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Machining and Related Properties of Aspen

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LAKE STATES ASPEN REPORT NO. 8

MACHINING AND RELATED PROPERTIES OF ASPEN

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FOREWORD

During and since World War II, there has been increasing interest in aspen (*Populus tremuloides*) in the Lake States, its availability and supply, properties and uses, and management. Aspen is a tree of primary importance in 20 million acres or 40 percent of the total forest area of the three Lake States - Michigan, Minnesota, and Wisconsin.

At an informal meeting at Madison, Wisconsin, in January, 1947, forestry representatives of several federal, state, and industrial groups in the Lake States agreed that it would be desirable to bring up to date what is known on aspen and make it available to anyone interested. The job of preparing this information in the form of reports was assigned to each of the groups listed below. The reports will be duplicated as rapidly as completed, and the entire project should be finished by the end of 1947. Each report will concern one aspect of the subject. Copies will be available from the Lake States Forest Experiment Station or from each contributor.

Report Number	Subject
1	Aspen Properties and Uses
2	Aspen Availability and Supply
3	Logging Methods and Peeling of Aspen
4	Milling of Aspen into Lumber
5	Seasoning of Aspen
6	Aspen Lumber Grades and Characteristics
7	Mechanical Properties of Aspen
8	Machining and Related Properties of Aspen
9	Aspen Lumber for Building Purposes
10	Aspen for Containers
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12	Small Dimension and Other Industrial Uses of Aspen
13	Aspen for Veneer
14	Aspen for Pulp and Paper
15	Aspen for Cabin Logs
16	Aspen for Excelsior
17	Aspen Defiberization and Refining of Product
18	Chemical Utilization of Aspen
19	Preservative Treatment of Aspen
20	Marketing of Aspen
21	Possibilities of Managing Aspen

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REPORT NO. 8

MACHINING AND RELATED PROPERTIES OF ASPEN

By
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INTRODUCTION

Aspen occupies 20 million acres of Lake States timberland, or 39 percent of the total forest area. In 1945 there were 6 1/3 billion feet of aspen saw timber 9 inches d.b.h. and larger, and a larger cubic volume of smaller material. The cut of aspen lumber was 152 million board feet in 1946, and the forest could sustain a much larger annual cut.

Machining is a broad term that includes sawing, planing, shaping, sanding, and in fact all important woodworking operations. The machining properties of any wood, like its mechanical and physical properties, are one of the considerations that determine the uses to which it may be put.

Aspen machines easily in the sense that power consumption is low and it does not dull tools rapidly. On the other hand, it is usually more difficult to machine a first-class smooth surface on aspen than on white oak, which is much heavier and harder, because the aspen fiber tends to sever less cleanly. For the principal current uses for aspen lumber, containers and construction lumber, its machining properties are fully adequate. For more exacting industrial uses to which aspen is sometimes put, such as core stock and millwork, a better quality of machine work is required. Measured by cabinet wood standards (as shown in table 1) aspen varies from fair to poor in machining properties. Where the conditions of use require it, however, much better than average results can usually be had if the user is prepared to take extra pains. Aspen is not unique in the above respects, however, for the troubles encountered in machining it are more or less common to other light hardwoods.

With aspen, as with most other woods, the quality of machining varies widely according to the conditions under which it is done. This report presents the best information currently available on the machining of aspen. Considerable work has been done on planing of aspen, and smaller amounts on shaping, sanding, turning, mortising, and boring. However, these subjects have not been covered exhaustively and further study is needed. This report also indicates how aspen compares in machining properties with 25 other hardwoods.

1/ Maintained by the U. S. Department of Agriculture, Forest Service, in cooperation with the University of Wisconsin, Madison, Wisconsin.

The aspen test material was collected from two sites, good and medium. It was in the 1 x 6-inch size, which means that it came from medium or larger trees as aspen goes. The density of the test material based on oven-dry weight and volume varied from 0.37 to 0.48, and averaged 0.42. This compares with averages of 0.40 for basswood and 0.43 for yellow poplar.2/ The moisture content varied from 4.7 to 7.4, and averaged 6.1 percent. Samples from the two sites were practically equal in specific gravity. The good site samples were of better average quality, having more clear or practically clear material and less material with brown streaks and numerous or coarse knots. The quality of different pieces in the test material varied widely. The tests were made on clear samples for the most part, but sufficient defective material was tested to show certain relationships between defects and quality of machining.

No consistent differences in the machining properties of clear aspen wood from the two sites were noted.

MACHINING TESTS

Planing

Almost every piece of lumber, except that going to rough uses, is planed as one step in its preparation. Other machining may or may not be done. Except for sawing, therefore, planing is the most important machining operation. Planing is used here in its broad sense to include not only the standard planer but related machines that employ planer-type cutter-heads, such as the matcher, molder, and sticker. Under the same operating conditions, results of planer tests would be expected to be about equally applicable to these machines.

The planing properties of a wood may be judged in several ways. Power consumption and rate of dulling of planer knives are considered highly important in Europe. But under American conditions the smoothness of the machined surface is considered most important because a good surface minimizes the amount of sanding that is needed for any exacting use.

Smoothness of surface is judged by the occurrence of planing defects, such as raised grain, chipped grain, fuzzy grain, or chip marks. With aspen, the most persistently troublesome planing defect by far is fuzzy grain. Chipped grain may be bad under certain conditions, but by so adjusting feed and speed as to get about 20 knife cuts per inch, it can be pretty well controlled. Chip marks also are sometimes very trouble-some, but an adequate blower system will take care of them to a large degree.

Among the factors that affect the results in planing are the feed (rate at which the lumber passes through the machine), the speed of the cutter-head in r.p.m., the cutting angle of the knives, the depth of cut, and the moisture content of the wood itself.

2/ "Strength and Related Properties of Woods Grown in the United States," U. S. Dept. of Agr. Tech. Bul. No. 479.

By the use of a special adjustable cutterhead, tests were made at cutting angles of 5, 10, 15, 20, 25, and 30 degrees. Taking all defects into account, the 30-degree angle proved to be the best for aspen at 6 percent moisture content, although 25 degrees was about as good.

Work on the effect of feed and speed was done at only the optimum cutting angle, 30 degrees. Two different machines were used - a sticker (first with a two-knife cutterhead, then with a three-knife head), and a standard-type 24-inch cabinet planer. By changing feeds, speeds, and cutterheads, planing could be done at six different rates varying from 7 to 45 knife cuts per inch. Work got progressively better as the number of knife cuts per inch increased up to 22 cuts, beyond which point little difference could be noted. Chipped grain which was particularly bad at the lower end of the scale was eliminated at 22 cuts per inch when taking a cut of 1/16 inch. The most practical number of knife cuts per inch for aspen appears to be somewhere between 13 and 22. The number of knife cuts per inch is governed by the relation between feed rates and speeds of the cutterhead. Modern planer-type machines, except small light ones, offer the operator some leeway in this respect.

The tendency to develop fuzzy grain can be substantially reduced by adequate drying. A rather limited number of tests showed that 25, 36, and 50 percent of the pieces developed fuzzy grain when planed at 6 percent, 12 percent, and 20 percent moisture content, respectively. To some extent fuzzy grain depends upon how the piece is fed into the planer. Some pieces will develop some fuzz in any event, but if it is practical to feed the lumber into the planer so that the cutterhead revolves "with the grain" rather than against it, the amount of fuzzy grain will be substantially reduced.

Aspen planes much better with a light cut of about 1/32 inch than with an appreciably heavier cut. There are, of course, conditions under which this is impractical, but wherever a roughing cut is followed by a light finishing cut results are improved.

In planing properties (judged by cabinet-wood standards) aspen is one of the poorer hardwoods, belonging in the same class with soft elm, sycamore, and cottonwood. This does not mean that a good job of planing cannot be done on aspen. It means that it is more difficult to do a good job than with many other hardwoods and that, unless exceptional care is taken, the percentage of good work will be lower.

Encased knots that are loose or unsound are common in aspen. Such knots often break in planing instead of surfacing smoothly as sound intergrown knots are likely to do. Since most aspen lumber is knotty, this is a rather serious drawback for some uses.

Shaping3/

Shaping tests have been made on 28 hardwoods at 6 and 12 percent moisture content using a two-spindle shaper operated at 7,200 r.p.m. Aspen and other soft, light woods, such as basswood, willow, and cottonwood, are among the poorest shaping woods (table 1). Aspen cuts much less smoothly on the end grain and has more tendency to fuzz on the side grain than the better shaping woods, such as hard maple and birch.

In the hope that better results on aspen might be obtained at higher speeds, a few tests were made on three other types of machines - an automatic shaper at 10,000 r.p.m., a high-speed router at 20,000 r.p.m., and a power plane at 18,000 r.p.m. The shaper and router used standard knives and cutters, and the power plane used a spiral cutter. Results on these three machines were very little better than on the two-spindle shaper at 7,200 r.p.m. Although the possibilities are not exhausted, this study has thus far failed to reveal any satisfactory way of doing a first-class shaping job on aspen.

Sanding

Since fuzzy grain is the commonest planing defect in aspen, being found in some degree, in 25 percent of the pieces even under fairly good planing conditions, the question arises whether or not it can be efficiently removed by sanding. Fuzzy grain must be sanded off in interior trim, but a moderate amount can be allowed in core stock. Detailed tests on the sanding of aspen were not made, but aspen has been found to parallel cottonwood, a related species, fairly closely in its general machining properties. Cottonwood is one of the poorer woods for sanding. It has more of a tendency both to show scratches and to develop fuzz in sanding than most hardwoods. Judging from limited sanding tests made with a small drum sander, aspen is quite similar to cottonwood in its sanding properties.

Two points of interest in this connection were noted. Fuzzing may develop in the sanding process if the aspen is sanded against the grain. It is desirable, therefore, to sand with the grain just as far as practical. The use of too coarse an abrasive, moreover, may increase fuzziness instead of removing it. It was noted, for instance, that No. 3/0 grit often produced a smooth surface where No. 1/0 grit merely made a fuzzy surface worse. In general, the woods with the greatest fuzzing tendency are the soft ones, and as might be expected, the woods with the greatest tendency to show scratches are the fine-textured woods.

3/ It is planned that additional shaping and sanding studies will be made by Messrs. Robert Craig, Jr. and Louis A. Patronsky of the University of Michigan Forestry School and that these will be dealt with later in a supplementary report.

Table 1.--Some machining properties of hardwoods[1]

Species	Planing	Shaping	Turning	Boring (smoothness)	Mortising (smoothness)	Sanding (scratching, fuzzing)
	Defect-free pieces	Good to excellent pieces	Good to excellent pieces	Good to excellent pieces	Fair to excellent pieces	Good to excellent pieces
	Percent	Percent	Percent	Percent	Percent	Percent
Ash	75	51	79	94	62	75
Aspen	26	7	65	78	60	--
Basswood	64	9	68	75	51	17
Beech	--	21	90	99	93	49
Birch	63	53	80	98	97	34
Buckeye	--	6	58	75	18	--
Cottonwood	21	3	70	70	52	19
Chestnut	74	24	87	91	72	64
Elm	33	11	65	94	75	66
Gum, black	48	23	75	82	24	21
Hackberry	74	10	77	99	70	--
Hickory	--	19	84	100	98	80
Magnolia	65	25	79	69	32	37
Mahogany	80	68	89	100	100	--
Maple, hard	54	62	82	99	95	38
Maple, soft	41	22	76	80	36	37
Oak, chestnut	--	23	90	100	100	75
Oak, red	91	21	84	99	100	81
Oak, white	87	28	85	95	100	83
Pecan	88	31	89	100	100	--
Sweetgum	51	21	86	92	58	23
Sycamore	22	8	85	98	96	21
Tupelo	--	43	79	62	35	34
Walnut, black	62	34	91	100	98	--
Willow	52	55	58	71	24	24
Yellow-poplar	70	12	81	87	63	19

1/ Figures are based on test material at 6 percent moisture content except in shaping (where an average for 6 and 12 percent was used) and in turning (where an average of 6, 12, and 20 percent was used).

Turning

Turning tests were made in a modified back-knife lathe running at 3,300 r.p.m. and using a milled-to-pattern knife that insured uniformity of size and shape in the turnings. Turnings were graded on a basis of smoothness of surface and sharpness of detail. Aspen proved to be one of the poorer turning woods, largely because of its failure to cut as smoothly as is desirable. Nevertheless, aspen is used for commercial turnings on a small scale for uses that are not too exacting. Under the conditions of this test, aspen turned better at 6 percent moisture content than at 12 percent, and better at 12 percent than at 20 percent. In general, the better turning woods are heavy or moderately heavy (table 1).

Boring

A standard type of 1-inch bit was used in a boring machine running at 2,400 r.p.m. with test samples at 6 percent moisture content. Holes were examined for smoothness of cut and measured for trueness to size, both of which factors would affect the quality of a dowelled joint. The amount of offsize was not great enough to equal smoothness of cut in importance, and the comparison in table 1 is based on the latter.

Aspen proved to be one of the poorer woods in both respects. Light woods in general bore less smoothly than heavy woods, showing a certain crushing and tearing tendency. Holes bored in light woods are, as a rule, more offsize than holes bored in heavy woods.

Mortising

For this test a boring machine equipped with a 1/2-inch hollow chisel mortiser was used. The mortises, which were cut in test material at 6 percent moisture content, were examined for smoothness of cut and measured for trueness to size because of the effect of those factors on the strength of a mortised joint. Mortises in aspen were fairly smooth-cut, but their size varied from that of the cutting tool about as much as in any wood tested. Smoothness of cut was the more important consideration, and the comparisons in table 1 are based on that.

GENERAL COMPARISON OF MACHINING PROPERTIES OF ASPEN AND CERTAIN OTHER HARDWOODS

Table 1 gives, in alphabetical arrangement, a comparison of the properties of aspen and 25 other hardwoods in six of the more common machining operations. In most of these operations, aspen is well down toward the bottom of the list. Examination of all test samples was quite rigid, and many of the imperfect ones were only slightly imperfect. It must be remembered that for many uses the highest standards of machining are not required and that for other uses machining can often be substantially improved by careful attention to details.

CERTAIN RELATED PROPERTIES

Extensive work has been done in recent years on steam bending, nail and screw splitting characteristics, variation in specific gravity, number of rings per inch, cross grain, shrinkage, and warping of hardwoods. Although these are not machining properties, they are related to machining and most of them are of great interest to woodworkers. Cottonwood was included in the original studies but not aspen. It is known, however, that aspen parallels cottonwood quite closely in many respects and enough new work has since been done with aspen to determine whether or not this is true of most of the above related properties. But because of the limited amount of testing done with aspen, the following information should be considered indicative rather than conclusive.

Steam Bending

Aspen, like cottonwood, is one of the poorer native hardwoods for steam bending. It cannot be recommended for this use.

Nail Splitting and Screw Splitting

Aspen resembles cottonwood in being one of the best native hardwoods as regards freedom from splitting when either nails or screws are driven. With nails, resistance to splitting has special application to the use of aspen in containers.

Variation in Specific Gravity

Aspen is more uniform in its specific gravity than most native hardwoods, and for the uses to which aspen is put this would be considered an asset. The test material averaged 0.42 based on oven-dry weight and volume, which puts it in the lightweight class of hardwoods.

Number of Rings per Inch

The aspen test material averaged 10.6 rings per inch as compared with 7.7 for southern cottonwood and 14.0 for the average of 25 hardwoods.

Cross Grain

Aspen, unlike southern cottonwood, is one of the more straight-grained hardwoods. The most extreme form of cross grain (interlocked grain) was lacking in the aspen tested, although it occurred in about one-fourth of the cottonwood samples. This accounts for the different rating of the two woods in this respect.

Shrinkage

No special shrinkage tests were made on aspen in this study. From earlier tests, however, it is known that very few hardwoods shrink as little as aspen.

Warp

No measurement data are available on the comparative warping tendencies of aspen. From experience and observation, however, aspen is assumed to belong among woods of moderate warping tendencies. The facts that it is relatively straight-grained and shrinks little tend to support this assumption.