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In-wood grinding and screening of forest residues for biomass feedstock applications

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ABSTRACT

Logging residues present a substantial near term opportunity as a bioenergy feedstock, but contaminants that can reduce their value can be introduced during collection. We studied the use of a trommel screen to reduce ash levels in ground forest harvest residues at time of production. Eight treatments of initial harvest type, grinder size, residue age, and screen usage were applied to southern pine plantation residues in the coastal plain of South Carolina, USA. Using the screen, the average ash levels of screened roundwood and clean chipped residue was reduced from 4.0% to 1.4% and from 11.9% to 6%, respectively. Average energy density increased 2–5% by screening. Without screening the feedstock, large grinder utilization with roundwood residues was 58% while the addition of a trommel screen reduced utilization to 47%. Screened roundwood residues were consistently more costly to produce than unscreened roundwood or screened clean chipped residue with either grinder size under a number of economic and operational scenarios on either a load weight or energy content basis. The screened clean chip systems and the unscreened roundwood material provided the most competitive residue on a cost per unit of energy basis.

1. Introduction

Political mandates and social pressures are continually increasing the need for renewably sourced energy fuels. Some regions, particularly the U.S. South, are well equipped to immediately provide woody biomass for energy applications [1]. There are numerous environmental benefits of biomass use for energy production [2]. Specifically, "woody biomass" is a suitable replacement for fossil fuels that can provide an additional offset of greenhouse gas emissions [3] and reduce SO_2 and NO_x emissions relative to coal use [4]. Work has already been done to develop co-firing systems that are operationally proven and have a number of environmental and economic benefits [2].

With such potential for woody biomass use in renewable energy processes, much work has gone into developing methods for harvesting and collecting this material. Numerous studies have examined the use of logging residue as a primary source of biomass fuel in energy and biofuel production [5–8]. Yet, in many cases logging residue is currently not utilized as a part of normal forest management regimes.

There is a demonstrated need to "pretreat" residue before it is transported to an energy facility [5]. Objectives of pretreatment typically include resizing and densifying the material to facilitate improved transportation to a facility, storage at a facility, and eventual processing for energy applications [9]. A number of in-woods options have been developed and tested, with research focusing on chippers and tub grinders [10]. However, there is not a substantial body of literature examining the use of horizontal grinders in energy applications with forest residues. Horizontal grinders could prove useful in

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Fig. 1 – Trommel screen fed by a horizontal grinder.

this setting, since they can handle a wide range of feedstocks [11]. This advantage has been observed with logging contractors that have demonstrated a greater ability to process limbs and branches with grinders as opposed to chippers [12].

Despite the potential benefits of using residual logging material as an energy feedstock, some challenges must be addressed. There are well-documented concerns of fouling and slag formation within some boiler types at biomass fired energy facilities due to aluminosilicate contaminants such as sand and soil [13–15]. This issue is of increased concern with logging residue, as it is frequently piled for extended periods of time, increasing the potential for contamination. Consequently, direct combustion of some forms of biomass may be limited [16]. Proposed solutions have included the use of additives such as kaolin and limestone to reduce the size of ash deposits [14].

A more direct approach would be to reduce the amount of fine material contaminants at the source, before the fuel is transported to an energy conversion facility. A number of sifting or screening utilities exist that can be used to separate the desired wood fuel from fine material. Specifically, trommel screens can be used between a grinder and a hauling truck in this capacity. Trommel screens tumble the feedstock material through a cylindrical screen. Rejected materials that fall through the screen are then conveyed from the machine separately from the feedstock. Unfortunately, this solution has not been well tested, and consequently has not been widely accepted by the forest products community.

In this study we quantified the effectiveness and cost of operating a horizontal grinder/trommel screen system with different types of residual forest materials. These configurations were examined in capturing residues from harvests of loblolly pine (*Pinus taeda* L.) plantations in the coastal plain of South Carolina.

2. Materials and methods

This study was conducted by monitoring and collecting samples from a number of active fuelwood removal operations where a trommel screen (Fig. 1) was used to remove fine materials from the grinding streams of piled logging residue (tops, limbs, etc.). Field trials were held in conjunction with active timber harvesting operations of a small lumber company in South Carolina. The operator used a grinder/trommel screen system fed by a wheeled front-end loader to capture residue following either clearcut harvests that produced roundwood or first thinnings where clean (pulp quality) chips were produced. Residues from roundwood harvesting were typically larger pieces removed during delimbing with a pull-through delimber while clean chipping residue consisted of smaller pieces of limbs and bark removed by chain flails. Two grinder sizes were included in the study - a large 580 kW Peterson 4600 and a small 340 kW Peterson 2400. Both grinder sizes were fed by a 170 kW John Deere Model 644J front-end loader. In addition, a 130 kW McCloskey Model 621 trommel screen fitted with 12.5 mm screen openings was used for some of the treatments.

A total of 8 treatments were examined with variables including initial harvest type, time since harvest, grinder size, and use of trommel screen. For each combination of grinder size and residue/harvest type, two ages of material (4 and 8-week post harvest) were also examined. The original

Table 1 – Original treatment block.

System	Harvest type	Weeks since harvest
Large grinder (screened)	Roundwood (clearcut)	4
Large grinder (screened)	Roundwood (clearcut)	8
Large grinder (screened)	Chipping (first thin)	4
Large grinder (screened)	Chipping (first thin)	8
Small grinder (screened)	Chipping (first thin)	4
Small grinder (screened)	Chipping (first thin)	8
Small grinder (screened)	Roundwood (clearcut)	4
Small grinder (screened)	Roundwood (clearcut)	8