Gasification: An Old Technology for a New Use

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Gasification: An Old Technology for a New Use
Process, Products, and Applications

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The Source of All Energy

West Central Research and Outreach Center
Making Biomass Energy

Carbon Dioxide (CO₂) + Water (H₂O) + Energy → Photosynthesis → Carbon-Hydrogen Bonds

Store Energy

Also:
- Starches (grains)
- Lignins (wood)
Converting Biomass Energy

Cellulose
(or Starch, Lignin)

Octane
Methane
Ethane
Heat
Conversion of Biomass to Energy

- Biochemical (mostly use microorganisms)
  - Bacteria
  - Enzymes
  - Chemical treatment

- Thermochemical (use heat)
  - Combustion (fire)
  - Gasification
  - Pyrolysis
Gasification

- Thermochemical conversion
- Converts biomass to vaporous gas (like natural gas, not a liquid fuel)
- Concept is very simple
  
  Biomass is heated with limited oxygen

  Typically 600-1000 °C
  30% of the oxygen needed  full combustion
Gasification Chemistry

Cellulose (or starch, lignin) + \( \text{O}_2 \) (30% needed for Combustion)

Heat → Gas (producer)

Methane
Ethane
Carbon Monoxide
Hydrogen
Historic Gasification Uses

• Coal Gasification ‘town gas’
  – Before natural gas was widely available
  – Started as by-product from coke production

• Transportation systems
  – In places/times with limited access to oil
Bus, Germany
Miami, Florida, 1981. A charge of 110 lb of wood in the generator of this wood-powered 8,000-lb Lincoln Continental limousine takes it 85 miles or so on flat Florida terrain. In 1981, under a contract from the Department of Energy, its owner toured many southern universities demonstrating producer gas technology, especially to engineering students. (H. La Fontaine, 1995 Keystone Boulevard, Miami, Florida 33181, USA)
Many Variations of Gasification

- Updraft
- Downdraft
- Fluidized bed
- Steam gasification
- Oxygen gasification
- Plasma arc gasification
THE GASIFICATION PROCESS

Biomass Falls in the top

Air is pushed in bottom

Gas is pulled out on the side

Animation Courtesy: www.woodgas.com
Gasification Feedstocks

- Almost any material with hydro-carbon bonds **CAN** be gasified
  - Virgin plant Material
  - Residues from agriculture
  - By-products from industry
  - Municipal solid waste
  - Municipal or ag Sewage sludge
Feedstock properties

- Organic components
  - Starch
  - Cellulose and hemicellulose
  - Lignin

- Contaminants
  - Minerals
  - Dirt and Sand
  - Industrial contaminants from primary use
Example Feedstocks

- Wheat Straw
- Turkey Manure
- Almond Shells
- Newspaper
- Orange Peels
- Wood Chips
- Oat Hulls
- Fish canning plant waste
Industrial Biomass and Garbage

- BTUs Vary
- Often Contaminated with a variety of substances
  - Contaminants may or may not be a problem
    - Depends on the substance and gasifier
- Moisture Varies
Wood Biomass

• High BTU
  – 9,000+ BTUs depending on wood, moisture
  – Cellulose, hemicelullose, lignin
• Few Contaminants
  – Bark may have some dirt and sand
• Can have higher moisture
Agricultural Biomass (not grain)

- Moderate BTU
  - per pound BTUs 6,000 to 7,000 when dry
- Often Contaminated with Dirt and Sand
- Moisture
  - Can be a large storage problem
  - Often not a problem if harvested dry
Gasification Chemistry II

Cellulose

+ Silica
+ Other Contaminants
+ \( O_2 \) (from air)

\[
\text{Ash (with silica and contaminants)}
\]

\[
\text{Methane}
\]

\[
\text{Ethane}
\]

\[
\text{Carbon Monoxide}
\]
Deciding on a Gasification System

• What is your goal?
  – Heat? Natural gas substitute? Ethanol?

• What is your feedstock?
  – Wood? Coal? Garbage?

• How much can you invest?
Maximizing Efficiency and Money

- Gasification produces HEAT very efficiently.
- Synthesis gas is hot and combustion of the low BTU gas generates more heat.
- Every additional step results in loss of energy.
- Gasification handles certain contaminants very well compared with other conversion methods
Gasification Uses

- Plastics, Resins
- Small chain hydrocarbons

**Industrial products**

- Combustion of Syn Gas
- Production of Steam
- Electric Turbine

**Energy**

- Use in a Combustion Engine
- Electric Generator
- Conversion to Liquid Fuels
- Use in a Combustion Engine
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Photos:
  » Wikipedia.org
  » www.woodgas.com

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