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System 6

Used to Make Kitchen Cabinet C2F Blanks from Small-Diameter, Low-Grade Red Oak

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Abstract

Hardwood dimension manufacturers can make profitable use of plentiful small-diameter, low-grade timber when System 6 technology is used. We describe a System 6 plant designed to make clear-two-face (C2F) blanks for the kitchen cabinet industry. Data for plant operation are taken from a study in which red oak bolts (from a reforestation clearcut) were used to make 33-, 29-, 25-, 21-, and 15-inch-long standard-size blanks. Sem jointing of short pieces was used to increase the quantity of 25-inch blanks. The economics of two options for plant operation is explained.

Computer Disclaimer Statement

Introduction

The hardwood dimension industry makes solid wood parts (cut to rough part sizes, or partly or fully machined) for use in making furniture and kitchen cabinets. The dimension companies usually purchase high-grade hardwood lumber and use regular production techniques to make these parts. However, they could make profitable use of abundant, inexpensive low-grade hardwood timber if they had System 6 plants.

We outline a typical System 6 plant that could be used by a hardwood dimension manufacturer who will make standard-size blanks instead of rough-dimension parts. Data from a study in which red oak bolts were used to satisfy clear-two-face (C2F) blank requirements for a kitchen cabinet company are used to determine plant production. The economics of two profitable methods for operating this plant is given.

System 6 has been explained in a series of research publications. Marketing differences between System 6 and conventional hardwood methods are given by Reynolds and Gatchell (1979). The new technology is explained in a second paper by Reynolds and Gatchell (1982). The process is shown schematically in Figure 1.

Because relatively few C2F blanks shorter than 21 inches were required in the kitchen cabinets made in this study, we included Serpentine end matching (Sem). Sem is a process that joins short pieces to make long pieces (Gatchell et al. 1977). The curved joint has a pleasing appearance when it can be seen, but often it is invisible (Hansen and Gatchell 1978). Although the joint is not as strong as a scarf or finger joint, it is strong enough for furniture and cabinet use (Gatchell and Peters 1981). The joint is made on a tape-controlled router (Coleman 1977).

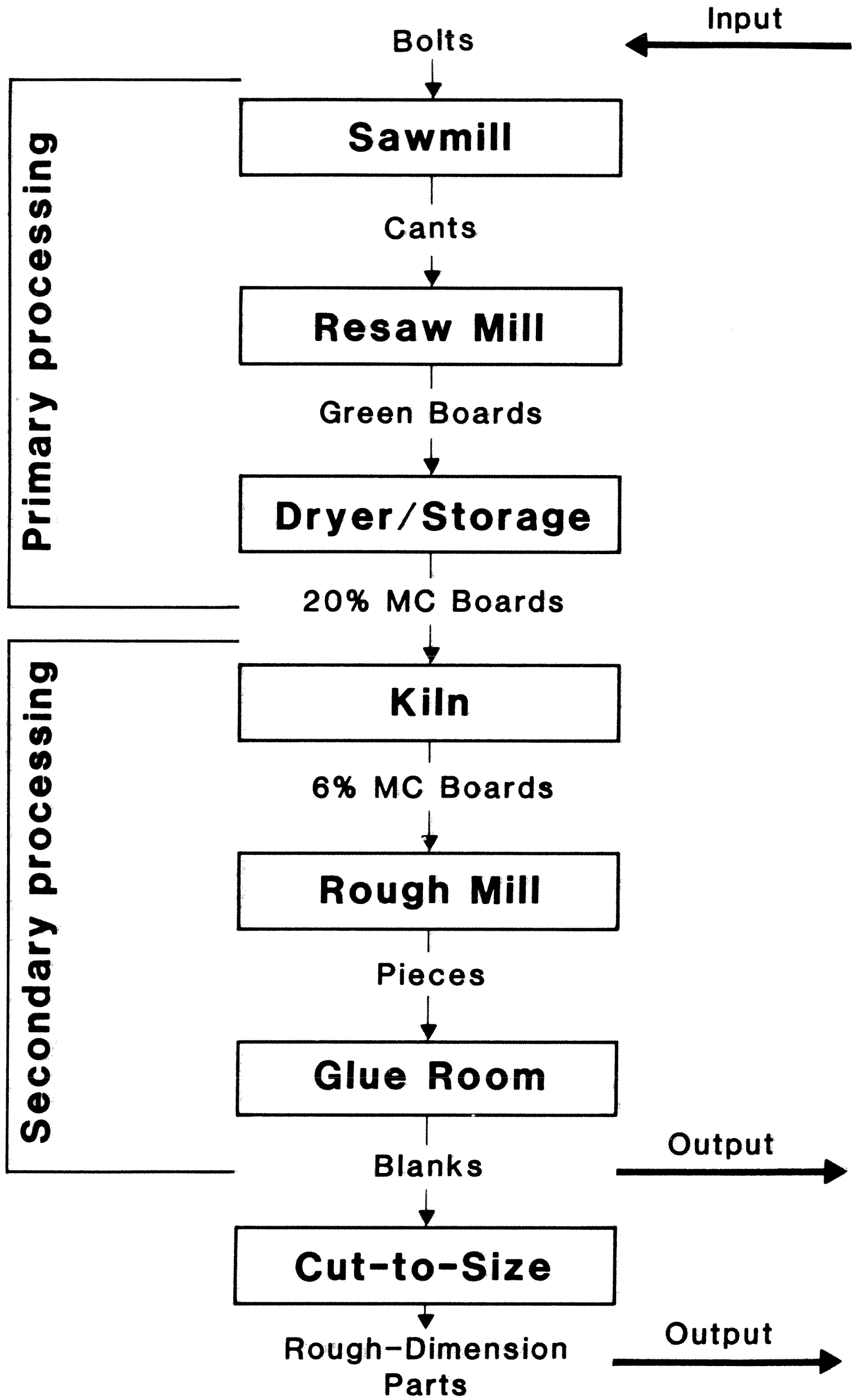


Figure 1.—System 6 process flowchart.

We will discuss five major topics: the System 6 plant, the raw material input—cants, the output product—blanks, manufacturing blanks, and economics. Each of these topics is divided into a general discussion pertinent to all System 6 operations and a specific discussion pertinent to the raw material and methods used to make the required blanks. As compared to a case study, this presentation should give the reader a wider appreciation of System 6.

System 6 Plant

The hardwood dimension manufacturer must have a System 6 plant to convert the small-diameter, low-grade timber to blanks economically. We assume that this will be a new plant in a new location. This assumption exemplifies the "worst case" because conversion of a current operation could use existing land and depreciated buildings, boilers, kilns, and machinery, which would lower costs. So, if a dimension company can make a profit with a new plant, it will profit more when some of the existing equipment and buildings are used.

The System 6 plant uses purchased cants as the raw material input. The primary processing begins at the resaw mill (Fig. 1). Here the cants are resawed to boards. All boards with at least one minimal size clear cutting (1½ by 15 inches) are kept, regardless of wane. Boards are immediately sticker stacked using ½-inch-thick stickers on 2-foot centers. Packages are made 4 feet wide by 3 feet high, each with 400 board feet. Packages are banded by two polypropylene straps to hold the boards and stickers in place during forklift handling. The packages are then transferred to the predrier. After drying to 20 percent moisture content (MC), the board packages are put in storage.

Boards required in the secondary processing end of the plant are transferred in packages to the kilns. After drying to 6 percent MC, the boards enter the rough mill. Here, the boards are made into defect-free pieces of blank lengths. The pieces are laid up into panels and are edge glued to blank widths. Planing the blanks completes the process.

Study Plant

System 6 plants can handle any capacity by adding machinery. A minimum-size plant uses one machine at each key location. Such a System 6 plant is described by Gatchell and Reynolds (1980).

A System 6 plant with one cant gangsaw to make boards from cants, one gang crosscut saw to crosscut boards to pieces, and one gang ripsaw to rip the pieces to specific widths is considered a minimum-size plant. When enough auxiliary equipment is added to keep these key machines running near capacity, the plant can convert 16 Mbf (thousand board feet) of cants to blanks per 8-hour shift. The blank output depends on the quality of blanks being produced.

Our study used a fully equipped 16 Mbf per shift input capacity plant. A 47-man payroll with two supervisors kept the kilns and boiler running 24 hours per day with a single-shift operation making blanks. The plant investment estimates (current of August 1982) are given in Table 1.

Table 1.—System 6 plant investment: 16 Mbf/shift input[a]

Item	Cost	
Machinery:		
Primary processing	$173,000	
Secondary processing	630,000	
Total		$ 803,000
Dryers, kiln, boilers, fuel handling	$637,000	
Buildings	260,000	
Total		$ 897,000
Land and improvements		100,000
Total		$1,800,000

[a] Details on equipment prices are available from the authors.

Raw Material Input

The raw material input for a System 6 plant is two-sided cants. The dimension company usually purchases these cants from hardwood sawmillers. Because System 6 cants are not yet a standard sawmill product, the dimension company will have to deal directly with sawmillers to get the correct cants.

System 6 bolt specifications are:

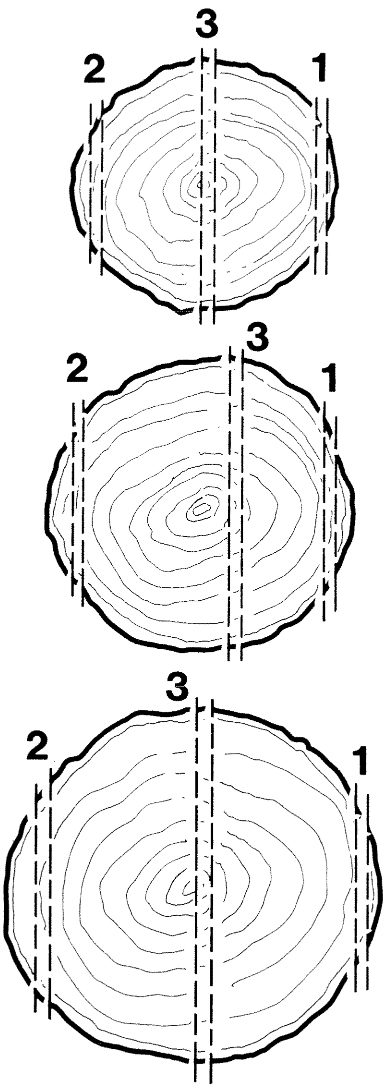
- 8 to 12 inches in diameter, small end inside bark (7.6 inches minimum to 12.5 inches maximum),
- 6 feet long (75 inches actual length),
- Sound quality—rot and dote not permitted, and
- 1½ inches maximum sweep.

The sawmiller saws only two cants per bolt. The bolt is loaded onto the carriage and is sawed into 3¼- or 4-inch cants (Fig. 2). The sawmiller should not try to make boards plus cants because it requires too much sawing, and the number of thicker cants is reduced.

Our experience has shown that the International ¼-inch Rule, without deductions, is a practical scale. Although it underestimates the board footage sawed from 8- and 9-inch-diameter bolts, it will overestimate the board footage sawed from 12-inch bolts. We have found no better way to estimate board footage in bolts of the 8- to 12-inch-diameter range used to make System 6 cants.

Red Oak Cants

We used low-grade red oak timber obtained from a reforestation clearcut in West Virginia for our study. A paper company was converting a mixed hardwood/softwood site into a softwood pulpwood plantation. All good hardwood timber was made to Factory Grade 1 and 2 sawlogs and to Factory Grade 3 sawlogs 13 inches and larger. The remaining timber was made to System 6 bolts or to hardwood pulp



Small-Diameter Bolts

1. Saw for 3-inch minimum face, turn 180°.
2. Saw to allow for two 3-1/4-inch-thick cants plus kerf.
3. Saw to make two 3-1/4-inch-thick cants.

Medium-Diameter Bolts

1. Saw for 3-inch minimum face, turn 180°.
2. Saw to allow for a 3-1/4-inch and a 4-inch-thick cant plus kerf.
3. Saw to make one 3-1/4-inch and one 4-inch-thick cant.

Large-Diameter Bolts

1. Saw for 3-inch minimum face, turn 180°.
2. Saw to allow for two 4-inch-thick cants plus kerf.
3. Saw to make two 4-inch-thick cants.

Figure 2.—Bolt sawing patterns.

bolts. Only the System 6 red oak bolts were used in this study. The bolt-diameter distribution and cant-thickness distribution found in this study (Table 2) are typical of the low-grade, small-diameter hardwood resource required by the sawmiller to meet System 6 bolt and cant specifications.

Cants were valued at $180 per Mbf, free on board the System 6 plant. The rationale for this price is as follows: The sawmiller should pay no more than $100 per Mbf International ¼-inch scale for the System 6 bolts. If he buys by cord measure, this is equivalent to $45 per cord. Our experience with small hardwood sawmillers shows that $50 per Mbf sawing charges will return a profit. System 6 bolt-to-cant sawing is simple and fast. We allow $30 per Mbf to bring the cants from the sawmill to the System 6 plant.

Cant scale versus bolt scale is a difficult choice. We have tried a number of cant scaling techniques and have yet to find one that is accurate and easy to apply. The System 6 cants have only two flat sides and are difficult to measure. We have found that using the bolt footage as the cant footage is possible because only cants are sawed from the bolts (Fig. 2). So, 1,000 feet of bolts become 1,000 feet of cants and no overrun is made in the sawmill.

Table 2.—Bolt and cant distribution by bolt diameter (per 100 bolts)

Bolt diameter		No.		No. of cants		
Class	Range (inches)	of bolts	Bolt[a] scale	3¼″ thick	4″ thick	Total
			fbm			
7	6.6- 7.5	2	17	4	0	4
8	7.6- 8.5	2	28	4	0	4
9	8.6- 9.5	14	260	16	12	28
10	9.6-10.5	30	658	18	42	60
11	10.6-11.5	34	908	0	68	68
12	11.6-12.5	12	402	0	24	24
13	12.6-13.5	6	236	0	12	12
Total		100	2,509	42	158	200

[a] International ¼-inch Rule used without deductions.

Table 3.—C2F blank requirements for 10 cabinet sets (all blanks 26 inches wide)

Blank lengths (inches)	No. of blanks	Total blank area	Blank surface area
		Percent	*Square feet*
33	6	9.0	36
29	15	19.8	79
25	29	32.4	131
21	32	30.1	121
15	13	8.7	35
Total	95	100.0	402

Output Product

The output from a System 6 plant always is blanks. Only one thickness and quality of blanks is made during a production run. Blanks can be made in all specific lengths or to a few specific lengths during the production run.

A study by Araman and others (1982) determined cabinet part requirements. These data from 11 major cabinet manufacturers were used to determine the least number of blank lengths that would result in no more than 10 percent end-trim loss when all parts were cut from blanks. For 4/4 thick clear parts, 12 standard blank lengths were determined: 15, 18, 21, 25, 29, 33, 38, 45, 50, 60, 75, and 100 inches long. All clear blanks made are 26 inches wide. Approximately 80 percent of the C2F cabinet parts (by surface area measure) can be made from blanks 33 inches long or less.

C2F Blank Requirements

A major kitchen cabinet manufacturer sent us his cutting bill of parts requirements for eight of his most popular oak cabinets. We translated the C2F parts requirements into C2F blank requirements. The number of blanks to make 10 sets of the eight cabinets is shown in Table 3. None of the C2F parts were longer than 33 inches.

Manufacturing Blanks

Primary Processing

Cants entering the System 6 plant are gang sawed to boards. The spacing between the saw blades determines the board thickness. All boards are sawed to the same thickness. Every board with at least one minimum-size clear cutting (1½ by 15 inches) is sent on to the stacker. After stacking, the packages of boards are brought to the predryer where they are dried to 20 percent MC. This completes the primary part of the System 6 processing.

Each board saved is tallied as a full-width board. Boards made from the rounded side of the cant will have wane on one edge, but they are considered as full width. Thus, each board sawed 4/4 thick, from a 3¼-inch-thick cant 6 feet long, will have 1½-board-foot measure. Each 4/4 board from a 4-inch-thick cant 6 feet long will have 2-board-foot measure.

In our study, all of the red oak cants were 6 feet long, and all were sawed to 4/4 thickness (1.182 inches actual). The usual System 6 practice is to use all boards, and grading is not done. However, in this C2F blank study, we wanted to test the feasibility of grading the boards into two groups: those boards grading No. 3A Common and Better and those not meeting the No. 3A Common grade.

After drying, the boards were graded by National Hardwood Lumber Association (NHLA) rules dropping the minimum lumber length and width requirements. Every board, regardless of wane, sawed from a 3¼-inch-thick cant and saved was tallied as a 3-inch board. For grading purposes, each of these boards must have at least one 3- by 24-inch clear cutting on the grade (poorer) face to qualify as No. 3A Common. Every board, regardless of wane, sawed from a 4-inch-thick cant and saved was tallied as a 4-inch board. For grading purposes, each of these boards must have at least one 3½- by 32-inch cutting or two 3- by 24-inch cuttings on the grade face to qualify as No. 3A Common. Obviously, most boards from the outside of the cant would not qualify as No. 3A Common or Better no matter how good they were because waney edges would make them too narrow.

The board distribution by grading was 39 percent of the board footage at No. 3A Common and Better and 61 percent below No. 3A Common (below grade).

We then compared total board output to cant input. For every 1 Mbf of cants (input) we had a total of 960 board feet of kiln-dried boards (output). This is a 4-percent underrun of boards from cants.

Secondary Processing

Packages of boards, at 20 percent MC, are transferred to the dry kilns for drying to 6 percent MC. The seven-step rough-mill process to make the defect-free pieces in the lengths required and to edge glue the pieces to blanks is:

1—Rough planing
2—Gang crosscutting to selected lengths
3—Gang ripping of pieces to specified widths
4—Defecting by crosscutting to blank lengths
5—Salvage ripsawing to specified widths when edge defects still remain
6—Edge gluing
7—Surfacing

In the 16-Mbf System 6 plant, we added a Sem option at step 4. Any piece entering step 4 that cannot have defects removed by being trimmed to a selected blank length is sent to the Sem room without being trimmed. These pieces have Sem joints made so the defects are removed. The Sem joints are then glued together and the piece is trimmed to a specified blank length and returned to the rough mill at step 5, where it is given a glue-joint edge on both sides.

System 6 rough-mill operation is simple. In general, follow the same sequence regardless of what blanks you are making. Two qualifications to this statement are: first, gang crosscutting lengths are selected depending on the blank lengths to be produced; and second, the pieces are made to the blank quality specifications. In this work, each piece was made to C2F quality standards as defined by Araman and others (1982).

In System 6 rough-mill operation, the rough-mill operators are permitted to work freely without interruption and to make as many blanks as possible in each length. A production control feature, unique to System 6 and discussed later, permits the rough-mill foreman to know in advance how many packages of kiln-dried boards must be used to produce the blanks needed.

In our study, we selected two gang crosscut saw spacings—gang crosscut lengths one and two (GCL-1 and GCL-2). In GCL-1, three saws are set up with 36 inches between saws 1 and 2 and 36 inches between saws 2 and 3. In GCL-2, four saws are set up with 29 inches between saws 1 and 2, 21 inches between saws 2 and 3, and 25 inches between saws 3 and 4. We anticipated that the 29-inch cuttings, because they are cut first, would help satisfy both the 29- and 25-inch requirements.

The seven-step rough-mill instructions that we followed are shown in Table 4. In GCL-1, any piece entering step 4 that could not be made into a 21-inch C2F piece was made into a 15-inch piece and Sem was not used. In GCL-2, any piece entering step 4 that could not be made into a C2F 21-inch piece was sent to the Sem room without being trimmed.

In the Sem room, scrap pieces were matched by width, grain (edge or flat), and color (light or dark). Each two matching piece set was then machined in the Sem router, the pieces were end-glued, and were then cut to a 25-inch length. The Sem machining and cutting to length were done so that the resulting 25-inch piece was of C2F quality. The Sem-joined 25-inch pieces were brought back to the rough mill at step 5 (Table 4) where they were ripped (glue joint edges) to the four allowable widths.

We ran half of the boards that did not meet No. 3A Common grade (below grade) using GCL-1. The C2F pieces were sorted by length, and the surface area of pieces per length was tallied. Then we ran half of the boards that met or exceeded No. 3A Common grade (No. 3A Common and Better) using GCL-1. Again, we sorted the C2F pieces by length and tallied the surface area per length.

The results are shown in Table 5. First, we combined the below grade and No. 3A Common and Better yields together to get the yield when all boards were used and presented the results in output per 1 Mbf of boards input. We also show the yields when 1 Mbf of the No. 3A Common and Better boards are used. Because the pieces are edge-glued to blank widths without loss of surface area, the piece surface area and the blank surface area are the same.

We ran the second half of the below-grade boards using GCL-2. We sorted by length and totaled the piece surface area. However, in the 25-inch piece lengths, we made two area measurements: those pieces with and without Sem joints. We then ran the second half of the No. 3A Common and Better boards using GCL-2. Again, we sorted by length and totaled the piece surface areas keeping the 25-inch with and without Sem pieces separated.

The GCL-2 yields based on output per 1 Mbf of boards input are shown in Table 5. We combined the yields from below-grade boards and No. 3A Common and Better boards when the 25-inch Sem-joint pieces were added to the 25-inch pieces without Sem. We used the yields from the No. 3A Common and Better boards when all the 25-inch pieces, with and without Sem, were added. We then computed these two totals without the 25-inch Sem-joint pieces, which enabled us to detect the effect of Sem on blank yield.

Production Control

In the System 6 plant, the input cants are made to System 6 boards and the boards are dried. The plant operators need a way to determine, in advance, the minimum board footage that must be rough milled using each GCL to obtain the required blanks.

System 6 secondary processing is designed to run without interruption until all the boards to be cut by the given GCL have been used. Then, the next GCL is set up and all the boards to be used are processed without stopping. The operators are not concerned with the quantities of blanks needed per length. When all the GCL's have been used and all the boards have been cut, all of the blanks needed will have been made. But not all blanks made will be the correct length. There will always be too many blanks in the longer lengths. It is a function of the production control technique to provide instructions on trimming the excess longer blanks to the required shorter blanks.

Table 4.—Rough-mill instructions

Step	GCL-1	GCL-2
1. Rough planing	Plane first side at 1.050″; second side at 1.000″	
2. Gang crosscut	36 and 36	29, 21, 25 (as remainder)
3. Gang ripsaw	1½, 2, 2½, 3, 3½	1½, 2, 2½, 3, 3½
4. Remove defect and trim to length	33, 29, 25, 21, 15	29, 25, 21, scrap to Sem
5. Salvage rip (if required) Sem jointing	1½, 2, 2½, 3 Not used	1½, 2, 2½, 3 25″ pieces only
6. Edge gluing	33 × 26, 29 × 26, 25 × 26, 21 × 26, 15 × 26	29 × 26, 25 × 26, 21 × 26, with 25″ Sem-joined and full-length pieces alternated
7. Surfacing	Abrasive plane both sides to 0.875″ (7/8) thickness	

Table 5.—Blank outputs per board quality input and by GCL (values in square feet of blanks surface area output per 1,000 board feet of boards input)

Board quality	Blank length					Total blank output
	33	29	25	21	15	
	Inches					
	GCL-1					
All boards	120	36	56	65	67	344
No. 3A Common and Better only	247	49	75	48	43	462
	GCL-2 (includes 25″ Sem pieces)					
All boards		84	92	204		380
No. 3A Common and Better only		168	89	284		541
	GCL-2 (without Sem)					
All boards		84	37	204		325
No. 3A Common and Better only		168	34	284		486

Table 6.—Minimum System 6 board footage input for GCL-1 and 2 to obtain the required blanks by board quality GCL and Sem use

Option	Board quality	Sem use	System 6 board input: GCL-1	GCL-2	Total	Blank output	Yield
				fbm		*Square feet*	*Percent*
1	All	Yes	528	620	1,148	402	35.0
2	All	No	1,276	126	1,403	402	28.7
3	No. 3A Common and Better	Yes	816	133	949	402	42.4
4	No. 3A Common and Better	No	818	145	963	402	41.7

We have two techniques to optimize the production of blanks. One makes use of linear programing (LP) in the computer program S60PT, and the other is a manual technique. Both are available from the authors. The manual technique is time consuming but not difficult. The LP model runs very rapidly and requires that the computer be capable of using a 15 by 50 matrix. The solutions in this paper were determined using the manual technique, but the LP model will give the same results.

We tested four combinations (we call them options) of GCL's and Sem to determine how many System 6 boards must be used to make the blank requirements shown in Table 3. The yield data per GCL are taken from Table 5. The four options are:

1. Use all boards with GCL-1 and GCL-2 using Sem.
2. Use all boards with GCL-1 and GCL-2 without Sem.
3. Use No. 3A Common and Better boards only with GCL-1 and GCL-2 using Sem.
4. Use No. 3A Common and Better boards only with GCL-1 and GCL-2 without Sem.

The results of the production optimization are shown in Table 6.

Options 3 and 4 use only the No. 3A Common and Better boards to make the required C2F blanks. The low-grade red oak cants used in our study had approximately 40 percent of all board footage in this grade classification. We consider that the 60 percent below No. 3A Common grade boards will be made into lower quality blanks. A discussion of this dual quality production of blanks is given in the economics section.

In the first option, roughly half of the System 6 boards were cut up using each GCL (46 percent GCL-1; 54 percent GCL-2). Almost all of the blanks were used without trimming (92 percent). The remaining blank requirements were made by trimming long blanks to shorter blanks. An 11-percent trim loss occurred but this was not serious as only a few blanks had to be trimmed. There was also 1 square foot of 21-inch blank surface area remaining.

When Sem was not used (the second option), the yield changed drastically. It was best to run almost all the boards using GCL-1 (91 percent). Only 59 percent of the blanks were used without trimming and those trimmed had an 18-percent waste. In addition, there were 50 square feet of 15-inch blanks remaining.

When only the No. 3A Common and Better boards were used, the use of Sem did not increase the yield much. In both options 3 and 4, most of the board footage (85 percent) was cut using GCL-1. However, only half (56 percent) was used without trimming, and the other half of the blank requirements was trimmed from longer blanks with a 24-percent trim loss. However, no extra blanks were made.

Options 1 and 2 apply when only C2F blanks are made because all boards will be used. Option 1 is superior to option 2 because of a higher yield and because so little blank trimming must be done. But, if only the better boards are used to make C2F blanks, option 4 is better than option 3 because Sem is not required. The economic viability of options 1 and 4 follows.

Economics

Will a new System 6 plant be profitable making the required C2F blanks using either options 1 or 4? We will make an economic analysis to determine the effects of cant input costs, manufacturing costs, C2F blank price, and working capital as compared to the plant investment. We use a cash flow analysis (CFA) program originally written by Harpole (1978) and adapted by Hansen for System 6 use.

To use the CFA program, the costs to produce blanks must be divided into fixed and variable costs. The revenues from the sales of blanks must also be calculated. The capital investment is divided into working capital, land, machinery, and buildings. The internal rate of return (IRR) is then determined.

Option 1

We analyzed option 1, which uses all the boards, GCL-1 and GCL-2, and Sem. The yield of required blanks was 35.0 percent of the System 6 board-footage input (Table 6). The System 6 plant has a 16.0 Mbf per shift input capacity. The blank output will be 5,600 square feet of blanks per shift.

We will set the C2F blank selling price at $1.95 per square foot, based on industry values in August 1982. If the System 6 plant runs a single shift of 240 days per year, the annual blank production will be 1,344,000 square feet worth $2,620,000.

We found that 1 Mbf of cants produced 960 board feet of System 6 boards, a 4-percent underrun. Therefore, the dimension company will have to purchase 16.6 Mbf of cants to produce 16.0 Mbf of boards per shift. The primary processing mill has the ability to handle this additional 4-percent cant footage.

The additional variable and fixed costs are shown in Table 7. The primary processing end of the plant has a 10-man, 1-foreman crew. Secondary processing has a foreman and 16 men plus 2 men for Sem, 5 men for full-time kiln operation, and 9 men for making the C2F pieces to planed blanks. Five men are required for full-time boiler and wood-fuel operation. The supplies, utilities, and so on are estimated using other CFA's for reference.

Working capital was estimated from cant costs (30-work-day supply)

Table 7.—Annual operating costs and revenues: C2F blanks from all boards (option 1)

Item	Year 1[a]	Year 2–10
Costs: Variable		
Cants $180/Mbf × 16.6 Mbf/shift × 240 shifts/year	$ 358,500	$ 717,000
Labor 47 men @ $6/hour plus 2 men @ $10/hour	453,000	604,000
Supplies	23,000	39,000
Utilities	31,000	52,000
Selling expenses	65,500	131,000
Costs: Fixed		
Management and administrative	70,000	70,000
Insurance	45,000	45,000
Maintenance	48,000	80,000
Costs: Total	$1,094,000	$1,738,000 (66% of sales)
Revenues: C2F blanks 1,344,000 ft² × $1.95/ft²	$1,310,000	$2,620,000

[a] During the first year, only half the annual production will be made.

Capital investment:	Land	$ 100,000
	Working capital	298,000
	Machinery and buildings	1,700,000
	Total	$2,098,000

and from the 30-day waiting period between the time the blanks were shipped until payment was received. Depreciation was based upon the new Accelerated Cost Recovery System. Accordingly, machinery was depreciated over 5 years and buildings over 15 years. Land was not depreciated. The undepreciated value of the assets and working capital was added to the after-tax cash flow in year 10. A tax rate of 46 percent was used in all analyses.

The CFA for this System 6 plant making C2F blanks using all the boards cut up by GCL-1 and GCL-2 with Sem shows a 21.3-percent rate of return (after taxes). The total investment was $2.098 million.

Option 4

The second choice that we analyzed was option 4, which makes C2F blanks using GCL-1 and GCL-2 without Sem from only the No. 3A Common and Better boards. In option 4, the boards are separated as they are fed into the rough planer —step 1 in the rough mill. The No. 3A Common and Better boards (40 percent of all boards) are put through the planer, and the remainder (60 percent) set aside for later use. It requires only 96 shifts per year to make the C2F blanks, and 144 shifts per year to cut up the below grade boards.

In option 4, Sem is not used, so capital investment is reduced by $100,000 and two men are taken from the System 6 payroll. The total investment is $2.0 million. We divided the capital investment and annual operating costs into a per-shift basis. Costs and investment for making the C2F blanks are 96/240 (40 percent) of the annual totals. We made 640,000 square feet of C2F blanks (per year) at $1.95 per square foot. This revenue compared to the partial costs and investment has a 34.8-percent rate of return. We used the same CFA as that in option 1.

If we make frame blanks from the below-grade boards on the other 144 shifts per year, we will expect a lower rate of return. A 56.0 percent yield of frame blanks from white oak below-grade boards was found in a previous study (Reynolds and Araman 1983), and we can expect the same from the red oak below-grade boards used in this research. We could make 1,290,000 square feet of frame blanks per year at $1 per square foot. This revenue compared to the partial costs and investment had a 10.2-percent rate of return.

The CFA of the total $2.0 million investment and the total operating costs for a full 240 shift per year to produce 640,000 square feet of C2F blanks and 1,290,000 square feet of frame blanks showed a 20.9-percent rate of return.

Internal Use of Blanks

The dimension company may decide not to sell C2F blanks at $1.95 per square foot but instead use the blanks to make the kitchen cabinet parts themselves. Given the likelihood of this eventuality, we have prepared an accounting-based cost summary so that existing accounting cost information can be used to further evaluate the blanks opportunity. In keeping with convention, the accounting cost summaries do not include any allowance for the cost of land, selling expenses, or working capital. As a result, operating costs in Table 7 would be reduced to $1,607,000 annually. Dividing this cost by the 1,344,000 square feet results in a cost per square foot of $1.20. Building and equipment costs are expressed through 10-year, straight-line depreciation allowances amounting to $0.13 per square foot. Combining the operating and depreciation costs results in a total cost per square foot of blank of $1.33 (option 1).

In deriving the cost per square foot of making C2F blanks via the fourth option, we used the costs and investment charges associated with that 40 percent of production—96 shifts—yielding C2F blanks. The annual operating costs less selling expenses came to $0.99 per square foot. Depreciation allowances for building and equipment came to $0.10 per square foot for a total cost of $1.09 per square foot of C2F blanks.

Increased Rate of Return

We stated that a dimension manufacturer presently making parts may wish to use existing equipment, buildings, and so on to make the System 6 plant, and the CFA's that we used indicate the effects of such a practice. When all boards are used to make C2F blanks as described in option 1 and the capital investment is reduced by 20 percent, the rate of return will increase from 21.3 to 25.5 percent. If only the No. 3A Common and Better boards are used as described in option 4, reducing investment by 20 percent will increase the rate of return from 34.8 to 41.0 percent.

Recommendations

Small-diameter, low-grade hardwood utilization to make C2F quality blanks using System 6 can be profitable. For an initial $2 million investment in a completely new System 6 plant, the owners can expect at least a 21.3-percent return on their investment. If C2F and other quality blanks are made, the return on investment will be better. If a company presently making rough-dimension parts from lumber converts to System 6 and low-grade hardwoods, much of the present equipment and buildings can be used, thereby reducing capital investment and bringing the rates of return well into the range of 30 percent.

Before making C2F blanks for sale or for internal use:

- Determine the C2F standard blank requirements.
- Determine if other blanks will be required, and if so, what requirements per blank quality will be met.
- Determine the quality of the input cants by sampling possible material sources.
- Decide if the two GCL's and options 1 and 4 used in this study are adequate or if others should be devised and tested.
- Determine the size of the blank market and design the System 6 plant accordingly.
- Run CFA programs to test the economic feasibility of proposed operations before the System 6 plant is built.

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Reynolds, Hugh W.; Araman, Philip A.; Gatchell, Charles J.; Hansen, Bruce G. **System 6 used to make kitchen cabinet C2F blanks from small-diameter, low-grade red oak.** Res. Pap. NE-525. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1983. 11 p.

Hardwood dimension manufacturers can make profitable use of plentiful small-diameter, low-grade timber when System 6 technology is used. We describe a System 6 plant designed to make clear-two-face (C2F) blanks for the kitchen cabinet industry. Data for plant operation are taken from a study in which red oak bolts (from a reforestation clearcut) were used to make 33-, 29-, 25-, 21-, and 15-inch-long standard-size blanks. Sem jointing of short pieces was used to increase the quantity of 25-inch blanks. The economics of two options for plant operation is explained.

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