Comminution of Unmerchantable Forest Residuals to Determine Power and Energy Consumption as a Function of Moisture Content and Size Reduction Range

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Introduction

- Fossil Fuels, currently the largest used energy source, are growing increasingly scarce.
- Research into biofuels is creating sources of sustainable energy that will be used as a substitute for these depleting resources.
- In the Pacific Northwest unmerchantable forest residuals-a byproduct of logging-is being looked into as a potential source of biojet fuel. However, the process of breaking down this byproduct is extremely energy intensive.
- Thus, research needs to be made to more efficiently turn the woody biomass into an energy source.

Objectives

- The goal of this research is to develop an equation based on Rittinger's Law, which states that the energy required for size reduction is proportional to the change in surface area of the material.
- This equation (see equation below) will be used to determine the energy that will be consumed for any given size reduction and moisture content of the woody biomass, which can then be used to predict the most optimal conditions for breaking down the forest residuals

Eq. 1:

$$E_{1\text{-}2} = C_{mc}\,(1/\chi_2 - 1/\chi_1)$$

X Represents the average particle size of the material and C_{mc} represents Rittinger's constant, which should only account for the influence of the moisture content.

Path #	Ave. PF	Gross Energy (kWh)	Net Energy (kWh)	Specific Energy (kWh/kg O.D.
1	0.667	11.642	1.659	0.0816
2	0.675	8.465	1.393	0.0707
3	0.812	2.619	1.134	0.0569
4	0.777	3.147	2.088	0.0997
5	-	-	-	-
6	-	-	-	-

Figure 3: This table represents the Path that the material was run through (see Figure 2) and the amount of energy consumed by the Hammermill. The important data is the specific energy which shows the total amount of energy per kilogram that was used for each Path in the particle size reduction.

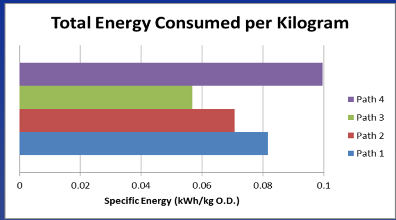

Figure 4: This bar graph is a representation of the Specific Energy for each Path shown in Figure 3.

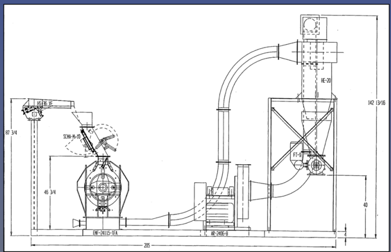

Figure 1: This figure (source: Bliss Industries, Inc., Washington State University, edited) represents tha Hammermill that was used in the particle size reduction of the Forest Residuals.

Screen #	Screen Size	Path 1	Path 2	Path 3	Path 4	Path 5	Path 6
8	1/4"	FS → 8					
6	1/8"		FS → 6				
5	5/64"	FS.8 → 5		FS → 5			
4	0.046"	FS.8.5 → 4	FS.6 → 4		FS → 4		
3	0.033"		FS.6.4 → 3	FS.5 → 3		FS → 3	
2	0.027"	FS.8.5.4 →2			FS.4 → 2		FS → 2

Figure 2: This figure shows how we ran through the material through the Hammermill for each moisture content. FS sands for feedstcok and the number represents the screen used. (Ex. Path 1 had four different screen sizes that were used and the first screen was screen #8 which was a ¼" screen.)

Methods

Overview

- To reach this objective the energy consumed by running the material through a small scale industrial Hammermill (see Figure 1 above) using 5 different levels of moisture content (6, 12, 18, 28, and 40 percent) is being measured.
- At each moisture content the material is being ran through multiple screen sizes to get varying particle size reductions (see Figure 2 above)

Data Collection

- The material was conditioned for 6% moisture content using a G-series elite conditioning chamber.
- 50 lbs. of material was used for each of the Paths shown in figure 2.
- A rotap testing sieve shaker was used to determine the average particle size after each size reduction.
- A rotap testing sieve shaker was also used to determine the starting average particle size of the whole feedstock before being run through the Hammermill.
- A fluke power reader was used to measure the energy consumed for each path and screen size.

Preliminary Results

- **Optimal Path**
  - Based on the data compiled from the completion of paths 1-4 for the moisture content of 6%, we predict that the optimal particle reduction range will be through Path 3. (See Figures 3 & 4)
  - Based on the same data the path that would consume the most energy would be Path 4.
- **Equation**
  - The four completed paths contribute data that will aid in the successful creation of equation 1.

Project Future

- Path 5 and Path 6 will be completed for the moisture content of 6%
- Feedstock will be conditioned to the moisture content of 12, 18, 28, and 45 percent
- For each of the moisture contents the feedstock will be ran through the Hammermill for each of the Paths and the energy consumed will be measured.
- After each screen size, for each of the moisture contents, a sieve analysis will be done to determine average particle size.
- The resulting data will be analyzed to create equation 1.

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