A TECHNICAL AND ECONOMIC EVALUATION OF USING THE WSTIWOOD PROCESS TO MANUFACTURE ASPEN BILLIARD CUES IN ALBERTA

Cuecorp Ltd.[1]

1989

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DISCLAIMER

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EXECUTIVE SUMMARY

Whereas the sapwood of both aspen and maple accepts polymer treatment very well, heartwood from either species does not. Heartwood can be visually detected in maple much easier than in aspen. This factor simplifies material selection.

It was determined that hardness, colourability and dimensional stability were directly correlated to the retention of the polymer which in turn was dependent on the amount of sapwood in the untreated blanks.

The maple cue blanks treated very well and exhibited a high degree of dimensional stability. They consumed between 34.4 and 62.5% of their oven dry untreated weight in polymer and the distribution of polymer was even throughout each sample.

Average polymer loadings for aspen in the first and second phases of the study were 51.6% and 115% respectively. The much higher value of 115% in the second phase was due to the careful selection of blanks cut from sapwood.

If aspen were to be used for production of cues, care would have to be exercised in selecting only premium quality sapwood.

Maple and aspen sapwoods both exhibited excellent colouring and mixture of dyes (red, green and blue) with the WSTIWOOD™ monomer posed no barrier to polymerization.

Prototype cues treated with the WSTIWOOD™ process and finished, were sent to a wholesaler of billiard products and a professional pool player for evaluation. Both evaluations were very positive and were based on the following criteria: appearance, finish, weight distribution, playback feel on impact, warp resistance and price.

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OBJECTIVE

The objective of this study was to determine the technical and economic feasibility of using the WSTIWOOD™ wood polymer composite treating process for the manufacture of aspen and maple billiard cues in Alberta.

Phase I of the study was a preliminary examination to see if the WSTIWOOD™ process could be adapted for this purpose and Phase II focused on refining the process, determining its effectiveness, developing cost data and testing market acceptance.

INTRODUCTION

In November of 1987 a workshop on wood-plastic composites was sponsored under the Canada/Alberta Forest Resource Development Agreement and held at the Univeristy of Alberta. One of the presentations given described WSTIWOOD™.

It was following this workshop that Cuecorp. Ltd. approached the Wood Science and Technology Institute Inc. (WSTI) of Fredericton, New Brunswick, with a proposal to do some R&D work on billiard cues.

Cuecorp Ltd. applied for and received funding assistance from the B4 Subprogram of the C/A FRDA.

WSTI was subcontracted to first do a preliminary assessment of the feasibility of treating billiard cues with wood polymers. If the results of Phase I looked promising then a second phase was to proceed involving more specific work.

Phase I commenced in April of 1988 and Phase II in August of the same year.

Methodology - Phase I

The Wood Science and Technology Institute received three samples of product from Cuecorp Ltd. to evaluate the effectiveness of the WSTIWOOD™ wood polymer composite process. The samples consisted of 1.25 inch square aspen blanks, unfinished aspen billiard cues, unfinished maple cues and finished maple cues.

The samples were given individual number codes, weighed and Shore Durometer[1] Hardness Type "D-2" readings were recorded. The general enhancement of flexure stiffness was also measured.

The 1.25 inch square blanks were all given full load treatments of polymer. Shell loadings were not attempted because the treated shell would be removed when the blanks were machined in a lathe.

The unfinished aspen cues were also all given full load treatments. The full length billiard cues had to be cut in half in order to accomodate them in the pilot plant testing facility. The sample numbers 1 to 6 were given colour treatments.

The finished maple cues were given clear and coloured, full load treatments as well as shell loadings. These cues were also sawn in half in order to be accomodated in the pilot plant.

Methodology - Phase II

The kiln dried aspen cue blanks (1.25"x1.25"x28.5") were separated into two groups and treated as follows:

- The first group of 12 cues was fully loaded with WSTIWOOD™ polymer of various colours.

- The second group of 24 cues was shell loaded with polymer containing black dye.

In addition, a batch of six kiln dried maple cue blanks (1"x1"x 28.5") were fully loaded with WSTIWOOD™ clear polymer as per Cuecorp Ltd.'s request.

[1]The Shore Durometer measures the relative surface hardness of the wood product. The durometer does not measure the actual hardness of the sample but an increase in durometer reading reflects a corresponding increase in hardness.

RESULTS AND DISCUSSION - PHASE I

1.25"x1.25" Aspen Blanks

Polymer consumption in the aspen blanks varied significantly. It ranged from about 4 to 80% by weight of untreated wood (Table 1). This variance appears to be directly related to the percentage of heartwood in the treated sample. The heartwood in most hardwood species has pore structures too small to allow the penetration of the unpolymerized chemical. It is important to maintain high quality control when choosing wood to be used in wood polymer composites. Sample number 10 contained a high amount of heartwood and only picked up 4.1% by weight of the polymer.

The durometer increase averaged 46%, which is significant and reflects a hardness increase of approximately 400%.

Conversion of polymer in the samples averaged 90%.

Unfinished Aspen Cues

The aspen cues were given full loadings using both clear and coloured polymers. The consumption again varied radically, as it ranged from around 10% to over 200% (Table 2). This reflects the difference between maximum consumption of polymer by heartwood and sapwood.

There was also a fluctuation in the durometer readings which corresponds to the polymer consumption. The more polymer in the sample the higher the durometer reading.

Maple Cues

The finish on the maple cues had to be removed prior to treatment. The cleaned cues were cut in half and treated with either clear or coloured full loadings or clear shell loadings.

Polymer consumption for the thinner (sm full) cue halves was in the range of 50 to 60% for full loading (Table 3).

Polymer consumption for the shell loadings of the thinner (sm shell) pieces of maple ranged from 5.4 to 13% (Table 3). The small variance in polymer consumption was probably due to the ends of the cues loading differently.

The handles of the cues did not treat as well as the maple shafts. It appears that the handles were turned from a very dense exotic hardwood, probably Ramin which does not respond well to wood polymer composite treatment.

Table 1. Results From Full Load Treatment of Aspen Squares.

Sample Number	Durometer Untreated	Readings Treated	% Increase	Mass (g) Untreated	Mass Treated	% Pickup	Mass Cured	Mass Baked	% Conversion
1	49	65	32.6	318.1	536.2	68.6	479.5	477.8	82.0
2	49	65	32.6	313.0	454.3	45.1	431.5	429.3	95.6
3	48	68	41.6	329.1	419.1	27.3	391.2	388.6	88.1
4	50	71	42.0	317.4	489.0	54.1	456.5	454.5	91.0
5	50	79	58.0	354.6	528.7	49.1	497.8	494.8	92.7
6	45	69	53.3	308.1	400.6	30.0	381.2	379.0	96.6
7	46	71	54.3	308.7	493.3	59.8	468.1	466.4	95.5
8	52	78	50.0	337.7	460.7	36.4	429.6	427.2	89.2
9	49	75	53.0	317.8	398.9	25.5	364.0	361.4	77.3
10	39	45	15.3	292.7	304.6	4.1	289.4	286.5	95.5
11	41	69	68.2	279.5	506.4	81.2	461.4	459.1	86.5
12	45	68	51.4	319.0	448.0	40.4	411.3	409.0	84.6
AVERAGE			46.0			51.6			89.5

Table 2. Results From Full Load Treatment of Unfinished Aspen Cues.

Sample Number	Durometer Untreated	Readings Treated	% Increase	Mass (g) Untreated	Mass Treated	% Pickup	Mass Cured	Mass Baked
1*	48	78	62.5	77.3	177.4	129.5	159.8	129.5
2*	48	75	56.2	189.4	291.4	53.9	274.1	53.9
3*	46	78	69.5	78.3	131.9	68.5	119.0	68.5
4*	45	53	17.7	196.0	243.8	24.4	236.5	24.4
5*	45	54	20.0	74.2	149.1	100.9	130.2	100.9
6*	47	50	6.3	183.2	273.2	49.1	256.4	49.1
7	45	64	42.2	65.5	144.4	120.5	121.1	120.5
8	48	55	14.5	77.1	107.8	39.8	95.2	39.8
9	47	68	44.6	77.9	94.9	21.8	89.7	21.8
10	45	75	66.7	81.4	156.9	92.8	139.6	92.8
11	35	76	117.1	58.1	179.9	209.6	134.7	209.6
12	39	42	7.6	67.3	76.0	12.9	67.7	12.9
13	40	41	2.5	67.2	76.5	13.8	68.9	13.8
14	43	70	62.7	72.6	183.1	152.2	154.2	152.2
15	48	73	52.0	89.5	150.6	68.3	137.5	68.3
16	42	71	69.0	76.6	149.6	95.3	136.4	95.3
17	48	60	25.0	199.0	349.0	75.4	301.1	75.4
18	36	48	33.3	170.4	211.1	23.9	198.9	23.9
19	44	73	65.9	186.7	445.5	138.6	357.7	138.6
20	49	50	2.0	213.6	252.1	18.0	234.7	18.0
21	46	55	19.5	201.0	233.1	16.0	216.2	16.0
22	49	48	2.0	215.6	234.1	8.6	215.3	8.6
23	43	68	58.1	177.3	463.3	161.3	372.7	161.3
24	43	51	18.6	208.1	298.6	43.5	270.7	43.5
25	49	67	36.7	203.0	271.5	33.7	245.0	33.7
26	47	74	57.4	201.3	456.2	126.6	398.0	126.6
AVERAGE	44.8	62.2	39.6	134.9	223.1	73.0	197.4	73.0

*colour treatment

Table 3. Results From Both Full Load and Shell Load Treatment of Maple Cue Samples.

Sample Number	Hardness (Shore Durometer) Untreated	Treated	% Increase	Mass (g) Untreated	Mass Treated	% Pickup	Mass Cured	Mass Baked	% Conversion
1 sm full	65	81	24.6	104.9	169.3	61.4	146.3	141.4	66.5
1 lg full	65	81	24.6	392.2	423.8	8.1	407.3	398.7	95.0
2 sm full	65	79	21.5	101.2	164.4	62.5	140.4	137.4	66.9
2 lg full	65	79	21.5	337.7	372.4	10.3	346.6	340.8	67.3
3 sm full	65	80	23.0	119.6	177.4	48.3	150.8	148.6	62.6
3 lg full	45	81	23.0	320.6	345.1	7.6	329.2	323.3	89.5
4 sm shell	65	70	7.7	118.2	126.8	7.3	115.6	-	-
4 lg shell	65	74	13.8	329.8	331.0	0.4	318.6	-	-
5 sm shell	65	72	10.7	107.0	120.9	13.0	107.6	-	-
5 lg shell	65	75	15.3	328.5	329.6	0.3	315.9	-	-
5 sm f-c	65	81	24.6	106.9	173.2	62.0	152.7	146.9	70.0
6 lg f-c	65	77	18.4	333.8	367.6	10.1	356.6	343.2	87.1
7 sm f-c	67	74	10.4	121.9	186.6	53.1	153.7	147.0	50.1
7 lg f-c	67	75	11.9	315.6	350.7	11.1	333.2	316.6	56.8
8 sm f-c	65	80	23.0	107.8	175.1	62.4	148.0	142.5	61.2
8 lg f-c	65	81	24.6	376.8	416.3	10.5	399.7	386.1	80.8
9 sm shell	67	71	5.9	115.0	121.2	5.4	113.0	-	-
9 lg shell	70	76	8.5	364.7	365.2	0.1	354.1	-	-

However, the handles were treated in the same manner as the maple halves of the cue during the full loading. The polymer pickup was probably all in the first few inches of maple that was attached to the handle.

There was a significant increase in the durometer readings for all of the treated samples.

The polymer conversions were all around 60% and can be increased by optimization of the treatment process.

There were several cue pieces that showed evidence of warp following curing. The warping is caused in part by the contraction of the polymer during curing. This problem can be easily rectified during the curing cycle by modifying the processing equipment and processing parameters. It was also noted that warp was more prevalent in the aspen pieces, which is understandable since aspen contained more heartwood and it was also discovered that some of the samples were not dried properly, i.e. down to 7%.

Tests

1) Dry Lean Test - (Cue samples placed against a wall at a 45° angle.) After leaning for four full days no warp was observed ineither the maple or aspen samples. The aspen samples were fully loaded while some maple samples were fully loaded and some shell loaded.

2) Wet Lean Test - (Samples were fully submerged in boiling water for 2 hours prior to standard lean test.) No warp was observed in either the maple or aspen samples following four days of leaning after 2 hours of boiling.

3) Weight - The fully loaded maple cues were too heavy but the ones that were shell loaded had acceptable weights. Of all the aspen samples that were fully loaded only two were of ideal weight. Most of the samples were too light indicating inadequate polymer treatment. Improper drying of aspen samples was apparently the reason given for the variation in weights of the aspen samples.

4) Hardness and Strength - Although both the fully loaded and the shell loaded maple samples displayed significant improvement further improvement is required.

   All of the fully loaded aspen samples showed some improvement but much more is required.

5) Finish - The buffed finish on both fully loaded and shell loaded maple samples was acceptable.

The buffed finish on the aspen samples was not as good as that on the maple samples and was due to the difference in surfacing during turning in the wood lathe. Aspen has a tendency to display a raised or fuzzy surface following machining.

6) Playability - The fully loaded maple samples were too heavy and therefore unacceptable. On the other hand the shell loaded samples were quite acceptable and performed very much the same as a standard, untreated maple cue.

Aspen samples that provided the proper weight handled well and were quite acceptable.

Samples were sent to a professional billiard player and a distributor of billiard products for evaluation. Both responses were very positive and copies of letters are referenced in the Appendix.

7) Colouring - All six coloured samples displayed good colouring qualities. The colour of the aspen samples however was much more pronounced than that of the maple. This is understandable as aspen is a much whiter wood than maple.

RESULTS AND DISCUSSION - PHASE II

Average polymer loadings of the aspen in the first and second phases of the study were 51.6% and 115% respectively (Table 4). The much higher value of 115% was due to a reduced presence of heartwood. Acceptable polymer loading for aspen ranges between 65 and 140% for full polymer impregnation.

It has been found that the greater the proportion of sapwood in a treated sample, the greater will be the hardness, colourability and dimensional stability.

The shell loading of aspen using black dyed WSTIWOOD™ polymer was not aesthetically pleasing. Two different black dyes were tried but to no avail. We feel that sufficient research could produce a desirable black.

If aspen were to be used for the production of cues, care would have to be exercised in selecting only premium quality sapwood.

Polymer consumption of the six maple cue blanks was consistent ranging from 34.4 to 62.5% based on oven dry weight (Table 5). Polymer distribution was even throughout each sample.

Table 4. Results From Full Load Treatment of Aspen Squares With Coloured Polymer.

Sample Number	Hardness Untreated	(Shore Durometer)[a] Treated	% Increase	Mass (g) Untreated	Treated	% Pickup	Cured	Bake
1	46	71	54.3	314.4	879.6	179.8	720.7	717.6
2	49	76	55.1	324.8	669.7	106.2	575.5	572.2
3	44	69	54.3	315.7	513.7	62.7	456.4	451.9
4	46	70	52.2	331.0	451.7	36.5	423.0	418.3
5	46	71	54.3	322.0	711.2	120.9	608.1	500.9
6	50	80	60.0	312.7	871.4	178.7	719.8	716.9
7	43	69	60.5	340.6	530.7	55.8	471.9	468.1
8	45	70	55.6	322.6	596.0	84.7	505.6	565.0
9	47	72	53.2	323.6	620.9	91.9	524.5	518.9
10	43	67	55.8	310.5	870.0	180.2	609.0	603.0
11	43	68	58.1	325.6	432.4	32.8	381.7	375.0
12	43	68	58.1	270.9	525.6	94.0	461.4	454.8
Average	45.4	70.9	56.0	317.8	639.4	102.0	538.1	525.2
C.V.[b]	5.3%	5.2%		5.3%	25.5%		20.5%	20.7
		Average Percent Polymer Loading[c]			115%		81%	77%

[a]The untreated squares measured 1.25"x1.25"x28.5" and were at a moisture content of 7%.

[b]C.V. = Coefficient of Variation

[c]Average Percent Polymer Loading is based on the oven dry weight of the untreated wood.

Table 5. Results From Full Load Treatment of Maple Squares With Clear Polymer.

Sample Number	Hardness (Shore Durometer) Untreated [a]	Treated	% Increase	Mass (g) Untreated	Treated	% Pickup	Cured	Bake
1	70	80	14.3	399.4	549.7	37.6	492.1	485.8
2	70	83	18.6	389.4	554.8	42.5	506.0	497.4
3	69	81	17.4	398.5	543.0	36.3	486.8	480.3
4	69	81	17.4	386.9	556.5	43.8	498.9	492.4
5	68	80	17.6	338.3	549.7	62.5	467.3	460.4
6	68	83	22.1	391.5	526.0	34.4	475.0	470.2
Average	69	81.3	17.9	384.0	546.6	42.8	487.7	481.1
C.V.[b]	1.3%	1.7%		6.0%	2.0%	-	3.0%	2.9%
		Average Percent Polymer Loading[c]			52%		36%	34%

[a]The untreated cues were at a moisture content of 7%.

[b]C.V. stands for the coefficient of variation.

[c]Average percent polymer loading is based on the oven dry weight of the untreated wood.

"Durometer hardness" of the maple cues increased from an average of 67 untreated to 80 treated. This represents an increase in hardness of 4 to 5 times that of the untreated wood (the durometer hardness scale is exponential).

CONCLUSIONS AND RECOMMENDATIONS

Research and development during Phase I and II have yielded some interesting information.

The maple cue blanks treated very well and exhibited a high degree of dimensional stability. If the cues were to be treated in the turned or semi-turned state, a special clamping device would have to be implemented to ensure alignment integrity during the polymerization process.

The maple cues consumed between 34.4 and 62.5% of their oven dry untreated weight in polymer. This range is normal for the sapwood from sugar maple.

The sapwood of aspen and maple treats very well whereas the heartwood does not. Heartwood is easily detected visually in sugar maple; much easier than in aspen. This simplifies material selection.

The aspen cues had a much wider polymer consumption range (between 51.6 and 115 based on the oven dry weight of the untreated wood); primarily due to the elusive presence of heartwood.

Aspen would be a potentially good wood for WSTIWOOD™ treatments if proper sapwood selection guidelines were followed.

The maple and aspen sapwoods both exhibited excellent colourable properties.

The mixture of dyes (red, green and blue) with the WSTIWOOD™ monomer posed no barrier to polymerization. This was evidenced by the durometer hardness values of the coloured WSTIWOOD™ samples being as high as the ones with clear polymer. Polymer consumption for coloured WSTIWOOD™ cues remained the same as that of clear cues for both maple and aspen wood species.

The WSTIWOOD™ treatment parameters can be optimized (specifically for the maple cue blanks) for time and energy efficiency during the first "market bound" treatments. Such parameters as vacuum/pressure times and polymerization time-temperature profiles could be adjusted accordingly.

One half of the aspen cues were treated with a solid black dye which proved unsuccessful. This particular black dye prevented polymer impregnation. The data from this batch of 12 cues were not included in this report.

COMMERCIAL SIGNIFICANCE

Based upon the positive results of the research trials, Cuecorp Ltd. has leased a 3200 square foot building in Vermilion, Alberta and plans to begin production of cues during the summer of 1989. Employment during start up will be 6 full time employees and within two years it will double to 12.

Production is projected to start at 5000 cues per month and within two years the company expects to be manufacturing 20,000 per month.

ACKNOWLEDGEMENTS

Mr. Martin Marshall, Chief Technician in charge of pilot plant operations.

Mr. Robert Butler, P. Eng., Chemical Engineering Consultant to the Wood Science and Technology Institute, Inc.

The B.4 Subprogram of the Canada/Alberta Forest Resource Development Agreement for providing funding for this project.

Mr. B.W. Karaim, Forest Industry Development Division, Forestry, Lands and Wildlife, for his assistance with editing the reports.

Dufferin
WHOLESALE & SERVICE

February 15, 1989

Brian Karaim
Alberta Forestry, Lands and Wildlife
#30, 8942 108 Street
Edmonton, Alta.

Dear Sir:

This letter is in response to a request by Cuecorp Limited regarding our evaluation of their newly developed billiard cues.

We have had the opportunity to view some of the prototypes and have also played with them.

We therefore provide the following as our evaluation:

Appearance: Excellent, coloring features should improve sales while maintaining aesthetics of wood.
Finish: Excellent, very smooth hard finish.
Weight Distribution: Better than conventional wood cues
Playback Feel on Impact: Comparable to quality ash cues.
Warp Resistance: Should eliminate rejects, very important from a retailers point of view.

Overall we feel very positive about these new cues and the potential they present both in sales and the impact they will have on the billiard industry. Of particular interest the cues will be retailed at competitive prices.

Trusting this to be of assistance.

Yours truly,

Rob Cameron,
President

Specialists in billiard room products and service.

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