

Discussions and Wrap-Up

Summary and Takeaways from Workshop

Overview

- Workshop topics
 - R&D of fluidized bed combustors and gasifiers
 - Industrial application of fluidized bed technology
- 12 countries represented
 - Austria
 - Canada
 - China
 - Denmark
 - Finland
 - France
 - Greece
 - Korea
 - Japan
 - Spain
 - Sweden
 - United Kingdom

Session 1: R&D

- **Heat and Mass Transfer to Fuel Particles in Fluidized Bed Combustors and Gasifiers**

Bo Leckner, Chalmers University of Technology, Sweden

- Rates of key processes for fuel conversion
 - Devolatilization
 - Char combustion
- Fundamental analysis relating heat and mass transfer coefficients to operating conditions and particle size ratio
 - Presentation of a range of published correlations

Session 1: R&D

- **Ash and Bed Material Research in Fluidized Bed Gasification of Biomass from Lab- to Industrial Scale**

Matthias Kuba, BIOENERGY 2020+, Austria

- Range of reactor sizes, from 4 mm lab scale to 15 MW industrial scale
- Ash–bed material interaction
 - Calcium layer on olivine increases catalytic tar destruction
 - Potassium silicates form, with potassium coming from fuel
 - Layer formation mechanism can be different depending on initial bed material
- Phosphorous-rich fuels present an interesting challenge
- Industrial systems can be optimized to take advantage of improved catalytic activity of used bed material

Session 1: R&D

- **Co-Firing of Torrefied Biomass and Coal in Oxy-FBC with Ilmenite Bed Material**

Robin Hughes, CanmetENERGY, Canada

- Development and first-of-a-kind demonstration of PFB(oxy)C of biomass
 - Starting with torrefied wood to ensure plant operability
 - Simulations to evaluate heat recovery
 - Efficient sulphur removal, improved by high P operation
 - Ilmenite enables oxygen carrier aided combustion (OCAC), which improves burnout performance

Session 2: Industrial Applications

- **GoBiGas – 10,000 Hours of Gasification**

Anton Larsson, Gothenburg Energy, Sweden

- GoBiGas is first large-scale plant (20 MW) for bio-methane through biomass gasification
- Dual fluidized bed gasification
- Availability has improved over time
- Addition of potassium to bed reduced problems with tars
- Efficiency of biomass to biogas conversion 50-60%

Session 2: Industrial Applications

- **Biomass Utilization Status and Example in Fluidized Bed Boiler in Korea**
Kyongil Park, KEPCO, South Korea
 - Korea has a Renewable Portfolio Standard, which stimulated use of biomass
 - Pellets chosen for ease of feeding
 - Pilot-scale CFB reactor tests
 - SO₂ and N₂O decreased with increasing biomass; NO increased slightly
 - Fine fly ash measured by cascading impactor, very finest ash when using biomass consisted of K and Cl

Session 2: Industrial Applications

- **Fluidized Bed Gasification and Combustion of Biomass**

Tomoyoshi Kumagai, IHI Corporation, Japan

- IHI has achieved 100% biomass utilization in both bubbling and circulating fluidized beds
- Have tested wood biomass, agricultural biomass and waste
- IHI also has twin bed gasifier (TIGAR)
 - Bubbling bed gasifier
 - CFB combustor

Session 2: Industrial Applications

- **State of Art CFB Gasifiers and Boilers for Biomass and Waste**

Juhani Isaksson, Valmet, Finland

- Valmet offers BFB and CFB systems for both combustion and gasification applications
 - Includes many of the largest boilers in the world, up to 1GW thermal input
- Many types of biomass have been processed
- Several gasification plants have been delivered, sizes in excess of 100 MW
- Applications of gasifier product gas
 - Industrial kiln fuel
 - Heat boiler boiler
 - Power production

Session 3: R&D

- **Low-Temperature Corrosion in Fluidized Bed Combustion of Biomass**

Emil Vainio, Åbo Akademi University, Finland

- Measurement of SO_3 in industrial boilers
- Hygroscopic deposits in FBC of biomass results in low-temperature corrosion
- Can occur at temperatures well above 100°C
- During downtime, salts result in corrosion

Session 3: R&D

Hydrogen Production from Biomass Feedstocks Utilizing a Spout Fluidized Bed Reactor

Peter Clough, Cranfield University, United Kingdom

- Calcium and nickel based chemical looping process for H₂ production
 - Calcium functions as sorbent
 - Nickel functions as catalyst
 - Particles combining both metals have been produced
- Has evaluated at laboratory scale with small spouted fluidized bed reactor
- Challenges with coking

Session 3: R&D

Opportunities of Hybridization of Concentrated Solar Power (CSP) Plants by Biomass Gasification

Alberto Gomez Barea, University of Seville, Spain

- Hybrid CSP plant is competitive when compared to thermal energy storage
- Biomass would allow better dispatchability
 - Could be implemented either on the energy generation side in parallel with solar collectors
 - Or implemented on power generation side through
- Longer running hours in hybrid configuration means better overall energy conversion efficiency
- Fluidized bed heat exchanger as part of integration

Session 3: R&D

Bed Material-Alkali Interactions during Fuel Conversion in a Fluidized Bed

Pavleta Knutsson, Chalmers University of Technology, Sweden

- Interactions of base bed material (e.g. ilmenite, olivine) with alkali components
 - Formation of sticky layer
 - Enhances catalysis of tar destruction
- Agglomeration not observed for ilmenite as base material with calcium and potassium
- Modeling of potassium substitution of calcium

Session 4: Applications

Assessing CFB Combustors Flexibility with Respect to Load Changes and Fuel Type

Aris Nikolopoulos, CERTH, Greece

- Focus on flexibility of CFB operation
 - Fuel flexibility
 - Rapid variation in firing rate
 - Increase turndown through flue gas recirculation
- Researching through combination of
 - CFD simulation
 - Process modeling
- Case studies

Session 4: Applications

Research & Development and Its Application of Circulating Fluidized Bed Boiler Technology in China

Junfu Lyu, Tsinghua University, China

- Coal washing is an option to reduce pollution associated with coal combustion
- Many large supercritical boilers, up to 600 MW, are being deployed in China
 - Nearly 3,000 units
 - Total installed capacity about 100 GW
- Development of CFB boilers in China
 - 660 MW ultrasupercritical boiler
 - Heat flux and heat transfer
 - SO_x and NO_x emissions

Session 4: Applications

Results from the 100 kW Dual Fluidized Bed Gasifier at TU Wien

Florian Benedikt, TU Wien, Austria

- TU Wien operates dual bed gasifier pilot plant
 - Newest version of gasifier includes restrictions to improve gas-solids mixing time
- Test campaigns
 - Studying various bed materials and combinations of bed materials to explore influence on gas quality, tars
 - Studying various fuels as well
- Studying sorption enhanced reforming (SER)
 - Improved hydrogen production, to 75% of gas

Session 4: Applications

Biggest BFB for Biomass Combustion in France – Lessons Learned

Mathieu Insa, EDF, France

- 140 MW bubbling fluidized bed
 - Brought online in 2010
- Several challenges encountered during initial period of plant operation
 - Biomass fuel preparation, storage, feeding
 - Corrosion and fouling
 - Particulate removal systems
 - But challenges have been addressed

Observations and Thoughts

- Broad range of presentations and scales
 - Combustion and gasification
 - Fundamental science and industrial implementation
 - Single particles as small as 10^{-4} meters
 - Industrial reactors approaching 10^2 meters
- R&D driven by several factors
 - Overall operability and performance
 - Regulations regarding emissions or renewable fuel mandates
- Very practical R&D taking place
 - Application to operating plants
 - Crosscutting topics that apply to both combustion and gasification
 - Good relationship between industry (suppliers, end users) and research community (universities, private companies)

Observations and Thoughts (2)

- Fluidized bed biomass combustion systems available at industrial scale
 - Many operating units worldwide
 - Nonetheless, challenges remain and there is much opportunity for improvements
- Fluidized bed biomass gasification continues to have challenges
 - Not technical showstoppers, but more economic/business-related
- Interesting opportunities for biomass gasification combined with other technologies
 - Renewable energy hybrid processes
 - Combination with coal combustion
- Both IEA-FBC and IEA Bioenergy Task 33 provide useful service for energy production community