Global view of total torrefaction process line including Beltomatic dryer, Biogreen CM600 torrefier, and briquette system for W2W project in July 2016, Arcata, CA

New technologies are helping to bring torrefaction on the verge of commercialisation

Fading out coal

Woody biomass is one fuel used to generate electricity, and when extraction rates do not exceed growth rates, biomass derived electricity is generally accepted to be renewable energy. Using raw biomass feedstock for electricity production presents several challenges including high moisture content, low-bulk density, low calorific value, high grinding energy requirements, hydrophilicity, relatively high grinding energy requirements, and non-uniformity of fuel properties and particle size. Torrefaction, which is a mild form of pyrolysis, is a pre-treatment process to improve the properties of biomass fuel and make it more suitable for electricity generation.

Torrefied biomass is being considered as a drop-in replacement for coal. Unlike raw biomass, torrefied biomass has very similar properties to coal and can be processed, handled, and burned with the same equipment used in existing coal-fired power plants. There is interest in co-firing torrefied biomass in existing coal-fired power plants or using 100% torrefied wood to replace coal at a given plant. This would allow existing electricity generation assets to remain in operation while reducing or eliminating the amount of fossilised carbon that is converted to free atmospheric carbon in the process.

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Norris Thermal Technologies worked with Schatz Energy Research Center to build, demonstrate, and test a Biogreen CM600 torrefier system during the summer of 2015. This torrefier was integrated with a Norris Thermal belt dryer and a briquetter manufactured by RUF Briquetting Systems to produce torrefied briquettes out of woody biomass. This demonstration plant produced up to 0.6 tons of torrefied briquettes per hour using woody biomass feedstock. The work was completed under the Waste-to-Wisdom research project, which was led by Humboldt State University and funded by the US Department of Energy Biomass Research and Development Initiative. The Biogreen machine was able to easily control the level of torrefaction by changing the residence time and reaction temperature for the raw biomass. The CM600 reliably generated consistent torrefied product with minimal operator effort.

The cooled, torrefied biomass produced by the CM600 was fed directly into the RUF briquetter, which compressed, or densified, the material into briquettes. Densifying either raw or torrefied biomass fuel will improve volumetric energy density, but densifying torrefied wood is more challenging because torrefaction breaks down lignin, which acts as a natural binding agent in the densification process. The combination of the CM600 torrefier and the RUF briquetter produced high-quality torrefied briquettes without the addition of binders.

Experimental data generated during the testing indicated that calorific value,

Biogreen model CM600 torrefaction system. Reactor sitting on a mobile trailer during testing for W2W project in July 2016, Arcata, CA

bulk density, and briquette durability were increased and grinding energy was decreased by torrefaction using the CM600. While calorific value (MJ/kg) and bulk density (kg/m^3) were increased, it should be noted that as much as 20% of the original bone-dry mass and energy content may be lost during the torrefaction process.

Further study

The torrefied briquettes were more durable than raw biomass briquettes immediately after production, which means that packing densities can be high at the point of origin resulting in more energy transported for a given volume. However, after a transportation simulation using an environmental chamber that varied temperature and humidity conditions over time for a synthetic transport cycle, the torrefied briquettes were found to be less durable than raw briquettes. This may result in material handling challenges at the receiving point. The data on this point was highly variable and researchers identified the transportation simulation as an area where further study seemed warranted.

Energy consumed during grinding was reduced by 70% after torrefaction. This is significant because coal-fired power plants grind feedstock before combustion and these results indicate that torrefied wood can likely be processed through existing grinders at power plants whereas raw biomass would require modifications to an existing coal grinding system.

The CM600 using an electrically heated screw to achieve and maintain the desired reactor temperature. The electrical demand, which is a function of temperature set point and residence time in the reactor, ranged from 200 to 450kWh per ton of torrefied material. About 90% of the electrical energy consumed was used to heat the reactor screw. While the electrically heated reactor does use more primary energy than an autothermal torrefier would, the CM600's electrically heated design does enable precise control of reactor conditions. This means that operators can easily customise the properties of the torrefied product for a specific market preference and repeatedly produce a very consistent product. Researchers identified that using the syngas produced in the CM600 to generate some of the heat for the reactor as an important topic for future research and engineering efforts. This would reduce the primary energy demand of the process while still allowing the precision control of reactor conditions.

For further details, look for an upcoming article in the *American Society of Agricultural and Biological Engineers Applied Engineering Journal*, which is expected to be published in the autumn of 2017. ●

For more information:

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Final torrefied briquettes from Biogreen CM600 torrefier in W2W project. July 2016, Arcata, CA