PROTOTYPE WOOD CHUNKER USED ON POPULUS 'TRISTIS'

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Abstract.--Populus 'Tristis' trees grown under short-rotation, intensive culture were sampled and chunked in a prototype experimental wood chunking machine. Data presented describe the character of the trees chunked, the energy and power requirements for chunking, and the chunking rate. Specific energy requirements for chunking Populus 'Tristis' are compared with chunking and chipping common Lake States' species from natural stands.

An essential objective of harvesting short rotation, intensively cultured (SRIC) plantations is to convert the trees into a useable form. Whole-tree chippers, which are commercially available, offer one means to reduce SRIC trees to chips for subsequent utilization for pulp and paper or energy. Although chips are used to produce energy they have several disadvantages due to their small particle size, low bulk density, and close layering characteristic that restricts air movement in storage piles or combustors that burn on grates. Chips are also not suitable as furnish for structural flakeboard because of their short dimensions in the fiber direction--they cannot be satisfactorily flaked.

To explore new utilization opportunities for small diameter trees including those from SRIC plantations, forest engineering researchers at the Forestry Sciences Laboratory in Houghton, Michigan, have been investigating new concepts for comminuting wood. A key result has been the development of a wood chunking machine that reduces small trees into particles much larger than chips. Our wood chunker is not yet commercialized, and we are just now introducing the wood chunking concept to industry. Thus, no data exist on the utilization of chunkwood in the composite wood material (CWM) and wood energy industries. Through future research and demonstration projects done in cooperation with industry and other interested organizations, we hope to document chunkwood's application to the wood energy and CWM industries.

Because of the excellent prospects for commercialization of our wood chunking concept, laboratory research was conducted on our prototype machine to determine overall performance and to document the power and energy requirements for several important Lake States' species (Arola et al. 1982; Arola et al., manuscript submitted to Forest Products Journal). The purpose of this paper is to provide similar documentation for chunking intensively grown Populus 'Tristis.'

CHUNKING TESTS AND RESULTS

Our basic wood chunker consists of three 1/4-inch curved blades attached to a driven, shaft-mounted disc (fig. 1). The blades, which vary in depth from zero at the leading edge to approximately 9 inches at the trailing edge, are mounted perpendicularly to the disc face with the trailing edges curved inward. Logs are fed into the blades by hydraulically powered feed rollers. As the disc rotates, the blades sever 2- to 5-inch long chunks from the bolts (fig. 2). We ran the machine at a no-load cutter disc speed of 220 revolutions per minute and a workpiece feed rate of 245 feet per minute.

Populus 'Tristis' samples were obtained from the North Central Forest Experiment Station's Harshaw Forestry Research Farm,

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which is located near Harshaw, Wisconsin, and is managed by the Maximum Fiber Yield Project at Rhinelander, Wisconsin. All material was cut into nominal 100-inch bolts. For each test bolt we determined the small and large end diameters, moisture content, length, and weight (table 1).

By instrumenting the shaft, we were able to record torque, integral of torque, cutter disc speed, and time. From these measurements we calculated the energy per cubic foot of solid material chunked, average torque and horsepower required, and the chunkwood production rate (table 1).

In general, with bolts ranging in diameter from 3.5 to 7.5 inches, the machine chunked wood at the rate of about 30 cubic feet of solid wood per minute and required about 35 horsepower. The mean energy requirement for Populus 'Tristis', with a moisture content of 46 percent and specific gravity of 0.3, was 1.2 hp-min/cu ft.

It took less energy to chunk intensively cultured Populus 'Tristis' than it did to chunk several species from natural Lake States' stands including Populus 'Tristis' cousin, aspen (fig. 3). Though energy requirement data aren't available for conventional chipping of Populus 'Tristis,' the tabulations for aspen and maple clearly show that it takes less energy to produce chunks than chips (table 2).

Table 1.--Results of chunking tests with hybrid Populus 'Tristis.'[1]

Item	Mean	Standard deviation	Minimum	Maximum
Bolt length (inches)	100.2	1.6	99.0	105.0
Bolt diameter (inches)				
Small end	4.3	.5	3.6	5.0
Large end	6.1	.7	5.3	7.4
Weight (pounds)	44.8	11.1	31.3	62.2
Chunking time (seconds)	2.6	.2	2.4	3.2
Moisture content[2] (green basis)	46.5	3.8	40.5	52.5
Specific gravity	.3	.03	.24	.34
Production rate (cu-ft/min)	29.3	4.7	22.7	39.3
Average torque (ft-lb)	832.4	141.8	661.0	1,108.0
Average power (horsepower)	33.5	5.6	26.8	44.1
Energy				
(hp-min/cu ft)	1.2	.1	1.0	1.3
(hp-hr/green ton)	1.1	.1	.9	1.3
(hp-hr/ovendry ton)	2.1	.2	1.8	2.6

[1] Based on a cutter disc speed of 220 rpm and feed rate of 245 feet per minute.

[2] Calculated by TAPPI Standard T18 M-53 (Technical Association of Pulp and Paper Industries 1967).

Table 2.--Comparison of energy requirements for chunking versus chipping.

Species	Chunks	Conventional chips[1]	Energy ratio (chunks/chips)
	- -hp-min/cu ft- -		%
P.'Tristis'	1.2	--	--
Aspen	1.4	3.8	37
Red maple	2.1	5.5	38
Sugar maple	2.5	7.6	33

[1] Papworth and Erickson 1966.

We conclude that the concept of chunking and the prototype wood chunker have excellent commercial potential--both from wood utilization and equipment development viewpoints. The unique physical character and size appear to give chunkwood some distinct advantages over conventional pulp-size chips. Two key chunkwood opportunities are as an intermediate furnish for the flake board/composite wood product industries and the wood energy industry. We are currently cooperating with the Forest Products Laboratory in Madison, Wisconsin and the Institute of Wood Research at Michigan Technological University in Houghton, Michigan to evaluate the suitability of chunkwood as a source of flakes. This cooperative research focuses only on aspen and dense hardwoods. Similar research should be directed at Populus 'Tristis.' Because the wood energy industry has not yet been exposed to chunkwood as an energy converter feedstock, studies or demonstration projects should be carried out to evaluate the suitability of chunkwood for solid fuel combustors, gasifiers, pyrolyzers, etc. We are seeking the cooperation of the wood energy industry to document this application.

In our opinion, chunking will provide a viable alternative to chipping and will help improve the market potential for small trees from natural and SRIC stands.

LITERATURE CITED

Arola, Rodger A., Robert C. Radcliffe, Sharon A. Winsauer, Edsel D. Matson. 1982. A new machine for producing chunkwood. USDA Forest Service Res. Pap. NC-211. 8 p. North Central Forest Experiment Station, St. Paul, MN.

Arola, Rodger A., Sharon A. Winsauer, Robert C. Radcliffe, Martyn R. Smith. Chunkwood production: a new concept. Manuscript submitted to the For. Prod. J. for publication.

Papworth, R. L., J. R. Erickson. 1966. Power requirements for producing wood chips. For. Prod. J. 16(10): 31-36.

Technical Association of Pulp and Paper Industries. 1967. TAPPI standard T18 M-53.

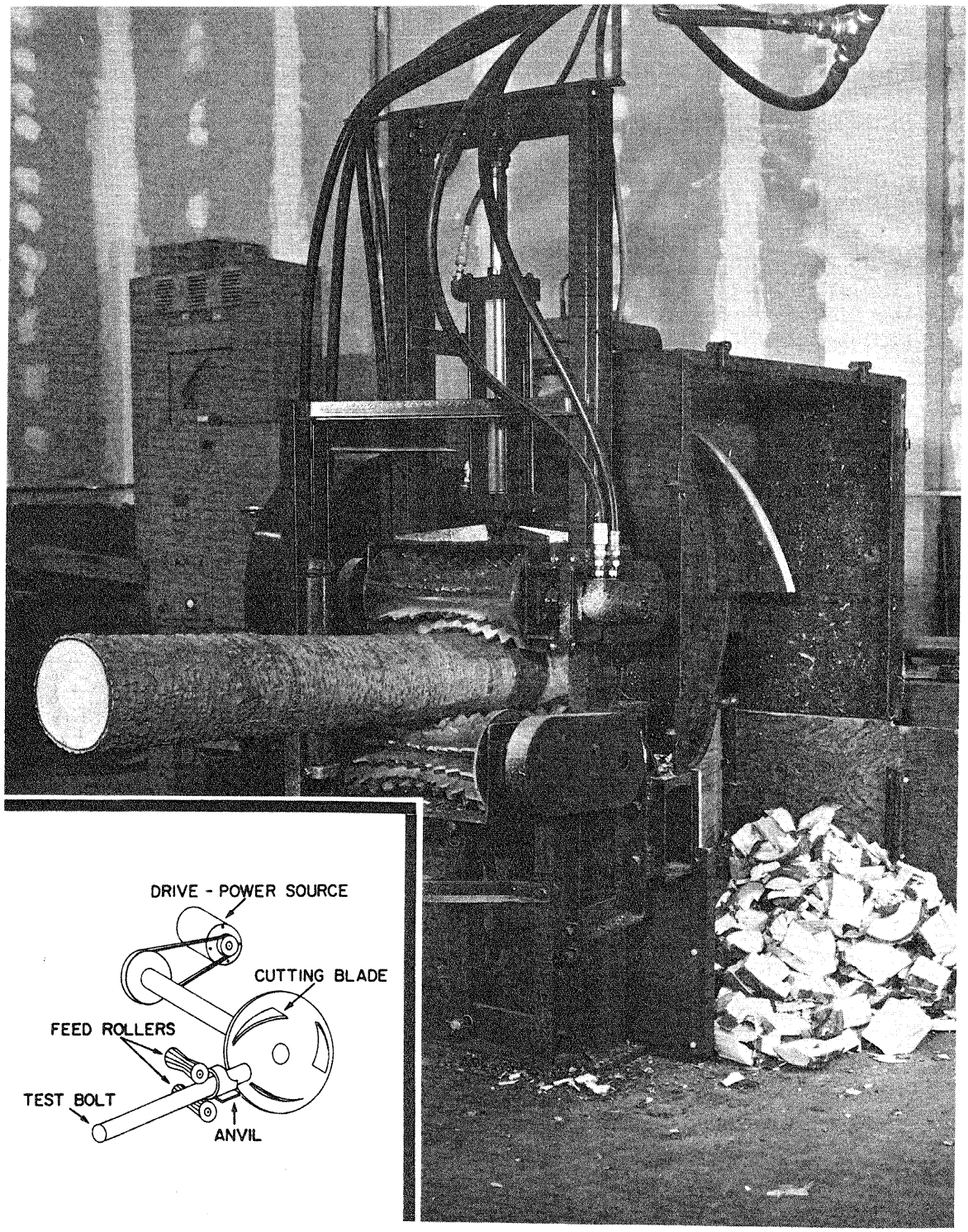

Figure 1.--Photo and simplified schematic of the experimental wood chunker.

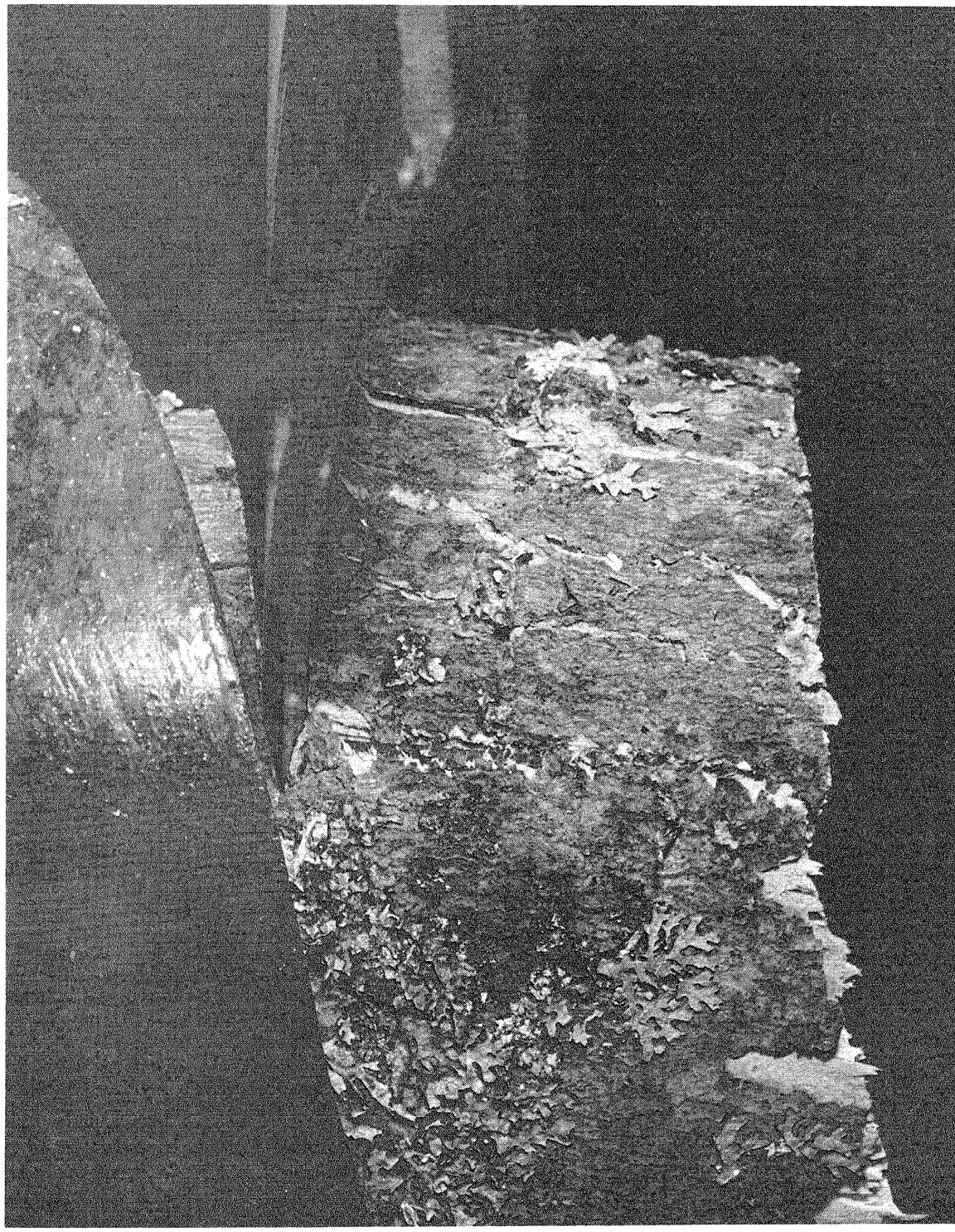

Figure 2.--Chunkwood being severed.

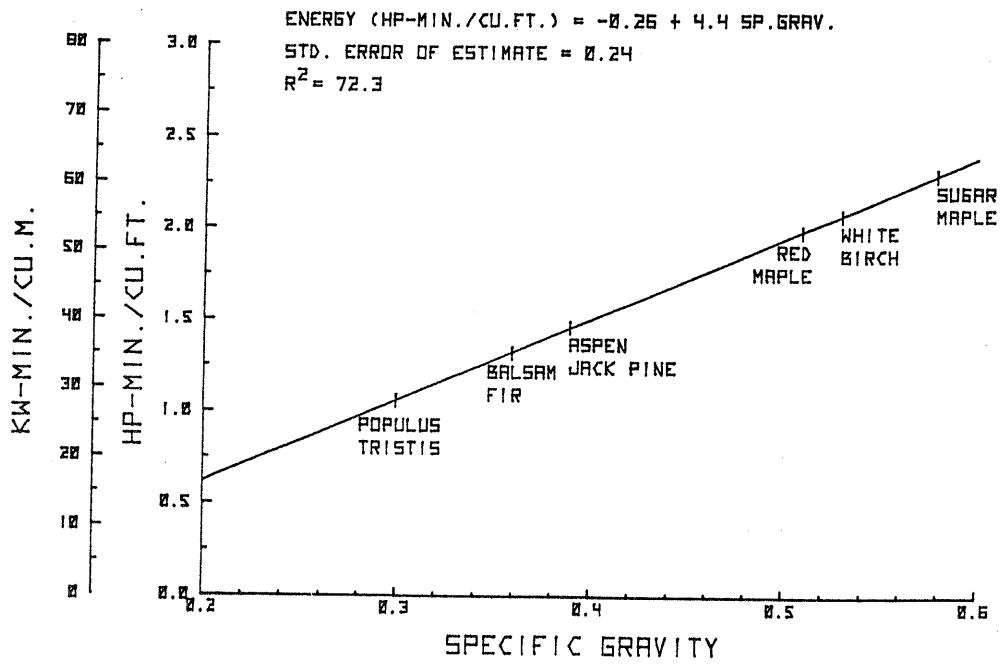

Figure 3.--Energy required to chunk several Lake States' species.