Rotary kiln pyrolysis-
First results of a 3 MW pilot plant

4th International Freiberg Conference on IGCC & XtL Technologies
3-5 May 2010 Dresden, Germany

Michael Halwachs
Overview

- About the project
- Balance of the pyrolysis pilot plant
- Results
- Outlook
About the Project

- Usage of agricultural residues (straw) for power generation is a widely unexplored source of energy
- Cheap feedstock
- Regional available in huge amounts

**Fundamental idea:** Co-firing of straw in an existing coal fired power station

**Problem:** high content of Chlorine (Cl) and Potassium (K) of the straw is harmful for boiler and heat exchanger of the power station
Troubleshooting:

- Split up of the biomass into a volatile fraction that can be used for co-firing and a char fraction by a pyrolysis process.
- The undesired components (Cl, K, Na) should be concentrated in the char fraction.

Pyrolysis-pilot plant Dürnrohr

- Jacked rotary kiln reactor (3 MW_{th})
• Austria’s biggest coal fired power plant

• built as a replacement for the Zwentendorf nuclear power station, a plant that was finished but due to a 1978 referendum never started up

• consists of two blocks → electrical output of 405 MW (operated by Verbund Austrian Thermal Power AG) and electrical output of 352 MW operated by the Energie-Versorgung Niederösterreich (EVN) AG

• The plant is powered by black coal imported from the Czech Republic and Poland but it can also use natural gas as a fuel

• In 2004 a heating plant (largest such in Austria, at the time) using the dissipated waste heat was opened
About the project
Flowsheet

Rotary kiln pyrolysis - First results of a 3 MW pilot plant
Michael Halwachs
Operating figures

- Fuel power of the rotary kiln reactor: 3 MW
- Throughput of straw: ca. 600 to 800 kg/h
- Pyrolysis temperature range: 450 – 630 °C
- Residence time of the feedstock: 30 – 45 min

- Pyrolysis gas characteristics
  - Content of pyrolysis oil (gravimetric): 40 – 200 g/Nm³
  - Content of pyrolysis oil (GC-MS): 30 – 100 g/Nm³
  - Dust and entrained char: 20 – 120 mg/Nm³
Feedstock

- Wheat straw (indoor stored)
- Wheat straw (field stored)
- Maize straw
- Straw pellets
- Sorghum straw
- Reed straw
- Palm nut shells
- Miscanthus straw
- Actiprot
Fuel Samples

Straw Pellets
Wheat Straw
Sorghum Straw
Reed Straw
Palmnut Shells
Miscanthus Straw

Rotary kiln pyrolysis - First results of a 3 MW pilot plant
Michael Halwachs

04.05.2010
Pyrolysis Char Samples
Balance of the plant

- Creating a model of the system
- Process simulation tool IPSEpro (stationary equation oriented flow sheet simulation)
- Validation of measured data
Part of the testing scheme

- **Straw**
  - Variation of the pyrolysis temperature
  - Variation of the residence time

- **Actiprot**
  - Variation of the pyrolysis temperature
Mass- and energy fractions of the pyrolysis products of straw controlled by the pyrolysis temperature.
Fig.: Mass- and energy fractions of the pyrolysis products of Actiprot controlled by the pyrolysis temperature.
Fig.: Separation of the chemical elements in pyrolysis gas, pyrolysis oil and char for a pyrolysis operation of indoor stored straw.
• Chemical efficiency

![Graph showing chemical efficiency vs. pyrolysis temperature](image)
Sankey-diagram for straw pyrolysis for the case of energy supply by pyrolysis gas, energy flows [kW]
Conclusions

- The process works technically correct
- The gaseous product is suitable for co-firing in a coal fired power plant
- The undesired components (Cl, K) are concentrated in the char fraction
- Efficiency is significantly higher than the electrical efficiency of smaller biomass fired power stations or CHP systems.
- Approximately 50% of the energy in the feedstock can be provided for co-firing
- Further investigations on usage of “biochar”
- More Fuels (e.g. sewage sludge, residues from agricultural and paper industry)
Outlook

- Connection of the pyrolysis process to the coal fired power plant.
  - Scenario 1: 1 x 30 MW (one rotary kiln reactor)
  - Scenario 2: 3 x 30 MW (three rotary kiln reactors)