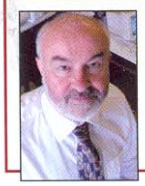
Fast Pyrolysis of Biomass



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Renewable energy is of growing importance in responding to concerns over the environment and security of energy supply. Biomass is unique in providing the only renewable source of fixed carbon, which is an essential ingredient in meeting many of our fuel and consumer goods requirements. It is also considered the renewable energy source with the highest potential to contribute to the energy needs of modern society for both the developed and developing economies worldwide. Wood, energy crops and agricultural and forestry residues are some of the main renewable energy resources available.

Of the available biomass conversion technologies for production of more usable energy forms, fast pyrolysis is the least developed. However, it offers the benefits of a liquid fuel with concomitant advantages of easy storage and transport as well as comparable higher power generation efficiencies at the smaller scales of operation that are likely to be realised from bioenergy systems compared to fossil fuelled systems.

Pyrolysis

Pyrolysis is thermal decomposition occurring in the absence of oxygen. It is also always the first step in combustion and gasification, but in these processes, it is followed by total or partial oxidation of the primary products. Lower process temperatures and longer vapour residence times favour the production of charcoal. High temperatures and longer residence times increase biomass conversion to gas, and moderate temperatures and short vapour residence times are optimum for producing liquids.

In fast pyrolysis, biomass rapidly decomposes to generate vapours, aerosols, gases and some charcoal. After cooling and collection, a dark brown mobile liquid is formed that has a heating value of about half that of conventional fuel oil. While it is related to the traditional pyrolysis processes for making charcoal, fast pyrolysis is an advanced process that is completed in seconds, with carefully controlled parameters, to give high yields of liquid. The essential features of a fast pyrolysis process for producing liquids are:

- very high heating and heat transfer rates at the reaction interface, which usually requires a finely ground biomass feed
- carefully controlled pyrolysis reaction temperature of around 500°C and vapour phase temperature of 400–450°C. The effect of temperature on yields and product spectrum is discussed in the section on pyrolysis liquid below
- short hot vapour residence times of typically less than two seconds
- rapid cooling of the pyrolysis vapours to produce bio-oil.

A Biomass plant

The main product, bio-oil, is obtained in yields of up to 75% wt on a dry-feed basis, together with by-product char and gas, which are used within the process to provide the process heat requirements, so there are no waste streams other than flue gas and ash.

A fast pyrolysis process includes drying the feed to typically less than 10% water in order to minimise the water in the product liquid oil, grinding the feed (to around 2 mm particle size in the case of fluid bed reactors) to give sufficiently small particles to ensure rapid reaction, fast pyrolysis, separation of solids (char), and quenching and collection of the liquid product (bio-oil). Virtually any form of biomass can be considered for fast pyrolysis. While most work has been carried out on wood because of its consistency and comparability between tests, nearly 100 different biomass types have been tested by many laboratories, ranging from agricultural wastes such as straw, olive pits and nut shells to energy crops such as miscanthus and sorghum, forestry wastes such as bark and solid wastes such as sewage sludge and leather wastes.

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Pyrolysis liquid—bio-oil

Crude pyrolysis liquid or bio-oil is dark brown and approximates to biomass in elemental composition. It is composed of a very complex mixture of oxygenated hydrocarbons with an appreciable proportion of water from both the original moisture and reaction product. Solid char may also be present.

Bio-oil has a higher heating value of about 16-17 MJ/kg as produced with about 25% wt. water that cannot readily be separated. It is composed of a complex mixture of oxygenated compounds that provide both the potential and challenge for utilisation. There are some important characteristics of this liquid that are discussed briefly below, of which the most significant is that it will not mix with any conventional hydrocarbon based fuels. Typically it is a dark brown, free-flowing liquid.

Applications of bio-oil

Bio-oil can substitute for fuel oil or diesel in many static applications including boilers, furnaces, engines and turbines for electricity generation.

Conclusions

There is substantial and growing interest in thermal processing of biomass for biofuels, to make both energy and chemicals. Fast pyrolysis is a new technology that offers the key advantage of directly producing a liquid fuel in high yield that can be stored and/or transported to the point of use. This provides considerably more flexibility in use and allows greater use to be made of economies of scale for power generation, and transport fuel synthesis.

Information on biomass and bioenergy research in the UK is published regularly in British Bioenergy News (www.supergen-bioenergy.co.uk) and in Europe and the rest of the world by ThermalNet (www.thermalnet.co.uk). Both networks publish a regular newsletter, details of which and requests for free copies can be obtained on the respective websites.

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