Introduction to CGPL

Combustion Gasification Propulsion Laboratory
Indian Institute of Science
Bangalore

Indian Institute of Science

- Established in 1909
- Institute of higher education in science and engineering
- More than twenty departments and centres
- Masters program in engineering and research degree in science and engineering

Combustion, Gasification and Propulsion Laboratory

- Part of Aerospace Engineering Dept
  - Involved in aerospace propulsion and combustion
    - Experimental
    - Computational
  - Associated with defense organizations, and other combustion groups, involved in the aerospace research programs

Biomass power research

- Early 1980's - look into the energy needs of agricultural sector through the route of gasification as a part of activity of ASTRA (Application of Science and Technology to Rural Areas, a centre at the institute)
- Both developmental and basic research activity

Major events in biomass research

- Biomass gasification activity – 1982+
- Phase I:
  - 1982 – 1986 – Initial studies on closed top, throat based system close to WW II class
- Phase II:
  - 1986 – 1994 Open top downdraft reburn system – issues of reactor materials and related design being sorted out
  - 1994 – Major Indo-Swiss test at IISc – 10 x 10 hrs – external inspection and analysis
  - 1996 – Major Indo-Swiss test in Switzerland – 10 x 10 hrs – analysis in 3 labs, one from India
  - 1996 – 2000 – Presentations of the science and the results in conferences and workshops in Banff, Canada, Stuttgart, Germany, RIT, Sweden, Riodegeneiro, Brazil, Italy,
- Phase III
  - 2002 - interaction with Engine manufacturers

Research projects in the area of Energy sector

- Over 50 projects have been handled on research and development in the last 5 years (Approx. 40 M USD)
  - 1999 – Major project of MNES – Strategic Development of Bio-energy (SDB)
  - 2000 – NBRAP – Biomass Atlas
  - 2001 – Major project of MNES – Advanced biomass gasification – high pressure gasifier and gas turbine (with BHEL, IICT, IITM)
  - 1999 – Eliminating classical grate concept in favor of screw extraction of char/ash at the bottom
  - 2002 – Breakthrough in gas cleaning – C ^{n} system – chilling the gas to < 7 C leads to a ultra clean gas (<ppb particulate and tar)

Technology packages developed

- Gasification of any biomass to electricity/heat.
- Package with electricity/heat + activated carbon
- Gas turbine adaptation to producer gas
- Precipitated Silica from rice husk/ash/char
- Biogas clean up (of hydrogen sulfide) to electricity via reciprocating gas engines)

Brief overview of technologies

- Gasification of biomass
  - Conversion of solid fuel to gas though thermochemical root
  - Use in IC engines for power generation or thermal applications
  - Use in gas turbines
  - Byproducts such as activated carbon

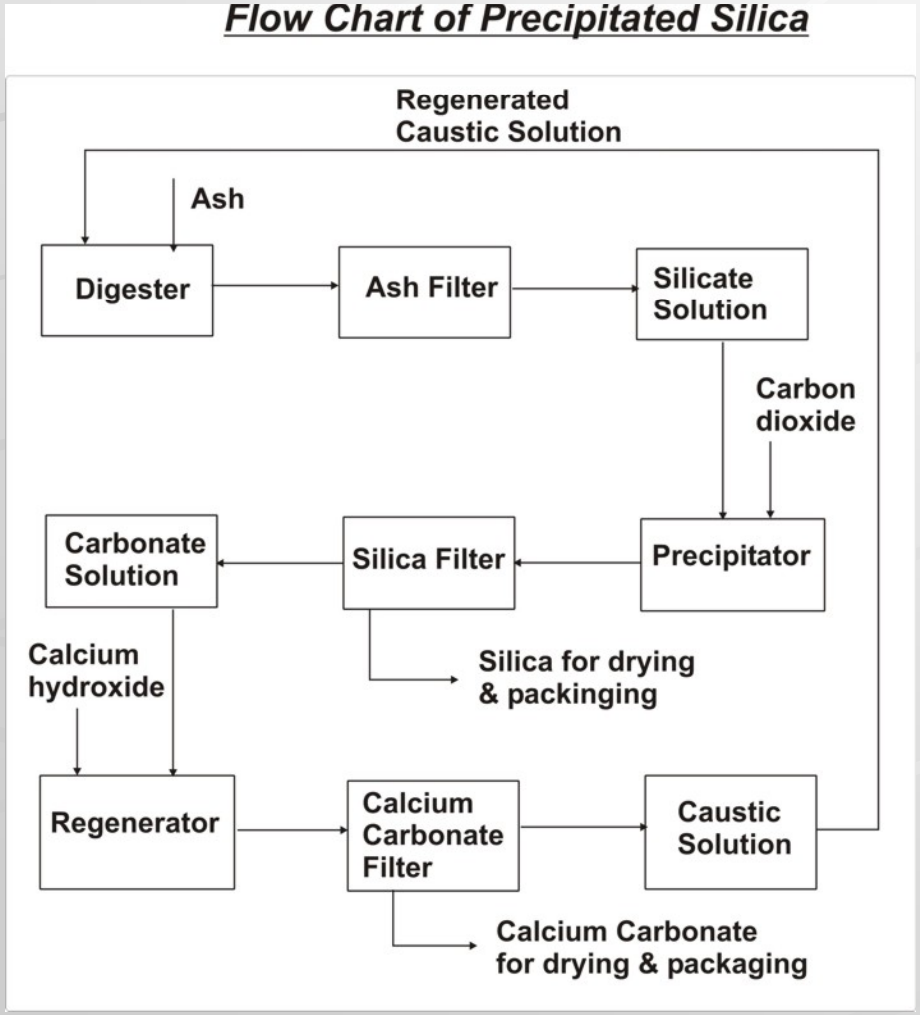
Other Biomass Devices

- Stoves
  - Powdery and solid biomass
- Semi-industrial applications for biomass combustion devices
- Driers
- Water heating systems

Precipitated Silica from rice husk ash

- Rice husk is a widely available agricultural waste
- It is largely used as a fuel—in small scale, and in large scale for electrical power generation and thermal needs
- Rice husk contains 20 % ash and leaves large amount of residue (about 25 %) after it is burnt causing a disposal problem
- Precipitated silica is a high value product (Rs. 40 per kg) having applications in rubber, cosmetics, tooth paste and many other industries
- Production of precipitated silica from rice husk thus solves the disposal problem ash and provides additional revenue stream
- Production cost about Rs. 26 per kg

Precipitated silica - process



- All operations at low temperature (<100ºC)
- Recycling of all chemicals used in the process
- Ability to control the properties of the final product

Sweetening of Biogas

- Biogas is a product of anaerobic biological degradation of biomass
- It consists of methane (50 – 70 %) and carbon dioxide
- Biogas from industrial effluents, sewerage treatment plants, etc also contains hydrogen sulphide, which
  - Is toxic and corrosive
  - On burning releases SO_2 to atmosphere
  - Makes biogas unsuitable to be used in IC engines

The process

- Converting H2S to solid sulphur through a redox process

$$2Fe^{3+} + S^{2-} \rightarrow 2Fe^{2+} + S\downarrow$$

$$4Fe^{2+} + O^{2-} \rightarrow 4Fe^{3+} + H_2O$$

- Two stage counter current operation for absorption
- Filtration of the sulfur generated
- Oxidation of the ferrous ions in the regenerator

Features of the process

- H_2S is converted into elemental sulfur, which has commercial value.
- Low H_2S concentration at the outlet (<10 ppm).
- Process works at ambient temperature with easy start up and shut down procedure.
- Capable of handling fluctuations in gas flow rates and H_2S percentages.
- Low running costs of Rs. 0.50/kWh (at 3 % H_2S) as scrubbing solution is completely regenerated

Summary

- CGPL has developed several biomass to energy technologies and byproduct utilization related to these technologies
- Industrialization/ commercialization of the technologies developed has been a major thrust

Thank you