Production, Cost and Chip Characteristics of In-Woods Microchipping

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Abstract

Emerging markets for biomass have increased the interest in producing microchips in the field. As a component of a large United States Department of Energy (DOE) funded project, microchipping has been trialed on a limited scale. The goal of the research was to evaluate the production, cost and chip characteristics of a mobile disc chipper configured to produce microchips. Multiple test loads of Southern Pine were chipped and analyzed during the study. The chipper was modified after each test in an effort to obtain an “ideal” microchip that met a narrowly-defined specification. This paper reports the resulting production rate, cost and chip characteristics.

Introduction

In-woods chipping of trees has been a component of forest harvesting for decades (Stokes et al 1987). These chipping operations produced either clean chips for the pulp and paper industry or whole tree (dirty) chips for energy production. Emerging biomass markets have increased the interest in producing a microchip in the woods. Wood pellet manufacturers as well as woody biomass ethanol and biodiesel startups have expressed interest in in-woods produced microchips.

A microchip has been defined as a chip between 1/4 and 3/8 inches in length (Steiner and Robinson 2011). A traditional pulp and paper chip is generally 1 ¼ inches in length.

Microchips potentially offer several advantages to traditional pulp chips. Steiner and Robinson (2011) list multiple advantages. These include; lower overall total system energy requirements, faster processing times, smaller equipment sizes and fewer processing steps. Whitelaw (2009) also suggests that microchipping can eliminate front end grinding in the pellet process and reduce the horsepower requirement for regrinding after the drying process.

Hein (2011), in an article for Canadian Biomass Magazine, quotes several industry sources, that also contend that microchips may reduce the required mill chipping and grinding capacity and offer better material characteristics. These include less variance (variability?) in moisture content, faster drying and easier chemical conversions.

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Microchips can be produced with either drum chippers or disc chippers (Hein 2011), Steiner and Robinson (2011) and Whitelaw (2009). Drum chippers are more commonly used to produce microchips due to their screening capabilities. Examples of chipper characteristics that may be modified to change chip characteristics include spout angle, knife angle, knife length, number of knives and disc/drum speed (Smith and Javid 1997) Watson and Stevenson (2007).

Methods

A Precision Husky WTC-2675[2] disc chipper was modified in an effort to produce microchips in the field. The chipper was equipped with an 8 knife disc rather than the traditional 3 or 4 knife disc. Over the course of the trial, knife length, knife and counter knife angle, as well as number of chip breakers and paddles were modified in an effort to produce microchips. This paper documents just two of the microchipper trials. For chip comparison, conventional chips were produced with this same chipper and disc, but with only 4 knives installed.

The goal specification was for 90% of chips produced to pass a ½ inch round-hole screen. This specification was set based on conversations with various biomass end users located in the southeastern United States.

Due to a low demand for in-woods pulp chips and whole tree chips during the time of the study, the number of loads produced was small. Each load produced was timed with a stop watch and mill load tickets were used to determine tons produced. Fuel consumption was recorded on a sample of loads. Fuel use was measured by topping the tank before and after individual loads and from the chipper's on-board computer.

Chip samples were taken from the spout of the chipper multiple times (minimum of 11) during each load to produce a sample representative of a whole van load of chips. Chip analysis included particle size analysis, moisture content and bulk density measurements. Particle size was measured by passing the samples through a stack of round-hole sieves.

Results and Discussion

Seventeen loads were sampled. . Table 1 shows the results of producing whole tree conventional chips and two trials of whole tree microchips. The average number of stems per load and average tons per load were similar for conventional chips compared to the first trial of microchips, but the conventional chips averaged approximately 10 tons/Productive Machine Hour (PMH) more than the microchipping. For the second trial

[2] The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others that may be suitable.

of microchipping, the number of stems per load was less and the tons per load was higher, but the microchip production (8.79 tons/PMH) remained lower than the conventional chips. These two trials showed that microchipping production was 12.8% and 11.1% less on average than producing conventional chips with the same chipper.

Table 1: Productivity data for a disc chipper producing whole tree conventional and microchips.

		Conventional Chips		
	Time (min)	**# Stems**	**Tons**	**Tons/PMH**
Min	16.59	278	21.05	76.14
Max	18.47	350	24.86	82.89
Avg.	17.59	320	23.33	79.52
Count	4			
		Micro Chips 1		
Min	15.21	177	19.25	54.77
Max	24.92	425	25.03	84.16
Avg.	19.73	312	22.41	69.37
Count	8			
		Micro Chips 2		
Min	20.65	76	26.68	58.91
Max	27.20	143	29.18	84.78
Avg.	23.96	121	27.81	70.73
Count	5			

Fuel consumption was not measured on every load. Table 2 shows the results for the fuel consumption as measured for the whole tree conventional chipping and the whole tree microchipping. Not enough data was collected to look for statistically significant differences in the results. The data indicates that the fuel consumption for microchipping was higher than that of conventional chipping with the same chipper. A difference of 0.62 tons/gal represents a 14.8% increase in fuel consumption to produce microchips.

Table 2: Fuel consumption for a disc chipper producing whole tree conventional and microchips.

	Conventional Chips	Micro Chips
Gallons	26	39
Tons	108.82	139.07
Gal/ton	0.24	0.28
tons/gal	4.19	3.57
Gal/hr.	18.76	19.53

In terms of chip particle size, the chipper did not meet the goal of 90% passing a ½ inch round-hole screen (actual screen size was 13 mm, which equates to 0.51 inches). Table 3 shows the results of the chip analysis. On average, 74% of the microchips produced passed the ½ inch screen. This compares to 47% of conventional chips passing the ½ inch screen, resulting in a difference of 36.7%. The average moisture content difference between the two chip sizes was 3%.

Table 3: Chip characteristics of whole tree conventional and microchips produced with a disc chipper.

	Conventional Chips	
	MC	**% Passing**
	(WB)	**(13 mm rd.)**
Min	0.44	38.4
Max	0.54	55.8
Avg.	0.47	47.1
Count	5	4
	Microchips	
Min	0.46	68.1
Max	0.56	82.1
Avg.	0.50	74.4
Count	8	7

The machine rate method was used to calculate the owning and operating cost for the chipper (Brinker, et al, 2004). The calculations assumed an off-road diesel cost of $3.50/gallon, 2000 scheduled hours per year and a utilization rate of 50%. The purchase price of the Precision Husky WTC 2675 disc chipper was $490,000. Using the chipping production rates measured during the study, a ton of conventional chips made from whole trees would cost $3.08/SMH ($0.08/ton) to produce at road side. The cost of producing microchips was $3.82/SMH ($0.11/ton). A difference of $0.03/ton was observed. This represents the cost associated only with the chipper.

Conclusions

Results indicate that the disc chipper can produce microchips, but currently cannot meet the narrow specification of 90% passing a ½ inch round-hole screen. On average 74% of the chips produced did meet the required size. Future adjustments to the chipper have the potential to further increase the percent of acceptable microchips produced. The study also indicated that producing microchips with the disc chipper reduced the chipping production rate by 10 tons/PMH an approximately 12% reduction in productivity. This reduction in productivity was also accompanied by an approximately 15% increase in fuel consumption.

The study results show the cost, in lost production and increased fuel consumption, of producing microchips in the field with a disc chipper. These costs may be feasible based on some of the potential advantages of processing cost savings that may be realized by the end-user after delivery of microchips.

References

Hein, T. 2011. *Small is beautiful: microchipping woody biomass*. Canadian Biomass Magazine. November-December. Pgs. 2.

Smith, D., and S. Javid. 1997. Chipper performance improved through analysis of critical angles. In Proc. of conf. on *Pulping Conference*. TAPPI. Peachtree Corners, GA.

Steiner, J. R. and M. Robinson. 2011. *Microchips; comparing wood microchips to conventional wood chips (typical anaylsis)*. Presented at the BioPro Expo & Marketplace, Atlanta, GA. March 14-16, 2011.

Stokes, B.J., W.F. Watson, and D.L. Sirois. 1987. Factors affecting power requirements for chipping whole trees. In Proc. of conf. *American Society of Agricultural Engineers Summer Meeting*, Baltimore, Maryland, June 28-July 1, 1987.

Watson, W. F. and R. Stevenson 2007. The effects of seasonal variation in wood moisture content on chip size and kraft pulping. In Proc. of conf. *Engineering, Pulping, and Environmental Conference*.TAPPI. Peachtree Corners, GA.

Whitelaw, Dave. 2009. CBI; *Continental Biomass Industries, Inc.* Available online at www.pelletheat.org/pdfs/CBI.pdf