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Production of High Quality Wood from Hard Maple Bolts

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INTRODUCTION

Many people have been concerned about the continuing use of high quality wood in the pallet industry where lower quality wood is acceptable. Using such species as black cherry, hard maple, white ash, basswood and oak in absolutely clear lengths is an economic waste and unnecessary in even a quality pallet. With increasingly higher prices offered for the upper grades of these species, a definite effort should be made to redirect that portion of wood which qualifies for higher value use into furniture type areas.

The purpose of this study was to determine the quantity of material that can be redirected, find potential markets, and work out production methods that could be easily adopted by pallet plants without major changes or additions to their current equipment. This bulletin deals primarily with the latter phase of the study on production methods by actual demonstration.

A commercial pallet plant sawing short bolts on a bolter saw was converted for a 1 1/2-day trial to sawing furniture squares. For this demonstration, hard maple bolts in 48-in. and 72-in. lengths were used. The materials produced were primarily 2 1/4 in. x 2 1/4 in. furniture squares with minor quantities of pallet lumber being produced. This report covers the phase of selection, grading the bolts, sawing and determination of grade and recovery. Most of the squares were subsequently air dried to an average moisture content of about 15% and used for steam bending of chair back posts in a furniture plant. Pieces not sufficiently long and clear enough to produce the bent chair back posts were used for lathe turnings on other furniture products. Results of using materials from this production run will be reported in the future.

The authors realize that redirecting high value material used by many pallet manufacturers will require effort on the part of both the pallet manufacturer and the user of high value wood. However, on the basis of actual experience to date, under commercial conditions it has proven economically advantageous in several trial cases to both the pallet bolter-saw operator and the furniture dimension user. Without a strong economic incentive to both buyer and seller it is doubtful that the concept of "highest value usage" would be accepted. It is therefore important that every effort be made to search out the most profitable situations and work on those.

The original intent of the program was to selectively sort out clear high quality species after sawing by the pallet mill. It was quickly determined that most sizes (principally thickness) sawn for pallets were the wrong size for furniture users. The second possibility was to select the better bolts and saw them into material offering the highest recovery to the furniture plant. The quality product chosen, because of random lengths possible, was furniture squares. The work reported here is the result of that concept of bolt selection. Results show recovery of clear material is not 100%, and when furniture squares are sawed the material is not generally useful for pallet manufacturers. Therefore, a more promising concept of sawing cants is being studied and will be reported in the future.

PROCEDURE

Species Selection

Hard maple is an important industrial specialty wood. For a purpose requiring hardness, strength, wearing ability, and good finish, it is very desirable (4). This even-textured wood can be bleached and stained to look like cherry. It is suitable for bending and makes good turnings. The Hardwood Market Report (7) ranks hard maple second only to birch as one of the most valuable Northern Hardwoods. For these reasons, and Michigan's abundance of bolts, hard maple was selected for use in this study.

Mill Selection

The mill selected for study is located in the northwestern part of Michigan's Lower Peninsula. The primary product of this mill is a standard industrial flat pallet using both hardwoods and softwoods.

Stumpage and cordwood are purchased for the mill from privately owned woodlots in the area. Independent loggers fell and haul the raw material to the mill. Upon delivery, logs are unloaded with a tractor unit equipped with a front end hydraulic loader. They are bunched in a storage yard and then bucked into pallet length bolts.

There were several reasons for selecting this mill for study. Among the most important were the simplicity of the mill operation, availability of required species, and the expressed interest of the owner to participate in the study.

The simplicity of the mill was important in order to obtain an accurate tally from each individual bolt. Other plants were excluded because numerous resaws and rip saws resulted in the dispersion of material from one bolt to several different machines, which would greatly increase the difficulty of getting an accurate count from any one bolt.

This mill also had the required species in quantity and quality. Various production samples taken during the year showed as much as 34% maple, 12% beech, 8% basswood; the remaining species consisted of disproportionate units of pine, oak, ash, elm and cherry.

Other factors that should be considered in mill production studies are the following:

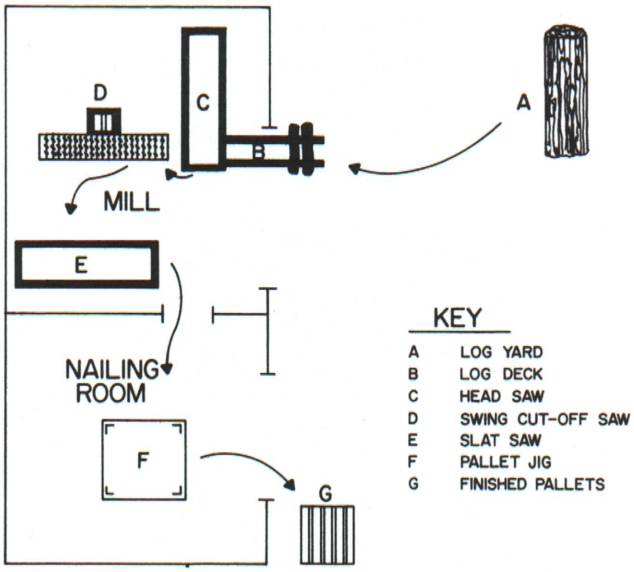
1. The log supply should be great enough to allow adequate time for diagramming the logs without slowing down the normal production of the mill.
2. The log deck or holding yard should be large enough to allow adequate diagramming space and time.
3. Logs should not be covered with mud that obscures defects on the end and bark surfaces nor should the bark be absent.

Mill Layout

This pallet mill is a garage-like structure approximately 20 ft. x 50 ft. with a poured concrete slab floor base. All equipment is secured to this base (Fig. 1). The mill contains three major pieces of equipment—a head-saw, a trim-saw, and a slat-saw. The head-saw, located perpendicular to the loading deck, is a 40-in. diameter—945 r.p.m. Brettrager bolter saw. Its primary function is to break the bolts down into cants 3 1/2 in. or 5 1/2 in. thick with random widths. For purpose of this report a cant is a large partially processed board. From the head-saw, cants are sent to a swing cut-off saw where they are trimmed to the required length. The cut-to-length cants are then carried over to a Brettrager slat saw equipped with a 36-in. diameter saw blade running at 1,050 r.p.m. At this point they are sliced either into pallet deck boards or runner stock. The cut stock is then carried to the nailing room and nailed into flat pallets with pressurized air-nail guns.

At full capacity, this mill is capable of producing 3.4 thousand board feet of pallet cut stock each 8-hour shift. It requires a minimum of five people to operate the mill with an additional supervisor to control log supplies and perform other managerial duties.

FIGURE I. FLOOR PLAN OF PALLET MILL USED IN THIS STUDY



Data Collection

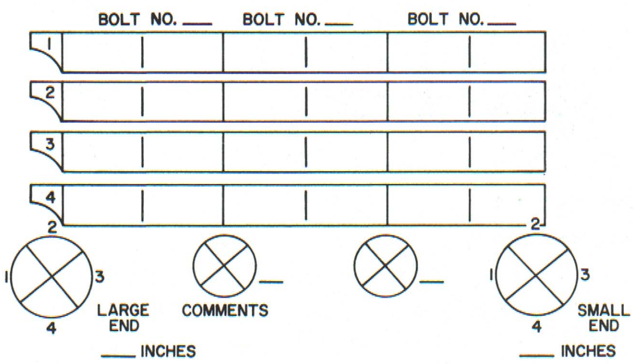
For this study 3.2 thousand board feet International 1/4 Inch Rule, 12 ft. hard maple logs were selected. Each log was bucked into 48-in. or 72-in. length bolts, then scaled, diagrammed and graded (Table 1). Net bolt scale was obtained by subtracting the amount of defective material from the gross scale. Defective material includes bolts with decay, wind shake, crook and twist.

Table 1. Distribution of 167 sugar maple bolts by diameter class, bolt length, and number of clear faces

Diameter Class	Bolt Length and Number of Clear Faces										
	4 Ft.					6 Ft.					
(Inches)	0	1	2	3	4	0	1	2	3	4	Total
6											0
7											0
8								1			1
9					2	1		1	1	1	6
10			2	5	1	1	2	4	4		19
11		3	4	5	9		3	2	4	1	31
12		1	3	9	13	1	2	3	2	2	36
13		5	3	3	18			2	2	1	34
14	1		1	4	7	1					14
15	1			3	4				1	1	10
16				2	4						6
17		1	1	2	3						7
18			1								1
19					2						2
Total	2	10	15	33	63	4	7	13	14	6	167

Each bolt was diagramed using standard Forest Service forms (8) (Fig. 2). Bolts were theoretically quartered, each quarter representing a face, and defects were recorded on the diagram forms using appropriate defect symbols. Visible end defects were also inspected and recorded. Each bolt was then numbered at the ends so recovery data could be collected from individual bolts.

FIGURE 2. HARD MAPLE BOLT STUDY



Sawing around was the pattern used in this study. The first cut was made to remove a slab from the face containing most defects. After its removal, the bolt was turned down 90° relative to the saw so the defective side faced the table. The bolt was then alligned parallel to the fence and another slab removed to expose a 3-4 in. face. Sawing parallel to the bark maximizes the yield of straight-grained stock, which is an important criterion for furniture dimension. Subsequently 2 1/4 in. cants were removed consecutively until an apparent grade loss occurred. At this time the bolt was turned another 90° and the remainder of the bolt was cut into cants.

Each cant removed from the bolt was carried to the slat saw where it was ripped into squares. The squares were recorded by number and generally graded according to the grading standards established by the National Hardwood Dimension Manufacturers Association (3). Squares were self-stickered and banded for transportation. Self-stickering squares facilitates air drying and is thought to reduce possible blue stain degrade.

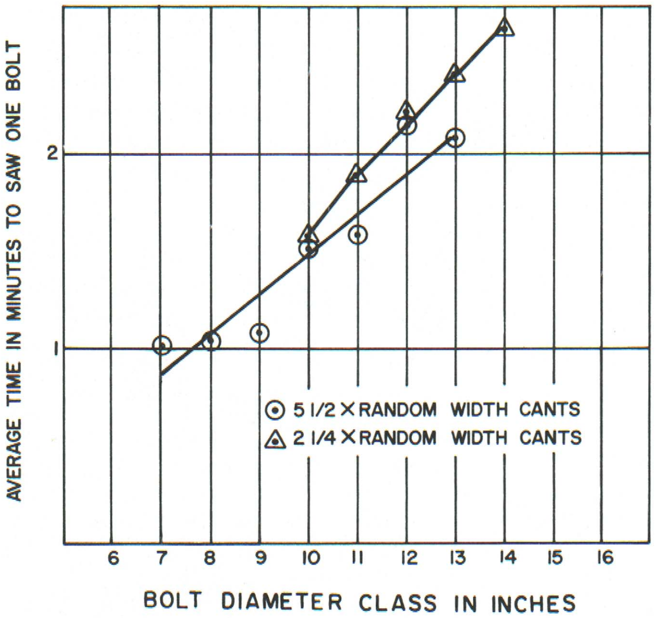
RESULTS AND ANALYSIS

Sawing Time for Bolt Breakdown

During this study, bolt conversion time was recorded whenever possible. Measured were the minutes required to convert a bolt into cants either 2 1/4 in. or 5 1/2 in. thick with random widths. The 2 1/4 in. cants were cut from both 4 ft. and 6 ft. bolts. Variations in sawing time were observed in each diameter class due to sawing different grade bolts. One reason for this was that the sawyer turned the bolt 90° when there was an apparent loss in grade. Thus bolts in lower grade classes required more turning than clear bolts.

Sawing time increased as a linear function of bolt diameter up to 14 in. diameter bolts. Bolts 15 in. - 20 in. in diameter exceeded the bolter saw capacity and required additional sawing time for slab removal. Data for sawing time versus diameter class are given separately (6) for sawing 2 1/4 in. cants from 4 ft. bolts, for sawing 5 1/2 in. cants from 4 ft. bolts and for sawing 2 1/4 in. cants from 6 ft. bolts. Figure 3 shows average time required to convert one bolt to cants versus the bolt diameter class in inches, irrespective of bolt grade.

FIGURE 3. AVERAGE TIME REQUIRED TO SAW 2 1/4 INCH THICK CANTS AND 5 1/2 INCH THICK CANTS FROM 4 FOOT BOLTS AS A FUNCTION OF BOLT DIAMETER

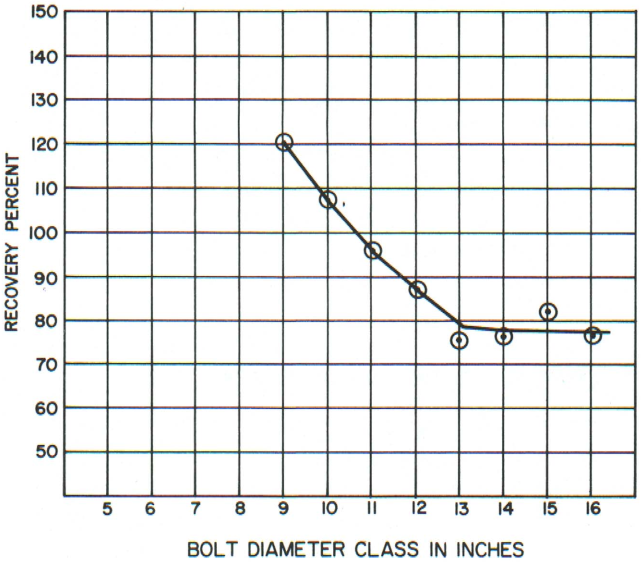


Percent Lumber Recovery

Recovery data was obtained directly from the mill tally record sheets. Squares from individual bolts were counted without regard to grade, and their actual board footage was calculated. Percent recovery equals actual board footage in the squares divided by the volume of wood in the bolts as measured by the International 1/4 Inch Log Rule (half the value for an eight foot log was used from the log rule table). Table 2 contains percent recovery for 2 1/4 in. squares cut from 4 ft. bolts.

The percent recovery data for 2 1/4 in. squares from 4 ft. bolts was plotted against bolt diameter for bolts 9 - 16 in. in diameter (Fig. 4). As bolt diameter increased, total yield decreased when measured as a percentage of the predicted yield. At least in part, this decrease in apparent percentage yield is attributable to the construction of the International 1/4 Inch Log Rule Scale.

FIGURE 4. PERCENT RECOVERY OF 2 1/4" by 2 1/4" SQUARES FROM 4 FOOT BOLTS BASED ON PREDICTED YIELD (Int. 1/4 Inch LOG Rule) VERSUS BOLT DIAMETER



For bolt diameters from 13 through 16 in., recovery leveled off at approximately 78%. The average percent recovery for logs in this study was 86%. The waste occurred in the outside slabs, sawdust, and on a wedge-shaped center containing the pith.

Table 2. **Recovery of 2 1/4 in. squares from 4 ft. sugar maple bolts**

1	2	3	4	5
Diameter Class Inches	**Avg. Predicted Volume[a]**	**Avg. Actual Mill Tally Board Ft.**	**% Recovery Col. 3÷Col. 2**	**Avg. Number of 2 1/4" Squares Per Log**
9	10	12	120%	5
10	15	16	107%	7
11	18	17	99%	9
12	23	20	87%	10
13	28	21	75%	11
14	33	25	76%	13
15	38	31	82%	17
16	43	33	77%	17
17	48	34	71%	18
Mean			86%	

[a]By International 1/4 Inch Log Rule (half of 8 ft. log scale) board feet.

Similar results regarding yield were obtained by Redman and Willard (9), Johnson (5), Bell and Calvert (1). Redman and Willard also investigated yield of usable furniture dimension cut from logs 26, 35, 43, 51, and 72 in. long. They found bolt length had no effect upon yield of number of squares per bolt. However, the longer bolts yielded fewer squares that were clear for their entire length.

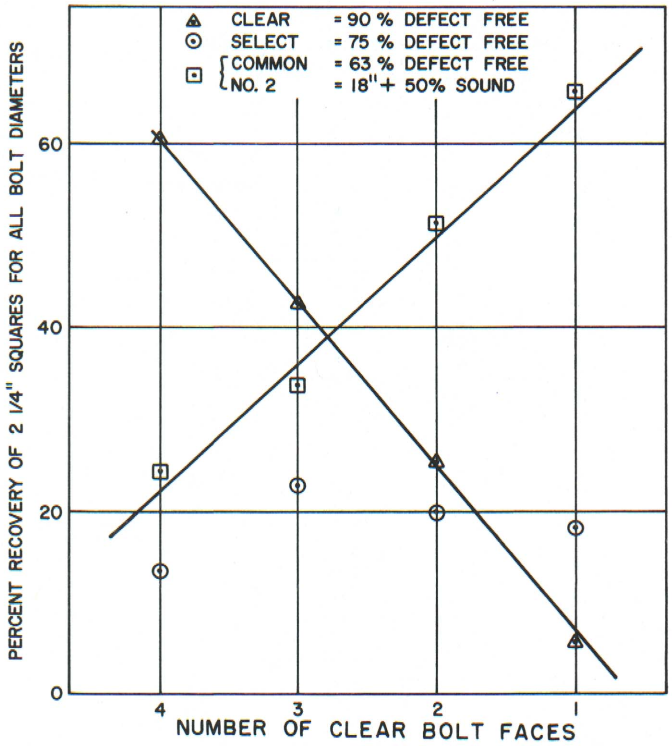
Grade Recovery from Bolts

Lumber grade recovery of 2 1/4 in. squares was analyzed as a function of clear quarter faces for the bolts (Fig. 2). Bolts with four clear faces averaged 60% clear squares while those with three clear faces averaged 43% clear material (Table 3). Although there was no apparent increase in yield of clear squares with bolt diameter for the highest grade bolts, bolts with three clear faces averaged 44% clear squares in diameters from 11 to 13 in. and averaged 54% clear squares in diameters from 15 to 17 in. (6). More of the select grade was observed for bolts with zero, one, two, or three clear faces than for those with four clear faces. Percent grade recovery as a function of the number of clear bolt faces is graphed in Figure 5.

Table 3. Grade Recovery of 2 1/4 in. by 2 1/4 in. squares by number of clear faces

Number of Clear Faces	Number of Observations	Percent Square Yield by Dimension Grade: Clear	Select	Common	No. 2	No. 3
4	64	60.27	13.53	6.45	17.81	1.95
3	44	42.83	21.64	10.38	23.18	1.97
2	36	25.16	19.76	12.58	38.76	3.74
1	5	7.14	18.41	20.32	47.38	6.75
0	2		22.62	36.91	23.81	16.67

FIGURE 5. PERCENT DIMENSION GRADE RECOVERY OF 2 1/4 INCH SQUARES BY NUMBER OF CLEAR FACES FOR ALL BOLT DIAMETERS



Overgrown knots, seams, and heavy bark distortions had a serious degrading influence on bolts up to 14 in. Bolts 14 in. and larger were able to grow enough wood over the defects so it was possible to produce some clear and select squares before defects appeared on the bolt's exposed surface.

The large number of common and No. 2 squares is a result of mineral stain and decay found in hard maple. Unsound knots, overgrown knots, and large bumps seemed to contain a large amount of decay which caused staining in the longitudinal direction. This stain is undesirable for exposed solids and turnings, causing a reduction in grade, usually to No. 2 or common.

Bolt Grades

A good bolt grading system would greatly simplify sorting of bolts for squares from those for pallet stock. However, there is no generally acceptable bolt grading system in use. Not until the late fifties did the Forest Service publish methods for developing bolt grades (10). One problem area is the limited research in the science of defect indicators. Differing end product requirements also make the assigning of a grading system difficult.

A bolt grading system which was examined in this study was the Pennsylvania-Bolt Grade System developed by the U.S. Forest Service in the Northeast (2). This describes bolt quality in terms of bolt diameter and the number of clear or defect-free quarter faces.

There are three grades in the "Pennsylvania Bolt Grade System." The grades are described in Table 4. Scale is to be based on the 1/4 Inch Log Rule in accordance with U.S. Forest Service scaling practices.

Table 4. Pennsylvania method-boltwood grades

Grading Factor	Bolt Grades							
	1			2			3	
Position	Butt Only	Upper Only		Butt Only	Upper Only		Butts-Uppers	
Scaling Diameter	12+	12-13	14+	10+	10-13	14+	8-13	14+
Clear Faces	3	4	3	2	3	2	1	1 or 50% clear on 3 best faces
Stain Diameter	1/4 Diam.			1/3 Diam.				
Maximu Sweep or Crook (%)	10			15				
Maximum Rot (%)	10			10				
Maximum Total Deduction (%)	15			25			50	

An analysis was made of the percentage of clear material in the squares derived when the bolts were segregated by Pennsylvania Bolt Grades. Clear square material in this case is defined as the sum of the length of defect-free material in the squares with 18 in. the minimum continuous length considered. Increments of measurements on the squares were made in steps of 2 in.: 18 in., 20 in., 22 in., etc. Squares cut from grade 1 bolts were 81% clear, those from grade 2 bolts were 77% clear, and those from grade 3 bolts were 67% clear. Not only are yields smaller for the lower grade bolts, but also the amount of clear material in the square is less.

Prediction of Dimension Grade Recovery

The pallet manufacturer or other short bolt user can predict the yield of 2 1/4 in. graded squares obtainable from hard maple bolts when the bolt diameters and number of clear faces are known. For example, 48 in. bolts in the 14 in. diameter class would average 33 board feet by the International 1/4 Inch Log Rule according to Table 2. They would produce on the average 24 board feet of cants and/or 13 furniture squares 2 1/4 x 2 1/4 x 48 in. long. From Table 3, 14 in. diameter bolts with four clear faces would yield an average of approximately 60% clear squares, 13.5% squares equivalent to a "select" hardwood dimension grade, 6% equivalent to a common dimension grade, 18% equivalent to a No. 2 dimension grade and 2% equivalent to a No. 3 grade. The No. 3 is a modification grade which allows sound cuttings.

CONCLUSIONS AND RECOMMENDATIONS

The investigation on hard maple bolts procured for pallet manufacture in Michigan indicated the following:

1. Grade yield from 4 ft. and 6 ft. bolts can be determined from the number of clear quarter faces on the bolts.
    a) Defect indicators on bolts include adventitious bud clusters, sound and unsound knots, limbs, seams, bird pecks and flutes. Many of these defects occur as bark distortions, decreasing in severity as bolt diameter increases. End defects on bolts, such as wind shake, grub holes, double pith, decay and mineral stain will also reduce lumber dimension grade.
    b) The more clear faces (ones without defect indicators) the higher the grade yield. Bolts with four clear faces had a cumulative total of 73% clear and select squares. Those with three and two clear faces had 65% and 45% respectively. Clear and select squares are more valuable than common and No. 2 grades. They require less machining per thousand board feet and less waste

is involved in their use at the furniture plant. The value per thousand, for a load of squares, depends on the number of clear and select squares. If common and No. 2 squares increase, the value per thousand will decrease. It is the user's responsibility to specify the percentage of clear and select squares required in a load of furniture dimension. Once an agreement has been made, the producer can select those bolts which will yield the required furniture dimension grade, by using information in Tables 2 and 3.

c) Bolt diameter also influences grade yield. Larger diameter bolts will have more clear material than the smaller diameter bolts with the same number of clear faces.

d) To segregate bolts into the highest product value groups, it is necessary to consider both diameter and the number of clear faces. These two variables influence furniture dimension grades obtainable from any one bolt.

e) The Pennsylvania-Bolt System incorporates diameter and the number of clear faces into a three grade system. Each grade in the system represents bolts with similar characteristics and value per thousand.

2. The volume yield of 2 1/4 in. squares can be predicted from bolt diameter.

   a) The International 1/4 Inch Log Rule underestimates yields for bolts under 10 in. in diameter. Actual yield compared to estimated yield decreases with an increase in bolt diameter.

3. The volume yield of pallet dimension can also be predicted as a function of bolt diameter.

4. Converting bolts into squares or pallet dimension takes approximately the same amount of sawing time. Initially, a new sawing technique will require more time until operators become familiar with the new method.

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