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System 6: Making Frame-Quality Blanks

from White Oak Thinnings

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Abstract

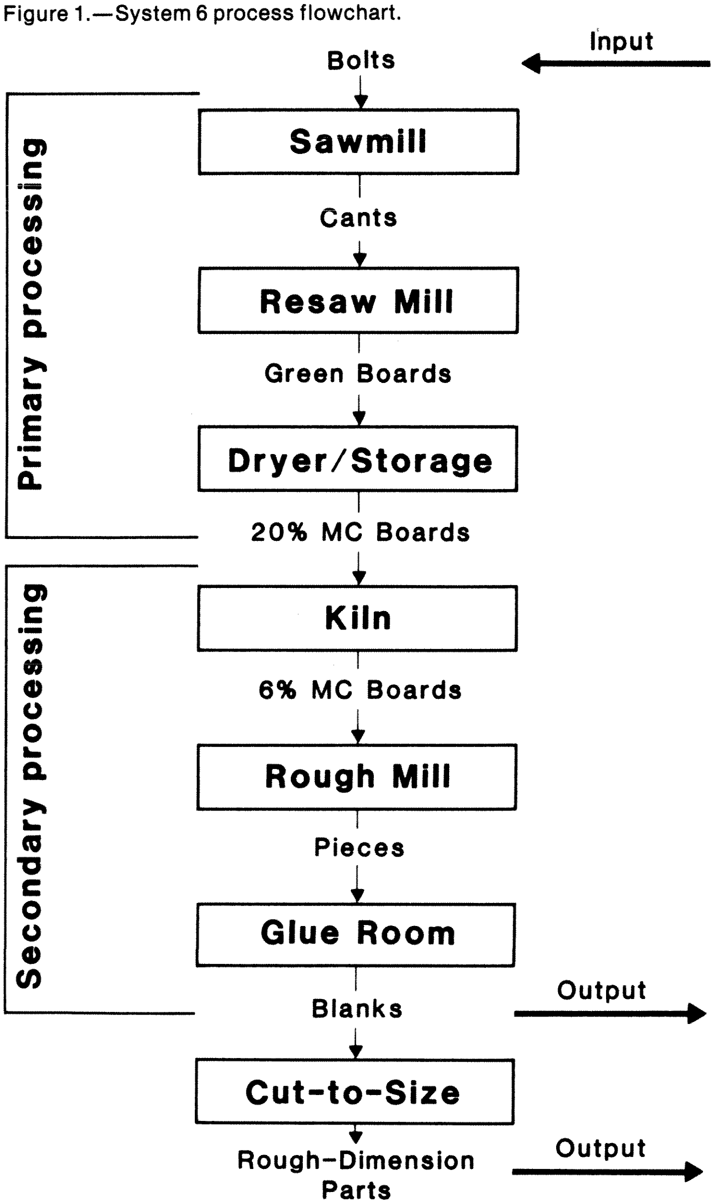
Low-grade white oak timber removed during a timber stand improvement cut on the Jefferson National Forest in Virginia was made into sawlogs, poles, 6-foot bolts, 4-foot bolts, pulpwood, and firewood. The 6-foot bolts were sawed to two cants per bolt; cants were resawed to 4/4 System 6 boards; boards were dried to 6 percent moisture content and made into frame blanks using System 6 technology. The blanks were used by an upholstered furniture company to make frames and were found to be very satisfactory. Yields of required frame blanks were good, 56 percent, when only the poorest two-thirds of all boards were used. The better boards can be used to make clear-quality blanks.

Introduction

In this paper we explain how we used System 6 processing technology with small-diameter, low-grade white oak timber to make standard-size blanks for frame parts. Upholstered furniture and recliner companies need strong, sound parts for the frames that will be covered with fabric. We made frame quality blanks in standard lengths, all 20 inches wide, and had a furniture company use these blanks to make their frame parts.

Using small-diameter, low-grade timber to make furniture-grade products with System 6 is new. The marketing differences between conventional hardwood methods and System 6 are explained in a research paper by Reynolds and Gatchell (1979). The System 6 technology is explained in a second paper by Reynolds and Gatchell (1982). The process is shown schematically in the Figure 1 flowchart. Standard-size blanks are explained in a research paper by Araman et al. (1982).

Figure 1.—System 6 process flowchart.



Frame Blanks

In a study made at the Forestry Sciences Laboratory, Princeton, West Virginia, to determine furniture parts requirements, requirements from 20 major furniture companies were divided into clear, core interior, and frame-quality classes (Araman et al. 1982). For each quality class, part size data were organized by thickness and length. In each thickness the least number of blank lengths were found that would yield all parts with no more than 10 percent end-trim loss. The resulting lengths and requirements for 4/4 frame-quality blanks are shown in Table 1.

Table 1. Standard-size 4/4 frame blank requirements (in square feet of blanks 20 inches wide)

Blank length	Quantity of blanks required[a]
Inches	*Square feet*
70	40
54	25
44	50
33	110
29	123
27	166
24	112
22	169
19[b]	83
17[b]	83
13[b]	39
Total	1000

[a] Data taken from Araman et al. 1982. We have assumed that 70 percent of the blanks are for upholstered furniture and 30 percent for recliner frames.

[b] Salvage length blanks: may be less than but no more than the requirement shown.

Frame quality material "may contain any defects that will not materially impair the strength of the individual piece for the use intended" (Hardwood Dimension Manufacturers Association 1961). This definition is too broad if blanks are to be purchased from many sources by many furniture and recliner companies, so we added the following quality specifications:

- No defects are permitted within 1 inch of either end.
- Defects within each piece making up the blank are limited to one-half the piece width with no more than one such defect per foot of piece length.
- Wane may not be on more than one edge, may not be more than one-half the piece thickness, and may not extend more than half the length of the piece.
- No shake or split longer than 1 inch will be permitted.
- Rot and unsound wood are not permitted.

Raw Material

We used small, low-grade white oak timber to make the frame blanks. Large quantities of timber of this quality are available from thinning cuts and from logging residues in the eastern hardwood forests. Our timber came from one such thinning cut made during a study at the Forestry Sciences Laboratory (Craft and Baumgras 1979).

The thinning study was done on the Jefferson National Forest, Giles County, Virginia. A heavy cut reduced the stand from 111 square feet to 53 square feet of basal area per acre. Approximately 60 percent of the timber was white oak (*Quercus alba*). Trees to be removed were felled, limbed, topped at 4-inch dob (diameter outside bark), and bucked to roundwood products with the following priority: Factory Grade 2 or Better sawlogs, poles, 6-foot sawbolts, 4-foot sawbolts, pulpwood, and firewood. The distribution by volume for all species is shown in Table 2.

Primary Processing

Twenty-five hundred board feet (157 bolts) of 6-foot sawbolts were randomly selected from the thinning study. Each of the 157 bolts was numbered and sawed to cants; the cants were resawed to boards and the boards from each bolt numbered. The bolt and board data are shown in Table 3.

In System 6, bolts 6 feet long are sawed to two cants 6 feet long. In this study the cants were sawed either 3 or 4 inches thick and had two rounded sides. System 6 boards are resawed from the cants. All boards that had a minimum of one clear cutting 2 by 18 inches were kept. All boards from a 3-inch-thick cant are tallied as 3-inch-wide boards containing 1-1/2 board feet each. All boards from a 4-inch-thick cant are tallied as 4-inch-wide boards of 2 board feet each. So System 6 boards are not like the random-width, random-length boards that make up hardwood lumber.

Boards were immediately sticker stacked and strapped in 4-foot-wide packages using four 1/2-inch-thick stickers per layer. The stacks of green boards were put into a forced air predryer (Cuppett and Craft 1975) three stacks high with a concrete top weight. The concrete is 4 inches thick by 48 inches wide by 72 inches long and exerts about 50 pounds per square foot pressure to prevent drying distortion in the top layers. The weather was warm (75° to 80°F days; 60° to 65°F nights) and no supplemental heat was used during the 20 days of predrying. Moisture content (MC) after predrying averaged 22 percent. Ten days of kiln drying at mild temperatures followed by 8 hours of conditioning brought the oak boards to 6 percent MC. Drying quality was excellent.

After drying, the System 6 boards were divided into two groups by grade—those meeting or exceeding 3A Common grade and those not meeting the 3A Common grade. NHLA (National Hardwood Lumber Association) standard rules were used. NHLA rules require a one-third yield of clear-face cuttings of 3 by 24 inch minimum size to qualify a board for 3A Common grade. Any number of cuttings that equal or exceed minimum size may be used to meet the one-third yield requirement. A full 3-inch-wide System 6 board will qualify for 3A Common if only one minimum size cutting is found. One 3-1/2-inch-wide by 32-inch-long cutting, or two minimum

Table 2. Distribution of roundwood products from thinning two oak-hickory stands

Product	Percent of volume
Sawlogs (10-inch diameter by 8-feet long, Factory Grade 2 minimum)	20
Poles (6-inch diameter by 8-feet long minimum)	4
6-foot sawbolts (8- to 12-inch diameter by 75-inch length, sound, with 1-1/2-inch maximum sweep)	27
4-foot sawbolts (6-inch diameter minimum)	14
Pulpwood (5-foot length)	32
Firewood (random length)	3
Total	100

Data taken from Craft and Baumgras 1979.

Table 3. Primary processing yields

Bolt diameter		Bolts	Bolt scale[a]	Bolt scale	Cants		Total	System 6 boards		Overrun bolt/board[b]
Class	Range				3″ thick	4″ thick		board feet	% board feet	
--- *Inches* ---		*No.*	*fbm*	%	--------- *No.* ---------					%
7	6.6- 7.5	12	121	5	22	2	24	194	6	60
8	7.6- 8.5	57	688	27	110	4	114	919	28	34
9	8.6- 9.5	44	716	28	45	43	88	947	29	32
10	9.6-10.5	31	660	26	8	54	62	793	25	20
11	10.6-11.5	12	314	13	0	24	24	350	11	11
12	11.6-12.5	1	32	1	0	2	2	30	1	-6
Total		157	2531	100	185	129	314	3233	100	28

[a] International 1/4-inch rule: no deductions
[b] Overrun = [(Board footage - bolt scale)/bolt scale] × 100

size cuttings, will qualify a full 4-inch-wide System 6 board for 3A Common grade. In our study, all boards not meeting or exceeding the 3A Common minimums were classified as below grade. The quality of the boards was not good; 68 percent of the footage was below grade and only 32 percent was 3A Common or Better.

Secondary Processing

In this System 6 study, boards were nominally 3 or 4 inches wide, or from the outside of the cants and had waney edges, and all were 6 feet long. Most boards had many defects. Regular hardwood lumber rough mill (secondary processing) techniques—individual crosscuts and rips to remove defects—are too slow to be used with the small, poor quality System 6 boards. In System 6 the initial board crosscutting is ganged so that all cuts in one board are made at the same time. The initial ripcuts are made two at a time. In this way most of the poor wood is cut out rapidly. The resulting pieces are given an individual crosscut or ripcut if needed. The pieces, now free of objectionable defects, are edge-glued to blanks. The secondary processing steps are shown in Figure 2.

Figure 2.—Secondary processing.

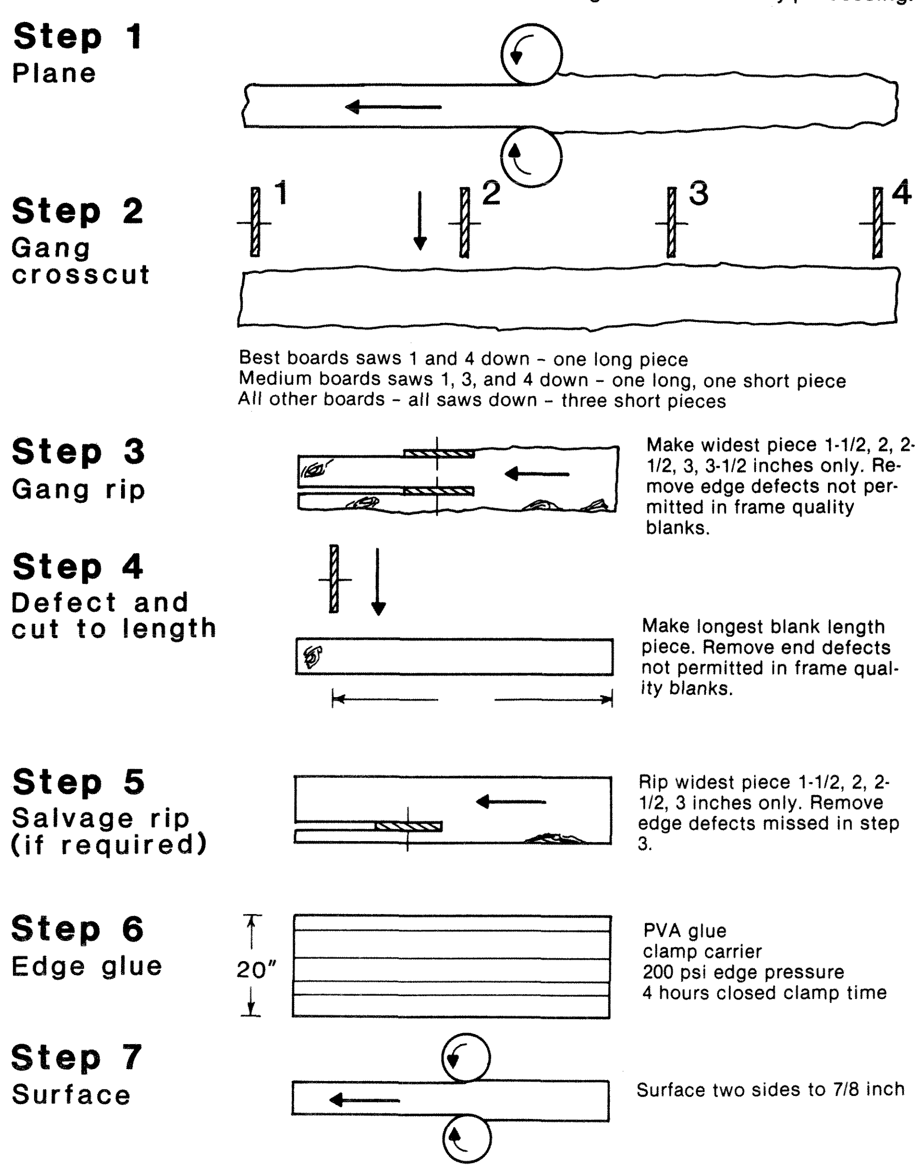


Table 4. Secondary processing instructions for each gang crosscutting length (All values in inches)

Secondary process	Gang crosscutting length			
	GCL-1 70, 44, 22	GCL-2 70, 33, 27	GCL-3 33, 29, 24	GCL-4 24, 22
Rough planing	Plane first side 0.975 inch; plane second side 0.940 inch abrasive planer			
Gang crosscut	Best: 72 Medium: 47, 25 Poor: 25, 22, 25	Best: 72 Medium: 39, 33 Poor: 20, 19, 33	Best, Medium, Poor: 36, 36	Best, Medium, Poor: 24, 24, 24
Gang ripsaw	1-1/2, 2, 2-1/2, 3, 3-1/2	1-1/2, 2, 2-1/2, 3, 3-1/2	1-1/2, 2, 2-1/2, 3, 3-1/2	1-1/2, 2, 2-1/2, 3, 3-1/2
Defect and trim to length	70, 44, 22 19, 17, 13	70, 33, 27 19, 17, 13	33, 29, 24 19, 17, 13	24, 22 19, 17, 13
Salvage ripsaw	1-1/2, 2, 2-1/2, 3	1-1/2, 2, 2-1/2, 3	1-1/2, 2, 2-1/2, 3	1-1/2, 2, 2-1/2, 3
Edge gluing[a]	70 × 20 44 × 20 22 × 20 19 × 20 17 × 20 13 × 20	70 × 20 33 × 20 27 × 20 19 × 20 17 × 20 13 × 20	33 × 20 29 × 20 24 × 20 19 × 20 17 × 20 13 × 20	24 × 20 22 × 20 19 × 20 17 × 20 13 × 20
Surfacing	Abrasive plane both sides to 0.875 inch (7/8 inch) final thickness			

[a] To standard blank sizes

We did not cut for all 11 blank-length pieces at one time. Instead we made four setups on the gang crosscut saw. In the first setup we cut to make 70-, 44-, and 22-inch blanks. This we called gang cross-cut length setup 1 (GCL-1). In the second we cut to make 70-, 33-, and 27-inch blanks (GLC-2). In the third we cut to make 33-, 29-, and 24-inch blanks (GCL-3). And in the fourth we cut to make 24- and 22-inch blanks (GCL-4). Pieces that could not be made to these lengths were made to 19-, 17-, and 13-inch blanks. Table 4 gives the step-by-step details for each of the four GCL's.

Four random samples of boards, 625 board feet each, were used to obtain yield data for each GCL. Each sample had 200 board feet of 3A Common and Better boards and 425 board feet of boards below 3A Common grade. Thus each sample was similar in quality composition—32 percent 3A Common and Better, 68 percent below grade—to the entire lot of boards sawed from the bolts.

For each GCL, the 3A Common and Better boards were processed first and then the below-grade boards. In this way we could determine the total blank yield by GCL and also the blank yield when only the below-grade boards were used. The yield results are shown in Table 5. (No 54-inch blanks were made with the GCL's used.)

Table 5. **Blank yields by GCL and board quality (in percent)**

GCL No.	Board quality	Total yield (%)	Yield by blank length in percent of total yield									
			70	44	33	29	27	24	22	19	17	13
1	All[a]	61.5	34.6	34.5					22.8	2.8	2.5	2.8
2	All	59.6	34.9		45.5		11.3			6.6	0.6	1.1
3	All	60.9			82.3	6.6		6.2		3.8	0.4	0.7
4	All	64.4						79.7	9.5	5.1	2.9	2.8
1	BG[b]	58.8	27.4	35.4					28.3	3.2	2.3	3.4
2	BG	55.8	24.7		50.6		15.3			7.2	0.6	1.6
3	BG	58.7			78.6	10.1		7.3		2.8	0.2	1.0
4	BG	63.2						78.9	8.2	6.7	3.0	3.2

[a] Yield data from boards 3A Common and Better combined with yield data from below-grade boards.
[b] Yield data from below-grade boards.

Processing Control

So far this paper has been a straightforward report on a research study. Now we will shift gears and consider means for using the yield data (Table 5) to obtain the required quantity of blanks (Table 1). Processing control is needed to determine the minimum number of boards to be cut by each GCL to obtain the blanks required.

The secret of efficient secondary processing is to have long production runs. Blanks are made, inventoried, and drawn from inventory as needed. More long blanks are made than are needed and shorter blanks not in inventory are made by trimming back the excess long blanks. One of the processing control requirements is to determine, in advance, how many long blanks are required for trimming.

Two techniques were developed to find the best combination of GCL's to obtain the required blanks. The first technique employs a computerized LP (linear programing) optimization; the second technique can be done by hand with a calculator. The LP technique gives the least board input answer and the computer cost is less than $1. The second technique approximates the LP answer but requires about 4 hours of manual calculations. Detailed explanations and instructions for both techniques are available from the authors.

Application of Processing Control

The yield values (Table 5) for all four GCL's, when all boards are used, were entered into the LP program. The blank length requirements (Table 1) were also entered. The least board footage to obtain the required blanks was 1,482 board feet. This LP solution is given in square feet, which is the same as board feet with 4/4 boards. The optimal LP solution chose to use only three GCL's. The quantity of blanks, in square feet, for each blank length for the three GCL's used is shown in Table 6.

The optimal combination of GCL's resulted in too many long blanks being made. Forty square feet of 70-inch blanks were required but 120 square feet were made. In this optimal combination, 169 square feet of 22-inch-long blanks were needed but only 85 square feet were made. The excess longer blanks were cut to fill the shortages of shorter blanks. The allocation of blanks for use and for trimming is given in Table 7.

Table 6. LP optimum distribution of blank lengths using all boards (in square feet)

Blank lengths (inches)	Gang cutting length			Total
	GCL-1	GCL-3	GCL-4	
70	120			120
44	119			119
33		414		414
29		34		34
24		31	48	79
22	79		6	85
19	10	19	3	32
17	8	2	2	12
13	10	3	1	14
Total	346	503	60	909
Area of boards used	563	826	93	1482
Percentage of total board area	38	56	6	100
Percent yield	61.5	60.9	64.4	61.3

Table 7. Area (in square feet) of blanks produced directly and by trimming, when all boards were used

Blank length (inches)	Blanks available	Blanks used without trimming	Blanks trimmed to or from other lengths	Blank waste	Blanks produced	Blanks required
70	120	40	32 cut to 25 × 54″ + 6 × 13″	1	40	40
			48 cut to 33 × 24″ + 15 × 22″	0		
54	0	0	25 from 70″ blanks		25	25
44	119	50	69 cut to 69 × 22″	0	50	50
33	414	110	102 cut to 89 × 29″	13	110	110
			202 cut to 166 × 27″	36		
29	34	34	89 from 33″ blanks		123	123
27	0	0	166 from 33″ blanks		166	166
24	79	79	33 from 70″ blanks		112	112
22	85	85	15 from 70″ blanks + 69 from 44″ blanks		169	169
19	32	32			32	Max. 83[a]
17	12	12			12	Max. 83
13	14	14	6 from 70″ blanks		20	Max. 39
Total	909	456	453 cut to 403	50	859	1000

[a] May be less than these values but no more.

Table 8. LP optimum distribution of blank lengths using below-grade boards only (in square feet)

Blank lengths (inches)	Gang cutting length GCL-1	GCL-3	GCL-4	Total
70	89			89
44	115			115
33	0	395		395
29	0	50		50
24	0	37	64	101
22	92		7	99
19	10	15	5	30
17	7	1	2	10
13	11	4	3	18
Total	324	502	81	907
Area of boards used	552	855	128	1535
Percentage of total board area	38	56	6	100
Percent yield	58.8	58.7	63.2	59.1

The 909 square feet of total blanks (output) were made from 1,482 board feet (input), for a 61.3 percent yield. Fifty square feet of blanks were wasted (5.5 percent) in trimming the excess longer blanks to make up shortages of shorter blanks. This brought the final yield to 859 square feet or 58.0 percent of the input board footage.

The yield values (Table 5) for all four GCL's when only the below-grade boards were used were entered into a second run of the LP program. Again the blank length requirements (Table 1) were entered. The least board footage to obtain the required blanks was 1,535 board feet. The same three GCL's were used; the quantity of blanks in square feet per length for the three GCL's is shown in Table 8.

As before, the optimal combination of GCL's tested resulted in blanks for use directly and for trimming. The allocation of blanks for trimming and for use is given in Table 9.

Table 9. Area (in square feet) of blanks produced directly and by trimming, when only below-grade boards were used

Blank length (inches)	Blanks available	Blanks used without trimming	Blanks trimmed to or from other lengths	Blank waste	Blanks produced	Blanks required
70	89	40	32 cut to 25 × 54″ + 6 × 13″	1	40	40
			17 cut to 11 × 24″ + 5 × 22″	1		
54	0	0	25 from 70″ blanks		25	25
44	115	50	65 cut to 65 × 22″	0	50	50
33	395	110	83 cut to 73 × 29″	10	110	110
			202 cut to 166 × 27″	36		
29	50	50	73 from 33″ blanks		123	123
27	0	0	166 from 33″ blanks		166	166
24	101	101	11 from 70″ blanks		112	112
22	99	99	5 from 70″ blanks + 65 from 44″ blanks		169	169
19	30	30			30	Max. 83[a]
17	10	10			10	Max. 83
13	18	18	6 from 70″ blanks		24	Max. 39
Total	907	508	399 cut to 351	48	859	1000

[a] May be less than these values but no more.

The 907 square feet of total blanks (output) were made from 1,535 board feet of below-grade boards for a 59.1 percent yield. There were 48 square feet of blanks (5.3 percent) wasted in trimming the excess longer blanks to make up shortages of shorter blanks. This brought the final yield to 859 square feet of required blanks or 56.0 percent of the input board footage.

We also investigated using only GCL–1 or only GCL–2 to make all the required blanks. These yield results were higher than expected but were lower than the yields from using the three GCL combinations. When all boards were used, the yields were 45.5 percent with GCL–1 and 54.9 percent with GCL–2. When only boards below 3A Common grade were used, the yields were 43.3 percent with GCL–1 and 50.1 percent with GCL–2.

System 6 is designed for long secondary processing runs. Runs of 10,000 square feet of blanks would be typical. Having determined the requirements of blanks by length, such as those shown in Table 1, we can determine the quantity of boards needed for each GCL. The kiln-dried boards are brought to the secondary processing mill in stickered packages. System 6 boards, 4/4, 6 feet long have 400 square feet of boards per package. The instructions to the mill operators will be to cut a given number of packages at each GCL.

Consider a run of 10,000 square feet of blanks to meet the Table 1 requirements. An overall yield of 58.0 percent was found when all boards were used. Thus 10,000 ÷ 0.580 = 17,200 square feet of boards, so 43 packages will be required. GCL 1, 2, and 3 will be used with 16, 24, and 3 packages, respectively.

When only boards below 3A Common grade were used, the overall yield was 56.0 percent. Thus 10,000 ÷ 0.560 = 17,900 square feet of below-grade boards required. Since 68 percent of the boards are below grade, 17,900 ÷ 0.680 = 26,300 square feet of boards or 66 packages will be required. GCL 1, 2, and 3 will be used with 24, 37, and 5 packages, respectively. There will be 21 packages of 3A Common and Better boards available for processing to higher valued blanks.

Discussion

What do we need? What do we have to make it with? How should we convert what we have to what we want? In this study these questions are answered for 4/4 frame blanks made by System 6 from low-grade white oak timber.

The frame blank requirements for upholstered furniture and recliner needs were derived from Araman et al.'s work (1982). We made frame blanks to the sizes and quantities specified. Quality of the frame blanks was better than most furniture companies require. We took these blanks to a furniture company with a frame plant in central Tennessee. They ripped the blanks to parts and made frames for loveseats. The yield of parts from blanks was good, and the frames were excellent.

The bolts did not look good. They were small, with 72 percent 9-1/2 inches in diameter or less. Making frame blanks or frame and higher valued blanks would be the best use for this wood. Some loggers do not want to buck stems for multiple markets as shown in Table 1. If loggers wanted to make only short roundwood products, the sawlogs could be made to System 6 bolts. We could have obtained better quality and more footage if the small-diameter sawlogs had also been made to 6-foot-bolts. We obtained approximately 850 board feet per acre (International 1/4-inch rule) of white oak 6-foot sawbolts. Another 550 board feet could have been made from the sawlogs, bringing the total to 1,400 board feet per acre from this thinning job.

Although we obtained a very good quantity of boards (28 percent over bolt scale), the quality (68 percent below 3A Common grade) was poor. This quality level, however, is satisfactory for frame blank use. The large number of small-diameter bolts caused both the high overrun and low quality level. The high overrun is due to the inaccuracies of scaling 7-, 8-, and 9-inch bolts with the International 1/4-inch rule. For instance, a pile of 7-inch diameter 6-foot bolts that scaled 1,000 board feet total would actually yield 1,600 board feet of System 6 boards (see Table 3).

Other System 6 research in which the boards from each bolt were graded showed that small-diameter bolts gave lower average grade of boards. The boards from the small-diameter bolts had lower than average blank yields. If more large diameter bolts had been used, the overall quality of boards would have been better and overrun would have been reduced.

Two techniques were developed for determining, in advance, the quantity of System 6 boards to be processed, using a combination of GCL's to obtain the optimal yield. Production scheduling will go forward with board quantities per GCL specified. The only changes to be made between GCL's are the saw spacing setup on the gang crosscut saw. All pieces leaving the gang crosscut saw are made to the longest, widest frame quality pieces specified. Blanks are edge glued, planed, and inventoried. Blanks required that are not in inventory are made by trimming the longer blanks. Because this is planned for in advance, there will always be enough longer blanks available.

In some cases upholstery or recliner manufacturers may need a limited supply of clear blanks. When wood of the quality level we found in this white oak is used to make clear blanks, yields will be low. It would be desirable in that case to separate out the 32 percent of all boards that are 3A Common or Better and use them to produce clear quality blanks.

Using all the System 6 boards, the yield of frame blanks from board footage was 58.0 percent. When only the boards below 3A Common grade were used, the yield was 56.0 percent. The blank yield drops only 2.0 percent when only the below-grade boards are used. This yield difference is small because a large number of defects are permitted in frame quality blanks.

Conclusions

The white oak timber we used in this study was of marginal quality but was good enough to make frame blanks. If clear blanks only were made, yields would be too low. If frame and clear blanks are to be made from timber of this marginal quality, the better boards should be sorted out and used for the clear blanks. If all the white oak timber from the plot that met the System 6 specifications had been used, the overall quality would have been improved and more quantity per acre would have been obtained.

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Low-grade white oak timber, removed during a timber stand improvement cut on the Jefferson National Forest in Virginia, was made into sawlogs, poles, 6-foot bolts, 4-foot bolts, pulpwood, and firewood. The 6-foot bolts were sawed to two cants per bolt; cants were resawed to 4/4 System 6 boards; boards were dried to 6 percent moisture content and were then made into frame blanks using System 6 technology. The blanks were used by an upholstered furniture company to make frames and were found very satisfactory. Yields of required frame blanks were good, 56 percent, when only the poorest two-thirds of all boards were used. The better boards can be used to make clear-quality blanks.

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Headquarters of the Northeastern Forest Experiment Station are in Broomall, Pa. Field laboratories are maintained at:

- Amherst, Massachusetts, in cooperation with the University of Massachusetts.
- Berea, Kentucky, in cooperation with Berea College.
- Burlington, Vermont, in cooperation with the University of Vermont.
- Delaware, Ohio.
- Durham, New Hampshire, in cooperation with the University of New Hampshire.
- Hamden, Connecticut, in cooperation with Yale University.
- Morgantown, West Virginia, in cooperation with West Virginia University, Morgantown.
- Orono, Maine, in cooperation with the University of Maine, Orono.
- Parsons, West Virginia.
- Princeton, West Virginia.
- Syracuse, New York, in cooperation with the State University of New York College of Environmental Sciences and Forestry at Syracuse University, Syracuse.
- University Park, Pennsylvania, in cooperation with the Pennsylvania State University.
- Warren, Pennsylvania.

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