Mechanical Fractionation

Separating biomass and municipal solid wastes

Fractionation capabilities and research at INL support innovative biomass feedstock processes, reducing costs and improving supply chain logistics.

Biomass ranges from food crops and wood residues to municipal solid waste and algae. By some estimates, the United States could produce more than 1 billion tons of biomass per year to feed the nation's growing bioenergy and bioproducts industries.

But to realize this resource's full potential, industry must first manage the inherent variability of agricultural biomass that arises from factors such as soil quality, harvest methods, rainfall amounts and storage conditions.

Even different fractions of the same plant – for example, the leaves, stems and cobs that make up a corn plant – can have vastly different chemical and physical properties. Additionally, biomass variability can result from external sources such as how much soil (a contaminant in the process) is collected during harvest. Municipal solid waste presents its own challenges as well.

Without the ability to adequately manage variability, biorefineries face a host of challenges ranging from clogged equipment to low efficiency during conversion.

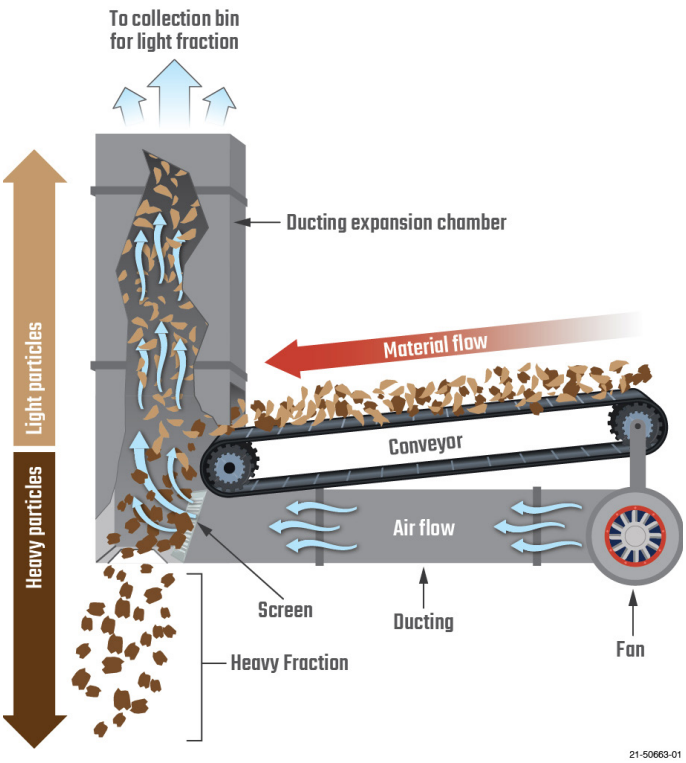
TRADITIONAL APPROACHES TO MANAGE BIOMASS VARIABILITY

Currently, most biorefineries cope with variability by making a homogenized biomass product using some combination of drying and grinding, an expensive preprocessing method that often fails to meet specifications. Blending is one potential approach to manage variability. Blending combines different feedstocks or the same feedstock with varied levels of quality.

Now, researchers at the Biomass Feedstock National User Facility are exploring a new approach – mechanically sorting biomass using its physical and chemical characteristics to create different anatomical fractions, sizes, shapes and densities.

Mechanical fractionation can significantly reduce variability at an affordable cost. Options under current consideration include modifying proven agriculture techniques (such as screens and air classification), as well as new ones (including optical sorters and robotic mechanisms powered by artificial intelligence).

Idaho National Laboratory



Materials can be separated using the power of gravity and air. Heavier particles fall while lighter particles rise.

BIOMASS FEEDSTOCK NATIONAL USER FACILITY

The Department of Energy's Biomass Feedstock National User Facility (BFNUF) at Idaho National Laboratory offers technology and expertise to help the U.S. bioenergy industry overcome biomass challenges at preprocessing facilities.

The user facility's Process Development Unit is a full-scale, fully integrated biomass preprocessing plant with a modular design that allows industry partners to explore a wide range of biomass preprocessing options.

MECHANICAL FRACTIONATION

The user facility also offers several mechanical fractionation technologies suitable for a wide range of biomass types, including corn stover, logging residues and municipal solid waste.

Air classification: Air classification is a well-established technique that separates fine, light materials from heavier materials using air. For example, early farmers tossed wheat into the air so that the wind would blow away lighter-weight chaff. During mechanical air classification, biomass is introduced to a fan that blows straight up. The heavy biomass particles drop through the fan while the finer, lighter particles blow up and away from the fan. Both fractions are collected for further processing or disposal. One study showed that air classification could be performed on biomass feedstocks for as little as $0.83 per dry ton, making it an affordable option for most biorefineries.

Screens: A mechanism that vibrates screens with different sized holes can separate biomass such as corn stover or logging residues into specific particle sizes.

Screens can also be used to separate mixed garbage into different fractions such as food waste and broken glass. Different types of screens can be used for different types of materials. For instance, disk screens are commonly used in municipal solid waste processing to remove smaller size fractions from the material stream.

Fractionation capabilities at INL allow for up to four particle size separations.

Specific gravity separation: A specific gravity separator at the Process Demonstration Unit is used to separate feedstocks of consistent particle size based on the density of the particles. While gravity drives the separation, it is aided by an up-flow of air that partially fluidizes the feedstock and a shaking inclined table. Together, these forces cause the feedstock to separate into particle streams of different densities as they move across the table.

Advanced technologies: Some advanced mechanical fractionation technologies take advantage of sensors that can recognize different types of biomass or municipal solid waste by their physical or chemical characteristics. For example, optical sensors powered by artificial intelligence can be trained to recognize different types of plastics based on their size, shape or color. The plastics can then be sorted with robotic arms or pneumatic mechanisms.

Additionally, hitting biomass or waste with ultraviolet light, X-rays or infrared light can cause the material to emit nonvisible wavelengths that can provide information about the chemical composition. This technique can be used to sort materials based on their chemical compositions.

REDUCING ASH

Screens and air classification are particularly useful for removing ash in the form of dirt and dust, which can take up significant weight in a bale of corn stover. Ash not only reduces conversion efficiency, but can also increase shipping, processing, heating, cooling and disposal costs. Using mechanical fractionation to remove ash early in the supply chain can help to avoid those costs.

INL innovates various kinds of machinery to meet fractionation needs in a cost-effective way.

Researchers at the user facility found that mechanical fractionation can reduce high ash concentrations found in plant-based feedstocks including corn stover, switchgrass and residential lawn clippings. Another study showed that air classification removed 40% of the ash content from forest residues, while removing only about 7% of the total biomass.

DIFFERENT PLANT FRACTIONS FOR DIFFERENT END PRODUCTS

Within a given type of biomass, differences in physical or chemical characteristics can make the individual plant tissues better suited for specific conversion processes. For example, one conversion pathway might work best using biomass with a specific cellulose percentage. Certain fractions of different biomass types can also be mixed to help the conversion process and meet biorefinery specifications.

Battelle Energy Alliance manages INL for the U.S. Department of Energy's Office of Nuclear Energy.

FOR MORE INFORMATION

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