EVALUATION OF KILN DRYING CHARACTERISTICS OF 8/4 CANADIAN ASPEN LUMBER IN A COMMERCIAL KILN

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TABLE OF CONTENTS

INTRODUCTION

There are large volumes of aspen (primarily Populus tremuloides) in the western sections of Canada. Present utilization is minimal, except for waferboard. Yet aspen has many desirable properties and characteristics, such as its low weight and freedom from splinters, that make it an attractive species.

Many potential aspen lumber producers are aware of research information that indicates that aspen cannot be dried successfully in conventional equipment. They therefore refrain from sawing this species. Yet, in the U.S. Lake States region, there is a substantial, viable aspen lumber industry.

In order to determine the potential for using aspen from the Province of Alberta for manufacturing lumber and thereby confirm or refute the frequently heard tales of difficulty in processing, an experiment was proposed in which a kiln load of 8/4 aspen lumber would be sawn, graded, dried, and re-graded. A comparison of grades, drying times, and other data would permit a technical and economic assessment of the commercial potential for this material in Alberta.

Specifically, the experiment was to measure the drying rate, evaluate the possible kiln schedules, estimate the drying cost, measure the grade loss due to drying using the NHLA standard rules, assess warp, splitting, and MC problems that would be considered degrade in softwood dimension, and measure shrinkage, warp and casehardening.

Procedures

Approximately 20,000 board feet of 8/4 aspen lumber was sawn at a small sawmill, producing 2 x 4 x 14, 2 x 6 x 14, 2 x 8 x 10, 2 x 8 x 16, and 2 x 10 x 14 dimension lumber. This lumber was brought to Edmonton, Alberta where it was graded by NHLA rules, numbered and sorted into five kiln packages according to size. Only those pieces that were No. 2 Common or better were accepted, Common in cutting yield. The results of this work are summarized in the following tabulation:

Size	Volume		Grade Distribution
	Inspected	Accepted	No. 1 + Better
2 x 4 x 14	3283 BF	29%	42%
2 x 6 x 14	5133	48	23
2 x 8 x 10			
2 x 8 x 16	1013	30	9
2 x 10 x 14	3706	17	15

Most of the 2 x 6 and 8's were sawn from the centre of the tree and contained the pith. Hence the lower recovery from these sizes. On the other hand, the 2 x 4's were sawn from the outer sections of the log and as a result had a higher average grade (or were so full of wane as to be cull).

The lumber was stacked using 2-foot spacings for the stickers. Sticker thickness was 3/4-inch. Stack width was approximately 4-feet. Each stack was covered with one layer of reject boards. Thirteen sample boards, approximately 24-inches long, were cut from the lumber using standard selection and preparation procedures. The samples were placed in pockets within the stacks.

During the stacking operation, 18 pieces were chosen for accurate thickness and width measurements, in order to measure shrinkage. In addition, any defects such as splits or shake were noted and marked on the boards, so that in evaluation after drying these defects would not be considered as drying degrade.

The lumber was loaded into the kiln several days after stacking. Sample boards were weighed daily, except on weekends. Kiln temperatures, dry-bulb and wet-bulb, were also recorded daily. Kiln conditions were fairly mild because the compressor size, approximately 5 HP, was much smaller than the size suggested for a 18 Mbf kiln (30 HP).

The load was dried until the average MC of the sample was 6%. This required 37 days. The lumber was then kept in dry lumber storage for 3 weeks before evaluation.

The dried lumber was then reinspected, regarding those pieces where drying degrade such as end splits, collapse, or warp was evident. (Each piece had been numbered to assist in comparison of before and after NHLA grades.) In addition, warp greater than 0.10-inches was measured and recorded. Bow and crook were determined by measuring the maximum deviation from a string stretched between the ends; cup was measured by noting the maximum deviation from a straight edge running from edge to edge; and twist was determined by measuring the height of one corner when the other three are held on a flat floor. The moisture content of every piece was measured with an electrical resistance type moisture meter that had been calibrated the same day with a calibration bar. The needles were driven into the piece 1/2 inch. Whenever a reading was found above 6% MC, another location was also tested on the same board to see if the high reading was a wet pocket (which it turns out were rare). The 2 x 8 and 10's were metered in two locations along the length, approximately 1/3 the distance from each end; the 2 x 4 and 6's in one location approximately 1/3 from one end.

After this data collection was completed, each piece was graded again using softwood grading rules; 2 x 4's were graded as Light Framing (Standard and Better, Utility, or Economy) and the other sizes as Structural Joists and Planks (No. 2, No. 3, and Economy). Because the lumber was generally thicker than was necessary, many wane defects could be minimized during surfacing. In cases where trimming or edging could upgrade a piece, this was noted.

Results of Drying Study

A. Suggested Kiln Schedules. A survey of the literature produced four kiln schedules, Appendix II. In adapting these schedules for use in a

low temperature dehumidification kiln, the relative humidity should be kept the same, while the dry-bulb is lowered to the levels required by the equipment.

B. Drying Rate and Drying Time. Using the data summary, Appendix IV, the drying time was 37 days. This is in comparison to softwood species of dimension lumber that is typically dried in 1 to 5 days. One of the more difficult to dry furniture woods, such as oak, would require 75 to 90 days in a commercial kiln. The average drying rate was 2% per day.

C. Final MC. The final MC of the 13 samples, Appendix III, ranged from 4.2 to 7.5%, with an additional sample at 14.3%. Based on the electrical moisture meter readings of every piece of lumber, Appendix IV, the final moisture content distributions were:

Under 7% MC	87%
7 to 9%	5
10 to 12	7
Over 12%	1

This distribution is excellent for furniture stock, but would generally be considered too low for construction dimension lumber. Most of the wet pieces were 2 x 6's and were found to be wet only in a small section, typical of a wet pocket.

D. Shrinkage. Both thickness and width shrinkages were measured. Textbook values are 3.6% radially and 6.6% tangentially. In drying, due to tension set (casehardening), the shrinkage in width (tangentially in this experiment) will be less than the text values. The results here, Appendix I, are a thickness (radial) shrinkage from green to 6% of 3.6% and a width (tangential) shrinkage from green to 6% of 5.3%.

E. Drying Cost. The cost of drying aspen dimension green-from-the-saw to 6% can be estimated using procedures outline in USDA Agricultural Handbook No. 528 and using the drying data collected in this study.

Equipment	$28.14/MBF
Interest	4.09
Maintenance/repair	12.09
Taxes/insurance	8.88
Stacking	8.40
Forklift	1.28
Kiln labor	18.98
Inventory	2.97
Degrade	4.50
Energy	27.50
Office overhead	.02
TOTAL	$117.44

It should be noted that capital costs and energy costs are the two largest items, followed by kiln labor and maintenance.

F. Collapse. Collapse after drying was noted in 19 pieces or 5% of the piece. All collapse was in the 2 x 6's. This evidence along with the higher final MC's in the 2 x 6's, suggests the presence of bacterial wetwood in the heartwood/sapwood zone. These are common observations with Lake States aspen as well.

G. Casehardening. Transverse prongs were sawn from all of the kiln samples. There was no appreciable casehardening.

H. Checks and Splits. Approximately 18% of the 2 x 10's and 11% of the 2 x 8's developed end splits in drying. Most of these splits were associated with pith or knots near the end. There were no splits noted with the 2 x 4 and 6's. These splits did not affect the NHLA grade except in two cases; however, the construction grade was lowered in almost all cases.

I. Warp. Crook averaged less than 0.3-inches per piece, with only a few pieces exceeding the allowable limit and lowering the grade after drying. Bow also averaged less than 0.3-inches and did not affect grade. Cup and twist were not important. Excessive warp with several 2 x 8's was due to the crookedness of the kiln floor. Oversizing of the lumber assured that any warp that did occur could be repaired by planing.

J. Hardwood Degrade. The only potential degrade affecting the NHLA grades was end splits. Two percent of the pieces were degraded. The other source of degrade, collapse, was severe enough to lower the grade of every board in which it occurred. (Note: In several cases the lumber shrank enough during drying that its board foot measure was lowered, thereby making it easier to achieve the required yield, which resulted in an increase in grade after drying.)

K. Softwood Degrade. With the softwoods, there were three degrading factors: collapse, warp, and end splits. However, in many cases, the degrade that would drop a No. 2 a No. 3 (or standard to Utility) is not considered because other naturally occurring criteria such as knots, wane, slope of grain, or shake already resulted in a lower grade. (The lower grades can tolerate more degrade).

2 x 4 Six pieces exceeded the crook allowed for standard and Better, but because of other factors, crook only lowered the grade of 1 piece. Likewise, there was excessive twist in three pieces, but none were lowered in grade.

2 x 6 Nineteen pieces had excessive collapse, but in only eight pieces did the collapse lower the grade. Thirteen pieces had excessive crook, but only in 6 pieces did the crook lower the grade. One piece had excessive bow and two had excessive cup, but none lowered the grade.

2 x 8 Ten pieces had excessive crook and seven pieces were lowered in grade. Four pieces had excessive bow and two were lowered in grade. One piece was lowered in grade due to twisting. two pieces were lowered in grade due to end splits.

2 x 10 Three pieces had excessive crook, but none were lowered in grade. Two of the three pieces with end splits were lowered in grade.

In summary, 8 percent of the pieces were lowered in grade due to drying degrade. This is a typical rate of drying degrade for softwood dimension lumber.

APPENDIX I -- SHRINKAGE DATA AND RESULTS FOR 8/4 ASPEN

Sample #	Thickness			Width		
	Green	7% MC	Shrinkage	Green	7% MC	Shrinkage
302	1.94"	1.89"	2.6%	4.03"	3.82"	5.2%
247	1.96	1.92	2.0	3.94	3.73	5.3
258	2.00	1.94	3.0	4.01	3.77	6.0
269	2.10	2.02	3.8	3.93	3.78	3.8
203	2.24	2.16	3.6	3.98	3.72	6.5
214	2.09	2.05	1.9	3.91	3.74	4.3
225	1.93	1.83	5.2	3.96	3.79	4.3
236	2.16	2.06	4.6	3.97	3.73	6.0
170	2.12	2.00	5.7	3.96	3.74	5.6
181	1.98	1.93	2.5	3.92	3.66	6.6
192	1.97	1.85	6.,1	4.10	3.76	8.3
159	1.96	1.88	4.1	3.96	3.73	5.8
91	2.21	2.11	4.5	6.12	5.80	5.2
50	2.06	2.00	2.9	6.00	5.71	4.8
64	2.27	2.23	1.8	5.8	5.56	4.1
78	1.97	1.91	3.0	6.12	5.88	3.9
15	2.02	1.91	5.4	5.88	5.61	4.6
29	2.00	1.97	1.5	6.10	5.76	5.6
	Average = 3.6%			Average = 5.3%		

APPENDIX II -- SUGGESTED KILN SCHEDULES FOR 8/4 ASPEN

1. Canadian Eastern Forest Products Laboratory, Report OPX192E
Aspen 1-3/4 to 2-1/4"

MC	Dry-bulb Temp.	Wet-bulb Temp.	Relative Humidity
Above 40%	140 F	133 F	82
30 - 40	150	130	57
30 - 7	170	120	24

2. US Forest Products Laboratory, Dry Kiln Operators Manual # 188
8/4 Aspen

MC	Dry-bulb Temp.	Wet-bulb Temp.	Relative Humidity
Above 35%	120 F	115 F	85%
35 - 30	120	113	80
30 - 25	130	119	71
25 - 20	140	121	56
20 - 15	150	115	34
15 - 7	160	110	21

3. US Forest Products Laboratory, Drying Eastern Hardwoods #528
8/4 Aspen, Low Collapse

MC	Dry-bulb Temp.	Wet-bulb Temp.	Relative Humidity
Above 70%	140 F	133 F	82%
70 - 60	140	130	75
60 - 50	140	125	64
50 - 40	140	120	54
40 - 30	140	110	38
30 - 25	150	100	18
25 - 12	170	120	24
12 - 8	180	130	26
8 - 4	200	140	30
Equalization	200	150	30

4. US Forest Products Laboratory, Drying Eastern Hardwoods #528
8/4 Aspen

MC	Dry-bulb Temp.	Wet-bulb Temp.	Relative Humidity
Above 60%	140 F	125 F	64%
60 - 50	140	120	54
50 - 40	140	110	38
40 - 35	140	100	25
35 - 30	140	95	19
30 - 25	150	105	23
25 - 20	160	110	21
20 - 15	170	120	24
15 - 7	180	130	26
Equalization	173	130	32

APPENDIX III - Initial and final MC's of Kiln Samples

Sample No.	Size	Green MC	Dry MC	Grain
1	2 x 8	74.2%	7.5%	F
2	2 x 8	59.6	7.3	F
3	2 x 8	61.3	4.4	F
4	2 x 4	106.4	4.2	Q
5	2 x 4	84.6	5.5	B
6	2 x 4	80.8	4.3	F
7	2 x 4	97.9	5.9	F
8	2 x 4	65.8	7.3	F
9	2 x 10	103.6	6.0	P
10	2 x 10	72.4	14.3	P
11	2 x 6	78.2	6.3	F
12	2 x 6	70.9	5.7	F
13	2 x 6	92.0	5.5	B

Grain: F = flat; Q = quartered; B = between F and Q; P = pith

APPENDIX IV -- Kiln Record Summary

Date	Elapsed Time (Days)	% Moisture Content Six Wettest Average	Temperature Dry	Temperature Wet
27 Aug	0	81 77	74	72
28 Aug	1	74 63	83	82
29 Aug	2	71 62	93	92
30 Aug	3	68 59	100	96
3 Sep	7	58 50	102	98
4 Sep	8	54 46	103	101
5 Sep	9	50 42	104	100
6 Sep	10	46 39	111	100
9 Sep	13	36 30	109	96
10 Sep	14	34 27	113	99
11 Sep	15	31 25	112	98
12 Sep	16	29 23	111	95
13 Sep	17	27 22	112	95
16 Sep	20	22 17	112	96
17 Sep	21	20 16	114	96
18 Sep	22	19 15	115	91
19 Sep	23	17 14	116	95
20 Sep	24	16 13	119	97
23 Sep	27	13 10	116	92
24 Sep	28	12 9	117	90
25 Sep	29	12 9	117	90
26 Sep	30	11 9	120	94
27 Sep	31	10 8	119	97
30 Sep	34	9 7	118	91
1 Oct	35	9 7	121	87
2 Oct	36	8 6	125	94
3 Oct	37	8 6	125	90

Run stopped on 3 Oct. 85.