Politechnika Wrocławska

Biomass torrefaction technologies

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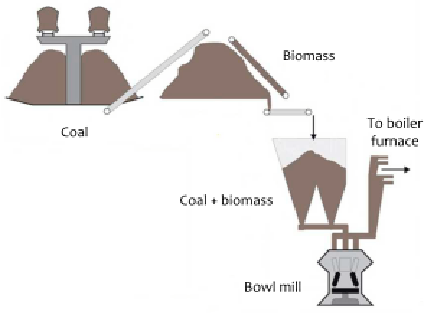
Wydział Mechaniczno-Energetyczny

Co-combustion

- Co-combustion of biomass is an important technology for CO_2-neutral electricity generation.
- Co-combustion of biomass is practiced in numerous plants, especially in Denmark, Belgium, Czech Republic, Poland.
- Typical co-combustion plants in the power plant sector are in the electrical output range of 50 MW to 700 MW.
- The majority of the plants are equipped with pulverized coal firing systems. However, biomass co-combustion is also implemented in fluidized bed systems (BFB and CFB) and in other boiler designs.

Co-combustion



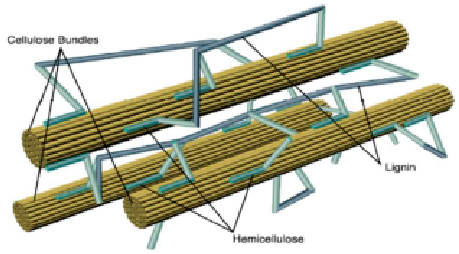
Source: Internet

Direct co-combustion:
Biomass and coal are burned in the same boiler, using the same or separate mills and burners, depending principally on the biomass fuel characteristics. Coal and biomass can be mixed before milling or coal and biomass are fed and milled by separated supply chains.

Co-firing in PF-fired boilers requires milling. Therefore the biomass has regularly to be dried and sometimes pelletized, that it can be milled to sufficient fine particles.

Co-firing in PF-fired boilers requires pretreatment of fuels, e.g. torrefaction.

Basic information of torrefaction

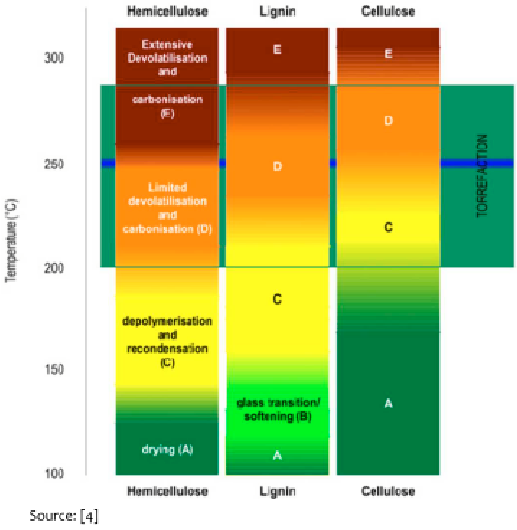


Source: [6]

Lignocellulosic biomass typically contains approx. 80% volatile matter and 20% fixed carbon on dry mass basis.

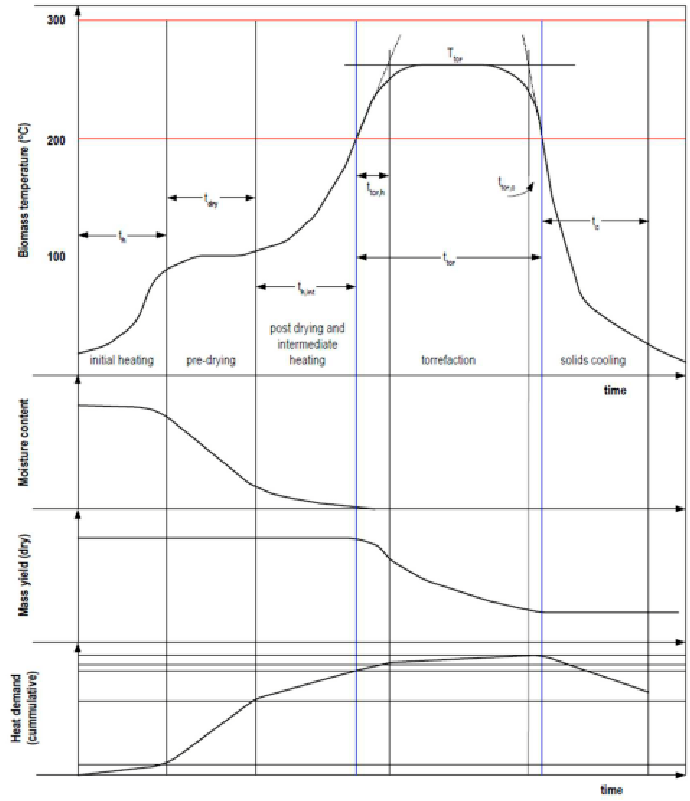
During the torrefaction process, solid biomass is heated in the absence of or drastically reduced oxygen to a temperature of approx. 200-350°C, leading to a loss of moisture and partial loss of the volatile matter in the biomass. With the partial removal of the volatile matter (about 20%), the characteristics of the original biomass are drastically changed.

Basic information of torrefaction



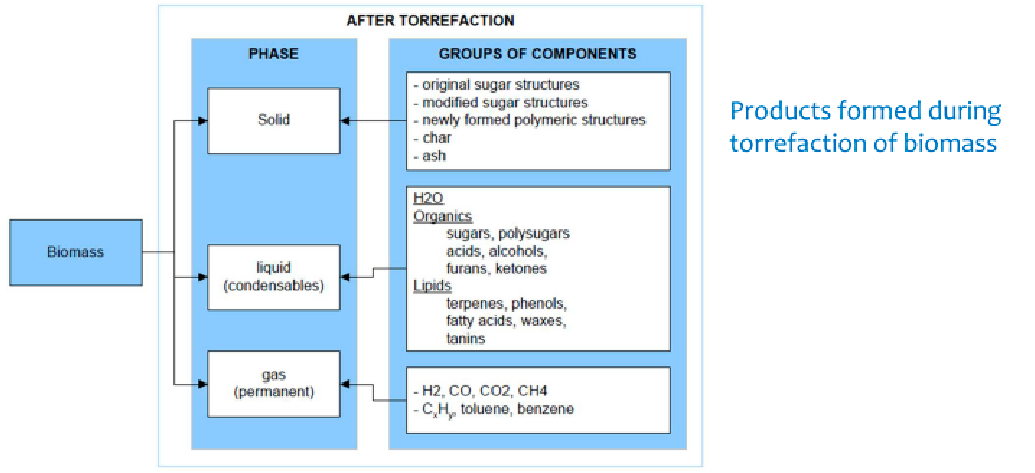
Source: [4]

During the torrefaction process, the tenacious fibre structure of the original biomass material is largely destroyed through the breakdown of hemicellulose and to a lesser degree of cellulose molecules, so that the material becomes brittle and easy to grind. The material then changes from being hydrophilic to becoming hydrophobic. With the removal of the light volatile fraction that contains most of the oxygen in the biomass, the heating value of the remaining material gradually increases.



Stages in the heating of moist biomass

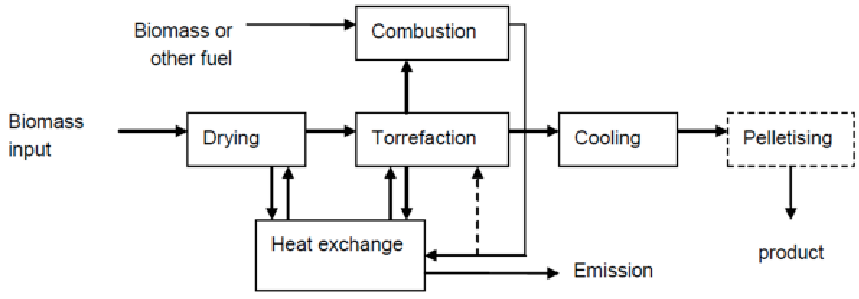
Source: [4]



Products formed during torrefaction of biomass

Source: [5]

Process diagram



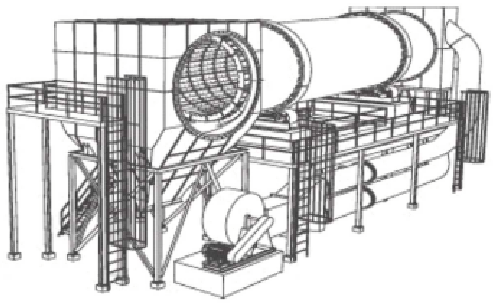
Overview of heat integration options

Source: [5]

Overview of reactor technologies

Reactor technologies	Companies involved
Rotating drum	CDS (UK), Torr-Coal (NL), BIO3D (FR), EBES AG (AT), 4Energy Invest (BE), BioEndev/ ETPC (SWE), Atmosclear S.A. (CH), Andritz , EarthCare Products (USA)
Screw reactor	BTG (NL), Biolake (NL), FoxCoal (NL), Agri-tech Producers (US)
Herreshoff oven/ Multiple Hearth Furnace (MHF)	CMI-NESA (BE), Wyssmont (USA)
Torbed reactor	Topell (NL)
Microwave reactor	Rotawave (UK)
Compact moving bed	Andritz/ECN (NL), Thermya (FR), Buhler (D)
Belt dryer	Stramproy (NL), Agri-tech producers (USA)
Fixed bed	NewEarth Eco Technology (USA)

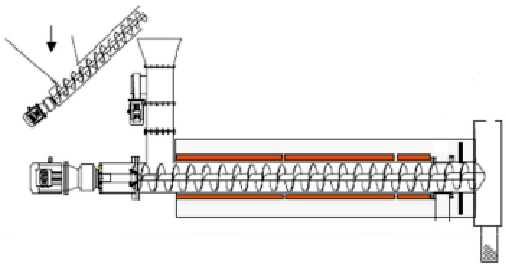
Rotating drum reactor



The rotating drum is a continuous reactor and can be regarded as proven technology for various applications. For torrefaction applications, the biomass in the reactor can be either directly or indirectly heated using superheated steam of flue gas resulting from the combustion of volatiles [5].

Source: [5]

Auger screw type reactor



A screw type reactor is a continuous reactor, consisting of one or multiple auger screws that transport the biomass through the reactor. The reactor technology can be considered as proven technology, and can be placed both vertically as well as horizontally [5].

Source: [5]

Torbed reactor

The particles to be processed are held in a shallow bed suspended by jets of the process gas stream that is forced through stationary angled blades at high velocity. The process gas stream impacts on and minimises the insulating microscopic gas layer around each particle. As a result, the heat and mass transfer rate is greater than in other types of reactor which means faster, more effective processing.

Source: www.torftech.com

Conclusion

- Issues with biomass as fuel: Low LHV, high moisture, low energy density, non-homogeneous, hygroscopic, poor grindability
- Torrefaction addresses most of these issues, delivering a fuel comparable to coal
- Torrefaction: thermochemical treatment process at 200-350°C to separate water, VOCs & hemicellulose in woody biomass
- Torrefied biomass:
  - Higher energy, lower moisture content; better grindability
  - Transport, handling & storage advantages due to higher bulk & energy density, homogeneity, hydrophobic property
- A competitive fuel when co-firing with coal in power plants.

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