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# Biomass Gasification 1974-2004

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#### FOUR GENERATIONS

Gasification 1974-2004

•Feedstocks

•Applications

•Feeders

#### HIGHEST AND BEST USE





## Why Gasify Biomass?

- Fossil Fuel/Gas Replacement
- Liquid Fuels
- Tax Incentives
- Pollution Control
- Ash Management
- Cycle Efficiency
- It sells
- It's fun

### Recent Biomass Gasification

#### 1974-1985

- Public Health Administration Refuse Gasification
- Syngas for Alcohol Fuels
- Tax incentives
- 1985-1998
  - □ 100-200 TPD Plants
  - □ Scaleup/Feeders
  - Power Generation
  - Hot Gas Filtration
- **1998-2004** 
  - □ Co-firing
  - NOx Control



300 psi 180 tpd, Clamecy France

#### Taxifiers

- Time Energy: North Powder, Belle
- Southern California Edison, Southern Companies
- Staged Combustion in Biomass Boilers



#### N Powder or Quincy

#### Fuel Ash and Nutrient Management



# Industrial and Utility Gasifiers





#### FUTURE ENERGY RESOURCES

www.future-energy.com

Figure 1

#### **Co-firing Biomass Boilers**

- Use unconventional fuels
- Reduce NOx
- Hot gas cleaning







### **Cofire Biomass with Coal**



Lahti, Finland

#### Gasification vs Direct Cofiring: Coal + Switchgrass

- 200,000 tons straw
- Ash utilization
- \$12 million investment
- Long term development





#### CHARITON VALLEY BIOMASS PROJECT

#### **Retrieving Bales From Storage**



#### Twine Remover & De-baler Infeed



#### **SWG Burner**



#### Sampling Flyash for Certification

#### **Gasifier Feed Systems**

- Background
- Requirements and Design Options
- Demonstrated Systems
- Challenges for Development

#### **Gasifier Feed Systems**

- Entrained Flow,
   Suspension
  - High pressure (Evergreen/Texaco, EERC)
  - Low pressure (Ensyn, Aerospace)





EERC Transport Reactor Development Unit (TRDU)

#### **Gasifier Feed Systems**

- Fixed Bed Updraft
  - Gasifiers (APCO, Heuristic)
  - Melters (Albany Research, IET, PNL)
- Downdraft
  - Industrial or pilot 10+ MMBtuh (Syngas)
  - Small scale 1 MMBtuh (CPC)
- Fluidized Bed (BFB, CFB)
  - Industrial 100 MMBtuh (BFC, Clinton, SEI, TVA, SCE)
    - **Research and Development** 
      - Large pilot 100 MMBtuh (GTI, FERCO, MTCI/Thermochem)
      - Small pilot 10 MMBtuh (CPC, Pioneer, Dynamotive, GE EER, Hynol, Surlite)
- Hydrolysis reactors (TVA, Weyco)
- Steam Carbonizer (DOD)

#### **Basic Systems**

Overcome Pressure
Meter Fuel
Transfer to Reactor





# Fuel Metering: Feedstock characteristics



#### **Uniform Metering: Cotton Waste, Wood**









#### Uniform Flow= Uniform Reactions





#### Engineer's Dream: Genetically Modified Feedstock





#### Low Pressure: Energy From Wastes

- Non-recycleable paper and packaging
- ISO 14001 Environmental accountability
- Waste and Recycling Markets
- Energy Markets and Residue Disposal





#### **Gasification-Combustion**



#### THE GASIFIER



#### **Gasifier Feed**



#### Fuel Distribution= Chemical Conversion



#### **Common Pressure Problems**

- Pressure Seals
  - Rotating Seals bearing type, lubrication
  - Gate Valve seals
  - Backpressure sealing extrusion device
  - Purge gas fuel voidage, density
    - Purge gas supply, recovery N2, CO2
    - Purge gas quantity
    - Gas displacement –density effects

### Low Pressure Example









#### **Melter Feed Development**



Metal, Slag and Gas Recovery From Waste to Energy Ash



#### Hi Tech Meltdown





- Electronic consumer waste cell phones and printed circuit boards
- Reduce recycling costs through energy recovery (80%)
- Electric arc and plasma enhanced melter



#### Process Development Issues

- High vapor space temperatures
- Minimize purge gas
- Technical, operation and maintenance
- Waste politics
- Sales Expectations
- Foreign culture
- Unique process





#### **Overcoming Pressure**







Lockhoppers, Valves Extruders

#### Pressurized Lockhoppers: GTI



#### Gate Valves for Biomass



#### Valve Seals, Guides







# Clamecy





# Clamecy







### TRANSFER TO GASIFIER



#### BIOMASS GASIFICATION FACILITY, Maui



#### PROCESS FLOW DIAGRAM



# Sunds (METSO) Plug Feeder



### PLUG SCREW FEEDER 1996



Fuel preparation needed for uniform feeding
 Extensive wear on extruder
 Multiple systems for 300 psig

#### INJECTOR



# Plant Modifications June-Sept 1997; Test Oct-Nov 1997



•Bagasse reclaim bin and elevator

- •Drip Tube and Rock Separation, Bagasse Sizing – chopper and hammermill – and densification
- Modified dryer
- •Day bin-weigh hopper, dust collection
- •Lockhopper-Meter Bin-Transfer
- Injector Seals
- •Inert Gas Generator, Compressor, Pressure Vessels and Recycle System
- Gasifier Modification
- Hot Gas Filters
- •Extensive controls, instrumentation safety
- •Improved Gas sampling and analysis (GC)

#### Lockhopper Valves





- Verified principles
- Additional mechanical requirements
- Actuators

#### **Meter Bin**



Level detection at pressure
 Uniform feeding

#### **TRANSFER SCREW**







#### FLARE



### Lock Gas Recovery



#### FEEDERS FUTURE DIRECTIONS

- Prepared Fuels
- Combination Feeders
- Improved Seals
- Continuous Technical Innovation
  - Fuels, fuel preparation
  - Maintenance and operation

#### **Densified Biomass 40 tph**



#### **Future of Applications**

- Liquid Fuels
- Utility
- Industry
- Small Heat and Power Generation CHP

#### SMALL SCALE GASIFICATION:

#### STILL IN DEVELOPMENT









#### Conclusions

Gasification works
It does not solve all fuel related problems
Fuel preparation is essential
It's fun