NORTH CENTRAL FOREST EXPERIMENT STATION 1992 FOLWELL AVE. ST. PAUL, MN 55108 FOREST SERVICE-U.S.D.A.

Research Note NC-293

1983

AIR DRYING OF CHUNKWOOD AND CHIPS

Joseph B. Sturos, *Mechanical Engineering Technician,*
Lynne A. Coyer, *Industrial Engineering Technician,*
and **Rodger A. Arola,** *Principal Mechanical Engineer,*
Houghton, Michigan

ABSTRACT.—A new method of comminuting wood has resulted in a new wood particle form called chunkwood, which is much larger than the common pulp-size chip. Chunkwood appears well suited for use as a fuel but nothing is yet known about its storage, drying, or combustion characteristics. This paper reports on two exploratory drying experiments we conducted to see whether chunks, with their much larger interparticle voids, dry more readily than chips. In one experiment we used natural convective ambient air to dry chunks and chips and found that chunks dried much faster than chips. In another experiment we used forced ambient air to dry chunks and chips and found that chips dried faster than chunks. However, the chunks offered much less resistance to forced air flow and thus required less fan energy. We recommend that larger, more controlled studies be undertaken to further document the ambient drying characteristics of chunkwood as compared to chips.

KEY WORDS: Energy wood, fuel, moisture content, biomass for energy, fuel enhancement, fuel characteristics.

Today wood is increasingly used for generating industrial energy—mainly process steam and heat. The principle source of energy wood has been mill residues. But recently, whole-tree chips have been gaining in use mainly because they are readily available in large quantities due to the commercial introduction and widespread use of whole-tree portable chipping machines. Although conventional whole-tree chips can be sucessfully combusted in solid fuel boilers, they are not necessarily the most desirable form for wood as a solid industrial fuel. For example, they tend to have high solid particulate emissions because of the high flue gas velocities when burned in industrial scale combustors. Additionally, chips tend to layer and thereby restrict the flow of underfire combustion air. Pulp-size chips also cause bridging problems, require considerable energy to produce, have a low bulk density, and layer closely when stored in piles and thus restrict the movement of air necessary for natural drying. This lack of venting in chip piles also contributes to heat build-up and fire danger.

In conjunction with harvesting operations, we have explored ways to comminute small diameter trees and logging residue into particles suitable for ring flaking for flakeboard production or for use as a solid fuel. As a result of this research, two different types of machine have been developed that produce "chunks" of wood that appear well suited for either use (Arola *et al.* 1982, Arola *et al.* in prep., Barwise *et al.* 1977, Barwise *et al.* 1982). The resulting chunks are much larger, require less energy to produce, and have somewhat greater bulk density than conventional pulp chips. They also exhibit entirely different bulking characteristics because of their chunky and irregular shape.

N. C. ARCHIVES

In a pile or thick layer of this material, large void spaces exist between particles. It was our belief that these chunks, with large interparticle voids, would dry faster and generate less solid particulate emissions when burned than conventional wood chips. However, because these chunks are a new particle form, information is not available on their storage, drying, or combustion characteristics. Our work in chunkwood production and drying is the beginning foundation.

For use as a solid fuel, any amount of drying prior to combustion is advantageous. Therefore, the purpose of our study was to determine drying rate differences between chunked wood and conventional pulp-size chips under ambient air test conditions.

METHODS

We established two simple drying experiments using ambient room air (drawn from within our seasonally heated machine shop building) to compare these new potential fuelwood chunks and conventional pulp-size chips. The first experiment used natural convective air drying while the second experiment used forced air convective drying. In these experiments we used wood from both aspen and red maple. The chips were made using a Morbark "Chip-Pac"[1] Model 3-48 chipper set to produce 3/4-inch long standard pulp chips. The chunks were made on our experimental chunking machine. From independent tests with the machine, we found that chunks ranged from 2 to 5 inches, and averaged 3.5 inches long. Particle cross sections ranged from about 1/2 inch up to the full diameter of the bolts being chunked (Arola *et al.* 1982).

In the natural convective air drying experiment, equal volumes of green chunks and chips were placed in separate 3.6 ft^3 (one-half of a 55-gallon barrel) cylindrical containers, set out in an open room, and allowed to freely dry (fig. 1). Initial tare and sample weights were determined. The green wood weights initially ranged between 60 and 85 pounds. To monitor moisture loss, both containers were periodically weighed. Because of time and space limitations and the preliminary nature of our study, the test was repeated only once, by species. Therefore, our results are not based on replications.

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

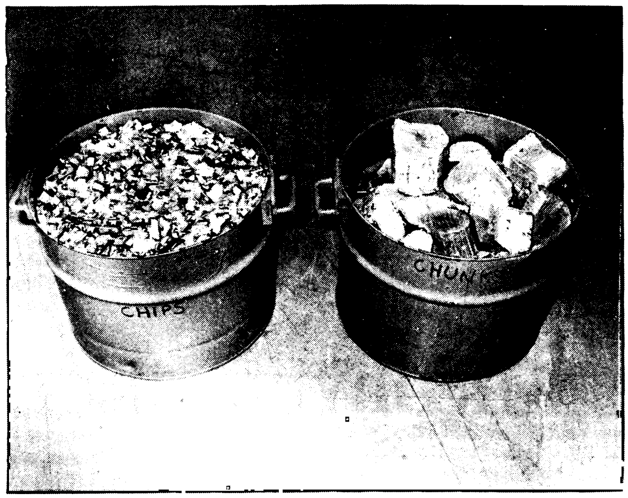

Figure 1.—*Test setup for natural convective drying of chips (left) and chunks (right).*

In the second experiment using forced air convective drying, we devised a test apparatus so that a known quantity of green chips or chunks could be dried by forcing ambient air through the particles. To begin, a 7.3 ft^3 cylindrical container (standard 55-gallon barrel) with a screened bottom insert was filled with chips, weighed, and set on a 7.5 hp variable volume blower system. The blower's inlet restrictor was adjusted to give a nominal 340 cfm of air flow through the filled barrel (fig. 2). The 340 cfm level was chosen because it was the lowest practical level at which this particular blower system would operate and not because it was optimum for drying. As the particle drying progressed, the following data were periodically noted: chip weight; elapsed time; air flow rate; pressure drop through the chips; ambient air temperature and relative humidity; and atmospheric pressure. We also determined beginning and ending moisture content. After the barrelful of chips was dried, an equal weight of chunks was dried following the same procedure. For this series of tests, five repetitions were made for each species using uncontrolled ambient room air. In all cases, we terminated the drying tests when the weight loss stopped or the drying rate was so slow that it was judged impractical to continue.

The aspen tests were run from the end of March until the end of May; the ambient air temperature averaged 73° F, and the relative humidity averaged 32 percent. The red maple tests were run between early June and early August. The ambient air temperature averaged 75° F, and the relative humidity averaged 60 percent.

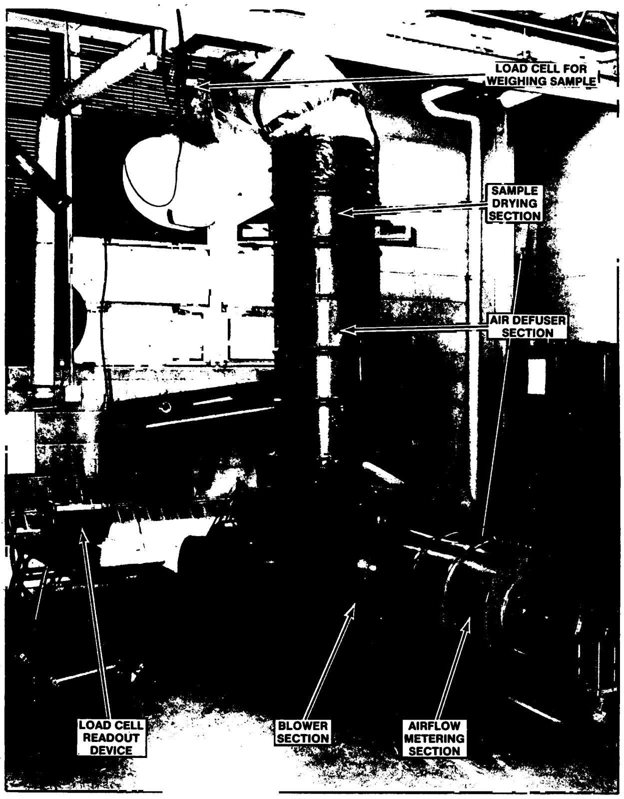

Figure 2.—*Test setup for forced air convective drying.*

For both experiments, we determined and plotted average moisture contents (wet weight basis).

In our second test series we calculated the energy used (power x time) based on the air horsepower dissipated within the wood bed. We calculated air horsepower from the equation (McDonald *et al.* 1967):

$$\text{Air hp} = 0.0001575 \text{ pQ}$$

where p = pressure drop across the wood bed in inches of water and Q = air flow rate in ft³/min.

EXPLORATORY RESULTS

In our natural convective air drying tests, we observed that the chunks dried much faster and to a lower moisture content than the chips for both species (fig. 3). This finding supports our belief that chunks dry faster than chips under natural convective air drying. (Conclusive data should be developed under conditions of controlled temperature and humidity.) Though unsubstantiated, we attribute the marked difference between drying rates of chunkwood and chips to the bulky character of the chunkwood, which gives larger air spaces (voids) and allows for easy air flow, as opposed to the flat character of chips, which layer closely and restrict air movement and trap moisture. We observed that at the end of our natural convective air drying tests, when the chips and chunks were emptied from the containers, the chunk container was completely dry while the chip container was rusty and wet. For the red maple (run during the more humid summer months), we actually found standing water at the bottom of the chip barrel.

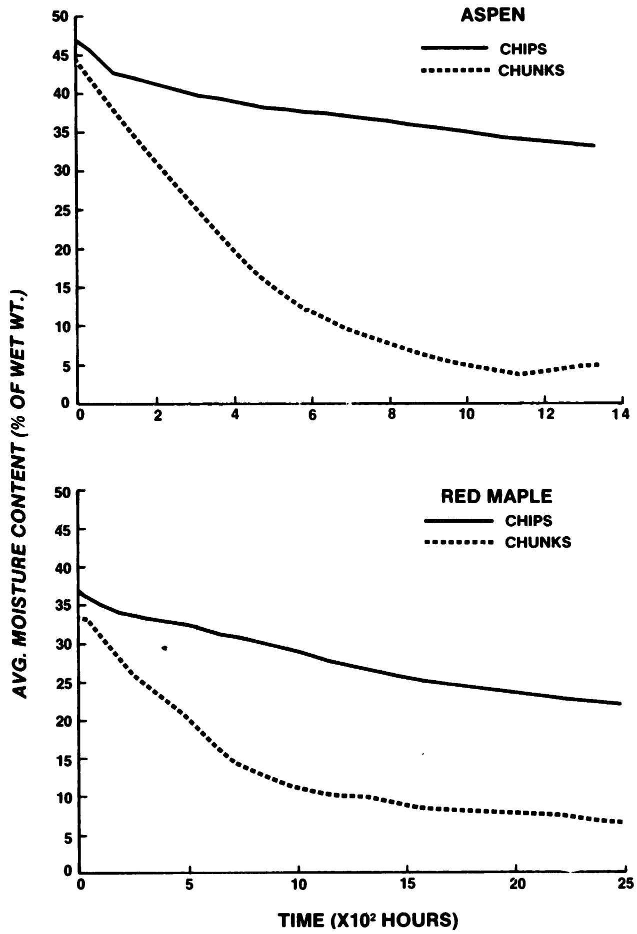

Figure 3.—*Time required for natural convective drying of aspen and red maple chunks and chips.*

In our forced air experiments, we found that the chunks dried slower than the chips (fig. 4); however, the pressure required to force the air through the chunks was much less than for the chips—consequently, the energy required was much less (fig. 5). These differences again are attributed to the chunks' larger interparticle void spaces, which offer much less resistance to air movement. In commercial practice, this energy advantage could possibly offset the added cost of the larger drying bin that would be required to give the same production rate (pounds of dry wood per hour) as for chips.

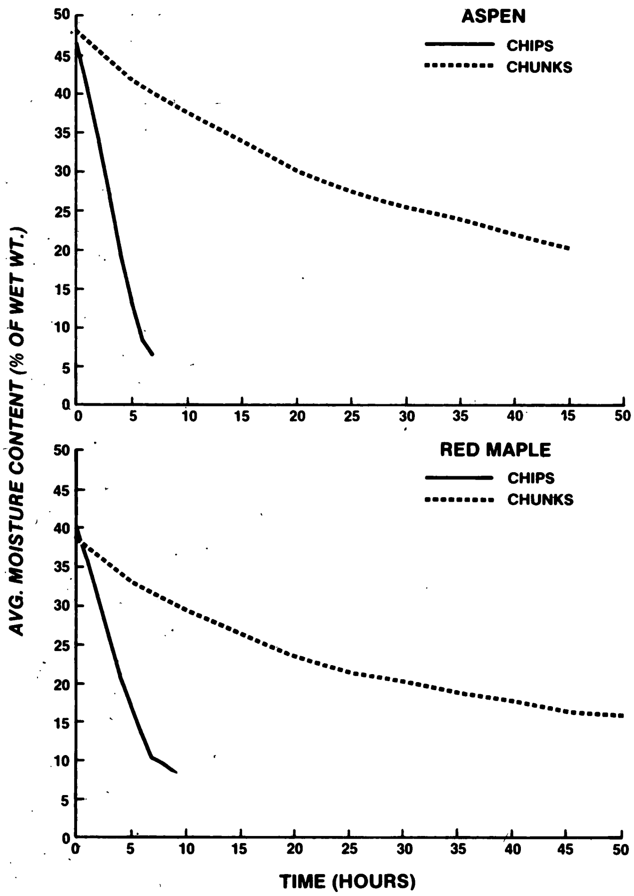

Figure 4.—*Time required for forced air convective drying of aspen and red maple chunks and chips. The curves represent the average of five repetitions.*

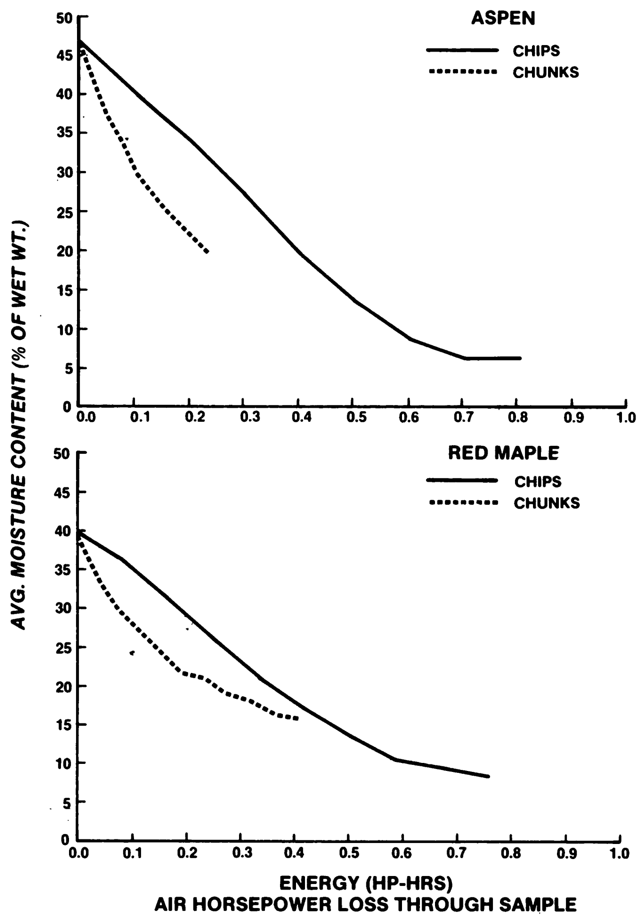

Figure 5.—*Energy required for forced air convective drying of aspen and red maple chunks and chips. The curves represent the average of five repetitions.*

We recognize the statistical limitations of our observations—particularly due to our inability to precisely control temperature and relative humidity. Nonetheless, we feel that this exploratory investigation has indicated that chunks have better drying characteristics than pulp-size chips. Based on our preliminary results, we recommend that more controlled investigations be conducted on a larger scale using ambient air drying of chunks in free-standing piles and in a silo with low velocity forced air.

LITERATURE CITED

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

Arola, Rodger A.; Winsauer, Sharon A.; Radcliffe, Robert C. Chunkwood production: a new concept! (In prep.).

Barwise, Robert D.; Arola, Rodger A.; Erickson, John R. Helical head comminuting shear. U.S. Patent 4,053,004. October 11, 1977.

Barwise, Robert D.; Arola, Rodger A.; Matson, Edsel D. Involuted disc slicer. P.C. 6170. Patent application filed February 26, 1982.

McDonald, J. E. In: Baumeister, Theodore; Marks, Lionel S., eds. Standard handbook for mechanical engineers. 7th ed. New York: McGraw-Hill; 1967: 14-70.

U.S. GOVERNMENT PRINTING OFFICE:1983-666-296/286