Effect of Initial Mixing on Enzymatic Hydrolysis of Ball Milled Wood

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Introduction

Dry Milling process is a very promising method to reduce the recalcitrance of biomass for biofuel production. The sugar yield can be as high as 89.4% (10 FPU/g rice straw, 5% solid). However, energy consumption could be 108 MJ/kg rice straw (Hideno et al., 2009)

Find a way reducing the severity of milling while maintain the high sugar yield and maintain a non-chemical process will be very favorable to reduce the cost of producing biofuels and will minimize the environmental consequences.

Effective initial mixing to promote good enzyme distribution and will finally have a improved sugar yield(Roche et al., 2009). The role of the mechanical action is to increase the amount of amorphous cellulose, which is more susceptible to enzyme attack than crystalline cellulose(Lenting and Warmoeskerken, 2001).

Torque rheometer is a candidate mixing unit because it has a very good mixing ability. Roller rotor was found to be most effective and efficient(Ahmed Salahudeen et al., 2011)

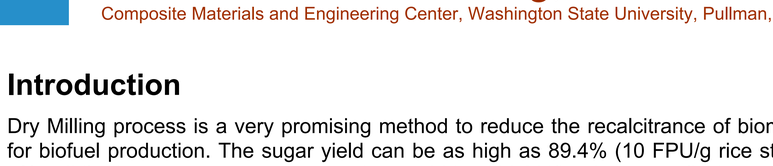
In this poster, torque rheometer is used as the prime mixing unit. Ball milled wood and enzymes were mixed inside torque rheometer before going into hydrolysis.

Objectives

A initial mixing process was added between ball milling and enzymatic hydrolysis process in order to improve initial dispersion of enzymes and increase sugar yield.

- Mixing action occur inside torque rheometer. The mixing torque can reveal the extent of fiber damage occur in this mixing environment. The mixing torque during mixing at different variables (Mixing time, Rotation speed) will be demonstrated.
- Effective initial mixing to promote good enzyme distribution and will finally have an improved sugar yield. The sugar yield at different mixing conditions will be compared.

Flow Chart



Course Milling → Ball Milling → Initial Mixing → Further Incubation

Ball Mill Conditions

Milling time: 60/80 mins	Rotation speed: 580 rpm
Temperature: 25 C	Jar/Ball materials: Aluminia
Jar Volume: 500 ml	Total jar number: 4
Ball (Diameter 6mm): 181.5g	Ball (Diameter 10mm): 89.5g
Ball (Diameter 20mm): 31.5g	Wood per Jar: 20g
Ball weight/Pulp weight: 15.1/1	Total jar number: 4

Reference

Ahmed Salahudeen, S., Elleithy, R. H., AlOthman, O. & AlZahrani, S. M. Comparative study of internal batch mixer such as cam, banbury and roller: Numerical simulation and experimental verification. *Chem. Eng. Sci.* **66,** 2502–2511 (2011).

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Lenting, H. B. M. & Warmoeskerken, M. Mechanism of interaction between cellulase action and applied shear force, an hypothesis. *J. Biotechnol.* **89,** 217–226 (2001).

Roche, C. M., Dibble, C. J. & Stickel, J. J. Laboratory-scale method for enzymatic saccharification of lignocellulosic biomass at high-solids loadings. *Biotechnol. Biofuels* **2,** 28 (2009).

Results

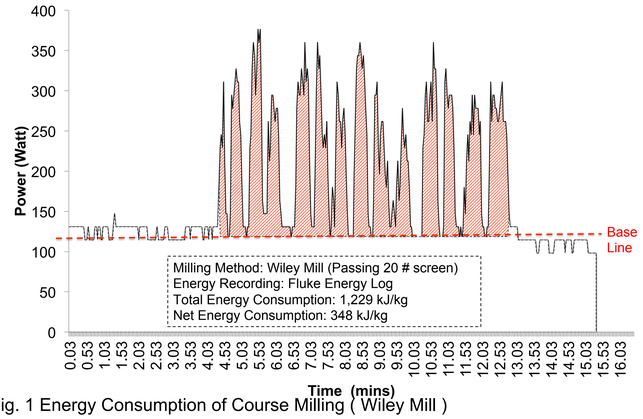


Fig. 1 Energy Consumption of Course Milling (Wiley Mill)

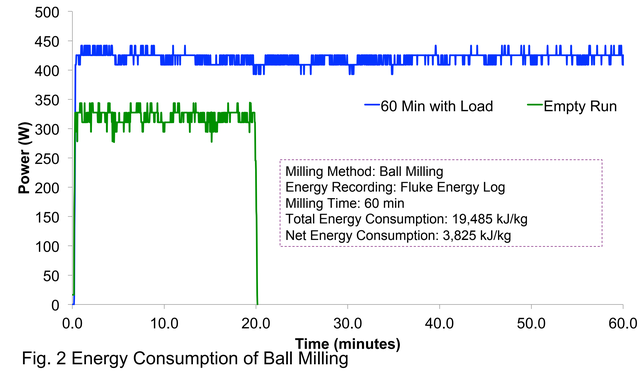


Fig. 2 Energy Consumption of Ball Milling

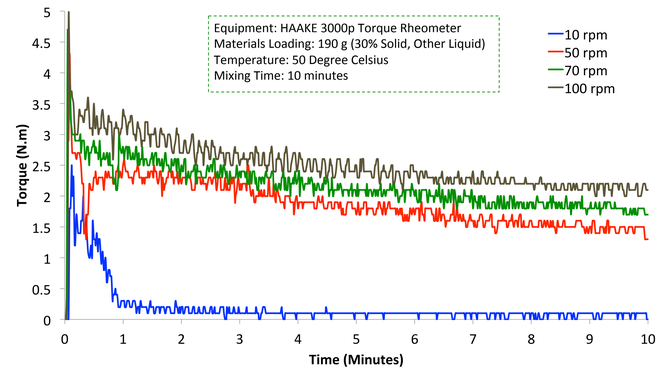
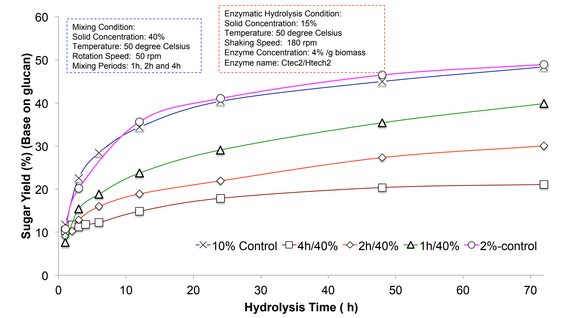
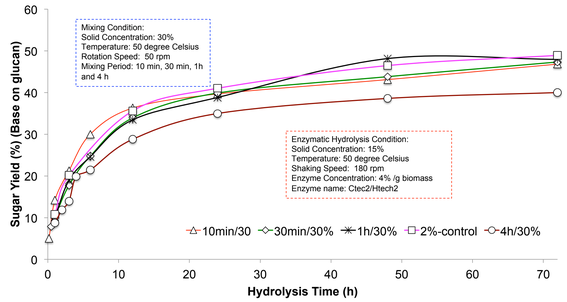


Fig. 3 Mixing Torque of Ball Milled Wood at Difference Rotation Speed.





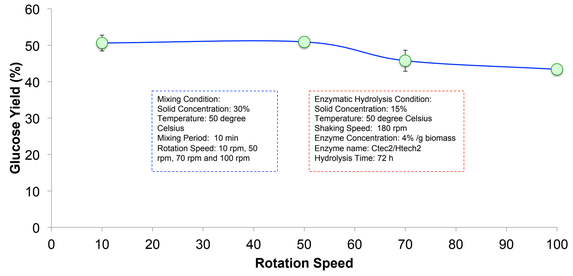


Fig. 4 a) Effect of mixing time on enzymatic hydrolysis of ball mill wood (40% solid); b) Effect of mixing time on enzymatic hydrolysis of ball mill wood (30% solid); c) Effect of rotation speed on enzymatic hydrolysis

Conclusion

In this poster, the effect of initial mixing of balled mill wood and enzymes on sugar yield were mainly presented:

- From mixing torque curve under different rotation speed, we can see a shearing thickening behavior of ball milled wood and enzyme slurry.
- The resistance of mixing dropped close to ½ of the initial resistance after 10 minutes torque rheometer mixing. The decrease of processing resistance will greatly save the energy consumption when mixing and transporting wood slurries in real world production.
- Enzyme activities might be under damage at higher rotation speed and long processing time.
- With higher solid loading, the detrimental effect was more obvious comparing with lower concentration. Friction between dry particles might be the reason of damaging enzymes
- In order to improve effectiveness of enzymatic hydrolysis, the mixing process is recommended to be controlled at lower rotation speed, shorter time and comparatively lower concentration.

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