# SPECIAL CONSIDERATIONS AFFECTING IMPROVEMENTS IN THE COLD SODA PULPING PROCESS

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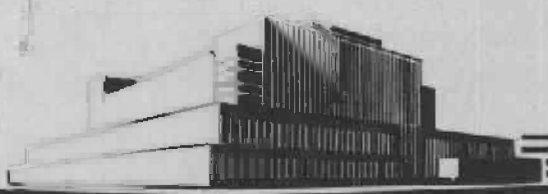

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

# SPECIAL CONSIDERATIONS AFFECTING IMPROVEMENTS IN THE COLD SODA PULPING PROCESS[1]

By

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## Summary

The cold soda process, a high-yield semichemical-type pulping method developed at the Forest Products Laboratory, was applied to several hardwoods to determine the effect of certain variables on liquor penetration, pulp opacity, and color. The species tested included aspen (Populus tremuloides), paper birch (Betula papyrifera), southern red oak (Quercus falcata), soft maple (Acer spp.), northern red and white oaks (Quercus spp.), elm (Ulmus spp.), ash (Fraxinus spp.), and yellow birch (Betula alleghaniensis).

The primary results were as follows: (1) The amount of caustic soda liquor absorbed by aspen and southern red oak woods was increased by (a) decreasing the moisture content of the wood, (b) decreasing the particle size, (c) increasing the hydrostatic pressure in the treating vessel, or (d) removing the air from the wood prior to treatment.

(2) For a given yield, an increase in the temperature during cold soda pulping decreased the opacity of the bleached pulp.

(3) Increased refining in disk mills decreased the freeness, increased the amount of fine fibers, and increased the opacity of the pulp.

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[1] Presented at the Sixth Annual Pulp and Paper Conference held at the College of Engineering, University of Florida, Gainesville, Fla., December 2, 1957.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

(4) Increased brightening of cold soda pulp with calcium hypochlorite decreased its opacity at a given density.

(5) Wet pressing bleached cold soda pulps with increasing amounts of pressure increased their density and strength but decreased both their opacity and brightness.

(6) Screw pressing aspen chips after they were treated with caustic soda and before they were fiberized increased the pulp brightness about 5 percentage points and appeared to remove some of its characteristic yellow color.

(7) The addition of anionic and nonionic surfactants to the caustic soda treating liquor slightly increased the strength, and in some cases the brightness, of cold soda pulps made from southern red oak.

## Introduction

There has been much evidence during recent months of increasing interest by the pulp and paper industry in the cold soda pulping process. The process, a semichemical-type pulping method developed at the Forest Products Laboratory, is now being used commercially in the United States to produce pulps from hardwoods for use in the manufacture of corrugating medium and printing papers. A European mill has begun to make toilet tissue from cold soda pulp. Other types of paper and board products may also find use for this pulp as further research promises to develop the process in the direction of greater versatility and more economical processing.

Basically, cold soda pulping consists of treating chips with a sodium hydroxide solution, draining off excess liquor, and fiberizing the softened chips in a disk mill. The process will operate satisfactorily at or slightly above room temperature. A chemical treatment of 1 to 2 hours is customary for steeps made at atmospheric pressure. The steeping time can be shortened to 30 minutes or less by applying hydrostatic pressure to the liquor surrounding the chips in the treating vessel.

Possibilities for conducting the process continuously are constantly being explored. It appears from results at the Forest Products Laboratory that cold soda pulps of good quality can be made by applying the caustic soda solution at the same time the chips are being broken down in a refining-type mill.[3] In this case the distribution of the chemical to individual fibers is

[3] Brown, K. J. and Hilton, R. D. New Fast Continuous Cold Soda Hardwood Pulping Process. Paper Trade Journal, Vol. 10, No. 21, pp. 42-46.

accomplished in a matter of seconds, and the advantages of continuous operation, uniformity, and better quality control are realized. An important feature of this particular continuous method is that there is no drain off and subsequent reuse of liquors that are contaminated with dissolved organic matter, which in the batch methods of treating will eventually darken the pulp.

Cold soda pulps that are produced from hardwoods at yields of about 92 percent are being used as partial substitutes for softwood groundwood pulps in printing papers. Using hardwoods for this purpose appears to be one of the more promising means of meeting the future fiber requirements of the industry. Before this can be done more extensively, however, certain quality problems must be solved. On the credit side, cold soda groundwood-type pulps from hardwood are usually slightly stronger and higher in freeness than the softwood groundwood pulps they are to replace (table 1). However, they are also denser and contain fewer fine fibers, two factors that make them more transparent than softwood groundwood. Furthermore, cold soda pulps prepared from dense hardwoods are somewhat darker than conventional groundwood pulps and have to be bleached for some uses.

Cold soda pulps for corrugating board are necessarily made stronger than the groundwood-type pulps by using larger amounts of caustic soda. The optimum yield for pulp of this quality is usually 87 percent. Amounts of material required to produce pulps from certain representative hardwoods by this process (and bleach them in the case of groundwood substitutes) are listed in table 2.

The cold soda process appears to be the least expensive of the chemical or semichemical processes now available. Examples of estimated costs of making cold soda and groundwood pulps are given in table 3. In comparison to softwood groundwood pulp, the extra cost for chemicals used in producing hardwood cold soda pulp in the northern United States would be more than offset by savings in wood and in costs for fiberizing energy. Energy required to fiberize cold soda pulps made from southern oaks and gums is about one half of that used to grind southern pines, but in this case the pulpwood costs are about the same. The total cost of manufacturing pulp by these two methods in the southern United States would be nearly the same if the cold soda pulp could be used unbleached.

Operating costs in the cold soda process could be lowered if shorter treating periods and more efficient use of the chemical could be accomplished. This means using improved methods to disperse minimum amounts of caustic soda quickly and uniformly to all of the fibers in the chip. Some factors to consider in experimentation on this problem of liquor distribution are the effects of using forced penetration mechanisms, air removal procedures, and chemical

additives in applying the caustic soda solution. The size and moisture content of the chips are also important factors. One of the purposes of this report is to review the results of some of the recent research made on penetration of caustic soda liquor at the Forest Products Laboratory and discuss their significance in connection with improving the process.

Other pulping studies reported here were concerned with improving the optical properties of cold soda pulps. In addition to lacking opacity and being darker in color than groundwood pulps, they have a yellow color that persists even after bleaching by conventional single-stage methods. These experiments were designed primarily to obtain an understanding of the optical characteristics of cold soda pulps so that future research can be directed at the sources of the problems.

## Experimental

Tests were made on southern red oak and eight other hardwoods. The other hardwoods, representative of the forests in the northern United States, included aspen and paper birch (which were tested individually), and a mixture of soft maple, red oak, white oak, elm, ash, and yellow birch. All the pulpwood was peeled and, unless otherwise stated, converted into standard-sized 5/8-inch chips for pulping experiments. Blocks used for penetration studies were cut from the heartwood of southern red oak logs.

### Liquor Absorption Variables

Pressure. --These experiments were designed to study both natural penetration and forced penetration at room temperature. The blocks of southern red oak heartwood were treated with a solution of 50 grams of caustic soda per liter at atmospheric pressure and under a hydrostatic pressure of 150 pounds per square inch (gage) for periods of 0.5 and 2 hours at 25° C. Previous penetration studies made with caustic soda liquor on aspen blocks indicated that 150 pounds per square inch (gage) was the most practical pressure for hydrostatic treatment in this process. [4]

The blocks were cubes with sides of 0.5, 1, or 2 inches. Treatments were made on several samples at a time (usually 5) placed in a wire basket that

[4] Brown, K. J. Aspects of Cold Soda Pulping in Relation to Penetration. Annual Technical Conference, American Paper and Pulp Association Committee on Coordination of Research. Report No. 9, pp. 28-32; June 2, 1953.

was suspended in a stainless steel autoclave of 0.8-cubic-foot capacity. The amount of solution absorbed by the blocks was determined from the difference in weight before and after the treatment. The extent of penetration through the blocks was observed by splitting them longitudinally and dusting phenolphthalein powder on the face of the split section to clearly outline the presence of alkali. Typical sections of blocks from these tests are shown in figure 1.

As shown in table 4, 2-inch blocks of red oak heartwood with a moisture content of 10 percent picked up 5 times more liquor in 0.5 hour at 150 pounds per square inch (gage) pressure than they did at atmospheric pressure. The blocks soaked for 2 hours at atmospheric conditions absorbed only 30 percent as much liquor as those impregnated with hydrostatic pressure for 30 minutes. Results of tests made on blocks that contained 35 percent moisture showed the same beneficial effects of increasing pressure but to a lesser degree (table 4).

Vacuum. --A vacuum of 26 inches of mercury was drawn on the 2-inch blocks and held for 5 minutes before the caustic soda liquor entered the autoclave. The extent of penetration into the blocks that contained 10 percent moisture was increased considerably by preevacuating the wood before it was steeped at atmospheric pressure, as shown in figure 2. Preevacuation also improved results of the hydrostatic treatment but to a lesser extent. Absorption values in table 4 show that removing the air from the wood before the blocks were steeped at atmospheric pressure was as effective as applying a hydrostatic pressure for 30 minutes. Recent cold soda pulping tests made on green aspen that contained 47 percent moisture also showed benefits from preevacuation. [5]

Particle size. --Decreasing the dimensions of the red oak cubes in the range from 2 inches on a side to 0.5 inch increased the liquor absorption in a range of from 60.0 to 82.8 percent during treatments of 30 minutes at 150 pounds per square inch (gage)(table 4). This increased absorption was probably due only to the greater amount of surface for a given weight on the smaller blocks; as shown in figure 1, the liquor had penetrated through only the open structure of the wood (vessels) and had left the surrounding dense fiber structure untreated to about the same extent in blocks of each size.

Cold soda pulping tests were made on predisintegrated aspen chips and compared to those made on standard full-sized chips. The small chips were prepared by passing normal chips through breaker plates in an 8-inch disk mill,

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[5] Brown, K. J. and Monsson, W. H. Cold Soda Pulping of Aspen by Improved Methods. Tappi, Vol. 39, No. 8, pp. 592-599.

and accepting the particles passing a 1/8-inch screen but held on one of 1/16-inch mesh. The average dimensions of these particles were 1/16 inch in both the radial and tangential directions and 5/8 inch in the longitudinal fiber direction. Comparisons of pulping tests made at both atmospheric pressure and hydrostatic pressure after preevacuation on both sizes of chips are given in table 5. After 2 hours of steeping at atmospheric pressure, the liquor penetration in the small particles was complete but the larger chips had dry centers. Penetration was found to be complete in both cases after the forced penetration treatments. Under both conditions of pulping the amount of liquor absorbed, and consequently consumed, was increased considerably by decreasing the chip size. The increased consumption of chemical decreased the pulp yield about 4 percent. Preparing the small chip particles probably did some damage to fibers since the pulps prepared from them had bursting strengths about 10 percent lower in each case (table 5).

Moisture content. --As shown in table 4, when the moisture content of the red oak 1-inch blocks was decreased from 35 to 10 percent, the amount of liquor absorbed in 30 minutes at 150 pounds per square inch (gage) was increased about three times. The effect on cold soda pulping of a decrease in the moisture content of aspen chips from 46 to 7 percent is shown in table 5. The drier chips absorbed 60 percent more liquor and produced 3.5 percent less pulp after being treated 10 minutes at 150 pounds per square inch (gage) following preevacuation. The difference in moisture content had no significant effect on pulp strength, which substantiates results of other experiments on green and air-dry aspen reported previously. [5]

Surfactants. --Standard-sized chips and 1-inch cubes prepared from southern red oak were treated with caustic soda liquors containing varying concentrations of several different types of surface-active agents to determine their effects on the rate of penetration and pulping characteristics in this process. Examples of typical results are given in tables 4 and 6. Adding 10 grams per liter of an anionic surfactant to the liquor increased by about 50 percent the amount of liquor absorbed by the air-dry blocks during 2 hours' atmospheric steeping (table 4). Blocks containing 35 percent moisture picked up only 30 percent more liquor with the surfactant present under similar conditions.

In contrast to the above, the addition of surfactants of both anionic and nonionic types to liquors used in treating red oak chips (containing 23 percent moisture) decreased slightly the amount of liquor absorbed (table 6). The presence of the surfactants did not affect pulp yield nor did it change the chip softening effect (measured by the fiberizing energy) of the caustic soda liquor. The strength properties of cold soda pulps made by both the

batch and continuous methods, using conditions described in table 6, were increased slightly by the addition of surfactants. Adding 5 grams per liter of an anionic surfactant to the liquor in the continuous system increased the pulp brightness from 40.2 to 42.4 percent. Pressing the treated chips (containing the surfactant) before the fiberizing operation increased the brightness still further to 43.7 percent.

Results of other block tests (not tabulated here) with both anionic and nonionic surfactants showed that in each case a concentration of 10 grams per liter was more effective than either 5 or 20 grams per liter. In a cold soda pulping solution, use of 10 grams per liter of a surfactant that cost 20 cents per pound would increase the cost of a ton of cold soda pulp about $4.50.

Presteaming. --The effectiveness of using steam to replace air in chips, and thereby improve penetration in the cold soda process, was investigated. Each of the presteaming methods described in table 7 increased the rate at which caustic soda liquor penetrated into paper birch chips, but only the mildest conditions of steaming gave satisfactory pulping results. Applying steam at a pressure of 5 pounds per square inch (gage) for 30 minutes before the caustic soda treatment did not change the pulp yield, but did increase the bursting strength about 5 percent in comparison with a treatment made at 55° C. without presteaming. Using the technique of "purging" the chips with steam at pressures of 25 and 50 pounds per square inch (gage) seriously decreased the pulp yield and strength (table 7). The increased darkening of the pulp at pulping temperatures higher than normal would probably limit this method to production of pulp for such products as corrugating board.

## Optical Properties

In making printing papers that contain cold soda pulp, the opacity, brightness, and color of the paper depend on the careful control of conditions during the pulping, refining, bleaching, and papermaking operations. Since each step in preparing the pulp and making the paper has a number of variables, many of which are interdependent, the problem of producing paper with optimum optical properties from cold soda pulp is complex. The following discussion contains typical examples of basic information needed on the effect of the variables before the proper paths toward improvements can be chosen.

Pulping temperature. --An investigation was made to determine the effect of the treating temperature on the opacity and strength of cold soda pulps produced at the same level of yield. Chips from a mixture of 6 hardwoods typical of the north-central region (50 percent, by weight, of soft maple and

10 percent each of red oak, white oak, elm, ash, and yellow birch) were treated with varying concentrations of caustic soda at different temperatures. A caustic soda concentration of 30 grams per liter at a temperature of 25° C. produced a yield of 91.5 percent; 17 grams per liter at 55° C. produced a pulp yield of 92.3 percent; and 9 grams per liter at 85° C. provided a yield of 90.6 percent. The cold soda pulps produced from these treatments were refined by circulation through an 8-inch disk mill and samples were taken at freenesses of approximately 300, 200, and 100 milliliters (Canadian Standard). Each pulp sample was bleached with calcium hypochlorite at both a 6 and 12 percent available chlorine level. Handsheets prepared from the pulps at a weight of 37 pounds per ream (500 sheets, 25 by 40 inches) were tested for opacity, brightness, and strength. Screen fractionation tests were also made on each pulp.

The results of the study are shown graphically in figure 3. Opacity values interpolated at a constant brightness of 68 percent decreased as the pulping temperature was increased. This effect was most pronounced for the pulps of low freeness. Figure 3 also shows that decreasing the freeness increases the opacity. For example, decreasing the freeness of pulp (produced at 25° C.) from 300 to 100 milliliters increased the opacity of the sheet about 4 percentage points at a brightness of 68 percent.

Other results obtained in this study were as follows: (1) Opacity, at a constant brightness, increased as the fraction of fine fibers was increased. (2) At an average pulp yield of about 91.5 percent, the amount of caustic soda consumed was not changed by variations in treating temperature. (3) The brightness of the unbleached pulps decreased from about 40 to 37.5 percent as the pulping temperature was increased in this range.

Refining. --According to Parsons,[6] the amount of light scattered by pulp in a sheet can be increased by increasing the unbonded fiber surface area in the sheet. This increase in light scattering power, and resultant increase in opacity, could be presumably brought about by either (1) cutting the fibers into smaller particles to increase the surface area or (2) using less pressure in wet pressing the sheet to decrease the bonded surface. The purpose of the work reported in this section was to determine the suitability of three types of pulp refiners to increase opacity as in (1).

Disk milling: Cold soda pulp produced from the mixture of 6 hardwoods under conditions given in table 8 was refined to various freenesses by recycling through a 36-inch-diameter double disk mill. Decreasing the pulp

[6] Parsons, S. R. Optical Characteristics of Paper as a Function of Fiber Classification. Paper Trade Journal, Tappi Section, Vol. 115, No. 25, pp. 314-322, December 1942.

freeness in this manner within a range of from 280 to 120 milliliters increased the amount of fine fibers passing through a 200-mesh screen in a range of from 23.7 to 28.0 percent. After the pulps were each bleached with 12 percent available chlorine in the form of calcium hypochlorite, tests made on handsheets showed that refining in the disk mill was effective in increasing both the opacity and strength of the pulp (table 8).

Beating: The bleached pulp from the last stage of refining in the disk mill was beaten in a test beater of 1.5-pound capacity until its freeness was about the same as that of commercial book-grade groundwood pulp. Beating increased the strength and density of the cold soda pulp considerably but decreased its opacity 2 percentage points (table 8). The decrease in amount of fines after beating (table 8) might be partly caused by increased coagulation of hydrated fibers in the screen classifier.

Jordaning: Bleached cold soda groundwood-type pulp prepared from a mixture of southern red oaks was subjected to a single pass through a laboratory jordan, using a moderate amount of pressure. Handsheets made from the pulps before and after jordaning were wet pressed at pressures of 10, 100, and 300 pounds per square inch (gage). Refining this pulp in the jordan decreased its freeness from 130 to 70 milliliters and also decreased both the opacity and brightness of sheets pressed at given pressures, as shown in figure 4. This refining action increased both the density and strength (as measured by breaking length) of the pulp. If the curves in figure 4 are used to compare the jordaned and unjordaned pulps at constant values of density and brightness in a range of wet press pressure of from 100 to 150 pounds per square inch (gage), this refining action appears to have had no effect on opacity.

Brightening. --The typical effect on opacity of brightening cold soda groundwood-type pulp is shown in figure 5. Increasing the amount of applied available chlorine from 8 to 10 percent (based on the moisture-free weight of the pulp) in bleaching a southern red oak cold soda pulp with calcium hypochlorite decreased its freeness from 85 to 70 milliliters and increased its brightness about 3 percentage points. At a given wet press pressure, this increase in brightness was accompanied by a decrease in the opacity of the handsheet of about 2 percentage points, as shown in figure 5. Increased brightening strengthened the pulp slightly (as measured by breaking length) without changing its density.

Wet pressing. --As indicated in figures 4 and 5, increasing the pressure during the wet pressing of cold soda pulpsheets increases both their densities and strength properties but makes them darker in color and more transparent.

Pulp color. --As mentioned before, treating wood with caustic soda at low temperatures gives the fibers a yellowish cast that persists even after bleaching. This color becomes noticeable in printing paper if more than about 25 percent of cold soda is present in the sheet. An experiment made on aspen sawdust to determine the cause of the yellowing involved treating samples with a 50-gram-per-liter solution of caustic soda for 2 hours at atmospheric conditions after the samples had been extracted successively with ether, alcohol-benzene, and hot water. Treatment of the sawdust after each extraction produced the same characteristic yellow color as treatment of an unextracted sample. But the color of a sample of Cross and Bevan cellulose prepared from the sawdust did not change after a similar treatment with caustic soda. This result supports the common belief that the yellow color is produced by the reaction of the alkali with lignin.

Multi-stage bleaching might be an effective way to remove the yellow color from cold soda pulp, but it would probably be costly. Experience has shown that the brightness and degree of yellowness of cold soda pulp depend partly upon the extent of washing given the pulp. In one series of experiments, the brightness of unbleached aspen cold soda pulp was increased from 49.0 to 54.3 percent by pressing out some of the colored liquor from the treated chips by a single pass through a screw press, before the chips were fiberized in the disk mill. Bleached pulp produced from the pressed material appeared to be somewhat less yellow. The use of surfactants in conjunction with washing operations also seems to have promise for improving the color of cold soda pulp.

## Conclusions

It may be concluded that:

(1) The rate of distribution of caustic soda solution to the centers of hardwood chips, during pulping by the cold soda process, can be accelerated by pre-evacuating the treating vessel, increasing the hydrostatic pressure during steeping, or decreasing the chip size.

(2) Air-dry wood absorbs more liquor, consumes more chemical, and produces less cold soda pulp at a given level of strength than green wood.

(3) From the standpoint of opacity and color, optimum treating temperature in the preparation of cold soda groundwood-type pulps is about 25° C.

(4) The opacity of bleached cold soda pulp can be increased by disk mill refining.

(5) If it is important to preserve opacity, cold soda pulps should be bleached only to the minimum acceptable brightness and their densities should be kept at the minimum level necessary to obtain the desired strength in the paper.

(6) The addition of surfactants to cold soda pulping liquor accelerates its penetration into wood with low moisture content and also improves washing operations.

Table 1.--Typical physical properties of unbleached cold soda and groundwood pulps used in printing paper production

| Species | Freeness (Canadian Standard) | Bursting strength | Tearing resistance | Breaking length | Density | Brightness (G.E. equivalent) | Fiber fraction passing a 200-mesh screen |
|---|---|---|---|---|---|---|---|
| | Ml. | Pts. per lb. per rm.[1] | Gm. per lb. per rm.[1] | Meters | Gm. per cc. | Percent | Percent |
| **COLD SODA** | | | | | | | |
| Southern red oak | 130 | 0.30 | 0.70 | 3,200 | 0.50 | 41 | 33 |
| North-central mixture[2] | 140 | .34 | .70 | 3,800 | .53 | 43 | 30 |
| **GROUNDWOOD** | | | | | | | |
| Southern pine | 70 | .22 | .59 | 2,100 | .36 | 56 | 45 |
| Spruce | 70 | .32 | .60 | 3,200 | .46 | 60 | 45 |

[1] Ream of 500 sheets, 25 by 40 inches.

[2] Chip mixture consisted, by weight, of 50 percent of soft maple and 10 percent each of red oak, white oak, elm, ash, and yellow birch.

Table 3.--Examples of estimated cost factors for manufacturing cold soda and groundwood pulps for use in printing papers

| Process | Pulpwood | | | Cost per ton of air-dry pulp (in slush form) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Species | Cost per unbarked cord | Required per ton of air-dry pulp[1] | Wood | Caustic soda (at 3.5¢ per lb.) | Energy[2] for chipping and fiberizing or grinding | Pulping labor ($2 per hr.) | Bleaching chemical, labor, and steam | Water (at 5¢ per 1,000 gal.) | Total (excluding depreciation and overhead) |
| | | Dollars | Cords | Dollars | Dollars | Dollars | Dollars | Dollars | Dollars | Dollars |
| | | | | BOOK PAPER (NORTHERN SPECIES) | | | | | | |
| Cold soda | Birch, maple, oak, elm, ash, aspen | 18 | 0.9 | 16.20 | 4.90 | 5.35 | 6.00 | 20.00 | 0.75 | 53.10 |
| Groundwood | Spruce (local) | 30 | 1.2 | 36.00 | None | 8.50 | 6.00 | 6.00 | .50 | 57.00 |
| | | | | NEWSPRINT (SOUTHERN SPECIES) | | | | | | |
| Cold soda | Oak, gum | 20 | .8 | 16.00 | 6.65 | 5.35 | 6.00 | 10.00 | .75 | 44.75 |
| Groundwood | Southern pine | 20 | .9 | 18.00 | None | 10.70 | 6.00 | None | .50 | 35.20 |

[1] Based on 83 cubic feet of solid wood for standard cord of unbarked logs.

[2] Based on cost of 0.75 cent per kilowatt-hour.

Table 2.--Cold soda pulp manufacturing factors

| Hardwood | Cold soda pulp yield | Materials and power required per ton of air-dry pulp | | | | |
|---|---|---|---|---|---|---|
| | | Pulpwood[1] | Caustic soda | Fiberizing energy | Bleaching chemicals[2] | |
| | | | | | Lime | Chlorine |
| | Percent | Cords | Lb. | Hp.-days | Lb. | Lb. |
| **MAGAZINE BOOK-TYPE PAPERS** | | | | | | |
| Southern red oak | 92 | 0.7 | 175 | 44 | 108 | 90 |
| North-central mixture[3] | 92 | .8 | 165 | 40 | 108 | 90 |
| Aspen | 92 | 1.2 | 155 | 39 | 86 | 72 |
| **NEWS-TYPE PAPERS** | | | | | | |
| Southern red oak | 93 | .7 | 155 | 40 | 86 | 72 |
| Aspen | 93 | 1.2 | 135 | 36 | 48 | 40 |
| **CORRUGATING BOARD** | | | | | | |
| Southern red oak | 86 | .8 | 255 | 25 | ..... | ..... |
| Aspen | 87 | 1.3 | 230 | 20 | ..... | ..... |

[1] Based on 83 cubic feet of solid wood for standard cord of unbarked logs.

[2] Required to prepare calcium hypochlorite and to bleach the pulp in a single-stage procedure. Small amounts of sodium silicate and caustic soda are also needed to control the pH.

[3] Average values for a mixture, by weight, of 50 percent of soft maple and 10 percent each of red oak, white oak, elm, ash, and yellow birch.

Table 4.--Effect of vacuum, pressure, surfactant, dimensions, and moisture content on the absorption of a caustic soda solution (50 grams per liter) at room temperature by cubes of southern red oak heartwood

| Cube dimensions (on each edge) | Pre-evacuation (vacuum) | Pressure drying steep (gage) | Duration of steep | Concentration of anionic surfactant | Solution absorbed (per 100 lb. of moisture-free wood) |
|---|---|---|---|---|---|
| In. | In. Hg | P.s.i. | Hr. | Gm. per l. | Lb. |
| | | MOISTURE CONTENT -- 10 PERCENT | | | |
| 2.0 | None | 0 | 0.5 | None | 11.7 |
| 2.0 | None | 0 | 2.0 | None | 17.6 |
| 2.0 | None | 0 | 2.0 | 10 | 26.4 |
| 2.0 | None | 150 | .5 | None | 60.0 |
| 1.0 | None | 150 | .5 | None | 74.0 |
| .5 | None | 150 | .5 | None | 82.8 |
| 2.0 | 26 | 0 | .5 | None | 59.3 |
| 2.0 | 26 | 150 | .5 | None | 77.0 |
| | | MOISTURE CONTENT -- 35 PERCENT | | | |
| 1.0 | None | 0 | 2.0 | None | 15.7 |
| 1.0 | None | 0 | 2.0 | 10 | 20.2 |
| 1.0 | None | 150 | .5 | None | 23.5 |
| 1.0 | None | 150 | .5 | 20 | 32.0 |

Table 5.--Effect of chip size and moisture content on chemical consumption, pulp yields, and pulp strength in the cold soda pulping of aspen at room temperature

| Treatment number | Average chip dimension[1] | | Chip moisture content | Caustic soda concentration | Pulping results (per 100 lbs. of moisture-free wood) | | | Pulp properties (at Canadian Standard freeness of 250 ml.) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Width | Thickness | | | Solution absorbed | Caustic soda absorbed[2] | Pulp yield | Bursting strength | Tearing resistance | Density |
| | In. | In. | Percent | Gm. per l. | Lb. | Lb. | Lb. | Pts. per lb. per rm.[3] | Gm. per lb. per rm.[3] | Gm. per cc. |
| **2 HOURS AT ATMOSPHERIC PRESSURE** | | | | | | | | | | |
| 922 | 1 | 1/8 | 12 | 25 | ..... | 8.5 | 91.2 | 0.53 | 0.64 | 0.64 |
| 944 | 1/16 | 1/16 | 12 | 25 | ..... | 11.4 | 87.9 | .47 | .64 | .63 |
| **5 MINUTES AT 150 P.S.I. (GAGE) AFTER VACUUM** | | | | | | | | | | |
| 2824 | 1 | 1/8 | 6 | 49 | 241 | 11.4 | 91.3 | .49 | 1.20 | .62 |
| 2855 | 1/16 | 1/16 | 7 | 46 | 301 | 17.8 | 87.0 | .44 | .65 | .59 |
| **10 MINUTES AT 150 P.S.I. (GAGE) AFTER VACUUM** | | | | | | | | | | |
| 2817 | 1 | 1/8 | 7 | 50 | 283 | 16.9 | 89.2 | .51 | .75 | .64 |
| 2800 | 1 | 1/8 | 46 | 49 | 176 | 10.9 | 92.4 | .51 | .88 | .66 |

[1] Constant length in the fiber direction was 5/8 inch.

[2] Includes caustic soda consumed and the unused chemical left in the chips after the treatment.

[3] Ream of 500 sheets, 25 by 40 inches.

Table 6.--Effect of certain surfactants in the cold soda pulping of southern red oak

| Surfactant | | Pulping results (based on 100 lbs. of moisture-free wood[1]) | | | Fiberizing energy | Pulp properties (at Canadian Standard freeness of 150 ml.) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Type | Concentration | Liquor absorbed | Caustic soda absorbed[2] | Pulp yield | | Bursting strength | Tearing resistance | Breaking length | Density | Brightness (G.E. equivalent) |
| | Gm. per l. | Lb. | Lb. | Lb. | Percent | Pts. per lb. per rm.[3] | Gm. per lb. per rm.[3] | Meters | Gm. per cc. | Percent |
| **BATCH TREATMENTS[4]** | | | | | | | | | | |
| None (control) | | 99.2 | 12.5 | 90.1 | 100 | 0.16 | 0.45 | 1,770 | 0.42 | 35.9 |
| Nonionic | 20 | 87.6 | 10.0 | 89.9 | 103 | .21 | .51 | 2,430 | .40 | 37.9 |
| Anionic | 20 | 92.0 | 11.0 | 90.7 | 103 | .22 | .53 | 2,400 | .42 | 35.7 |
| **CONTINUOUS TREATMENTS[5]** | | | | | | | | | | |
| None (control) | | 231 | 11.3 | ..... | 100 | .25 | .65 | 3,000 | .46 | 40.2 |
| Anionic | 5 | 234 | 11.5 | ..... | 101 | .33 | .59 | 3,500 | .51 | 42.4 |

[1] Treated wood contained 23 percent moisture.

[2] Includes caustic soda consumed and the unused chemical left in the chips.

[3] Ream of 500 sheets, 25 by 40 inches.

[4] Made in a digester at 28° C. and 150 pounds per square inch (gage). The concentration of caustic soda was 50 grams per liter and the treating time was 30 minutes.

[5] Made in a roll mill at 30° C. and a production rate of 350 pounds of chips (moisture-free basis) per hour. The concentration of caustic soda was 51.5 grams per liter.

Table 7.--Effect of presteaming in the cold soda pulping of paper birch

| Treatment number | Presteaming conditions | Caustic soda treatment[1] | | Treated chips having a density over 1.05 grams per centimeter | Pulp yield | Pulp strength properties at Canadian Standard freeness of 250 ml. | | |
|---|---|---|---|---|---|---|---|---|
| | | Average temperature | Chemical consumed by reaction (moisture-free wood basis) | | | Bursting strength | Tearing resistance | Density |
| | | °C. | Percent | Percent | Percent | Pts. per lb. per rm.[2] | Gm. per lb. per rm.[2] | Gm. per cc. |
| 2896, 2913 | None (control) | 55 | 8.6 | 75 | 86.3 | 0.70 | 0.87 | 0.63 |
| 2891, 2928 | 0.5 hour at 5 p.s.i. (gage) | 58 | 9.5 | 100 | 86.3 | .74 | .74 | .62 |
| 2903, 2919 | 1 purge[3] at 50 p.s.i. (gage) | 63 | 8.1 | 100 | 83.1 | .58 | .96 | .61 |
| 2912 | 2 purges[3] at 25 p.s.i. (gage) | 55 | 8.2 | 100 | 79.6 | .65 | .80 | .61 |

[1] Chips were steeped for 1.5 hours at atmospheric pressure in a solution of 50 grams per liter of caustic soda.

[2] Ream of 500 sheets, 25 by 40 inches.

[3] Steam released immediately after reaching indicated pressure.

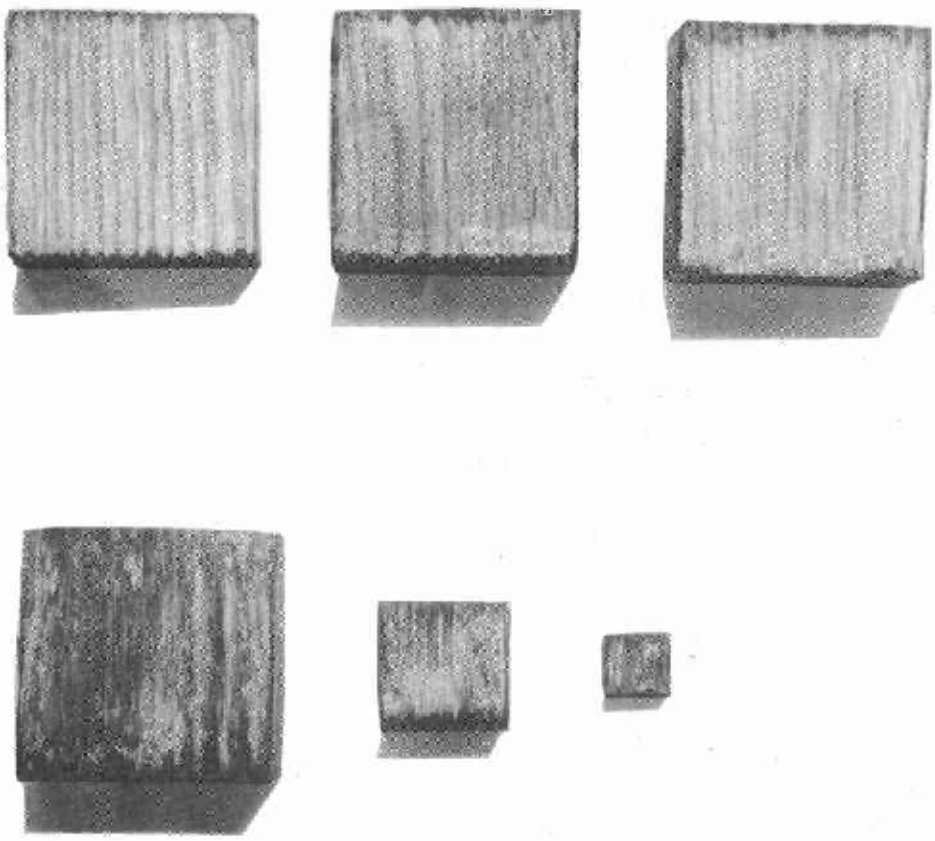

Figure 1. --Split sections of southern red oak blocks showing extent of caustic soda liquor penetration. The top three blocks show the effect of atmospheric steeping for 0.5 hour (left block),for 2 hours (center), and 2 hours with surfactant. The bottom series shows the extent of penetration after hydrostatic pressure treatment with 150 pounds per square inch (gage) for 0.5 hour on blocks 2 inches square (left), 1 inch square (center), and 0.5 inch square.

Z M 112 579

Table 8.--Effects of disk mill and beater refining on physical and optical properties of bleached cold soda pulp[1]

| Number of passes through disk mill | Freeness (Canadian Standard) | Fiber fraction passing a 200-mesh screen | Bursting strength | Tearing resistance | Density | Brightness (G.E. equivalent) | Opacity (37-lb. sheet[2]) |
|---|---|---|---|---|---|---|---|
| | Ml. | Percent | Pts. per lb. per rm.[2] | Gm. per lb. per rm.[2] | Gm. per cc. | Percent | Percent |
| **DISK MILL-REFINED COLD SODA** | | | | | | | |
| 1 | 280 | 23.7 | 0.12 | 0.29 | 0.30 | 67.9 | 80.9 |
| 2 | 240 | 26.5 | .15 | .38 | .32 | 67.7 | 81.2 |
| 3 | 120 | 28.0 | .24 | .55 | .38 | 68.3 | 83.0 |
| **BEATER-REFINED COLD SODA[3]** | | | | | | | |
| 3 | 65 | 26.0 | .45 | .63 | .59 | 69.4 | 81.0 |
| **COMMERCIAL BLEACHED GROUNDWOOD[4]** | | | | | | | |
| | 70 | 43.4 | .27 | .55 | .49 | 69.0 | 92.7 |

[1] Prepared from a mixture of six north-central hardwoods by steeping the chips for 1 hour at 150 pounds per square inch (gage) and 23° C. in a 14-cubic-foot digester with a caustic solution of 25 grams per liter concentration (treatment No. 4190).

[2] Ream of 500 sheets, 25 by 40 inches. Test sheets weighing 37 pounds per ream were pressed at 60 pounds per square inch (gage).

[3] Pulp from third pass through the disk mill was refined in a 1.5-pound test beater.

[4] Prepared from an equimixture of spruce and aspen.

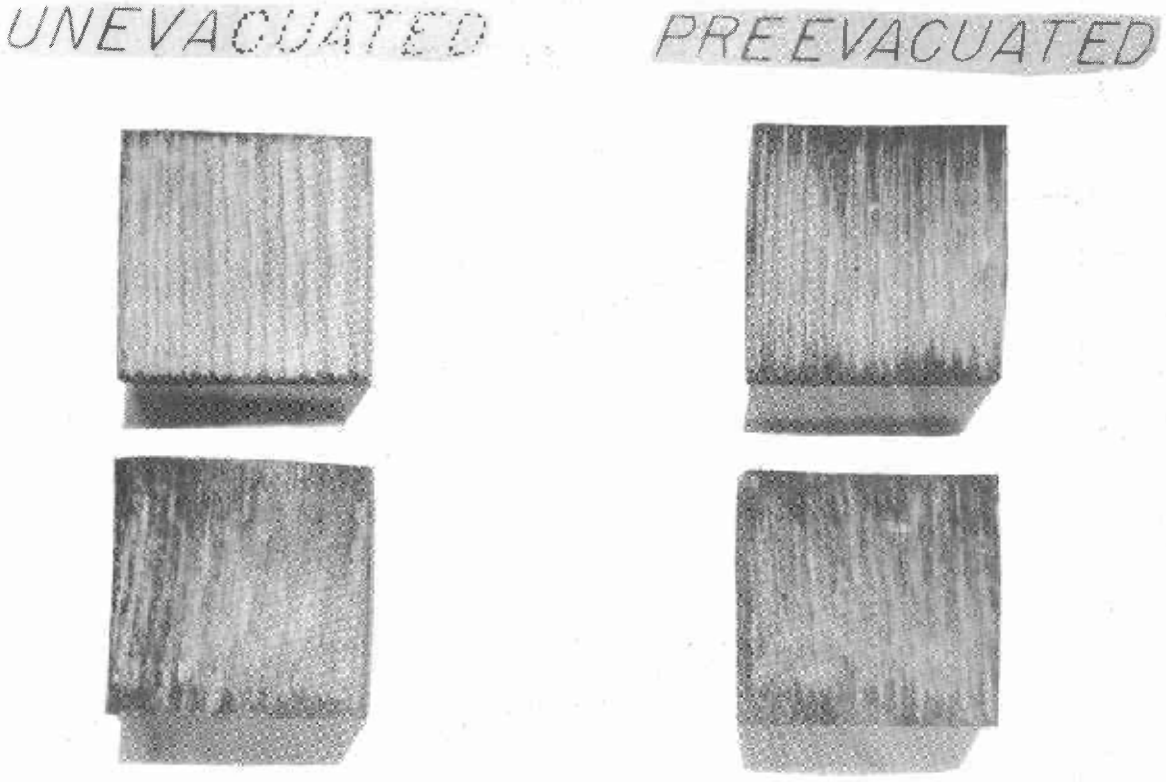


Figure 2. --Split sections of southern red oak blocks showing the effect on caustic soda liquor penetration of removing air before atmospheric and hydrostatic impregnation. All blocks were impregnated for one-half hour but upper pair were treated at atmospheric pressure and lower pair at a pressure of 150 pounds per square inch (gage).

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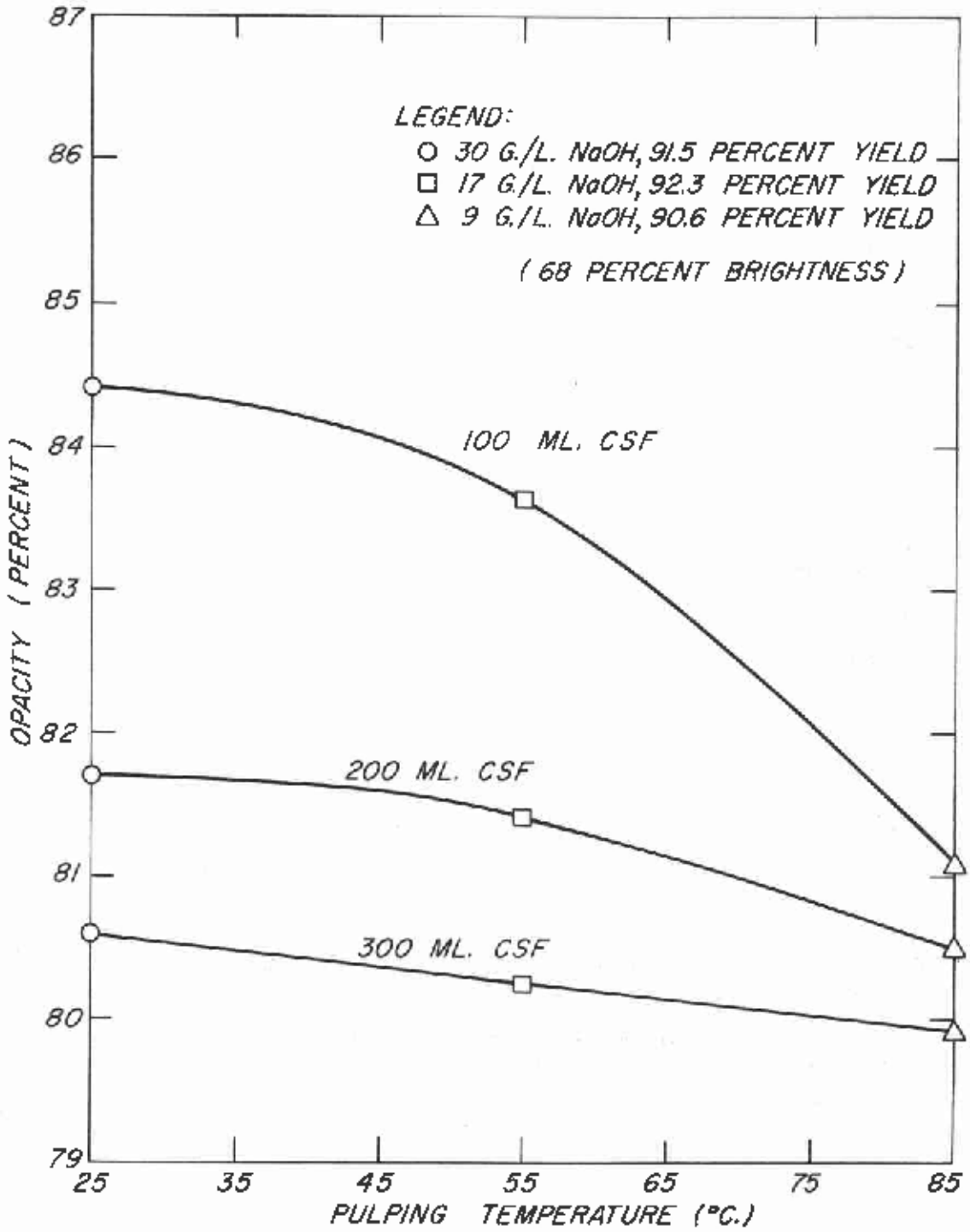


Figure 3. --Relations between pulping temperature and opacity of southern red oak cold soda pulp bleached to 68 percent brightness at freenesses of 100, 200, and 300 milliliters (Canadian Standard).

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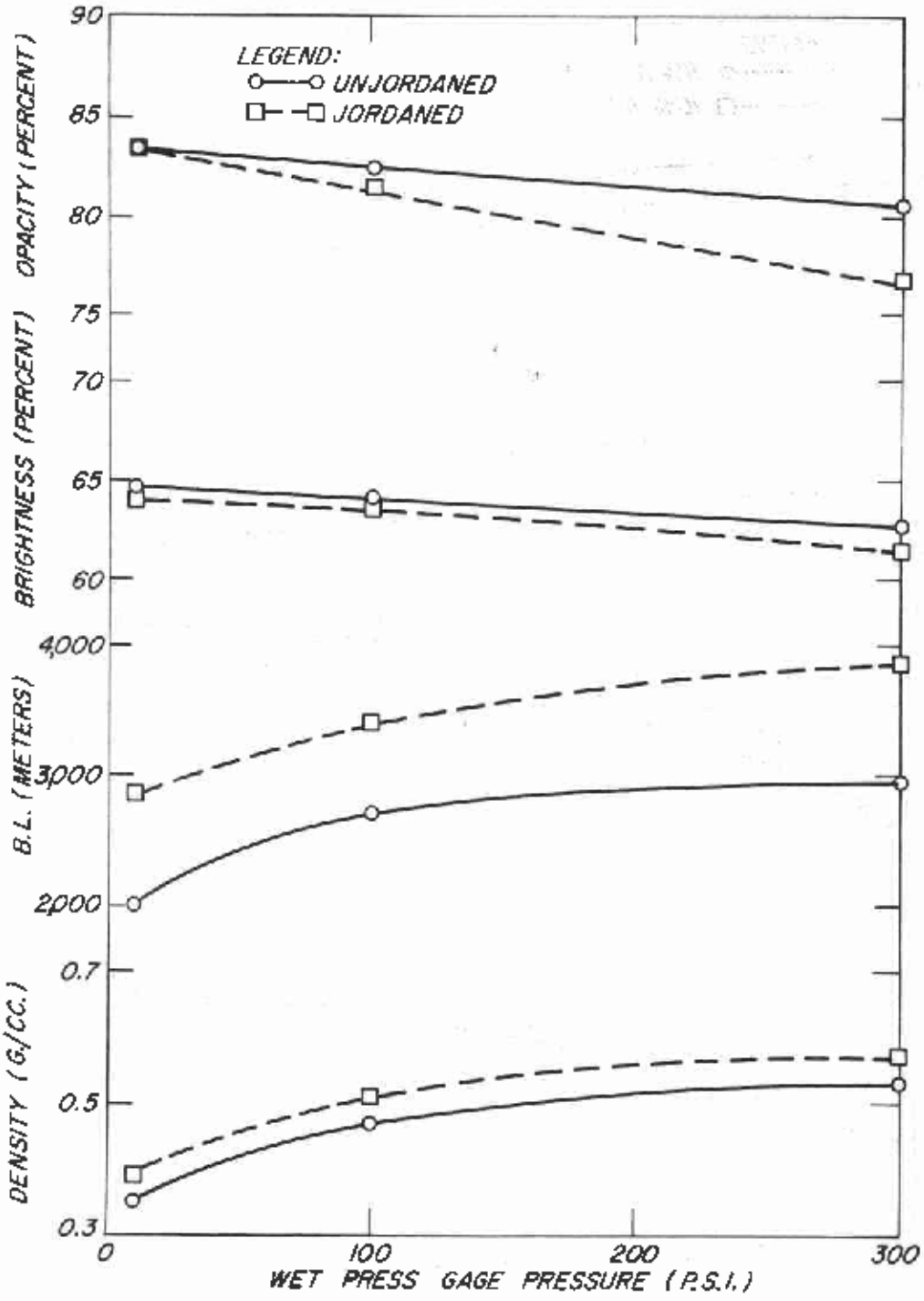


Figure 4. --Effect of jordaning on the optical and physical properties of bleached red oak cold soda pulpsheets pressed at various pressures. Freenesses (Canadian Standard) were 130 milliliters for the unjordaned pulp and 70 milliliters for jordaned pulp.

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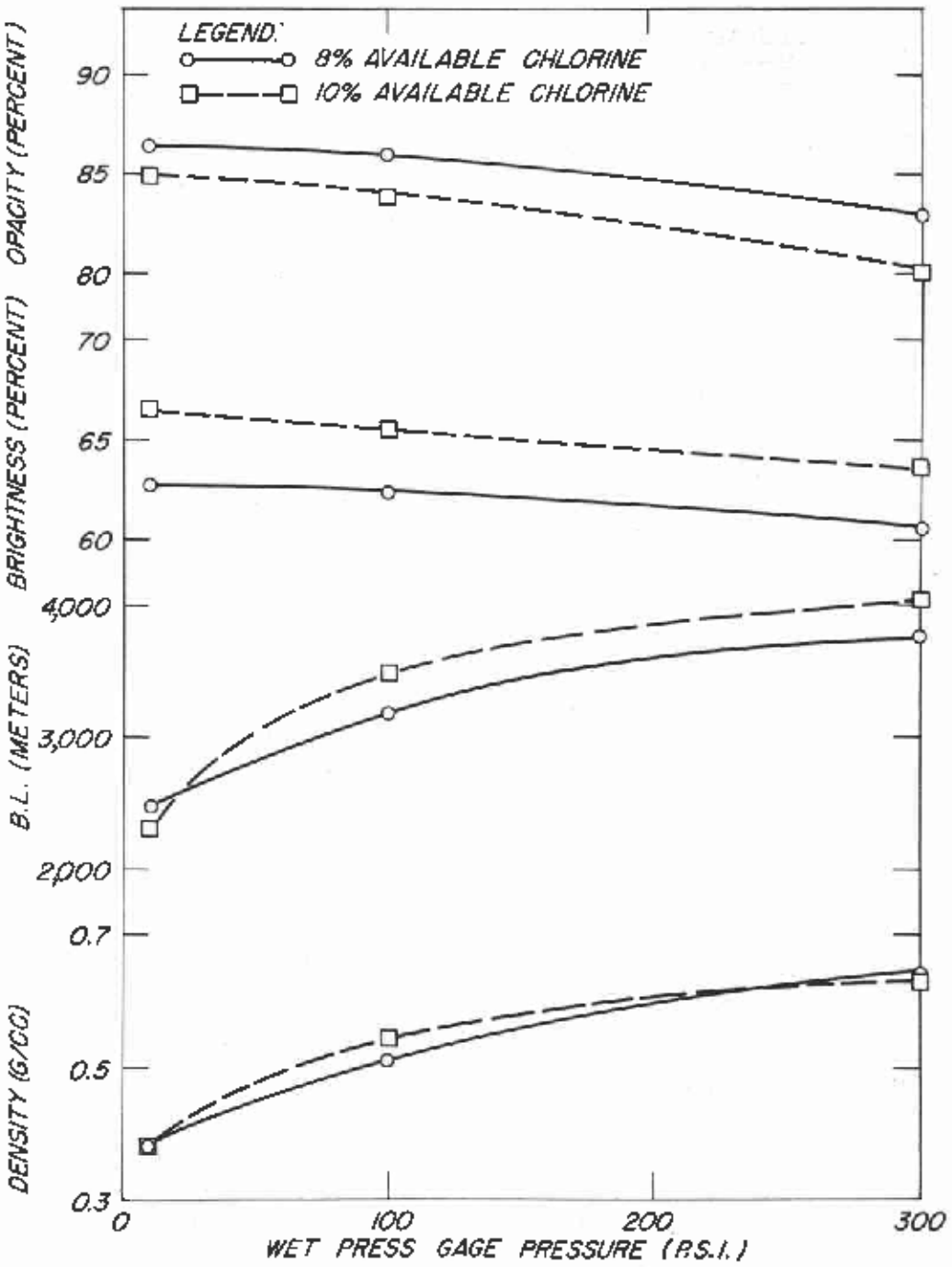


**Figure 5.--Effect of bleaching chemical (calcium hypochlorite) on the optical and physical properties of red oak cold soda pulpsheets pressed at various pressures. Freenesses (Canadian Standard) were 85 milliliters for 8 percent available chlorine and 70 milliliters for 10 percent available chlorine.**

Z M 112 545