Torrefaction

From Wikipedia, the free encyclopedia

Torrefaction of biomass can be described as a mild form of pyrolysis at temperatures typically ranging between 200-320 °C. During torrefaction the biomass properties are changed to obtain a much better fuel quality for combustion and gasification applications. Torrefaction combined with densification leads to a very energy dense fuel carrier of 20-25 GJ/ton.

Biomass can be an important energy source to create a more sustainable society. However, nature has created a large diversity of biomass with varying specifications. In order to create highly efficient biomass-to-energy chains, torrefaction of biomass in combination with densification (pelletisation/briquetting), is a promising step to overcome logistic economics in large scale green energy solutions.

Process

Torrefaction is a thermo chemical treatment of biomass at 200 to 320 °C. It is carried out under atmospheric conditions and in the absence of oxygen. During the process, the water contained in the biomass as well as superfluous volatiles are removed, and the biopolymers (cellulose, hemicellulose and lignin) partly decompose giving off various types of volatiles. The final product is the remaining solid, dry, blackened material which is referred to as "torrefied biomass" or "bio-coal".

During the process, the biomass loses typically 20% of its mass (dry bone basis), while only 10% of the energy content in the biomass is lost. This energy (the volatiles) can be used as a heating fuel for the torrefaction process. After the biomass is torrefied it can be densified, usually into briquettes or pellets using conventional densification equipment, to further increase the density of the material and to improve its hydrophobic properties. With relation to brewing and food products, torrefication occurs when a cereal (barley, maize, oats, wheat, etc.) is cooked at high temperature to gelatinise the starch endosperm creating the expansion of the grain and creating a puffed appearance. The cereal can then be used whole or flaked. In brewing, the use of small quantities of torrefied wheat or barley in the mashing pocess aids in head retention and cling to the glass. Additionally, torrefied cereals are generally less expensive than equal amounts of malted products.

Added value of torrefied biomass

Torrefied and densified biomass has several advantages in different markets, which makes it a competitive option compared to conventional biomass (wood) pellets:

Higher energy density

Energy density of 18 - 20 GJ/m3 compared to 10 - 11 GJ/m3 driving a 40 - 50% reduction in transportation costs.

More homogeneous composition

Torrefied biomass can be produced from a wide variety of raw biomass feedstocks while yielding similar product properties. The main reason for this is that about all biomass are built from the same polymers (lignocellulose). In general (woody and herbaceous) biomass consists of three main polymeric structures: cellulose, hemicellulose and lignin. Together these are called lignocellulose. The chemical changes of these polymers during torrefaction are practically similar resulting in similar property changes.

Hydrophobic behavior

Torrefied biomass has hydrophobic properties and when combined with densification make bulk storage in open air feasible.

Elimination of biological activity

All biological activity is eliminated reducing the risk of fire and stopping biological decomposition.

Improved grindability

Torrefaction of biomass leads to improved grindability of biomass. This leads to more efficient co-firing in existing coal fired power stations or entrained-flow gasification for the production of chemicals and transportation fuels.

Markets for torrefied biomass

Torrefied biomass has added value for different markets. Biomass in general provides a low-cost, low-risk route to lower CO2-emissions. When high volumes are needed, torrefaction can make biomass from distant sources price competitive.

Large scale co-firing in coal fired power plants

- Torrefied biomass results in lower handling costs;
- Torrefied biomass enables higher co-firing rates;
- Product can be delivered in a range of LHVs (20 – 25 GJ/ton) and sizes (briquette, pellet).
- Co-firing torrefied biomass with coal leads to reduction in net power plant emissions.

Steel production

- Fibrous biomass is very difficult to deploy in furnaces;
- To replace injection coal, biomass product needs to have LHV of more than 25 GJ/ton.

Residential/decentralized heating

- Relatively high percentage of transport on wheels as cost in supply chain makes biomass expensive. Increasing volumetric energy density does decrease costs;
- Limited storage space increases need for increased volumetric density;
- Moisture content important as moisture leads to smoke and smell.

Biomass-to-Liquids

- Torrefied biomass results in lower handling costs;
- Torrefied biomass serves as a 'clean' feedstock for production of transportation fuels (Fischer–Tropsch process), which saves considerably on production costs of such fuels.

References

- Bergman, P.C.A.; Kiel, J.H.A., 2005, "Torrefaction for biomass upgrading", ECN report, ECN-RX—05-180
- Bergman, P.C.A.; Boersma, A.R.; Zwart, R.W.H.; Kiel, J.H.A., 2005, "Development of torrefaction for biomass co-firing in existing coal-fired power stations", ECN report ECN-C—05-013
- Bergman, P.C.A., 2005, "Combined torrefaction and pelletisation – the TOP process", ECN Report, ECN-C—05-073
- Bergman, P.C.A.; Boersma, A.R.; Kiel, J.H.A.; Prins, M.J.; Ptasinski, K.J.; Janssen, F.G.G.J., 2005, "Torrefied biomass for entrained-flow gasification of biomass",ECN Report ECN-C—05-026.