ETIP Bioenergy
European Technology and Innovation Platform

Power and heat via gasification

DEFINITION

Gasification is a thermochemical conversion process at 800-1,300°C using a sub-stoichiometric amount of oxygen (typically $\lambda = 0.2\text{-}0.5$). Under these conditions, the biomass is fragmented into raw gas consisting of rather simple molecules, such as: hydrogen (H_2), carbon monoxide (CO), carbon dioxide (CO_2), water (H_2O), methane (CH_4), H_2S, NH_3, HCl, etc. Solid by-products are: tar, char, and inorganic matter. For gasification, any lignocellulosic material is suitable as feedstock. This includes wood from forestry, short rotation coppice, and lignocellulosic energy crops, such as energy grasses and reeds and biomass from dedicated felling of forestry wood.

PROCESS TECHNOLOGY

After size reduction, the raw material is moved into the gasifier. Depending on the desired raw gas composition, typical gasification agents are oxygen and water/steam. The combustible part of the raw gas consists of H_2, CO, CH_4 and short chain hydrocarbons; the non-combustible components are inert gases. A higher process temperature or the use of steam as gasification agent lead to an increased H_2 content. High pressure, on the other hand, decreases the H_2 and CO contents.

Entrained-flow gasifiers operate at high temperatures (1,000-1,300°C) and are suitable when a low CH_4 content is preferred, however feedstocks with very low particle sizes are required. Bubbling and circulating bed gasifiers operate at lower temperatures (800-1,000°C) and can use highly heterogeneous materials.

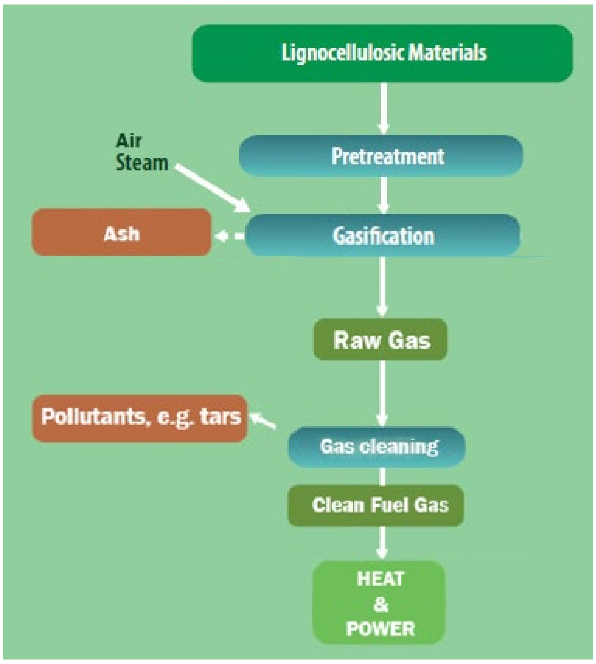

Figure 1: Power and heat via gasification value chain

The process heat can either come from an autothermal partial combustion of the processed material in the gasification stage or allothermally via heat exchangers or a heat transferring medium. In the latter case, heat may be generated by combusting the processed material (i.e. combustion and gasification are physically separated) or from external sources. After the gasification process, impurities such as dust, inorganic matter, bed material, tars and alkali compounds are removed through various cleaning steps. The cleaned raw gas, now a clean fuel gas, must meet the quality requirement of the power (and heat) generating unit.

APPLICATIONS

- Use as engine or gas turbine fuel: The clean fuel gas can be used in spark-ignited (Otto) engines and in compression (Diesel) engines and for gas turbines for power and heat production. Engines are applied for power generation in the range 15 kW - 10 MW. Biomass-to-electricity efficiency in practice lies between 25-30%, and the overall performance between 80-85%.
- Stand-alone power production: For waste fuels (MSW, RDF etc.) conventional incinerators have a lower efficiency (approximately 25%) compared to other thermal power plants because the steam superheat temperature is limited to 400-450°C due to corrosion. A gasifier can be linked to a gas boiler via an intermediate gas cleaning to remove alkalis and chlorine, and overcome the limitations on the superheat temperature, thereby allowing a more efficient (30-35%) steam cycle.
- Use for co-firing: In existing large-scale power plants, co-firing is used to replace part of the fossil fuels (coal, oil, natural gas) with renewable energy carriers. Here the feedstock can be gasified before feeding gas to the boiler (indirect co-firing) to achieve technical advantages such as higher fuel flexibility and cleaner combustion.
- Industrial high-temperature process heat: Gasifiers are also used to produce a fuel gas that wholly or partially substitutes fossil fuels in industrial high-temperature applications such as the pulp and paper industries and cement kilns.

EXAMPLES OF DEMOPLANTS

https://www.etipbioenergy.eu/databases/production-facilities

Location: Skive (Denmark)

Plant: Skive gasification plant, run by city of Skive; operational since 2008, (TRL 9)

Electrical power: 6 MW_{el}, sold to grid

Thermal power: 13 MW_{th}, delivered via district heating network

Technology: Bubbling fluidized bed gasifier

Feedstock: Pelletized forest residues

Link: https://www.skivefjernvarme.dk/, https://www.ieabioenergy.com/wp-content/uploads/2018/02/5-Gasifier-Skive-DH_DK_Final.pdf

Location: Vaasa, Finland

Plant: **Vaasa plant**, owned by Vaskiluodon Voima, operational since 2012 (TRL 9)

Feedstock input: 140 MW

Technology: Circulating fluidized bed gasifier, product gas feeding into a coal-fired power plant (overall capacity of 230 MW_{el} and 170MW_{th})

Feedstock: mainly woodchips made from forest residues (up to 90%), the rest being energy peat and agriculture residues

Link: https://www.vv.fi/wp-content/uploads/sites/8/2017/03/Vaskiluodon_Voima_2013_v4-painoon-2.pdf

More information on www.etipbioenergy.eu.

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