Biomass Gasification

Process and Applications

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Biomass gasification basics (1)

- Biomass gasification is a thermo-chemical conversion process in which solid biomass reacts with a limited amount of air (or another oxydising agent), resulting in the production of a combustible gas.
- The gas (called producer gas) can be used for the production of power (in a gas or diesel engine), or for thermal applications (e.g. in a boiler or dryer).

Biomass gasification basics (2)

- The gasification process comprises a number of endothermic and exothermic reactions. Reaction products are:
  - Producer gas (CO, H_2, CH_4, CO_2, H_2O and N_2 when air is used)
  - Char (solid carbon)
  - Tars (condensable vapours)
  - Ash (from the biomass)
- The producer gas typically has a Net Calorific Value between 4-6 MJ/m^3, i.e. about 5-7 times lower than that of natural gas(36 MJ/kg) or biogas (22 MJ/kg). Depending on the application, it may need to be cooled down and cleaned of tars and solid particles.

Advantages and drawbacks

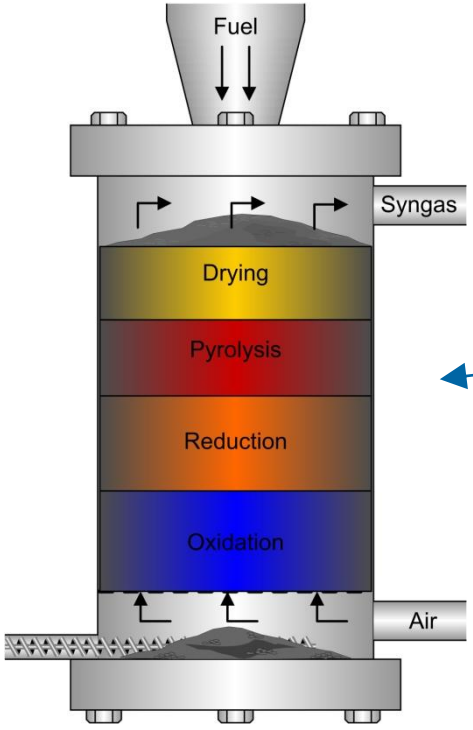
- Advantages of gasification
  - Applicable at small scales (~10 kWe upward)
  - Relatively high conversion efficiencies (η_e>15%)
  - Modest investment costs (~1500 US$/kWe at small scales)
  - Suitable for some agricultural residues and wood
- Main drawbacks of gasification
  - Technical and managerial skills required
  - Sensitive to fuel quality
  - Solid and liquid effluents
  - Not suitable for all types of loads (turndown ratio)

Biomass characteristics

- Important biomass characteristics related to gasification:
  - Moisture content (should be as low as possible)
  - Ash content and composition (e.g. melting behaviour)
  - Morphology and bulk density (should be constant)
  - Volatile matter content
- Getting the biomass fuel up to the required specifications is a very important aspect!

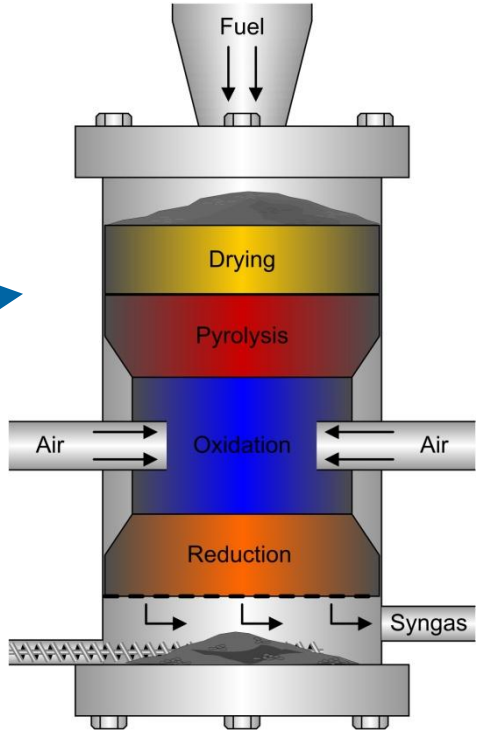
Gasifier types: fixed bed

- **Fixed bed** reactors are relatively straightforward vessels. The biomass enters from the top and moves down by gravity.



Updraft gasifier. A simple type of gasifier, with a high efficiency and relatively insensitive to biomass variations. However, the raw gas contains large amounts of tar which, depending on the application, may need to be removed.

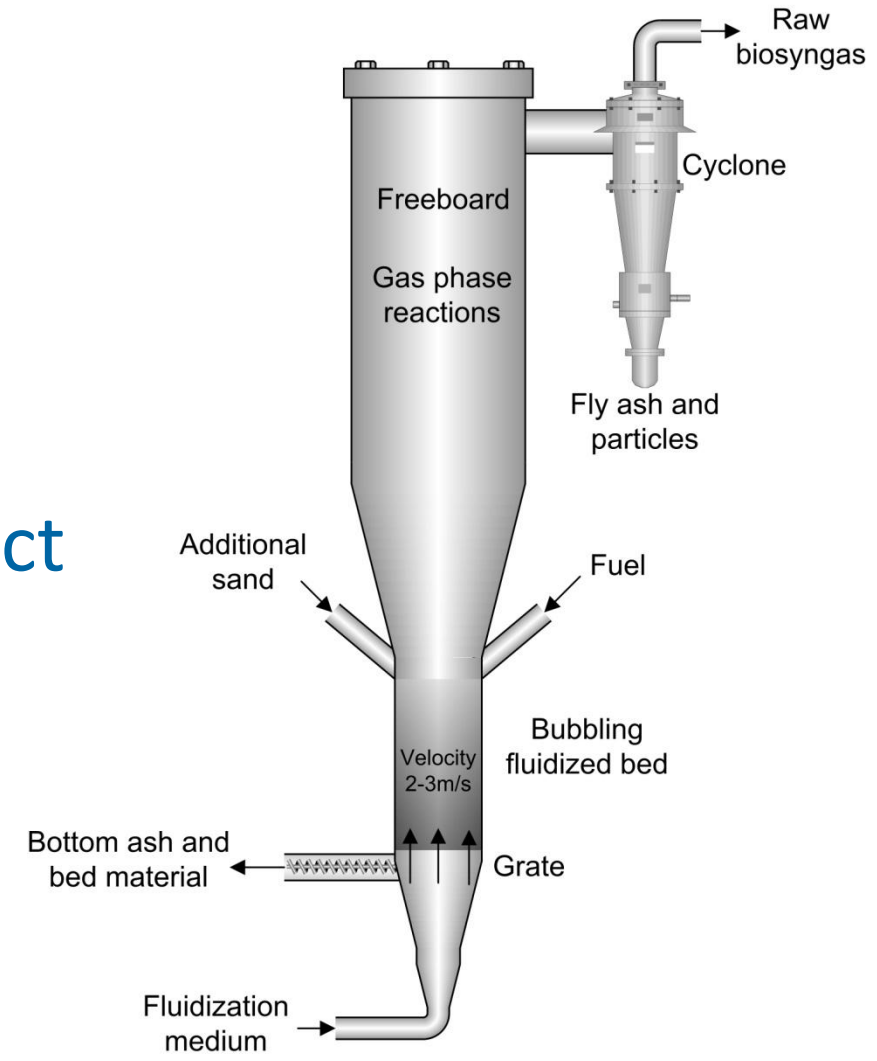
Downdraft gasifier. This type produces little tar which makes it more suitable for engine applications. However, it requires more strict fuel specifications (moisture, size) and its scalability is limited.



pictures: www.gasification.eu

Gasifier types: fluidised bed

- In **fluidised bed** gasifiers, the biomass is brought into an inert bed of fluidised material (e.g. sand). Such systems are less sensitive to fuel variations but produce larger amounts of tar and dust. They are more compact but also more complex, and usually used at larger scales.



Bubbling fluidised bed gasifier

picture: www.gasifiaction.eu

Gas conditioning

- “Raw” producer gas is very hot and contains ash and tar
- When the gas is to be used in an engine, it needs to be cooled down (volume reduction!) and cleaned:
  - Cooling down can be done with a wet scrubber
  - Cleaning with one or more filters, e.g. bed filter, cyclone…

Gas utilization

- Power production (Electricity, shaft)
  - Gas engine
  - Diesel engine (requires > 20% diesel)
  - Engine derating!
- Heat production
  - Drying processes, e.g. in agro-industry
  - Cement kilns
  - Steam or hot water production
- Other (syngas)
  - Chemical industry
  - Fisher-Tropsch diesel (BtL)

Case study: village electrification (1)

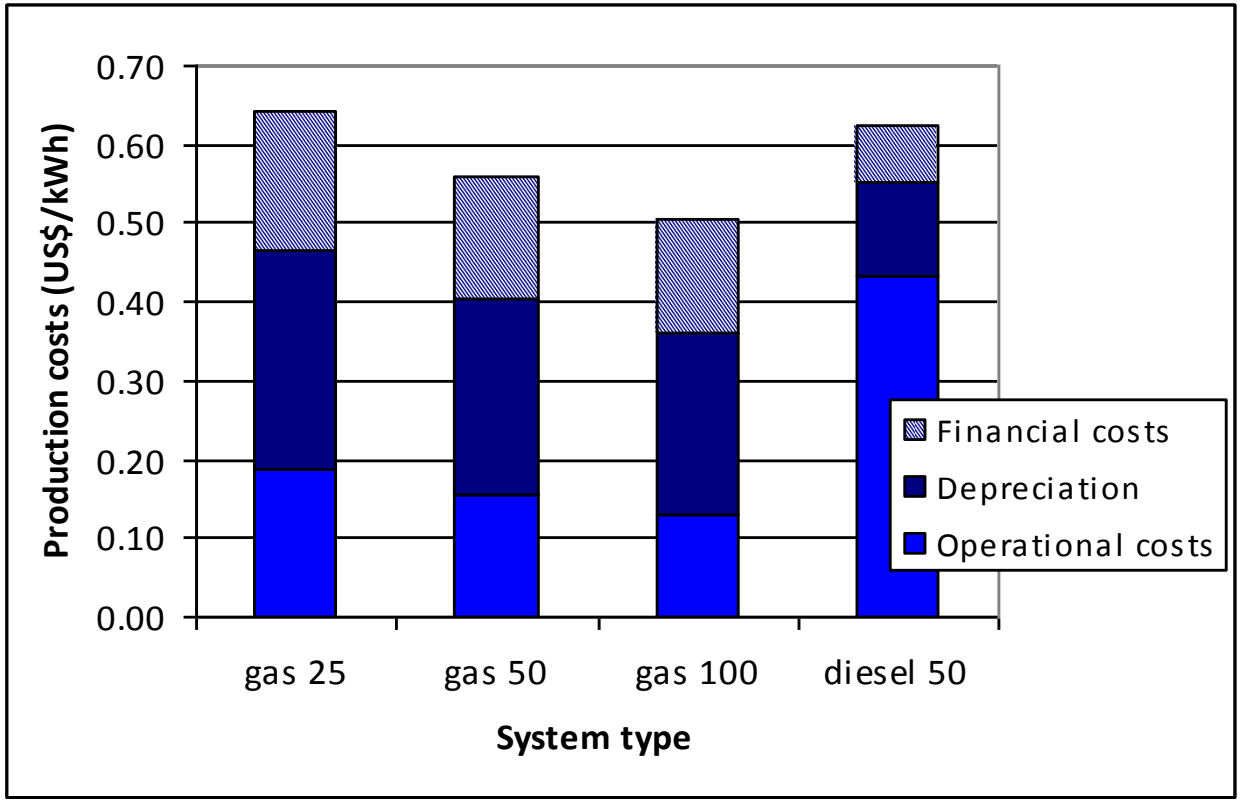
- Based on fixed bed downdraft gasification system of Indian make (Ankur Scientific)
- 50 kWe system supplying electricity to an isolated grid
- Fuel used: fast growing wood (Leucaena), locally grown by farmers.

Case study: village electrification (2)

- Annual electricity production: 42,000 kWh (4200 h/a, 25% loading rate, 20% losses and own consumption)
- Wood consumption: 1.5 kg/kWh, approx 80 t/a (moisture content 20%)
- Operation and maintenance by two full time staff

Case study: village electrification (3)

- Production and distribution costs: approx 0.56 US$/kWh
- More than 70% are capital costs (depreciation and interest), rest is operational costs



Thank you for your attention.

Questions?

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