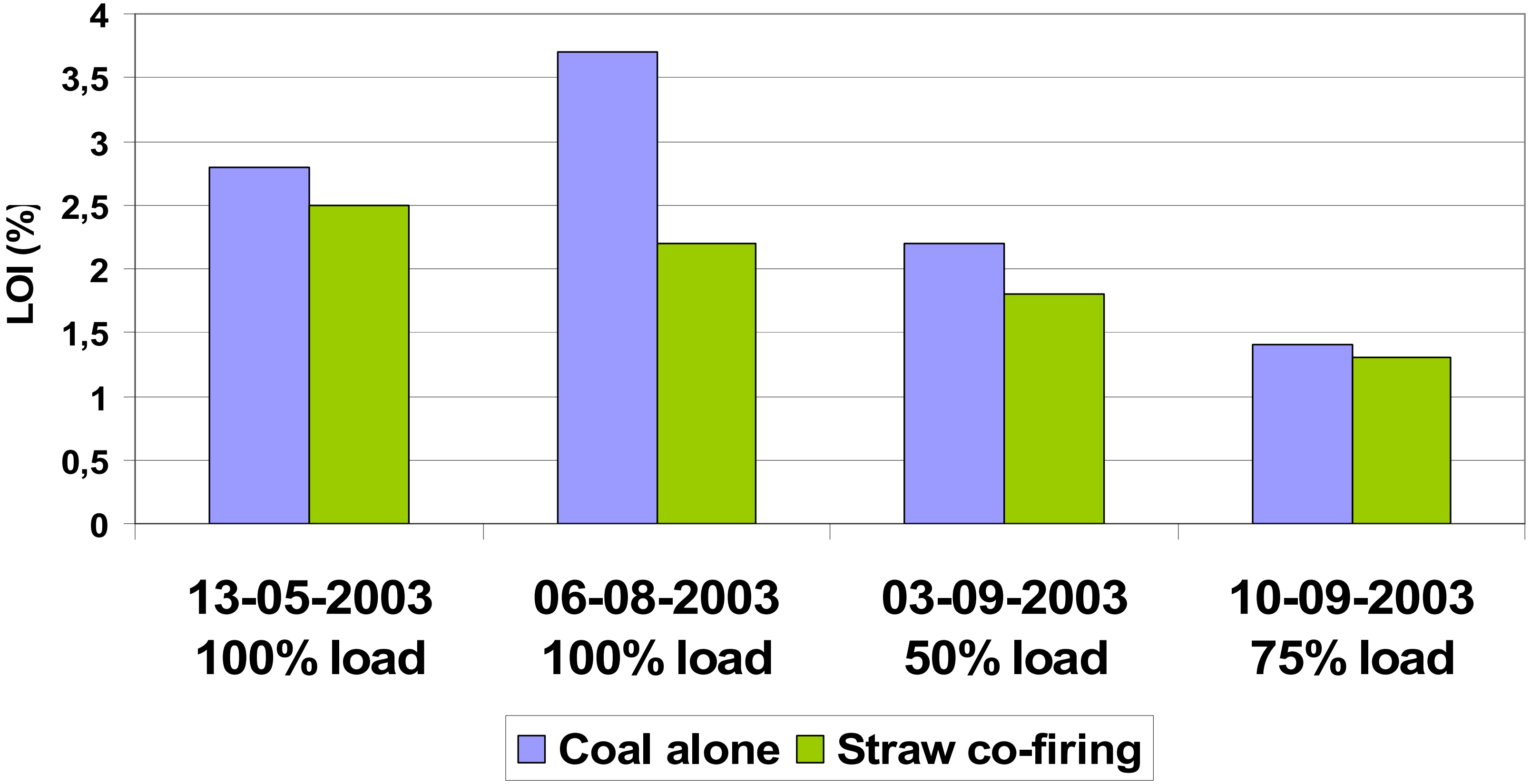
Main fuels

- South African coal (low alkali)
- Colombian coal
- Danish straw



LOI in fly ash



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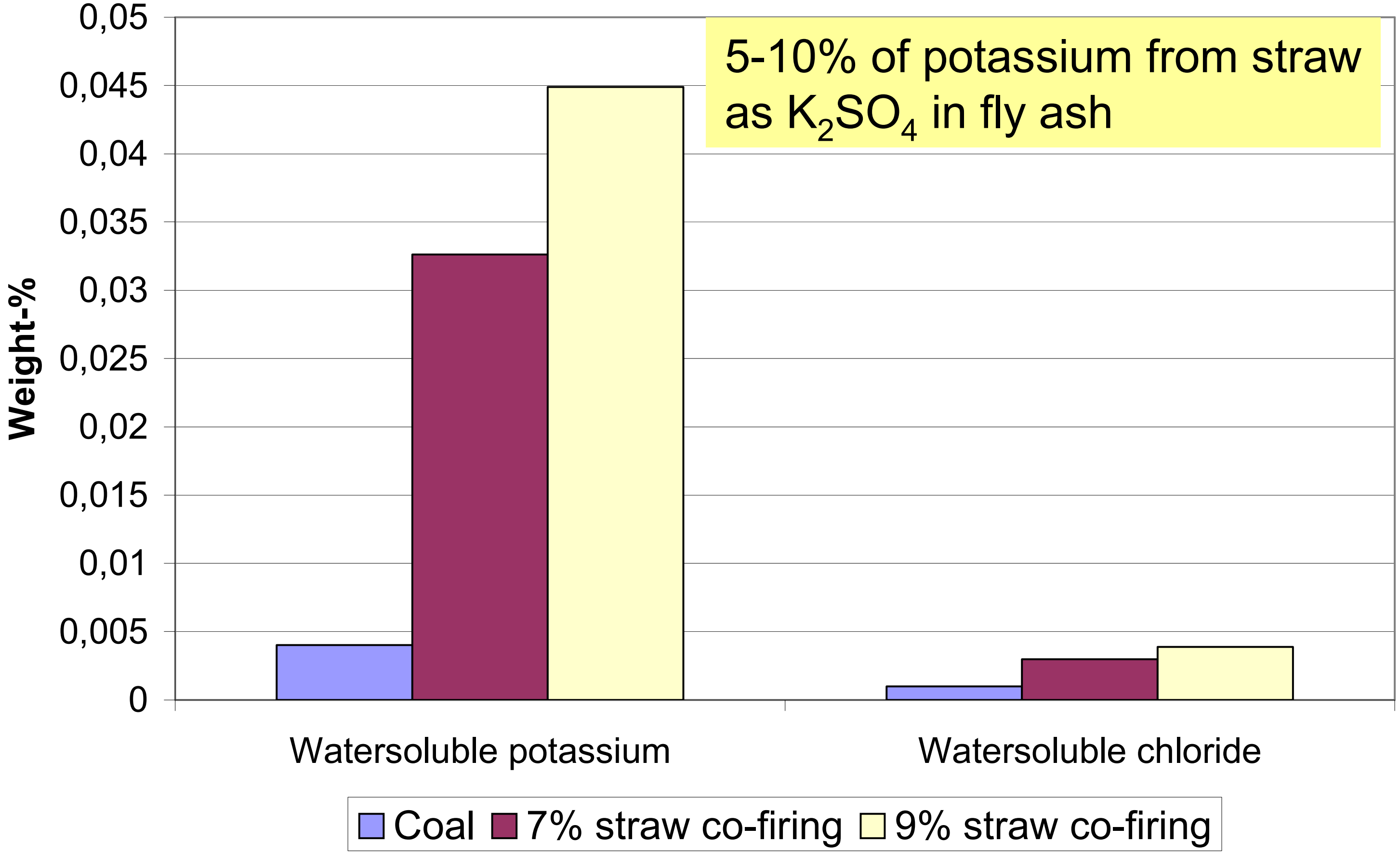
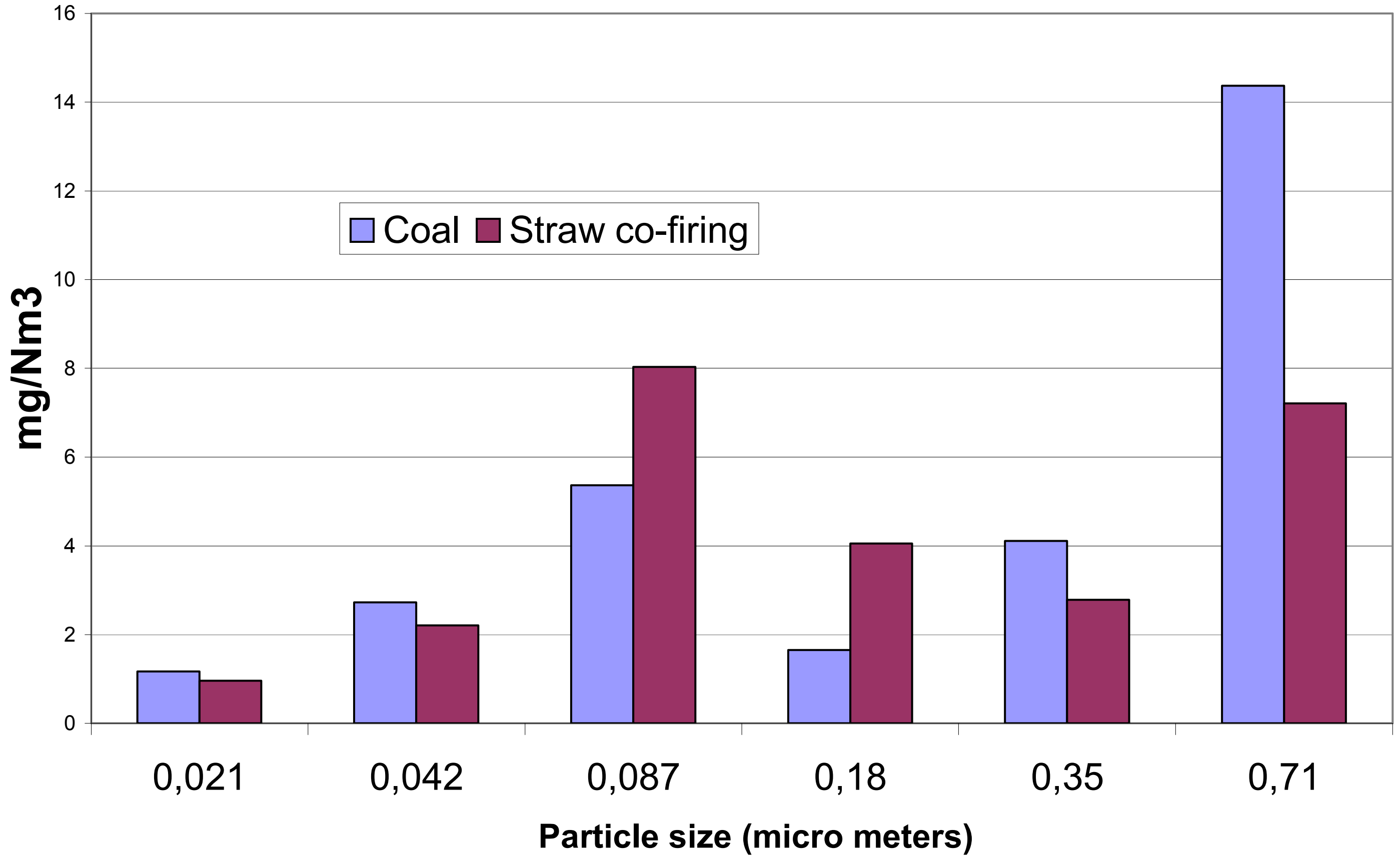
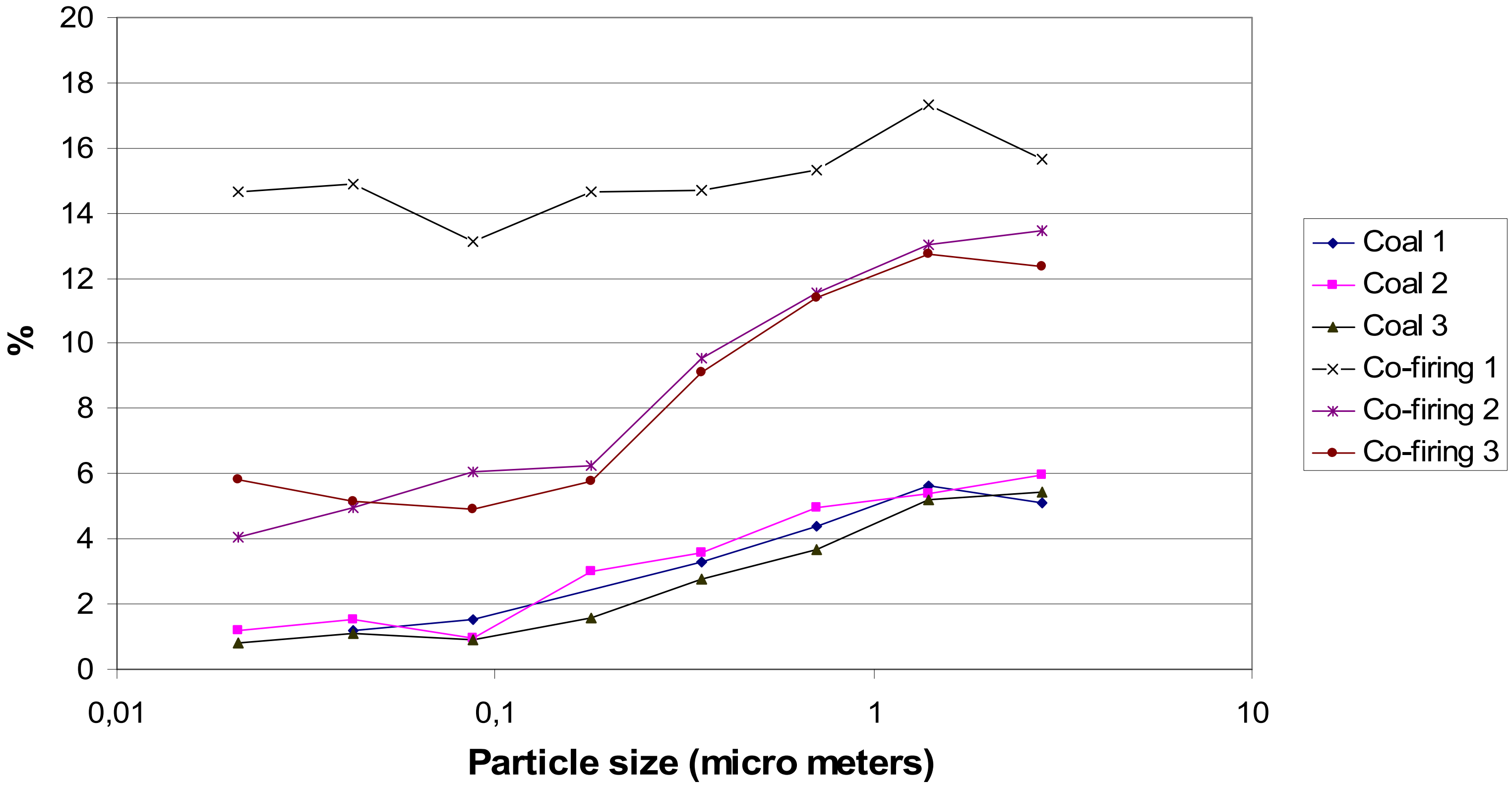
Water soluble potassium and chlorine in fly ash



Impactor measurements of submicron particle size distribution



Impactor measurements – chemical composition
Potassium measured by EDX



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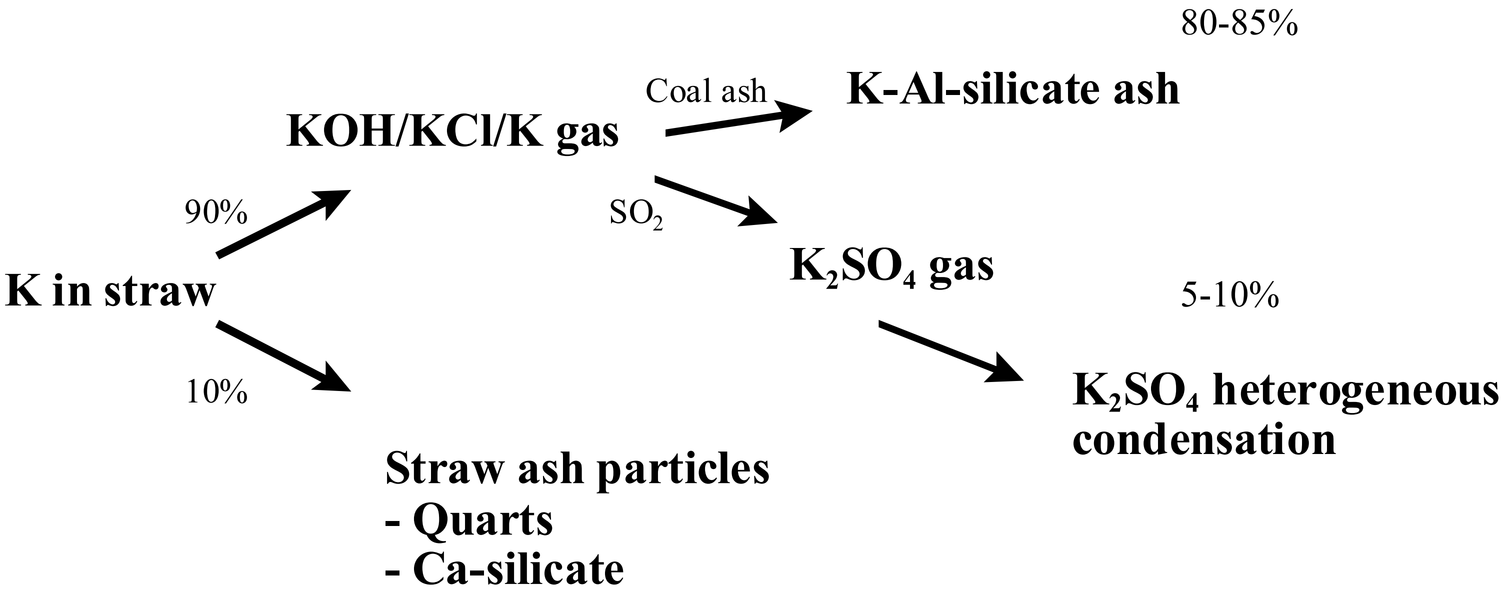
Potassium chemistry at co-combustion of straw in coal-fired PF boiler



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Utilisation of fly ash from straw co-firing

- Coal fly ash is mainly used for cement and concrete in Denmark
- Fly ash from co-firing of straw at Studstrup unit 4 is presently used for cement production – low alkali coal is required
- Use of fly ash from co-firing in concrete is <u>not allowed</u> by EN450
- A revised EN450 will allow co-firing of 20% straw (dry mass basis) if quality requirements can be met
- A compliance test programme initiated in cooperation with Danish concrete industry
- By amendment of national rules use of co-firing fly ash in concrete in Denmark is expected by the end of 2004

Deposit formation and corrosion

Deposit formation:

- No slagging/fouling problems at Studstrup unit 4
- No need for increased soot blowing

Corrosion:

Results from Studstrup unit 1 1996-98:

- No chloride corrosion
- No chloride detected in corrosion samples
- At 10% straw corrosion rates are similar to coal alone
- At 20% straw increased corrosion rates (factor 2-3) due to potassium sulphate

Studstrup unit 4:

- Long term corrosion tests initiated in September 2002

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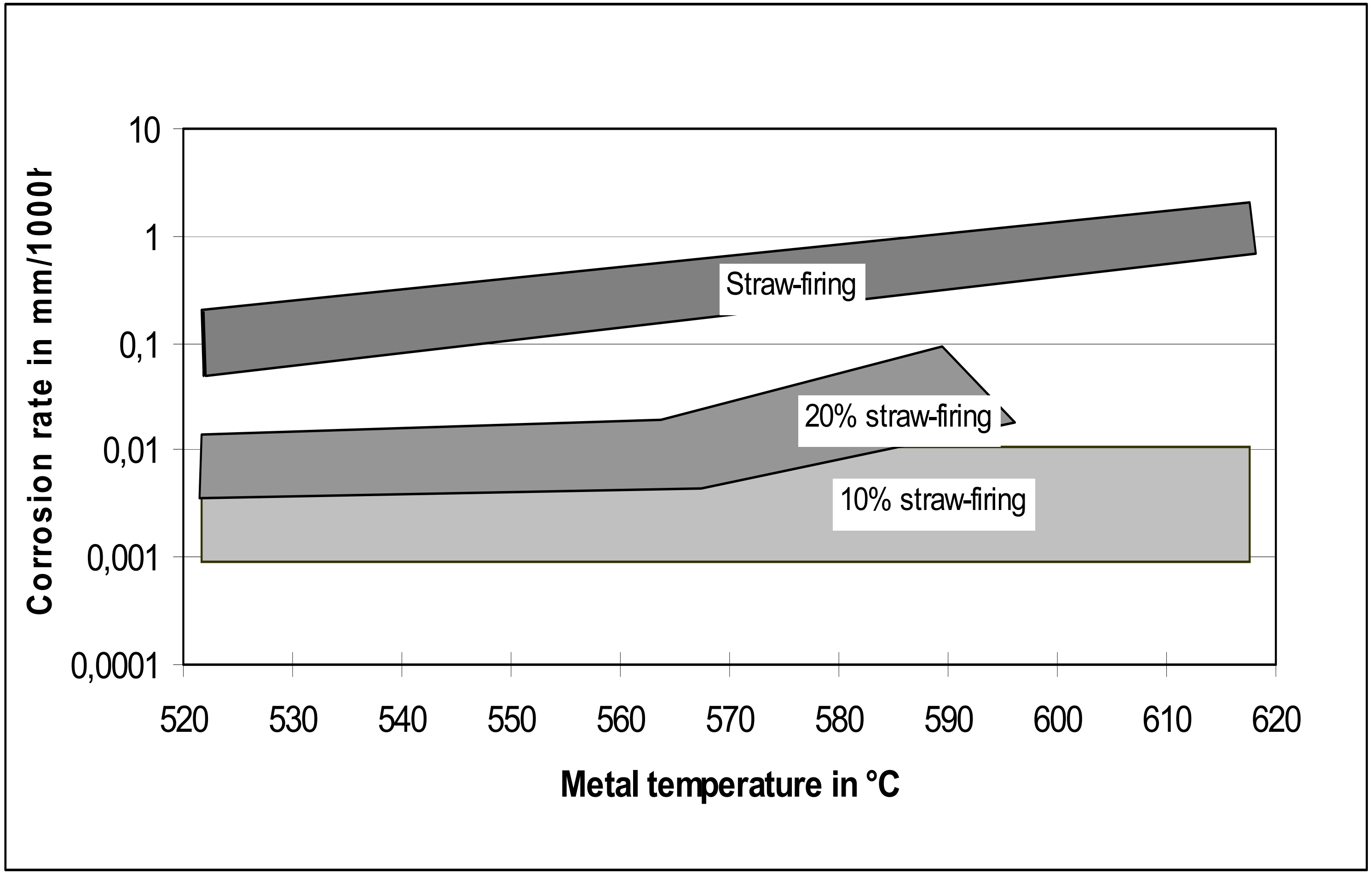
Trends for corrosion rates for austenitic TP347HFG



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High dust SCR catalyst deactivation

Slip stream reactors for exposure of high dust SCR catalysts at Studstrup unit 4 (straw co-firing) and Studstrup unit 3 (coal)

- 3x3 elements
- 150x150x500 mm elements
- Flue gas downstream ECO
- Flue gas temperature 310-380C
- Design flow 4,6 m/s
- Soot blowing by air
- November 2002 – July 2003
- 5000 hours of exposure
- 7% straw on energy basis

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High dust SCR test plant

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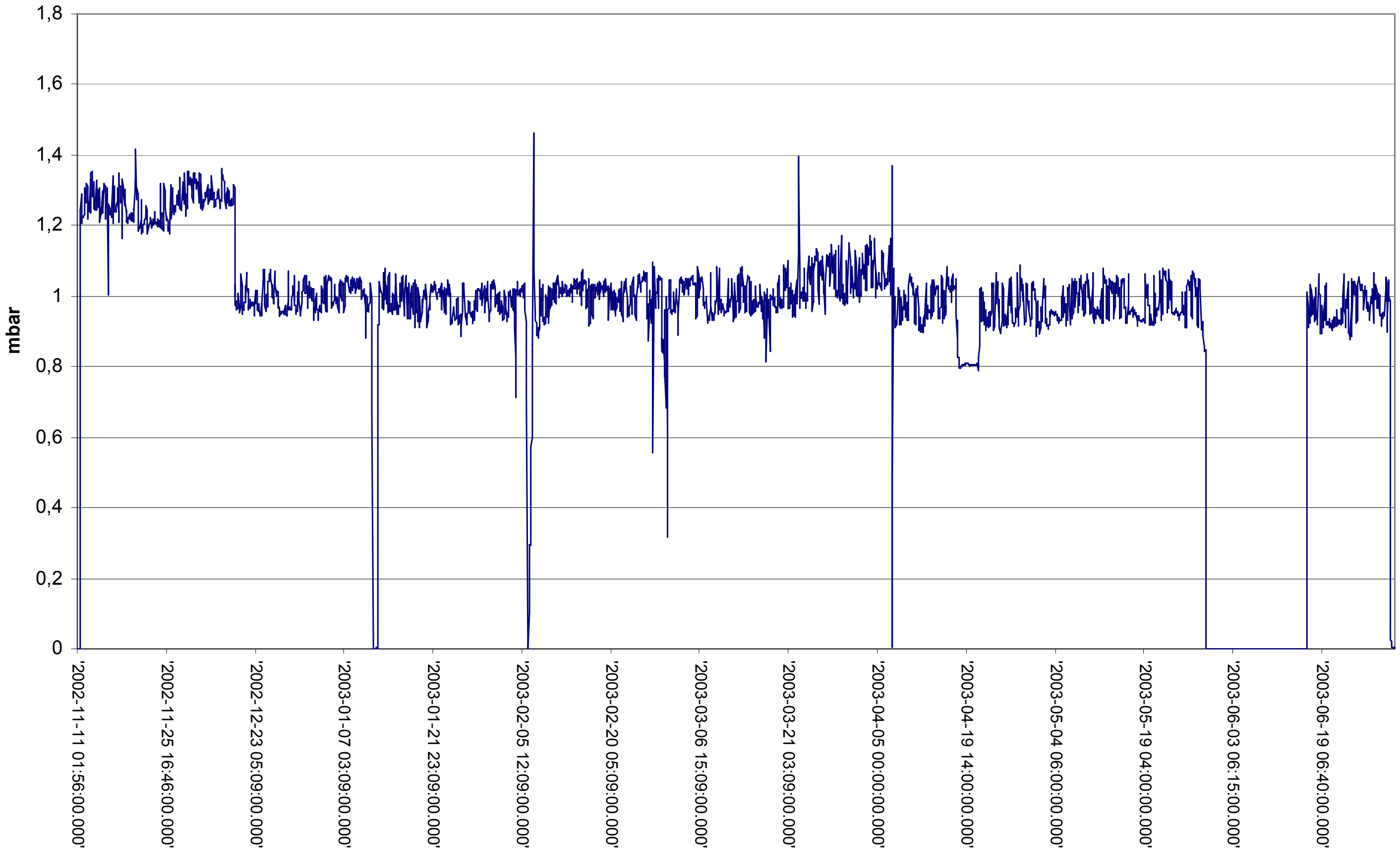
Pressure loss for the coal/straw high dust SCR reactor



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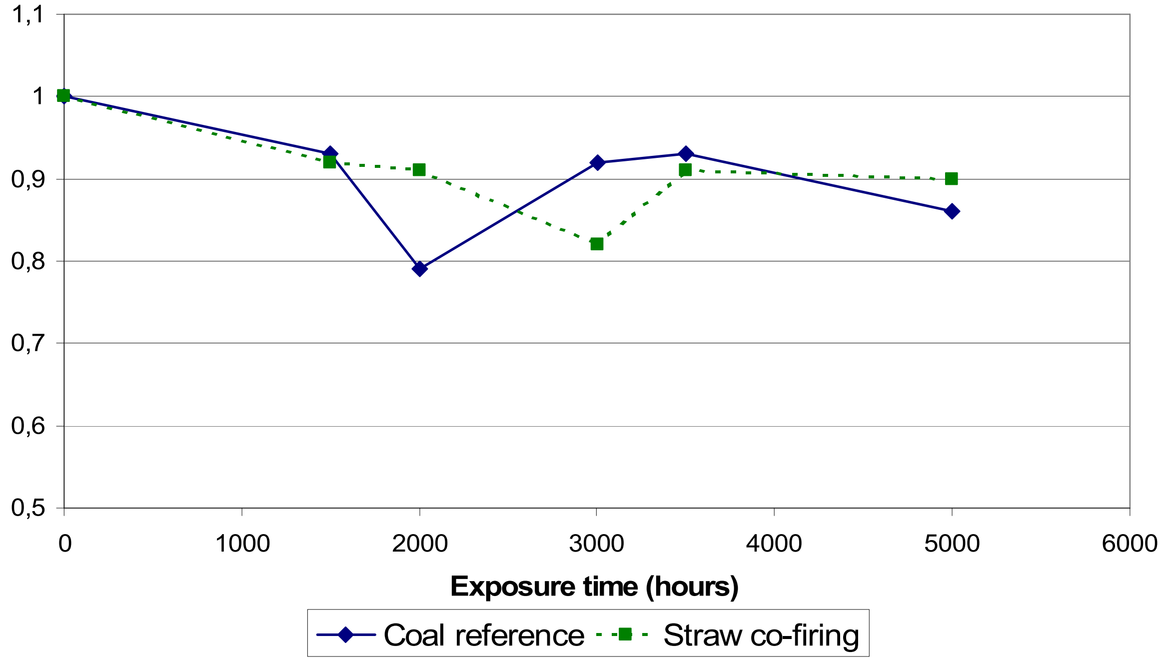
High dust SCR catalyst deactivation

Results for Topsoe catalyst
Relative catalyst activity vs. exposure time



No distiguishable difference in deactivation rate
Similar results for two other catalyst types

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Conclusions

from two years' operation of 10% straw co-firing at Studstrup unit 4

- Acceptable availability of the straw pre-processing unit has been achieved
- LOI in fly ash is reduced by co-firing
- NO_x emissions by co-firing are maintained at the same level as coal firing alone or marginally reduced
- No increase in boiler deposit formation
- Fly ash can be used for cement production and in near future presumably also for concrete
- No increase in deactivation of high dust SCR catalyst by 7% co-firing

Further work on straw co-firing

IN PROGRESS:

- Long term corrosion tests
- Studies on alkali-chlorine-sulphur chemistry
- CFD based model for co-firing plant optimisation

IN PLANNING:

- Long term high dust SCR catalyst deactivation tests