"Biomass Torrefaction as a Preprocessing Step for Thermal Conversion"

"Reducing costs in the biomass supply chain"

There have been many studies to identify biomass sources and quantities in the United States. These studies have shown there is at least one billion tons of biomass available for conversion. What is not taken into account is the logistics of aggregating and transporting the biomass to the processing locations. These aggregating and transporting costs are high enough to make a significant portion of the biomass uneconomical to utilize for conversion. In addition to these costs there are inherent problems with most types of biomass. This paper will address some of the major challenges with biomass and how torrefaction can help to improve the feedstock and reduce the costs associated with biomass aggregation and transportation.

Biomass Challenges

There are a number of quality and logistical challenges which biomass sources have in common. Foreign debris is common among many types of biomass. Forest waste has a large content of residual dirt. Construction waste and MSW (Municipal Solid Waste) include metal items, glass, plastics, and other materials which can damage equipment and release harmful chemicals when burned. Feedstock sources must have the foreign materials separated out before the conversion process to prevent damage.

Inconsistent moisture is also prevalent in biomass feedstock. Unprocessed forest residue and urban wood waste may have 20%-50+% moisture depending on time left to dry and moisture in location. MSW also has a wide range of moisture content just because of the inconsistent nature of the feedstock. Ag residue moisture also varies depending on the type of biomass and time of harvest. Moisture variation in the feedstock requires adjustments to the conversion process. These adjustments reduce the efficiency of the process and increase costs.

Biomass typically degrades over time due to natural decomposition. Biomass does not store well without careful protection. Biomass is prone to natural decomposition and breakdown with exposure to moisture, pests, and other environmental conditions. The high moisture content of some sources of biomass naturally accelerates the decomposition process.

Biomass is bulky. The density of baled ag waste, collected wood residue, or MSW often fill the transport container before it reaches the maximum weight. Since the transportation containers could carry more if the biomass had a higher density densification would result in lower transportation costs.

Biomass generally requires pre-processing before conversion into other products. Biomass can rarely be used in the conversion process without a reduction (grinding) operation to make a consistent particle size. This pre-processing provides a consistent material so complete conversion can take place. Inconsistent biomass size cause un-reacted materials to pass through the conversion process and reduce efficiency.

Biomass is not as efficient to collect and transport as other feedstocks. Grains, coal, oil, and natural gas all have well developed and efficient collection and transportation systems. Biomass collection and transportation costs are much higher because the material is typically batch loaded and unloaded. Other developed feedstock sources have high speed continuous flow loading and unloading systems.

These biomass challenges are not insurmountable. Minimizing the effects and costs associated with these challenges results in a more economical feedstock supply.

The Torrefaction Process

The torrefaction process is typically a combination of two distinct steps with an additional pelletization step after the process in selected applications.

The pre-processing step consists of separating any foreign materials from the feedstock and grinding to produce a more uniform particle size. The separated and ground material is then delivered to the torrefaction equipment.

During the torrefaction process the biomass is heated in an oxygen depleted environment to 200-300°C just long enough for the moisture and some of the hydrocarbons to off gas. The volume of the original material is reduced by 30% - 70% while the material retains over 90% of the original energy in the biomass. The gas is captured and used to provide the power for the torrefaction process. The torrefied material has higher energy content because the moisture and other components were removed in the heating process. The material is dry and brittle compared to the original biomass.

In comparison conventional wood pellets contain approximately 8 – 11 GJ/m^3 torrefied wood pellets contain approximately 15-18.5 GJ/m^3 (2).

Pelletization is can be used with torrefaction to convert the material into a more transportable form. The pelletization process increases the mass density of the product, eliminates dust problems, and provides a medium which conveys easily for material handling.

Torrefaction Reduces Feedstock Costs

The torrefaction process addresses several of the biomass challenges mentioned previously.

The torrefaction process requires the biomass to be ground or chipped before processing. This preparation step allows the separation of foreign materials and dirt before torrefaction. This can eliminate significant downstream conversion problems with slag formation and other foreign material problems.

Normal feedstock moisture ranges from 10% - 50+%. The torrefaction process completely dries the biomass and the resulting material has 1%-6% (1) moisture. This provides two main benefits because the resulting feedstock has a consistent moisture level for the conversion process and it reduces transportation costs associated with moving unwanted water. The resulting chemical conversion also stops the biomass decomposition and moisture absorption.

The torrefaction process increases the caloric density of the material. Torrefied material has a caloric density of approximately 20 MJ/kg (1) compared to wood chip density of approximately 11 MJ/kg (1). When the torrefaction process is combined with pelletization it provides an extremely dense renewable feedstock for processors. The pelletization process increases the mass density to approximately 750 kg/m^3 (2) and the energy density to approximately 16.75

GJ/m^3(1). The pelletized material can also be moved like coal or grain with existing handling systems and hopper bottom containers.

Torrefaction produces a material that is free from foreign materials with consistent moisture. The torrefied material also has a higher energy content and density. The material is also resistant to decomposition and pelletized material transports using common grain handling equipment. These factors can reduce the logistics costs by over 50% (2) while also improving economics for thermal conversion. The resulting material can also be burned in existing coal fired or wood pellet systems without modification.

Process Equipment Development

Several companies around the globe are working on commercial scale torrefaction processing equipment at various stages of development. This process appears to be a beneficial feedstock upgrade for several conversion technologies. Given the current development paths of these companies there may be economical regional scale or semi-mobile equipment options. Current cost projections for the processing and pelletization are $40-$50/ton of product including capital costs. The young nature of this process application and its limited introduction should allow for significant process improvements and economies of scale as the capacities are increase and processing experience is gained.

There are several well established companies who can provide the pre-processing and pelletization equipment in commercial scale designed for the application and environment. This equipment can either be powered by diesel or electrical power depending on the location and infrastructure. The pre-processing and pelletization equipment is utilized in commercial applications globally.

Summary and Conclusions

Torrefaction solves several biomass challenges and converts biomass into a consistent feedstock with higher energy density and lower transportation costs. The development of regional scale or mobile torrefaction processing equipment will provide a more cost effective solution for opportunistic collection of biomass located in remote areas.

Torrefied material is not a good fit for all biomass conversion processes. It is not a good feedstock for chemical conversion. The chemical changes in the biomass make it much harder to break down. Torrefaction is a good preprocessing step for general combustion, wood or coal fired applications, and gasification.

The commercial scale deployment of biomass torrefaction will depend on many factors including the total conversion costs/ton, biomass pricing, carbon credit pricing, capital cost deferment because of reduced emissions, and utilization biomass within the existing process.

Torrefaction will likely be a regional solution like many of the biomass opportunities available today. The maturity of the technology and processing experience will provide a reduction in processing costs and drive more widespread usage as it becomes economically viable.

References

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