U. S. FOREST SERVICE

RESEARCH NOTE NC-112

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A DENSITY-GRADIENT TECHNIQUE FOR OBTAINING WOOD AND BARK CHIP DENSITY

ABSTRACT. — Describes a density-gradient column used to measure wood and bark chip densities for segregation purposes.

OXFORD: 812.31:811.7:176.1 *Populus spp.* **KEY WORDS: aspen, moisture content, segregation, specific gravity, density gradient column.**

Expanded utilization of existing woodlands may involve chipping of entire trees[1] and subsequent segregation of the wood and bark chips. Several methods of accomplishing the segregation are being examined. Some are based on differences in specific gravity (density). Because these methods may require processing of the chips at conditions ranging from "water-soaked" to "air-dried," it is necessary to know how density varies with moisture.

Densities are usually measured using liquid-displacement techniques[2] based on ovendry (o.d.) or green volumes with o.d. weights[3]. Densities calculated using o.d. weights with green volumes are not useful because they do not represent true density. The use of o.d. weights with o.d. volumes gives true densities, but they are not useful for our purposes.

Initially, we obtained true densities by weighing the chips at various moisture contents and determining their volumes by liquid displacement. Two liquids, water and a fluorocarbon (FC-77 obtained from 3M)[4], were tested. Specific-volume errors resulted from adhesion of air bubbles to chip surfaces, and liquid losses due to evaporation and absorption of the liquids by the chips. The measurements were unsatisfactory. The next attempt was made using a "density-gradient" column.

When two miscible liquids of different densities are put in a long cylinder of small diameter, interdiffusion of the liquids results in a density gradient, with the densities of the two liquids as the upper and lower limits. A particle having a density intermediate to these limits will, when placed in this column, sink to the point in the column at which its density equals that of the mixture (fig. 1).

A working column 110 cm. long and 10 cm. in diameter was assembled according to procedures outlined by Wiley[5]. Petroleum ether (density = 0.6358) and chlorobenzene (density = 1.1066) were used as liquids because: (1) they are immiscible with water, and therefore will not absorb water from the chips, (2) they give a desirable density range, and (3) they are not dangerously toxic. The petroleum ether is quite volatile, but satisfactory.

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[1] *Arola, Rodger A. Tremendous challenge remains — effective debarking of chips. Pulp & Paper 44(1): 79-83. 1970.*

[2] *Tappi Standard T18m-53.*

[3] *Stamm, A. J. Wood and cellulose science. Chapter 3. New York: Ronald Press Co. 1964.*

[4] *Mention of trade names does not constitute endorsement of the products by the USDA Forest Service.*

[5] *Wiley, R. E. Setting up density gradient laboratory. Plast. Technol. 8(3). 1961.*

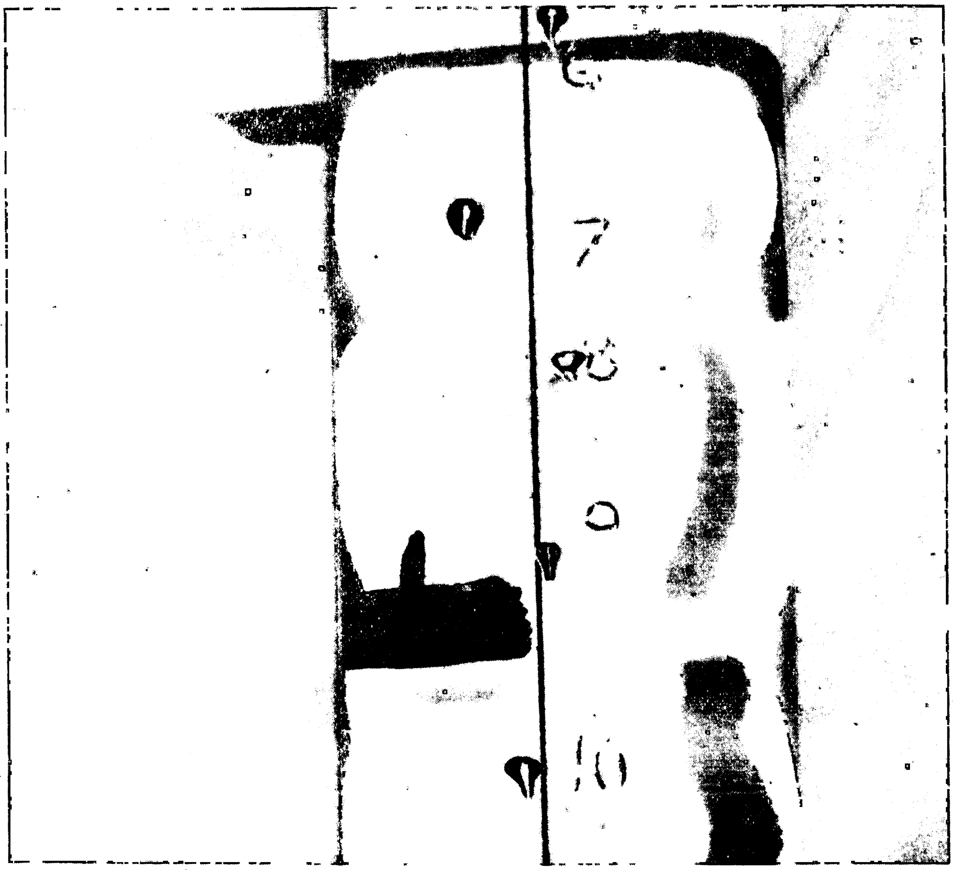

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Figure 1. — *Wood chips suspended in a density-gradient column.*

The column was prepared by first pouring in the heavier liquid and then the lighter liquid. Normally little mixing occurred. A set of small glass beads was then introduced into the column for calibration. The beads were previously blown from glass tubing and then standardized according to A.S.T.M. methods[6] with the following variations: a Westphal balance was used to determine the exact densities of the solutions that supported the individual beads instead of a pycnometer. This enabled us to speed up the standardization and still maintain an accuracy better than $\pm$ 0.0004 g./ml. for each bead.

[6] *Specific gravity and density of plastics, A.S.T.M. D792-60T, Amer. Soc. Testing Materials, Philadelphia, Penn.*

The beads were lowered in a wire basket suspended on a motor mechanism. The motor mechanism provided for a slow removal of objects from the column without unnecessary stirring.

The beads normally clustered at the junction of the unstirred liquids. They were distributed linearly throughout the column by stirring with a long glass rod. If a linear distribution was not attained, the beads were manipulated by introducing the original liquids. To lower a bead, the lighter liquid was added to the liquid near the bead with a pipette. To raise a bead, the heavier liquid was added to the column near the bead. After 24 hours, stable bead positions were obtained.

The column prepared as described had a gradient of 0.67 g./ml. to 1.09 g./ml. and a sensitivity of about 0.004 g./ml. per cm. This column remained stable

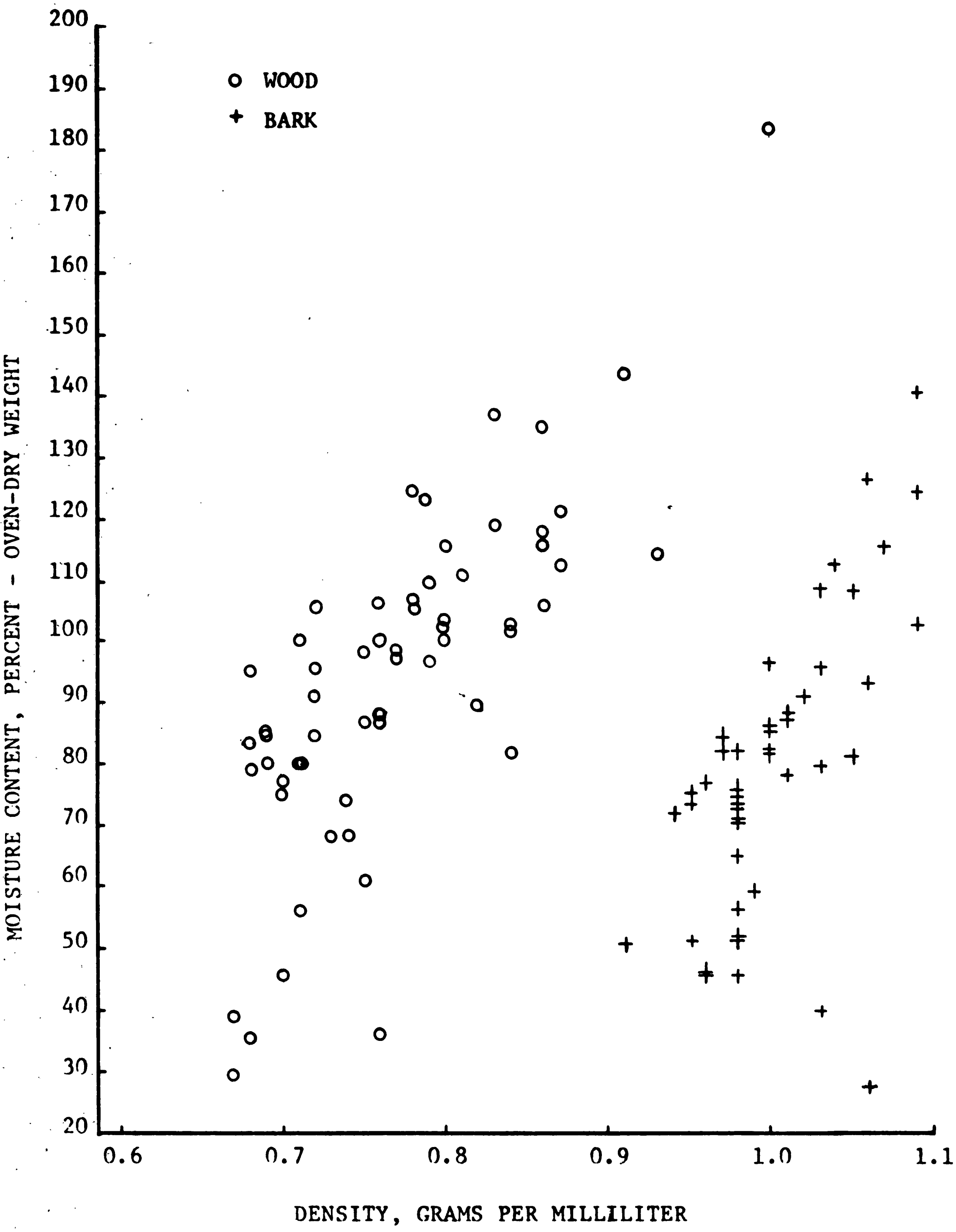

Figure 2. — *Moisture content versus density for aspen wood and bark chips.*

for a period of several weeks and throughout the checking of several hundred chips.

The column was tested using air-dried aspen wood and bark chips, according to the following procedure. A set of standardized beads was lowered into the column using a wire basket attached to the motor mechanism. A marked chip was then weighed and dropped into the column. When the chip stopped sinking its position was noted and its density determined by comparison with the positions of the standardized beads. This was repeated for five to ten chips, after which the chips were removed with the wire basket. The chips were then oven-dried and weighed[6] to permit calculation of moisture content.

The results can be separated into three areas: (1) floating chips, (2) sinking chips giving off air bubbles, and (3) sinking chips not giving off air bubbles.

Obviously the densities of the floating chips can not be determined using this technique and the minimum density of the column is the limiting factor.

The sinking chips giving off air bubbles stopped settling in 10 seconds on the average, although they continued to evolve air bubbles for a short time. At least another minute elapsed before the chip changed position noticeably. However, the change after 10 minutes was never more than 0.03 density units. Since it took 10 seconds to reach a relatively stable position, this position was chosen for determining the density.

Chips with moisture contents greater than 75 percent (on an o.d. basis) did not evolve air bubbles as they sank. These chips reached an equilibrium position in about 10 seconds and remained relatively fixed in that position. Their positions were compared with the standardized beads for density determinations.

Graphing moisture content versus density for chips that sank shows that the minimum moisture content ranged from 30 to 90 percent (fig. 2). In addition, none of the bark chips floated (all densities were greater than the minimum column limit).

These preliminary tests seem to indicate two possible bases for segregation of aspen wood and bark chips. First, if all chips had a 95 percent moisture content, segregation could be accomplished by simply placing them in a liquid with a density of 0.90.

Secondly, if wood and bark chips with moisture contents less than 90 percent were placed in a liquid with a density of 1.00, all of the wood chips would float and some of the bark chips would float. However, as the chips absorbed the liquid, the bark chips would probably sink before the wood chips, resulting in segregation. Further studies are being carried out to examine these possibilities.

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