Biomass Conversion Agitation Strategies

Gregory Benz

Benz Technology International, Inc

Accredited Member

LEE ENTERPRISES CONSULTING, INC.

Background: 40+ years experience in agitation industry

Performing consulting services to developers, operators and investors both in the US and internationally

Expertise: World's largest bioeconomy consulting group - over 100 subject matter experts (SME's)- all areas of the bioeconomy.

Approach: Project interdisciplinary teams to meet exact needs of specific projects.

POC: Handle projects with one agreement and single point of contact.

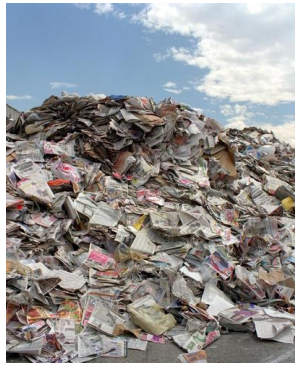
Cost Advantage: Single POC = lower administrative costs = lower project cost.

Cellulosic materials can be hydrolyzed into sugars, which can be converted to fuels or chemicals. This presentation discusses wet conversion only, rather than pyrolysis.

Some examples of biomass

Corn Stover

Switchgrass



MSW

Wood chips

Reaction schemes

- Batch
- Fed batch
- Continuous
- Agitation systems and requirements may vary with each

Agitation Systems

- Solids mixers: can handle damp solids. Expensive, not scalable to large sizes . Typically less than 10,000 gallons capacity. Normally have horizontal shaft and paddles or ribbons.

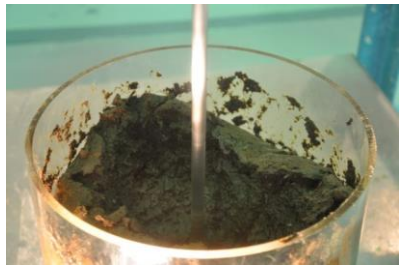
- Turbine agitator: limited to nominally liquid slurries, with enough free water to fill in voids plus 1-2% more. Inexpensive and can be scaled to large sizes.

Reaction scheme agitation requirements

- Batch: no limit on % solids if solids mixer is used. If turbine is used, limited to whatever % solids has some free water. That will depend on type of solids and pretreatment, but typically less than 14% solids
- Fed batch: starting with a small liquid heel, solids and enzyme may be added at a rate that allows liquefaction of cellulose to keep the mass fluid as cell walls break down. This makes use of a turbine agitator feasible and desirable. Solids content being added can be 20-30%; sometimes more
- Continuous: If tanks in series are used, the first stage should have enough residence time to assure enough liquefaction for a turbine. This could still allow high % solids

“Wet” testing needed to verify turbine design

- Test for both mixing and viscosity (turbine apparatus can be used as a viscometer)
- Can be done at a vendor lab, customer facility or consultant facility in some cases



At vendor

At Benztech

At user facility

Mixing Test Protocol Summary

- Choose appropriate size of impellers for task. Ratio of impeller to tank diameter will need to be 0.5 to 0.65 for high effective solids content; smaller for already hydrolyzed slurry
- Avoid baffles or tank internals for high-solids slurry
- Avoid flat or cone bottom tanks. ASME F&D is ideal
- Establish shaft speed needed to assure complete motion throughout the tank

Viscosity Test Summary

- Use impellers with known power draw characteristics
- Run tests at speeds of 10-50 rpm, typically, to cover probable full-scale speed range
- Measure power, or torque and speed
- Use the impeller power characteristic to back-calculate Reynolds number, and then calculate apparent viscosity as a function of shaft speed.
- Fit the data to an appropriate rheology model

Scalability is the key

- Only turbine agitators can be scaled to reactor volumes of hundreds of thousands of gallons
- Inexpensive and simple to maintain

Proven Results with Turbine Agitators

- Techniques described here using turbine agitators have been successfully applied to corn stover, switchgrass, corn fiber, several kinds of cane, municipal solid waste, beet pulp, shredded wood and others, using a variety of pretreatment methods.
- No size or feasibility issues with this approach.

Gregory T. Benz
Benz Technology International, Inc.
g.benz@benz-tech.com
+1 937-289-4504

Lee Enterprises Consulting
www.lee-enterprises.com
1+ 501 833-8511