Fast Pyrolysis

FEEDSTOCK CLASSIFICATION

Primarily lignocellulosic biomass, but any biomass or organic material may be considered.

FEEDSTOCK EXAMPLES

- alfalfa
- corn stover
- crop residues
- debarking waste
- forage grasses
- forest residues
- hulls
- municipal solid waste
- pomace, scrap and spoilage (fruit & vegetable processing)
- sawdust
- spent grains
- spent hops
- spent yeast
- switchgrass
- waste wood chips
- wood chips

FEEDSTOCK RESTRICTIONS

Solid or liquid feedstocks must be processed to a small particle or droplet size to assure high heat transfer rate in the process (less than 6 mm or ¼ inch, but 1 to 2 mm is preferred). Feedstock should be dried to less than 10 percent moisture content.[1,2,3]

PROCESS DESCRIPTION

Fast pyrolysis refers to the rapid thermal decomposition of biomass and organic compounds in the absence of oxygen to produce liquids, gases and char (also called flash pyrolysis). Small particles of biomass material are fed into a pyrolysis reactor vessel with high heat transfer rates and essentially no combustion occurring. At a temperature of around 500°C, the biomass flashes into a vapor, which then may be cooled, condensed and recovered as a liquid bio-oil product. The vapor may be converted to hydrogen through a reforming process as alternative to condensing to oil.[4] Non-condensable gases are typically recycled for co-firing into the reactor vessel, while char is extracted for fuel or as a commercial product. The processing time from feed to quench, typically less than two seconds, must be fast to ensure a high yield of bio-oil.

Prior to development and commercialization of fast pyrolysis over the past 25 years, pyrolysis was a relatively slow cooking process where the product is a thick, low quality, two-phase tar-aqueous mixture in low yields at processing times ranging from minutes to hours. Traditional "slow" pyrolysis has been used industrially as a source of char and extractives from the tar, such as turpentine, but has been displaced by fast pyrolysis for biorefining.

PRIMARY BIOBASED PRODUCTS

Primary biobased products are **pyrolytic bio-oil**, a free-flowing, dark brown liquid that is a complex, combustible mixture of oxygenated hydrocarbons, and **char**, a carbon product. The vapor may be converted to hydrogen through a reforming process as alternative to condensing to oil.

Process design and feedstock characteristics affect yields. Reported yields by mass weight of feedstock dried to less than 10 percent moisture:[1, 2, 3, 5] pyrolytic bio-oil (approximately 60 to 75 percent), char (approximately 13 to 25 percent). Assuming conversion of 72 percent of the biomass feedstock to liquid on a weight basis, the yield of pyrolytic bio-oil is about 560 L/ton (148 US Gal/ton).[5]

PROCESS BYPRODUCTS

Non-condensable, combustible gas mixture (approximately 10 to 20 percent yield by mass weight, mainly carbon monoxide, carbon dioxide, hydrogen and methane), typically recycled into the reactor vessel for process heating.

MAJOR EQUIPMENT

Feedstock mill, feedstock hopper and feeder, pyrolysis reactor vessel with burner (commonly a vortex or fluidized sand bed design to obtain high heat transfer), cyclone collector for char and reactor sand, pyrolysis vapor quench tank, and bio-oil storage tank.

ENERGY REQUIRED

Heating within the pyrolysis reactor vessel is an energy intensive process, but the recycled combustible gas byproduct can supply 75% of the heating needs.[3]

CAPITAL AND OPERATING COST

Ensyn announced a CN$9 million bio-refinery in 2003 for start-up in 2004/05 to be located in Renfrew, Ontario. The Ensyn facility will occupy 50,000 square feet, employ 16 workers initially, and be capable of processing 60 tons of dry feedstock per day.[2] Operating costs are not reported.

COMMERCIALIZATION STATUS

Commercially available, research ongoing. A commercial scale plant was commissioned in 1989 by the Ensyn Company, which had 6 plants operating by 2003 producing a reported 5 million gallons of bio-oil per year.[2] The DynaMotive Corporation has more recently reached the commercialization phase.[3] BTG Biomass Technology Group BV is involved in the engineering of a 50 ton/day fast pyrolysis plant for clean wood residues. This plant was to be constructed and commissioned in 2003.[6] Further research and commercialization efforts for new reactor designs and fast pyrolysis processing are ongoing worldwide. PyNe – The Biomass Pyrolysis Network – is a global network of active researchers and developers of fast pyrolysis, has been established to discuss and exchange information on scientific and technological developments on pyrolysis and related technologies for the production of liquid fuels, electricity and chemicals.[7]

COMMERCIAL SUPPLIERS

Ensyn Group, Inc. **http://www.ensyn.com/**, based in Boston, MA USA (617.266.7600).

DynaMotive Energy Systems Corporation, http://www.dynamotive.com, based in Vancouver, BC Canada (604.267.6000).

BTG Biomass Technology Group B.V.; http://www.btgworld.com/ P.O. Box 217; NL-7500 AE Enschede, The Netherlands (Tel +31 53 486 11 86).

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[2] Biomass Processing. Ensyn Group, Inc. http://www.ensyn.com (20 April 2004).

[3] Green Fuels to the World. DynaMotive Energy Systems Corporation. http://www.dynamotive.com (April 14, 2004).

[4] Day, Danny, Eprida, Inc., Robert J. Evans, National Renewable Energy Laboratory, James Lee, Oak Ridge National Laboratory, Don Reicosky, USDA-Agricultural Research Service, June 2003. Economical CO2, SOx and NOx Capture from Fossil Fuel Utilization with Combined Renewable Hydrogen Production and Large Scale Carbon Sequestration. Eprida, Inc., 6300 Powers Ferry Road, Suite 307, Atlanta, GA 30339 http://www.eprida.com/hydro/ecoss/presentations/symposiums.htm (May 18, 2004).

[5] Brown, Robert C. 2003. Biorenewable Resources Engineering New Products from Agriculture. Iowa State Press, Ames IA.

[6] BTG Biomass Technology Group B.V.; Flash Pyrolysis. http://www.btgworld.com/technologies/pyrolysis.html#links (April 21, 2004).

[7] Pyrolysis Network Bio-Energy Research Group, Aston University. http://www.pyne.co.uk/ (April 23, 2004).