Biomass fuelled combustion technology

The size and model of equipment for commercial scale applications should be carefully scoped prior to purchase. This scale of heat plant also generally needs bulk delivery of fuel. The fuel could be wood chips, hogged fuel or wood pellets. Each fuel type has different transport, storage and combustion characteristics. These issues and securing a fuel supply are important aspects of the process of using wood fuel on a commercial scale. They should be assessed as part of assessing equipment selection.

Heat plant is always designed for specific grades and characteristic of fuel. For example, if using wet fuel then a fluid bed type combustor, however if the fuel is drier, then conventional combustor technology may suit. For conventional combustors there are however a range of types of fire grate. It's essential to take the type of grate into account according to the fuel available e.g., an open weave reciprocating grate would be of little use for sawdust when a pin hole grate is likely to be more appropriate.

The most important aspect to consider when choosing heat plant is the type and availability of biomass fuel over the expected economic life of the equipment. One thing is near certain with biomass fuel – it will change its sources and type over the life of any facility. If fuel type or sources is expected to change over the life of facility then a more flexible technology should be considered. If the fuel can be made consistently such as specification compliant wood pellets then a more narrow equipment choice can be made.

Identify the fuel over the expected life of the facility and then consider technology that suits that fuel.
(not the reverse)

Combustion[1]

Direct combustion is the best established and most commonly used technology for converting biomass to heat. During combustion, biomass fuel is burnt in excess air to produce heat. The first stage of combustion involves the evolution of combustible vapours from the biomass, which burn as flames. The residual material, in the form of charcoal, is burnt in a forced air supply to give more heat. The hot combustion gases are sometimes used directly for product drying, but more usually they are passed through a heat exchanger to produce hot air, hot water or steam.

[1] From Summary of Biomass Combustion Technologies, By Salman Zafar. March 28, 2019 https://www.bioenergyconsult.com/biomass-combustion-systems/

The combustion efficiency depends primarily on good contact between the oxygen in the air and the biomass fuel. The main products of efficient biomass combustion are carbon dioxide and water vapor, however tars, smoke and alkaline ash particles are also emitted. Minimization of these emissions and accommodation of their possible effects are important concerns in the design of environmentally acceptable biomass combustion systems.

Biomass combustion systems, based on a range of furnace designs, can be very efficient at producing hot gases, hot air, hot water or steam, typically recovering 65-90% of the energy contained in the fuel. Lower efficiencies are generally associated with wetter fuels. To cope with a diversity of fuel characteristics and combustion requirements, a number of designs of combustion furnaces or combustors are routinely utilized around the world

Underfeed stokers

Biomass is fed into the combustion zone from underneath a firing grate. These stoker designs are only suitable for small scale systems up to a nominal boiler capacity of 6 MWth and for biomass fuels with low ash content, such as wood chips and sawdust. High ash content fuels such as bark, straw and cereals need more efficient ash removal systems. Sintered or molten ash particles covering the upper surface of the fuel bed can cause problems in underfeed stokers due to unstable combustion conditions when the fuel and the air are breaking through the ash covered surface.

Grate stokers

The most common type of biomass boiler is based on a grate to support a bed of fuel and to mix a controlled amount of combustion air, which often enters from beneath the grate. Biomass fuel is added at one end of the grate and is burned in a fuel bed which moves progressively down the grate, either via gravity or with mechanical assistance, to an ash removal system at the other end. In more sophisticated designs this allows the overall combustion process to be separated into its three main activities:

- Initial fuel drying
- Ignition and combustion of volatile constituents
- Burning out of the char.

Grate stokers are well proven and reliable and can tolerate wide variations in fuel quality (i.e. variations in moisture content and particle size) as well as fuels with high ash content. They are also controllable and efficient.

Fluidized bed boilers

The basis for a fluidized bed combustion system is a bed of an inert mineral such as sand or limestone through which air is blown from below. The air is pumped through the bed in sufficient volume and at a high enough pressure to entrain the small particles of the bed material so that they behave much like a fluid.

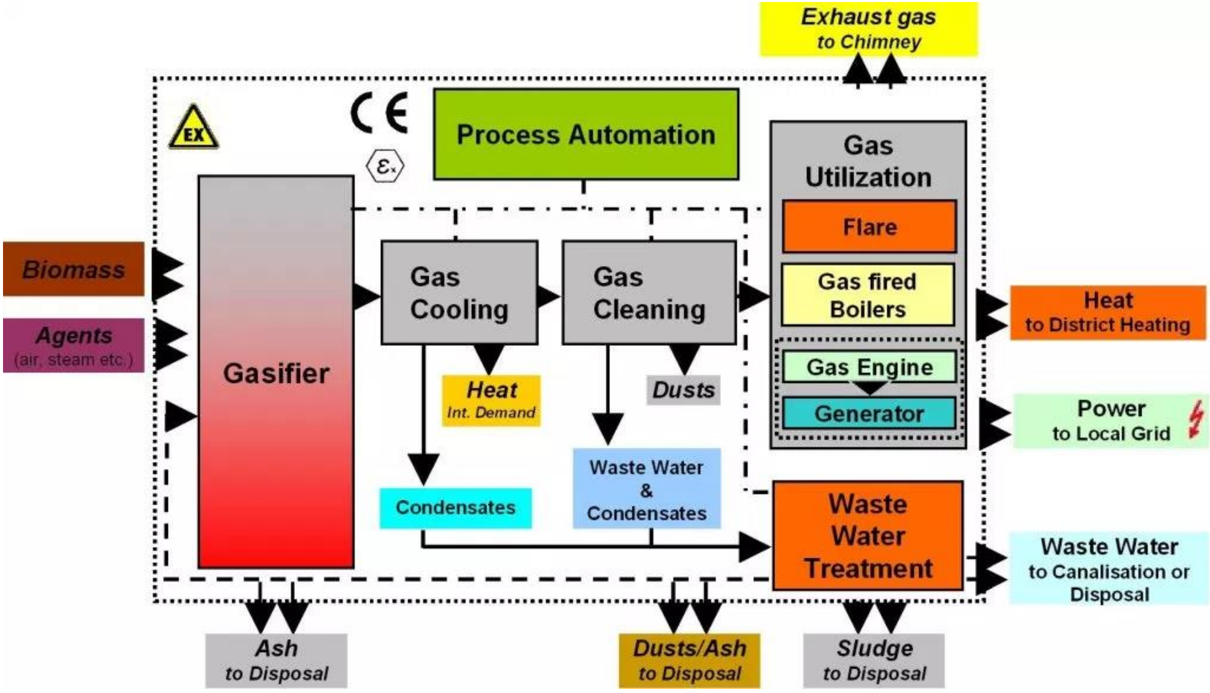
The combustion chamber of a fluidized bed plant is shaped so that above a certain height the air velocity drops below that necessary to entrain the particles. This helps retain the bulk of the entrained bed material towards the bottom of the chamber. Once the bed becomes hot, combustible material introduced into it will burn, generating heat as in a more conventional furnace. The proportion of combustible material such as biomass within the bed is normally only around 5%. The primary driving force for development of fluidized bed combustion is reduced SO2 and NOx emissions from coal combustion.

Bubbling fluidized bed (BFB) combustors are of interest for plants with a nominal boiler capacity greater than 10 MWth. Circulating fluidized bed (CFB) combustors are more suitable for plants larger than 30 MWth. The minimum plant size below which CFB and BFB technologies are not economically competitive is considered to be around 5-10 MWe.

Gasification technology

Gasification[2] is a process that converts organic or fossil based carbonaceous materials into carbon monoxide, hydrogen and carbon dioxide. This is achieved by reacting the material at high temperatures (>700 °C), without combustion, with a controlled amount of oxygen and/or steam.

The resulting gas mixture is called syngas or producer gas and is itself a fuel. The power derived from gasification and combustion of the resultant gas is considered to be a source of renewable energy if the gasified compounds were obtained from biomass.



Layout of a Typical Biomass Gasification Plant[3]

The advantage of gasification is that using the syngas is potentially more efficient than direct combustion of the original fuel because it can be combusted at higher temperatures to improve thermodynamic efficiency.

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[2] Acknowledgement http://en.wikipedia.org/wiki/Gasification

[3] https://www.bioenergyconsult.com/biomass-gasification/

Syngas may be burned directly in gas engines, used to produce methanol and hydrogen, or converted via the Fischer–Tropsch process into synthetic fuel. Gasification can also begin with material which would otherwise have been disposed of such as biodegradable waste. In addition, the high-temperature process refines out corrosive ash elements such as chloride and potassium, allowing clean gas production from otherwise problematic fuels.

The Wood Technology Research Centre at the University of Canterbury undertakes research into gasification from wood fuel and have built a 100kW pilot scale dual fluidised bed gasifier. See information on gasification terminology