Renewable Energy and Fuel from Waste

Thermochemical Pathways

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Gasification Overview

What Is Gasification?
1. Gasification is a thermochemical conversion process in which any carbonaceous feedstock is converted into a combustible gas through partial oxidation; essentially into a mixture of CO and H₂.
2. Feedstock experience: Heating and drying, pyrolysis, devolatilization, and combustion
3. C₅H₁₀ + n/2 O₂ = n CO + m/2 H₂ is the overall reaction
4. Gasifier is a high capital cost device ($50,000,000-500,000,000) and is the main unit in the IGCC plant

Why Gasification?
- Ability to recover 72% - 85% of the chemical energy stored in the dirty feedstock into clean gas
- Feedstock flexibility: refinery residuals, coal, biomass, as well as:
  - Municipal Waste
  - Industrial Waste
  - Domestic Waste
  - Sawdust Sludge
  - Rubber
  - Contaminated Water

Product flexibility:
- Fuel, chemicals, and fertilizers
- Plausible environmental impact: Amenable for pollutant and gas clean up, CO₂ capture for EOR
- Added power station efficiency due to higher operating temperature

Current Technology & Objective

Gasification Technology:
- Three primary technologies are distributed: Sasol-Lurgi: 34%, GE 31% and Shell at 28%
- 1) fixed/moving bed gasifiers
- 2) fluidized/bubbling bed gasifiers
- 3) Entrained flow gasifiers

Current focus: Two-stage, upflow with multiple feed-inlets high conversion rate (>99%), high throughput, and high HV

Work in Progress

1) Characterizing the physical and chemical properties of feedstock using traditional proximate and ultimate analysis method: Examining the physics and chemistry of gasification as applied to a wide variety of feedstock, from refinery residue to industrial, agricultural and/or municipal waste, to biosolids.
2) Carrying out “systematic” zero-dimension analysis:
- Composition, Heating Value, and gasifier reactions:
  - Biomass =⇒ CH₄, CO, Δ H = 131MJ/kg
  - Cellulose =⇒ CH₄, CO, Δ H = 131MJ/kg
  - Peat =⇒ CH₄, CO, Δ H = 131MJ/kg
  - Coal =⇒ CH₄, CO, Δ H = 131MJ/kg
  - Tire waste =⇒ CH₄, CO

World gasification database (NETL 2007):
- Current gasification capacity has grown to 56,238MMth with a total of 144 plants operating 427 gasifiers.
- Located in 27 countries, Asia/Australia at 34% and Africa/Middle East at 27% of this capacity.
- Consumption rate: Coal 55%, petroleum 33%. Others 12% natural gas, pet coke, and biomass/wastes.
- Syngas usage: Chemicals 45%, Fisher-Tropsch 28%, power generation 19%, and gaseous fuel 8%.