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Forest Products Laboratory

General Technical Report FPL-GTR-65

PLYMAP
A Computer Simulation Model of the Rotary Peeled Softwood Plywood Manufacturing Process

Henry Spelter

—COSTS—

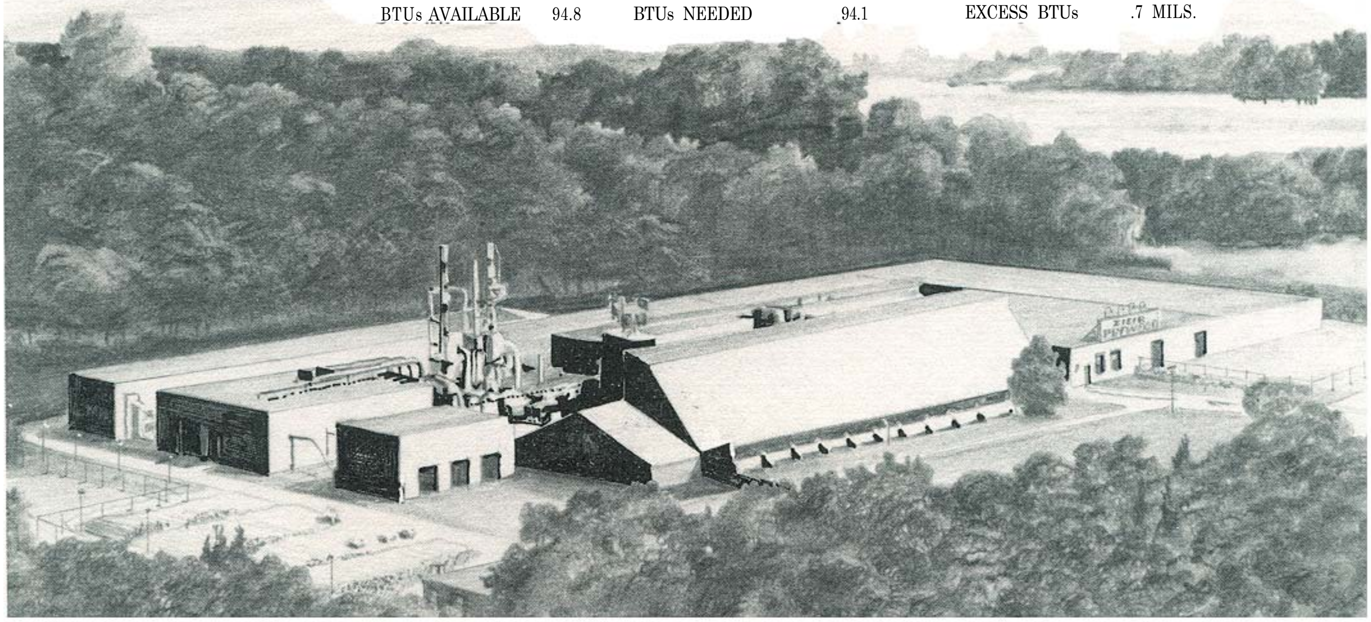
EMPLOYEE HOURS	104.0	HRS/HR	WAGES	14.50	$/HR	PER MSF (3/8)	51.05
DIESEL USAGE	30.1	G/HR	COST	1.25	$/GAL	' '	1.15
PROPANE USAGE	10.4	G/HR	COST	.75	$/GAL	' '	.24
ELECTRICITY	2943.0	KWH	COST	.05	$/KWH	' '	4.51
NATURAL GAS	.0	THERMS	COST	.85	$/THRM	' '	.00
WOOD	19.7	CUNITS	COST	99.02	$/CUNIT	' '	59.90
GLUE	2097.6	LBS	COST	14.34	$/100LB	' '	9.23

--REVENUES--

PLYWOOD, GRADE	30.8	MSF/HR	PRICE	350.00	$/MSF	REV/MSF PAN	165.11
PLYWOOD, MILL CERT	1.2	MSF/HR	PRICE	275.00	$/MSF	REV/MSF PAN	5.02
PLYWOOD, BLOWS	.7	MSF/HR	PRICE	70.00	$/MSF	REV/MSF PAN	.70
B VENEER, 3/8	.2	MSF/HR	PRICE	55.00	$/MSF	REV/MSF PAN	.00
TARGET CORES	411.6	NUM/HR	PRICE	.70	$/CORE	REV/MSF PAN	8.89
CHIPS	2.7	TONS	PRICE	41.00	$/TON	REV/MSF PAN	3.42

-MARGINS-

NET COSTS/MSF	139.2 $	REVENUES/MSF	170.8 $	MARGIN/MSF	31.6 $
SF/CFT RECOVERY	16.0	PRODUCTION/YR	55.7 MMSF	MARGIN/YR	1.76 $MIL.
BTUs AVAILABLE	94.8	BTUs NEEDED	94.1	EXCESS BTUs	.7 MILS.



Abstract

This report documents a simulation model of the plywood manufacturing process. Its purpose is to enable a user to make quick estimates of the economic impact of a particular process change within a mill. The program was designed to simulate the processing of plywood within a relatively simplified mill design. Within that limitation, however, it allows a wide range of options to be incorporated so as to customize the program to a variety of situations.

The program should not be confused with a linear program-based optimization model. This program does not seek an optimum solution from a range of alternatives, but only makes calculations based upon user-entered assumptions.

Keywords: Process simulation, modeling, plywood

March 1990

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A Computer Simulation Model of the Rotary Peeled Softwood Plywood Manufacturing Process

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Introduction

The production of plywood panels from wood involves fairly complex industrial processes. Plywood mill designs, however, follow a generally similar pattern and usually include the following: a log debarking and bucking area; block conditioning; peeling/clipping/veneer stacking (the green end); drying and dry veneer sorting and stacking; veneer upgrading involving defect plugging and edge gluing; a panel layup area; pressing; and panel finishing. Koch (1972), Baldwin (1981), Lutz (1974), and Sellers (1985) further describe these processes.

Because the production process is complex, changes in log type or size, output mix, and equipment can have far-reaching effects on the utilization of resources within a mill and also on its economics. The PLYMAP computer program was developed to readily calculate the effects of such changes. This report describes the model and provides instructions for its use.

During a run, the program prompts users to specify the amount of wood that is to be peeled and other processing and economic parameters that define the physical and economic environment of a mill. Given these parameters, the program calculates machine center utilization rates in terms of number of shifts required. Users can then adjust the wood input volume and other process assumptions to achieve a realistic materials flow balance. Once the final parameters are set, the program calculates input costs and output values, and translates these into a profit and loss statement for the mill. This enables users to analyze alternatives and compare proposed changes before implementing them. Such a capability can be useful in evaluating new equipment purchases, planning mill design modifications, and understanding the physical and economic impacts of new technology.

Scope of Model

The PLYMAP computer model is a detailed representation of the rotary peeled softwood plywood manufacturing process. A general diagram of the process is shown in Figure 1. The model itself follows this general outline but is limited in scope in some important respects. Three key limitations are (1) only one veneer thickness can be specified per run; (2) purchases of outside veneer are not modeled; and (3) only one grade and thickness of panel can be laid up per run. These limitations simplify the use of the model without unduly detracting from its primary purpose, which is to estimate the potential economic effects of a processing change.

The various process steps shown in Figure 1 and model calculations are described in Section A. In Section B, procedures to run the model are outlined and illustrated.

Section A-Data Requirements and Model Equations

Log Handling and Storage

General

Douglas Fir and Southern Pine are the two most widely used species groups in North American rotary peeled plywood mills. Increasingly, they are being augmented by White Woods such as white fir and white spruce, other softwoods such as Hemlock and ponderosa pine, and softer hardwoods such as Yellow Poplar and Red Alder. Each species has different physical properties, which affect their processing. The PLYMAP model contains the physical properties of four species or groups: Douglas Fir, Southern Pine, white fir, and ponderosa pine. Table 1 lists their properties. To simulate the processing of another species, one of the four whose properties come closest must be used.

Required Inputs

The data required for this part of the program include the species, log diameter classes (up to five), and number of loaders. The cost of natural gas is included here for computing convenience. The parameters, each identified by a character string are as follows:

NSPECIE	Species (Douglas Fir, white fir, ponderosa pine, or Southern Pine)
NUMDIAM	Number of diameter classes (1, 2, 3, 4, or 5)
DIAM(I)	Diameter of the ith diameter class
PCTW(I)	Percentage of logs in diameter class i (total must add up to 100)
DLOADER	Number of logyard loaders (default is 2)
HP	Average horsepower of logyard loaders (default is 200)
DIESEL	Cost of diesel fuel ($/gal, default is $1.25)
THERMS	Cost of natural gas ($/therm, default is $0.65)

Calculations

Hourly diesel consumption by the loaders is calculated based upon manufacturers' data regarding diesel consumption (DIESCONS) by horsepower for a medium level of use intensity:

DIESCONS = 2.222 + 0.00167*HP + 0.000105*HP**2

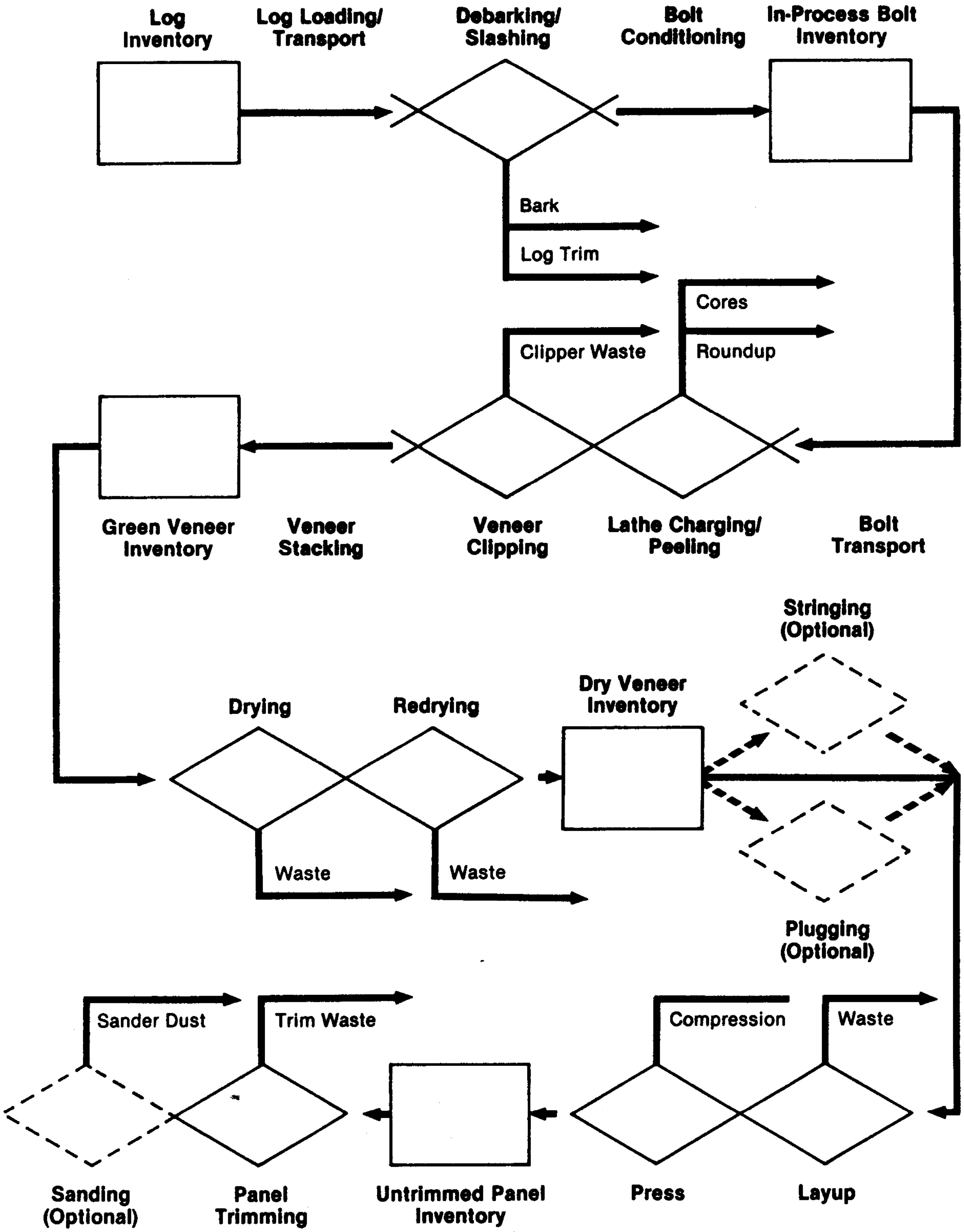

Figure I-Diagram of rotary peeled plywood manufacturing process.

Table 1 – Physical properties of timber species contained in PLYMAP

Species	Specific gravity	Moisture content (percent) Sap-wood	Heart-wood	Sapwood width (in.)	Shrinkage (percent) Radial (thickness)	Tangential (width)	Heating value ($x10^3$ Btu/OD lb)[a] Wood	Bark
Douglas Fir	0.45	115	37	1.875	4.8	7.6	9.0	9.9
White fir	0.37	160	98	1.875	3.3	7.0	8.1	8.9
Ponderosa pine	0.38	148	40	6.0	3.9	6.2	9.1	9.5
Southern Pine	0.50	113	32	6.0	4.6	7.4	10.4	9.3

[a]OD, ovendry.

Log Debarking

General

Logs are debarked to assure clean wood residues suitable for pulping and to reduce wear on knives. Ring-type debarkers are normal. Debarker productivity depends on the speed at which logs are fed and on log spacing. Overall system efficiency rates (lineal feet of logs processed per unit of feed rate) range from 80 percent for pulpwood size logs to 40 percent for large diameter logs (Koch 1972). The specification of the number of logs processed per hour determines the supply of wood to the other downstream process centers in the rest of the mill.

Required Inputs

BLPHR Number of long logs processed per hour (default is 50)
STLNGTH Average length of long logs (default is 34.8 ft)
DEBFPM Effective debarker feed rate in feet per minute (default is 50 ft/min)

The term "effective debarker feed rate" indicates that the user should adjust the speed at which a stem is processed by unused debarker time due to gaps between logs and other operational interruptions.

Calculations

The number of debarkers required to handle the volume of wood is calculated. For the purpose of calculating annual output and profits, the unit of measure in this and all other machine utilization calculations is one shift per day. Hence, a calculated machine utilization rate of 3 is equivalent to one machine operated three shifts per day, 6 is two machines operated three shifts per day and so on. Since labor costs are based on machine utilization, it is important to calibrate machine utilization rates to realistic levels (i.e., close to some multiple of 1) because the program does not automatically do this.

DBUTIL = (BLPHR*STLNGTH)/(60*DEBFPM)

The weight of green bark generated (BARKPH) is calculated based on the following formula developed for Southern Pine (Row and others 1965) (Douglas Fir and white fir bark volumes are assumed to be 10 percent higher):

BARKPH = (0.0639*DIAM(I) + 0.0176*DIAM(I)**2)*BLPHR*STLNGTH

Average large end diameter of the first 8-ft bolt from the log of the ith diameter class,

LDIAM(I) = (1.117-0.0027*DIAM(I) + 0.19/DIAM(I))*DIAM(I)

Debarker hourly throughput (DEBFPH),

DEBFPH = DEBFPM*60

Log Bucking

General

Tree-length logs are cut into peelable blocks by circular cutoff saws normally positioned after the debarker on the log deck. These may consist of large individual saws, double saws that make two cuts in one pass, or a bank of saws on a slasher deck into which logs are fed. Capacity varies with saw type.

Required Inputs

BLENGTH Average length of bucked blocks (default is 8.6 ft)
SLASHFPM Slasher saw throughput (default is same as debarker, 50 ft/min)

Calculations

Calculations in this part of the program are as follows:

Slasher throughput per hour (FPHSLASH) (hourly slasher capacity (SLASHFPM) times the number of shifts); number of shifts per day (SLUTIL) is initialized to one:

FPHSLASH = SLASHFPM*60*SLUTIL

Log stems per hour (STEMPH) (lineal feet of logs per hour/length per long log):

STEMPH = FPHSLASH/STLNGTH

Number of blocks per stem (BLKSPSTM) (rounded off to the next lower unit):

BLKSPSTM = STLNGTH/BLENGTH

Lineal feet of trim (TRIMOFF) (trim per log times number of logs):

TRIMOFF = (STLNGTH-BLKSPSTM*BLENGTH)*STEMPH

Average diameter (ADIAM) of blocks entering vats:

ADIAM(I) = (DIAM(I) + LDIAM(I))/2

Cubic feet of trim (TRIMCF), based on the average of short and long end diameters:

TRIMCF(I)=3.142*ADIAM(I)**2*TRIMOFF/(144*4)

Slasher utilization (SLUTIL) (volume in divided by volume out):

SLUTIL = DEBFPH/FPHSLASH

Calculations begin with SLUTIL initialized to 1, then are repeated after actual requirement has been determined.

Lineal feet of block output from slasher (OUTSLASH) (volume in less trim waste):

OUTSLASH = FPHSLASH-TRIMOFF

Log Conditioning

General

Almost all Southern and most Western plywood mills heat blocks prior to peeling. Heat conditioning reduces depth of lathe checks, which improves veneer tightness and resistance to rough handling. Knots are also softened, reducing knife wear. On the other hand, if relative humidity is low, steam heating can dry out ends, causing heartcheck. Blocks not uniformly conditioned (i.e., hot, soft ends with cold, hard centers) are also more prone to spinout.

Some Western mills in areas with mild climates peel blocks cold, but may have to pay a price in increased veneer loss due to splitting. Higher nosebar pressures, which are sometimes used to improve veneer tightness, can compress the veneer, making it necessary to target a thicker peel. High nosebar pressures may also contribute to spinout.

Blocks are conditioned in steam chests or in water-filled vats. Generally, blocks submerged in water heat up faster and more consistently than do blocks steamed in chests. Most Southern mills use water-filled vats while most Western mills use drive-in steam chests.

Required Inputs

SDEVHMC	Standard deviation of moisture content (MC) in heart veneer (default is 5 percent)
SDEVSMC	Standard deviation of MC in sap veneer (default is 18 percent)
STEAM	Temperature of heating medium (default is 175°F)
TEMPFI	Target temperature at 4-in. core (default is 125°F)
TEMPIN	Temperature of wood entering vats (default is 45°F)

VATL	Vat length (default is 80 ft)
VATH	Vat height (default is 16 ft)
CLOADER	Number of loaders used to move blocks in and out of vats (2)
HPC	Average horsepower of vat loaders (default is 200)

Calculations

Lineal feet capacity of a vat (VATCAP) (assuming 75 percent loading efficiency):

$$VATCAP = (12*VATL/ADIAM)*(12*VATH/ADIAM)*BLENGTH*0.75$$

Vat loading time (VATLOAD) (hours):

$$VATLOAD = VATCAP/OUTSLASH$$

The basic pattern of warming at any point within a log takes the form of an S-shaped curve over time. This can be represented by the following equation derived from the Weibull distribution function:

$$TEMPFI = STEAM-(STEAM-TEMPIN)*EXP(-(HOURS/B)**C$$

Where TEMPFI, STEAM, TEMPIN, and HOURS are respectively the target block temperature, steam temperature, initial block temperature, and hours heated, B and C are parameters, and EXP is the exponential constant 2.71. From the viewpoint of calculating the required vat capacity, the item of interest is the time needed to heat blocks up to some desired temperature. Transposing the above equation results in the following equation for heating time:

$$HOURS = B*(-LOG((TEMPFI-STEAM)/(TEMPIN-STEAM)))**(1/C)$$

Required heating times vary with density and MC. This effect is incorporated in the parameter, B, which is posited to have the following makeup:

$$B=C+G*GSG$$

where C and G are parameters and GSG is green specific gravity (calculated from base specific gravity and average wood MC). This expression was substituted into the equation, and parameters were statistically estimated. The data base was obtained from experiments on heating frozen and nonfrozen 24-in. blocks inside a steam chest to various target temperatures measured at a point 2 in. from the block center (Feihl 1972). As an illustration, the following equation was estimated for nonfrozen blocks:

$$HOURS = (12.4+ 18.0*GSG)*(-LOG((TEMPFI-STEAM)/(TEMPIN-STEAM)))**0.63$$

For frozen wood, a similar equation was derived but one that accounted for the additional time required to overcome the latent heat of melting ice. According to Feihl and others, block diameter increases heating time in proportion to the square of the diameter. Consequently, to generalize the equations to a block of any size, the following multiplier was used to adjust estimates:

(ADIAM(I)/24)**2)

Figure 2 illustrates the general pattern of heating within a block. The top line represents data obtained from field measurements of 14-in. Douglas Fir blocks heated in a steam chest at 155°F (Grantham and Atherton 1959). The lower line represents the heating curve generated by the equation described above for the same conditions. The deviation between the two lines is due to the fact that the measured temperature readings were made closer to the surface (at a point 3 in. from the center axis, 2 ft from one end) than the data upon which the equations were based (2 in. from the center in the middle of the block).

Total vat cycle time, then, including vat loading and unloading time and an assumed half hour warmup period (hours), is

VATCYCLE = 2*VATLOAD + HOURS + 0.5

Number of vats required (VATNUM) (total cycle time divided by time to load a vat) is

VATNUM = VATCYCLE/VATLOAD

Loader diesel fuel consumption calculations are identical to those in the log-handling section.

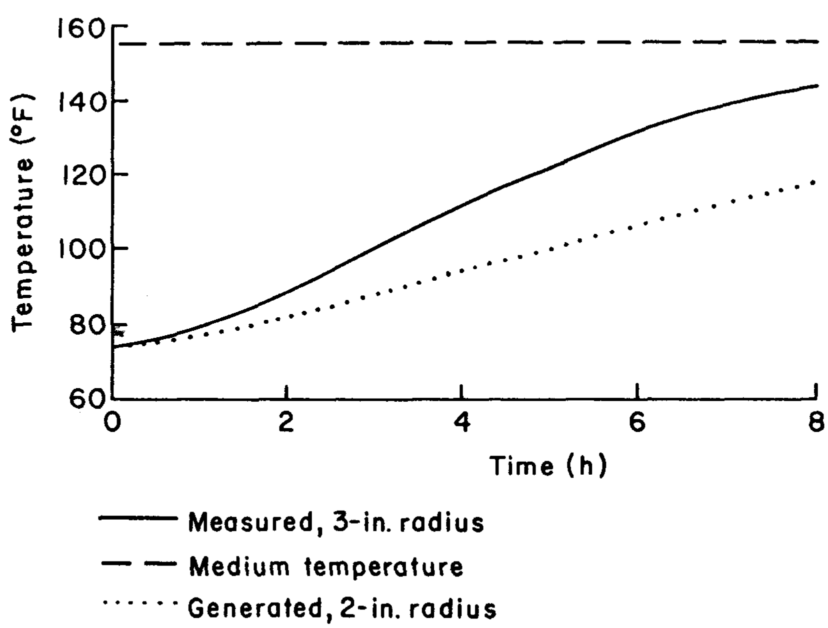

Figure 2–Heating curves for 14-in.-diameter blocks.

Peeling

General

In most mills, the lathe throughput exceeds dry end capacities, and thus, lathes are not run throughout the day. Conditioned blocks are scanned for size and shape and positioned in the lathe charger so as to maximize recovery of full-width veneer. If blocks are not prerounded, they are turned several times with the nosebar open to remove larger protrusions such as stubs and butt flares. After initial roundup, the trashgate is closed, and the veneer ribbon moves down a conveyor to be clipped.

Required Inputs

LINPOS	Type of carriage drive, hydraulic or mechanical (default)
IROUND	Prerounding (0 is no (default), 1 is yes)
SPUR	Average spur width (default is 0.8 in.)
VTHICK	Veneer thickness (default is 0.1 in.)
SDEVVT	Veneer thickness standard deviation (default is 0.006 in.)
CORE	Target core radius (default is 2.15 in.)
CHARGE	Charging time; defined as time from coredrop to knife contact with next block (default is 3 s)
FPML	Target veneer sheet speed (default is 425 ft/min)
RPML	Maximum lathe rotations per minute (default is 400 r/min
NBAR	Nosebar type (0 is fixed or small roller (default), 1 is large diameter roller)
SPINOUT	Spinout rate (default is 0.02)
SPINCORE	Average radius of cores that spin out (default is 3.6 in.)
DTIMEL	Lathe and green end downtime rate (default is 0.07)
PLUGRPB	Block plugup rate due to slivering (default is 0.0625, or 1 in 16)

Calculations

Lineal footage of roundup and full-width veneer are calculated. Full-width sheets are calculated by sapwood (SAPLINFT) and heartwood (HRTLINFT). Roundup is assumed to be entirely sapwood (RNDLINFT). The volumes are generated from the basic equation

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LINFT = 2*3.142*(REV*RADIUS-(VTHICK/12)*((REV-1)**2 + (REV-1))/2)
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where RADIUS is the radius of the relevant portion of the block and REV is the number of revolutions, or the width of the particular zone divided by the thickness of the veneer. For sapwood roundup, RADIUS is the block's large end radius while REV is the taper divided by the target veneer thickness (i.e., ((LDIAM(I)-DIAM(I))/2)/VTHICK). For sapwood full width, RADIUS is the block's small end radius while REV is the sapwood layer (i.e., SAP) divided by VTHICK. For heartwood, RADIUS is the block's small end radius less the sap layer width, while REV is the thickness of the zone from the start of the heartwood layer to the target core, divided by VTHICK. Veneer footage is also tallied separately for blocks peeled to target and for blocks peeled to average spinout core. Veneer footage per block is the weighted average of the two.

Peeltime per block is calculated on the assumption that, after the completion of roundup, the sheet speed is the target sheet speed. Since spindle speed must increase to maintain a constant sheet speed as block diameter declines, the target sheet speed can be maintained only up to the point where the spindles reach maximum speed. After that, sheet speed declines linearly with block diameter. Speed at core is

FPMM=(2*3.142*CORE/12)*RPML

Hence, average sheet speed after the point where maximum spindle speed are reached is the average of beginning and ending speeds:

FPMC = (FPML + FPMM)/2

Average sheet speed during roundup is assumed to be one-half of the target sheet speed, reflecting spindle acceleration and the pause while the trashgate is closed. Total peeltime (in seconds) is, then, the sum of the lineal footage of veneers peeled during the three phases (roundup, target sheet speed phase, and decreasing sheet speed phase) divided by their respective speeds, plus charge time:

PEELTIME = (RNDLINFT/(0.5*FPML) + YLINFT/FPML
+ CORLINFT/FPMC)*60 + CHARGE

Peeltime is also dependent upon the type of conveyor system used between the lathe and the clipper. If the green end is direct coupled, the lathe must slow down to the clipper's speed. This should be factored in the assumed target veneer sheet speed (FPML).

Similar calculations are made to get average peeltime for spinout cores. If blocks are prerounded, initial roundup time is set to zero. The number of blocks peeled per minute (BLTPM), adjusted for number of lathes, is

BLTPM = LTUTIL*60/PEELTIME

While blocks peeled per hour (taking into account operational downtime and an assumed 10-s pause for each incidence of sliver plugup) is

BLTPH = BLTPM*60*(1-DTIMEL)/(1 + (BLTPM*PLUGRPB*10)/60)

Total lineal footage of blocks handled per hour (BOLTLFPH) is

BOLTLFPH = BLTPH*BLENGTH

Number of lathes required to handle the inflow of blocks from the log conditioning area (LTUTIL) is

LTUTIL = VATLFPH/BOLTLFPH

As before, calculations are done twice, once with LTUTIL initialized to 1, the second time with the proper value.

Clipping

General

The function of veneer clippers is to remove defects and produce veneer of a standard size. The clipper acts as a bottleneck to the lathe if the conveyor trays are filled. Clipper speeds are set at two rates, one for roundup veneer, another for full-sheet veneer. Roundup veneer contains many defects and hence requires more clips. This reduces clipper speed, usually to between 200 and 300 ft/min. Full-sheet speeds range from 300 to 400 ft/min for guillotine clippers and up to 500 ft/min or more with rotary clippers. Most lines operate with a single clipper, but some have two in order to clip roundup and full-width sheets separately. The model assumes a single clipper line. Recovery at the clipper depends on whether the objective is to clip for volume or grade. If for volume, then waste is relatively low. If for grade, waste is greater, and the proportion of full-width sheets in the mix declines. The model recovery equations are based on clipping for volume.

Required Inputs

KANS	Indicates whether A and B grade veneers are sold (default) or processed within the mill
RUPTRASH	Proportion of roundup veneer that is sent directly to be chipped (default is 0.50)
FSHFPM	Clipper speed, full-width sheets (default is 375 ft/min)
RUPFPM	Clipper speed, roundup veneer (default is 250 ft/min)

Calculations

Calculate incoming footage of veneer per bolt in linear feet according to speed of processing (roundup (RUPLINFT) or full-sheet (FSHLINFT) width):

$$\text{RUPLINFT} = (1-\text{RUPTRASH})*\text{RNDLINFT} + 0.1*\text{SAPLINFT}$$
$$\text{FSHLINFT} = \text{HRTLINFT} + 0.9*\text{SAPLINFT}$$

These veneer footages are multiplied by recovery factors to obtain green veneer (by full, half, random, and fishtail) and clipper loss volumes. The recovery factors are based on studies by Funck and Sheffield (1985). Next, calculate roundup (CRUPFPH) and full sheet (CFSHFPH) veneers processed per hour:

$$\text{CRUPFPH} = \text{RUPLINFT}*\text{BOLTPH}$$
$$\text{CFSHFPH} = \text{FSHLINFT}*\text{BOLTPH}$$

Calculate average clipper time (in hours) needed to process roundup veneer (CRUPTIME) and full-sheet veneer (CFSHTIME), taking into account green end downtime:

$$\text{CRUPTIME} = \text{CRUPFPH}/(\text{RUPFPM}*60*(1-\text{DTIMEL}))$$
$$\text{CFSHTIME} = \text{CFSHFPH}/(\text{FSHFPM}*60*(1-\text{DTIMEL}))$$

Calculate number of clippers needed per hour:

$$\text{CLIPPER} = \text{CRUPTIME} + \text{CFSHTIME}$$

Green Veneer Stacking

General

Mechanization of green veneer stacking has become common in plywood mills. Generally, half- and full-width sheets are stacked automatically, while random widths and fishtails are stacked manually. Some mills have installed stackers for random widths as well. Elements of an automatic stacking system include a sheet diverter, a veneer moisture meter (common practice in the West if heart and sap veneer is segregated), and a mechanical or vacuum sheet-handling device that places sheets into a bin. Staffing requirements with an automatic stacking system usually include a tender to unjam wedged veneers and empty filled bins, two stackers to pull random sheets, and one fishtail saw operator. As the rate of veneer production is normally greater than the ability to dry the veneer sheets in conventional dryers, the stacked veneer is placed in inventory until ready for drying.

Required Inputs

FSHWDTH   Target full sheet width (default is 53.25 in.)

Random sheets are assumed to average 14 in. in width, while fishtail widths are assumed to be 12 in.

Calculations

Veneer recovery was estimated by grade. Grade recovery equations were based on data of second growth Douglas-fir utilization in mills located on both sides of the Cascades (Cahill 1982; Fahey 1974). Since the target core diameter in these studies was 5.3 in., the equations contain adjustments for specified target cores below that level such that additional veneer recovery is tallied as C or D grade. The equations were estimated for logs between 7 and 25 in. Figure 3 shows the relationships.

If A and B grade veneer is separated and sold, as can be specified in the previous clipper section, then green stacking is likely to be manual with many pullers. This can be accommodated by specifying a larger stacking crew in the staffing section. Ribbon speed (lathe section) may also have to be slower.

Veneer Drying

General

Green veneer is dried to prevent the glue from overpenetrating the wood and to avoid steam-induced blows in the hot press. Two types of dryers are generally used: jet impingement and longitudinal. Jet impingement dryers dry veneer about one-and-a-half times faster than longitudinal dryers but use more electricity. In the South, where most of the veneer is sapwood and drying needs are consequently high, jet impingement dryers predominate. In West Coast mills that peel mostly old-growth or large-diameter timber, longitudinal dryers are usually used.

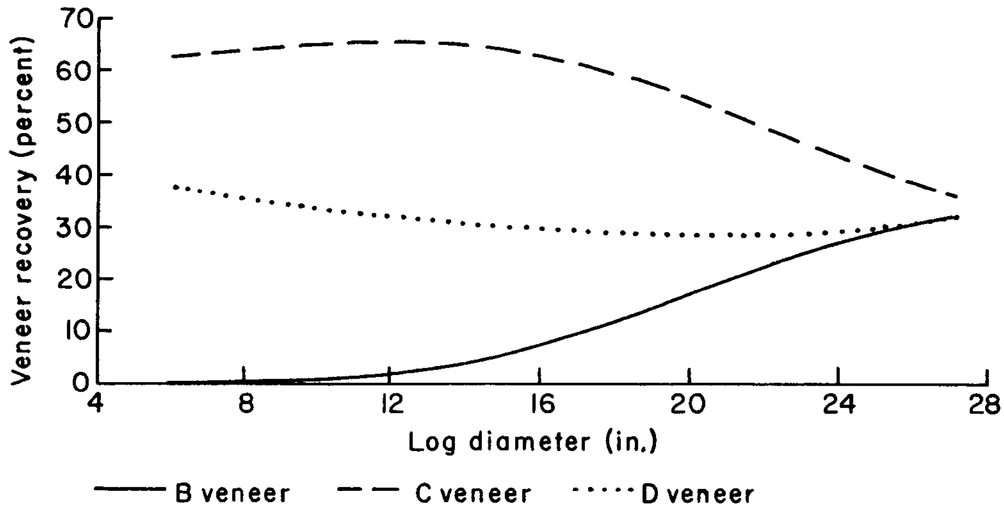

Figure 3 –Veneer recovery estimates by block diameter.

Required Inputs

AV	Average forced air velocity inside dryer (default is 4,000 ft/min)
DTEMP	Dryer temperature (default is 355°F)
TEMPAMB	Ambient temperature inside mill (default is 60°F)
DRDOWN	Operational dryer downtime ratio (default is 0.05)
FMC	Dry veneer target MC (default is 4 percent)
REDRYMC	Highest acceptable MC (default is 8 percent)
DTYPE	Dryer type, Jet (J) or longitudinal (L) (default is J)
DRYERLT	Dryer length (default is 100 ft)
DDECKS	Number of decks (default is 4)
DLOSS	Percentage heat loss through dryer (default is 17 percent)
DEXHAUST	Percentage heat loss through dryer exhaust (default is 40 percent).

Dryer heat loss default assumptions are based on studies by Corder (1975).

Calculations

Drying times for heartwood and sapwood veneer were calculated using drying rate equations developed for a jet impingement dryer by Comstock (1971). If the dryer specified is longitudinal, drying times are increased by 50 percent. Variables controlling drying time are dryer temperature (DTEMP), forced air velocity (AV), veneer thickness (VTHICK), wood specific gravity (BSG), and veneer MC (both values from USDA Forest Service 1987), and target final moisture content (FMC).

Dry veneer width (DVENWD) and dry veneer thickness (DVENTH) are calculated on the assumption that shrinkage below fiber saturation (30 percent MC) is linearly related to moisture. Maximum shrinkage varies slightly by species (Table 1). For simplicity, it was assumed that average width shrinkage was 7.5 percent and that average thickness shrinkage was 4 percent. For each percentage drop in target MC below 30 percent, therefore, width decreases by 0.25 percent, and thickness decreases by 0.13 percent (note that this equation is valid only for target MC below 30 percent):

$$DVENWD = FSHWDTH*(0.925 + 0.0025*FMC)$$
$$DVENTH = VTHICK*(0.96 + 0.0013*FMC)$$

The MC of dry veneer is affected by variability in green veneer moisture and thickness. To calculate the percentage of redry veneer, the dry veneer moisture standard deviation is calculated from green moisture and thickness variabilities. Then, the difference between the redry (REDRYMC) and target moisture (FMC) amounts is divided by the estimated dry veneer standard deviation. This ratio represents the number of standard deviates the redry level is from target. Based upon the assumption that the dry veneer moisture distribution is normal, the number of standard deviates is converted to percent redry. The percent redry rate is applied to the total dried volume to get redry volume.

The number of primary dryers required is the ratio of hourly stacked green veneer to hourly dryer capacity. Hourly dryer capacity is based upon dryer size, drying time, and operational downtime. If it is specified that A and B grade veneers are sold, then veneer input is restricted to C and D grade veneers only.

As in other sections, the model indicates only the required amount of machine capacity to handle the volume of veneer. If this is unbalanced (i.e., too much or too little of the available capacity is used, given a range of allowable process parameters), then the user should change the initial log input. The model gives users the option of returning to the starting point here to change that assumption.

Veneer Redrying

General

Dried sheets above a stated MC must be redried. Veneer can be redried in conventional convection ovens used for primary drying or in microwave ovens. If convection dryers are used, a drying schedule similar to that used for heartwood is used. Redrying in a convection dryer often results in much veneer that is overdried. The brittleness makes the veneer more prone to breakage during handling, resulting in significant losses.

Required Inputs

Specify the type of redryer used, conventional (default), or microwave (radiofrequency).

RDTYPE	Redryer type; conventional is 1, microwave is 2
RDRYLSS	Redry loss rate; default is 0.15.

Calculations

Number of secondary dryers was calculated by dividing redry volume by hourly capacity. For calculating redrying capacity of conventional dryers, the same size dryers were assumed as stated for primary dryers. Drying schedules were assumed to be the same as for heartwood veneer. For calculating redrying capacity of microwave redryers, a batch load that is 26 in. high was assumed. The drying schedule varies between 12 and 18 min, depending on initial veneer MC.

Dry Veneer Stacking

General

Veneer emerging from dryers is sorted and stacked by dimension and grade. Stacks of veneer may be held in inventory for a period of time to allow for cooling and for moisture to equalize within sheets.

Required Inputs

DREJECT   Rate of veneer loss in primary drying; default is 0.02

Calculations

Veneer volumes are calculated by full, half, random, and fishtail categories and by grade.

Veneer Stringing

General

To improve plywood quality and facilitate layup automation, half- and random-width sheets are sometimes unitized and recut into standard full-width sheets. Incoming strips are aligned and passed over an anvil where the leading edge is clipped to assure that each strip will fit tightly against the preceding strip. Strands of hot-melt adhesive are put on the veneer over which threads are placed. Immediately the two are pressed by a cooling roller. The trailing edge of the strip is clipped to create a surface that will match that of the next strip. Unitized sheets are then sawn in half and clipped to produce 4 by 8 corestock. This basic technique is also used to edge glue higher grade face veneers.

Required Inputs

DIST   Distance between infeeding strips of veneer; default is 0.2 ft
STRFPM   Stringer speed; default is 82 ft/min
SLOSS   Stringer loss factor; default is 0.02

Calculations

Productivity in terms of sheets per hour (SHTSPH) is calculated for an 8-ft machine from formula supplied by the manufacturer:

SHTSPH = (2*3600)/(n*(T(1) + (60*DIST/STRFPM) + (60*GVENLT)/STRFPM + T(2) where

n	is veneer pieces per sheet (based on average width of random strips),
T(1)	cam cycle time (0.7 s),
T(2)	time for sizing (0.7 s), and
GVENLT	veneer length, calculated from bolt length and spur assumptions.

Panel Layup

General

Panel layup consists of applying adhesive to individual sheets and stacking them in the desired panel construction. The traditional method of applying adhesive involves the use of glue spreaders through which corestock is passed by a core feeder. A pair of glue-coated rollers apply the adhesive onto both sides of the passing sheet. A corelayer positioned at the outfeed end of the spreader places the glue-coated sheets onto an uncoated full sheet. When the full sheet is completely covered, a pair of workers place a full sheet onto the corestock to restart the cycle.

Glue spreaders are relatively labor intensive, but they offer an advantage in that thin-or-thick veneer is easily identified and discarded. This helps reduce panel delamination, the likelihood of which increases with uneven veneer thicknesses. Automated layup lines using spray, curtain, or foam methods of glue application have been widely adopted over the past several decades. These result in greater productivity, but thin-or-thick veneer is not easily identified. The amount of veneer thickness variation (specified in peeling), the volume of veneer discarded in layup, and the volume of reject panels due to delamination (specified in the press section) are all interrelated. These relationships are not incorporated into the model as no published studies have quantified the relationships. The user must therefore specify appropriate values for these variables based upon the type of layup method used and the kinds of losses that have been experienced.

Required Inputs

Required inputs fall into two categories: machinery-related process inputs and adhesive mix inputs.

Machinery variables are as follows:

WASTLU	Core loss factor; default is 1 percent
LUPFPM	Layup line speed, expressed as lineal feet of panels per minute; default is 63 ft/min
TPNTHK	Nominal panel thickness; default is 1/2 in.
ADHWST	Adhesive loss factor due to cleaning, spills, evaporation, but net of trim and core loss; default is 0.05
PLIES	Number of plies in a panel; default is 5. (This number depends on nominal panel and veneer thicknesses, so a number that is consistent with those variables should be specified. Model assumes all veneer thicknesses are the same.)

VENRUF	Veneer surface quality; rough (1) intermediate (2), smooth (3).
FACE	Face grade; C or C-plugged and better (If C-plugged and better is specified, the model assumes the panels will be plugged and sanded. Otherwise, these work centers are skipped.)
IHIMOIS	Type of glue mix used; low-moisture or high-moisture
IFOAM	Type of layup system; foam or other

Adhesive mix variables are as follows. The adhesive cost is based on a 10,000-lb batch. Ingredients must be expressed in terms of thousand pounds that add up to the 10,000-lb unit. That is, if water represents 30 percent of the mix, enter 3,000.

GLUADH	Adhesive; default is 6,500 lb
GLURESPC	Resin solid content share of adhesive; default is 0.43
GLUEX	Extender; default is 600 lb
GLUFIL	Filler; default is 700 lb
GLUCAUS	Caustic soda; default is 350 lb
GLUBLD	Blood; default is 0 lb
GLUH2O	Water; default is 1,850 lb
COSTPF	Solid resin cost; default is $0.33/lb
COSTEX	Extender cost; default is $0.12/lb
COSTFIL	Filler cost; default is $0.10/lb
COSTSC	Caustic soda cost; default is $0.07/lb
COSTBLD	Blood cost; default is $0.45/lb
RYLTY	Adhesive system royalty payment, if any; default is $0.00 per thousand square feet single glue line basis (MSGL)

Calculations

Glue spread rates (in pounds per thousand square feet, single glue line basis) are calculated from the following equation for Southern Pine-type adhesives:

SPREAD = (50.3-0.75*FMC + 0.00741*TEMPAMB-3.25*(VENRUF-1)
+((VENRUF-2)*FMC*0.125)*(VENRUF-1)/2)*(1.08-0.001292/DVENTH**2)

This states that glue spread is reduced for increases in veneer moisture (FMC), increased for higher mill temperatures (TEMPAMB) (a proxy for veneer temperature), and reduced with decreasing veneer surface roughness (VENRUF). Glue spreads also increase with thicker veneer (DVENTH). For Douglas Fir and white fir, these spreads are reduced by 15 percent. If foam gluing is-specified, spreads are reduced by an additional 24 percent.

The components of the adhesive mix are multiplied by their respective costs and divided by 100 to obtain the cost of glue on a per hundred pounds basis.

The number of plywood panels constructed per hour (LUPPH) is defined as the number of layup stations (STATLUP) times throughput per hour divided by average panel length:

LUPPH = STATLUP*60*LUPFPM/GVENLT

The lineal foot equivalent is number of panels times average dry width:

HRLUPLF = LUPPH*DVENWD

Average wood thickness in a panel (PTHICK) is number of plies times dry veneer thickness:

PTHICK = PLIES*DVENTH

Cubic footage is expressed as

HRLUPCF = HRLUPLF*GVENLT*PTHICK/12

The number of layup stations required is the ratio of net dried veneer input to the volume handled:

STATLUP = (DVCFPH-SCFLSS)/(HRLUPCF + WSTLUCFPH)

where

DVCFPH	is total dried veneer leaving dryers,
SCFLSS	losses in stringer (if used),
HRLUPCF	cubic foot volume, and
WSTLUCFPH	losses in core material.

Veneer Plugging

General

Dried veneer sheets that contain defects beyond permissible bounds can be upgraded by punching out the defects and filling the hole with a matching piece of solid veneer. To prevent plugs from falling out, the area is often taped. A more recent productivity-enhancing method is to apply a hot-melt adhesive around the edges of the plug. Veneer plugging is most likely to be used in mills that focus on sanded and specialty plywood items. This part of the model is entered only if C-plugged or higher grade face veneer is specified.

This step precedes layup, but is placed out of sequence in the program for computing convenience.

Required Inputs

AVPROD Average plugger productivity in sheets per hour; default is 150

Calculations

For simplicity, it was assumed that only face sheets were upgraded (that is, panel grades are limited to low grade backs, such as C or D; this eliminates panel grades such **as** AA or AB). The number of face sheets is equal to the number of assembled panels. Therefore, the required number of plugging machines (PLUGGER) is the number of face sheets (LUPPH) divided by the average hourly plugger productivity (AVPROD):

PLUGGER = LUPPH/AVPROD

Pressing

General

Hot pressing follows panel assembly. Freshly assembled panels must be moved quickly from layup to the press to prevent the glue moisture from being absorbed into the wood. Panels are usually placed in a cold press to consolidate panels and extend assembly times. Pressure in the press brings the opposing veneer surfaces into close contact, while the heat cures the adhesive. The pressure also compresses the wood somewhat. Some of this recovers, but a part is permanent. The loss in thickness, along with shrinkage, should be factored in when targeting the thickness of the veneer at the lathe. Compression loss can be diminished by incrementally reducing the initial pressure during the press cycle and by watering panels after they leave the press.

Required Inputs

PRPRSS	Press pressure; default is 175 lb/in*
LODTIM	Time to unload and load press, from press opening to closing. (This is expressed in terms of time per opening, since most of the loading time is a function of press size. With automatic loaders, the actual unloading/loading time of panels is independent of press size and takes on the order of 15 s. This must be factored into the calculation on a per opening basis. The default for the entire cycle is 2.5 s per opening.)
PRTEMP	Press temperature; default is 280°F
PROPEN	Number of press openings; default is 32
NUMCYC	Number of pressure reductions during the pressure cycle; default is 1 (constant pressure during the cycle)
PCPBLW	Panel blow rate; default is 0.02

Calculations

Press times (PRTIM) were calculated on the basis of one panel per opening and are a function of press temperature and panel thickness. Press schedules vary by glue mix, and estimates obtained from this equation can be overidden if an alternative schedule is used.

PRTIM = (-3.25 + 2400/PRTEMP)*(-0.8093 + 4.5597*PTHICK-1.9528*PTHICK**2)

These time values are reduced by 4 or 6 percent if high-moisture or foam gluing is specified, respectively.

Press capacity per hour (PRCPPH) (in terms of panels) is based on number of press openings (PROPEN), loading time (LODTIM), and press time:

$$PRCPPH = (3600*PROPEN)/((LODTIM*PROPEN) + (PRTIM*60))$$

The number of presses (PRESSES) required is determined by converting the panels into cubic feet and taking the ratio between layup and press capacity volumes:

$$PRESSES = HRLUPC/PRCFPH$$

Percentage panel thickness loss due to compression (COMPLSS) is calculated as a function of press pressure (PRPRSS), press temperature (PRTEMP), time in press (PRTIM), and final MC (FMC):

$$COMPLSS = EXP(-7.4 + 0.057*LOG(PRTEMP/PRTIM) + 0.4*LOG(FMC) + 1.2*LOG(PRPRSS))$$

If two- or three-stage press pressure cycles are stipulated, 2.4 or 3.4 percentage points are deducted from the estimate, respectively.

Next, the percentage of panels that fall below permissible thicknesses is calculated. First, the lower bound of permitted thickness is established. Although 1/32 in. is the permitted variability, slightly greater amounts are usually allowed in anticipation of some thickness recovery in the field as moisture is reabsorbed. The lower bound, then, is assumed to be 1/29 in. less than the nominal panel thickness:

$$LATH = TPNTHK-1/29$$

The precompression panel thickness is the number of plies times the average dry veneer thickness, plus some swelling caused by absorption of moisture from the glue and the thickness of the glue film in the glue lines (GLULNS):

$$EXPNTHK = PLIES*(DVENTH + 0.0015) + 0.002*GLULNS$$

The postcompression thickness is the precompression thickness times the compression loss (COMPLSS):

$$APNTHK = EXPNTHK*((100-COMPLSS)/100)$$

The variability of the panel thickness is a function of the underlying variability in veneer thickness that was specified in the lathe section (adjusted for shrinkage):

$$STDPNTH = PLIES**0.5*SDEVVT*(0.96 + 0.0014*FMC)$$

The underlying distribution of the panel thicknesses was assumed to be normal. The difference between the average compressed panel thickness and the lowest permissible thickness is divided by the variability of the dried panels. This gives the number of standard deviates the lower bound lies from the mean. The proportion outside this deviation is calculated from the standard normal distribution. This volume is assumed to be downgraded and sold at lower mill grade prices.

Finishing

General

After pressing, hot panels are usually stacked and set aside to allow the adhesive to cure from the residual heat in the stack. When they are cool, the panels are sent through a finishing line consisting of trimsaws that cut the panels to their final size. If the panels have high grade faces or are underlayment grade, they are also sent through a sander for full or touch sanding. Sheathing grades are generally not sanded.

Required Inputs

There are no required inputs for trimming. Finished panel sizes are assumed to be 4 by 8 ft.

If C-plugged or better grade face veneer was specified in the layup section, then sanding is assumed and two inputs are needed:

SPNTHK	Panel thickness after sanding; default is 0.47 in.
SNDFDR	Sander feedrate; default is 144 ft/min

Calculations

Thickness of sanded wood removed (THKRMV) is calculated as

$$THKRMV = APNTHK-SPNTHK$$

Volume of sander dust removed is the number of pressed panels (PRCPPH) times the volume of dust per panel:

$$SNWSTVL = PRCPPH*(THKRMV*GVENLT*DVENWD)/12$$

Staffing

General

Staffing in a plywood mill depends on the size of the mill, the type of equipment used, and the grades of plywood produced. Staffing needs are determined in the PLYMAP model by assumptions regarding crew size per machine and machine utilization. Machine utilization is determined by the volumes of wood and the machine speeds specified in the previous sections. Crew sizes are specified in this section for those work centers where crew sizes can be most variable. For most centers, crew sizes are fairly standard and values are assumed to reduce the burden on the user.

Required Inputs

WAGE	Average wage per hour, including fringe benefits; default is $14.5
OPLATH	Crew size per lathe; default is 2
OPGST	Crew size per green veneer stacking line; default is 8
OPDRY	Crew size per dryer, infeed; default is 1.34
OPRDR	Crew size per redryer, infeed; default is 1
OPDST	Crew size per dryer, veneer stacking; default is 3

OPSTRING	Crew size per veneer stringer; default is 2
OPLUP	Crew size per layup station; default is 4
OPSHIP	Total crew size, shipping; default is 3.0
SUPERV	Total number of supervisors; default is 9

Other work centers have assumed crew sizes as follows: Log and bolt loading are based on the specified number of loaders; chipper (1); clipper (1); plugging machine (1); finishing line (2).

Calculations

Indirect labor requirements (forklift and maintenance crews) are calculated from the number of major work centers used. The size of the entire forklift crew is projected off the number of lathe and press shifts:

$$FLEMP = (LTUTIL + PRESSES)*2$$

Thus, a mill utilizing one lathe for two shifts per day and two presses for three shifts per day is projected to have a total of 16 forklift operators. Similarly, the maintenance crew is calculated from

$$XMEMP = 3*LTUTIL + DRIERS + PRESSES$$

This results in a total maintenance crew of 18 in this example if, in addition, the mill uses two dryers three shifts per day.

Core Value

General

Block cores are generally sold to be sawn into 2 by 4 studs. The value of a core depends on the number of studs that may be recovered from it. Cores below 4.2 in. in diameter have value only for their chip content unless a specialty market can be found for them, such as landscape timbers. In most cases oversize spinout cores are also chipped. The assumption in this program is that oversize cores are chipped.

Required Inputs

Core value is determined from selling price of studs and chips.

STUDS	Producer price of studs; default is $160 per thousand board feet
CHIPS	Selling price of chips; default is $40 per bone dry unit (BDU)

Calculations

The number of studs that can be recovered from a core (CORNUM) can be estimated as

$$CORNUM = (CORE* 10-18)/4$$

where CORE is the target core radius and decimal values are dropped.

The value of the core (VCORE), then, was assumed to be the number of recoverable studs times 50 percent of the mill selling price for studs (converted to a price-per-piece basis) (STUDS) and the value of the residual chip volume in a core (expressed in tons) times the chip selling price (CHIPS):

```
VCORE = CORNUM*STUDS*0.00533*0.5 + (0.0218*GVENLT*CORE**2
        -0.365*CORNUM)*BSG*62.4*CHIPS/2400
```

where BSG is the specific gravity of the wood (Table 1).

Timber Costs

General

Timber is generally purchased on a per board foot basis using a variety of board foot scales. However, the most common scale used is the Scribner Decimal C system, and that is assumed in the program. Even within this system, there is some variability regarding the assumed length of each scaled log. In the Pacific Northwest coastal area, logs are measured on a long log basis, which generally means 32 ft or longer. Elsewhere, logs are segment scaled on a so-called short log basis where a long log is sold as if it consisted of shorter segments. This affects their scaled volume and their nominal per board foot value.

Required Inputs

DLOG Delivered log cost, $ per thousand board feet Scribner Decimal C scale (For Douglas Fir, long log basis scale is assumed; elsewhere, short log scaling. Defaults are $260 for Douglas Fir, #2 sawlog; $180 for Southern Pine sawtimber grade sawlog; $220 for white fir sawlog; and $200 for ponderosa pine.)

Calculations

Since timber costs vary by size, a relationship between the specified log cost and a log of any size needs to be established. For Douglas Fir, the ratio between the cost of a log of any size and the cost of an average No. 2 grade sawlog was estimated to be

```
PRAT = ((4.42-4.88/DIAM(I)**2)/1.65)*DLOG
```

For other regions, the estimated relationship was

```
PRAT=((3.19-5.15/DIAM(I)**0.5)/1.76)*DLOG
```

Next, values per board foot are converted to a common cubic foot basis. For the U.S. West Coast,

```
SCRTOCUB = 10.52-0.0294*DIAM(I)-93.46/DIAM(I) + 307.8/DIAM**2
```

For elsewhere,

$$SCRTOCUB = 5.42 + 0.11 *DIAM(I)-14.92/DIAM(I)$$

Finally, since the model simulates the processing of only one 8-ft block from the narrow end of the long log, a correction is needed since the smallest segment in a log has a lower value than the log overall. For Douglas Fir long logs, this correction was

$$CORRFAC = 1.00-6.65/DIAM(I)**2$$

For short logs, the correction is

$$CORRFAC = 1.00-2.58/DIAM(I)**2$$

Cubic foot wood cost (WOODCPCF), then, is

$$WOODCPCF = SCRTOCUB*PRAT*CORRFAC$$

Cubic foot values derived by these equations may be altered by specifying a different scribner log value if the user calculates wood costs differently.

Energy Costs

General

Plywood mills use considerable electrical energy to power machinery, diesel fuel to power loaders, propane to power forklifts, and depending on the available supply of combustible residues, natural gas or other fuels to heat dryers, presses, and conditioning vats.

Required Inputs

Diesel fuel and natural gas costs were specified previously. Additional inputs are as follows:

PPROPANE	Propane cost; default is $0.75/gal
CPKWH	Cost of electricity; default is $0.05/kWh

Calculations

Electricity costs were estimated for the main machine centers in a mill. Diesel and propane costs were based on the number of specified loaders and calculated forklifts.

Overhead and Depreciation

General

Overhead and depreciation consist of (1) operating supplies (such as, knives, saws, banding straps), (2) maintenance supplies, (3) property taxes and insurance, and (4) capital depreciation.

Required Inputs

OPSUPL Operating supplies as fraction of direct labor costs; default is 0.13

XMASUPL Maintenance supplies as fraction of direct labor costs; default is 0.125

TAX Annual property taxes and insurance costs; default is $0.25 million

CAPITAL Amount of depreciable capital; default is $6 million

RATE Annualized interest rate to be applied against capital invested; default is 0.08

RYRS Capital recovery period; default is 10 years

Calculations

All costs are calculated on an annual basis. They are divided by annual production (3/8-in. basis) to obtain costs per thousand square feet.

Revenues

General

Primary product revenues are generated by the specified grade and amount of panel produced. These fall into three categories: (1) those that meet thickness requirements, (2) those that are downgraded because of failure to meet minimum thickness requirements, and (3) shop grade panels (blows). If B and better grade veneer is not processed within the mill, revenue is also generated by their open market sale. Byproduct revenues generated by sales of cores and green pulp chips are usually deducted from gross timber costs.

Required Inputs

PLYAPAPR Price of panels that meet grade; default is $190/10^3ft^2$, surface measure

PLYMILPR Price of mill certified panels; default is $155/10^3ft^2$, surface measure

PLYREJPR Price of rejects; default is $65/10^3ft^2$, surface measure

BVENPR Price of B and better grade veneer; default is $55/10^3ft^2$, surface measure

Calculations

Revenues are calculated by multiplying the various outputs by their respective selling prices. Revenues from residues and by-products are deducted from wood costs to get net wood costs.

Section B – Model Simulation Instructions

The procedure for running the program involves three steps: (1) loading it onto a personal computer, (2) customizing it to the user's situation, and (3) analyzing the effect of contemplated changes. These steps are discussed in the following paragraphs.

Loading the Program

The program can be contained on either 5.25-in. or 3.5-in. diskettes. The user should transfer the contents onto the computer's hard disk where processing is faster. A math coprocessor will speed simulation times on otherwise slow machines. Refer to disk operating system manuals for instructions regarding loading and transferring files.

The disk contains two files. One is a file called DEFLT, which supplies the default values used by the program if the user omits values for particular parameters. This file is a read only file to prevent accidentally changing its contents. The other file is the compiled executable version of the PLYMAP program. This means that upon typing the word PLYMAP, the program begins.

Customizing Program Assumptions

The default values supplied with the program are unlikely to match a mill's parameters in every respect. When using the system for the first time, more appropriate values should be supplied to make the model more relevant to a particular situation. There are over 100 parameters, and it would be cumbersome indeed to have to supply values every time the program is run. However, this procedure needs to be done only once because the parameter values can be saved and recalled for subsequent use. The process of customizing the program is illustrated step by step in the following pages.

The general format followed throughout the program is to prompt the user to make yes-no decisions. These lead to further prompts until all the information needed by the system has been supplied. The following example assumes a mill with a one-lathe green end, two dryers, and two presses.

Running the program begins by typing the word PLYMAP, which initiates a request for a label by which to identify the run (Screen 1).[1] This can be a date or any eight character string that will be meaningful to the user.

Next, the program prompts for the file name, which contains default parameter values. When using the program for the first time, use the default values provided with the system. They will be used automatically if the user response is N. Typing Y followed by the name DEFLT is another way to achieve the same end. If the user has already saved a file with customized values, then the name of the file should be entered. After this is specified, the screen clears and starts processing the log deck part of the manufacturing sequence (Screen 2).

---

[1]In the screens, underlined entries represent a user response, a blank underlined space represents a new line response.

In this and subsequent sections, the sequence of steps are as follows. First, the program prompts the user to specify if the default values are acceptable. If the response is Y, it prints out the assumptions followed by the results of important calculations and a further prompt asking if these results are acceptable. If the answer is Y, it proceeds to the next section. If N, it prompts for a value for each of the parameters and repeats the process.

The next section (Screen 3) asks for the size of the logs that are to be processed. Up to five diameters may be specified. For simplicity, we specify only 14-in. logs. The response to the initial prompt is N followed by a 1 (to the prompt for the number of diameters) and 14 100 to the prompt for diameter and percentage of total logs. If more than one diameter size is specified, the percentages should total to 100.

SPECIFY TODAY'S DATE (I.E.: 02/27/89): 12/30/88
DO YOU WANT TO USE OLD INPUTS?(Y/N) Y
SPECIFY INPUT FILE NAME: DEFLT

Screen 1

ARE DEFAULT VALUES OK FOR LOG DECK (INFEED) (Y/N) Y

# LOADERS	2.00	POWER(hp)	200.00
GAS ($/Thrm)	.85	DIESEL FUEL($/g)	1.25
SPECIES	D.FIR		

DIESEL FUEL CONS(g/h) 13.51

TO REDO THESE VALUES TYPE N. TO CONTINUE HIT NEW LINE _

Screen 2

	DIAMETER	percent LOGS
1	12.0	40.0
2	14.0	60.0

type Yes if these values are correct N
ENTER N. OF DIFF. DIAMETERS (LIMIT 5, def: 2) 1
ENTER DIAMETER(1) & percent OF TOTAL BOLTS (eg. 12 25)14 100
\# DIAM percent WOOD
\- - - - - - - - - - - - - - - - - -
1 14.0 100.0

TO REDO THESE VALUES TYPE N. TO CONTINUE HIT NEW LINE _

Screen 3

In the debarking section (Screen 4), we want to specify values different from those contained in the default assumptions, so N is the response for the initial prompt. Of the three parameters, average stem length is acceptable, so when that prompt appears, the response is to hit the enter key. For the other two, specific values are entered. The program calculates that with these assumptions, 3,998 lineal ft/h of logs can be processed and, at the specified debarker feed rate, the number of blocks can be handled by a debarker operating one shift per day.

In the log slashing section (Screen 5), the calculated throughput drops to 3,830 lineal ft/h. The difference between debarker and slasher outputs is due to log trim and sawkerf losses.

```
ARE DEFAULT VALUES OK FOR DEBARKING (Y/N) N
SPECIFY NUMBER OF LOGS PROCESSED PER HOUR (def: 50.): 112
AVG. STEM LENGTH (def: 34.80 ft): _
EFFECTIVE DEBARKER FEEDRATE (def: 40. fpm) 65
    LOGS PER HOUR 112.00 STEM LENGTH 34.8
    DEB FEEDRATE 65.00

    # DEBARKERS  LIN FT/HR
         1.00          3897.60
-----------------------------------------------------------
TO REDO THESE VALUES TYPE N.   TO CONTINUE HIT NEW LINE _
```

Screen 4

```
ARE DEFAULT VALUES OK FOR SLASHING (Y/N) N
SLASHER STEM THRUPUT (def: 70.00 feet per min): 65
SPECIFY AVERAGE BOLT LENGTH (def: 8.60 ft): 8.55
    SPECIFY THRUPUT 65.00 BOLT LENGTH 8.55

    # SLASHERS  LIN FT/HR
         1.00        3830.40

-----------------------------------------------------------
TO REDO THESE VALUES TYPE N.   TO CONTINUE HIT NEW LINE _
```

Screen 5

For block conditioning (Screen 6), the default values are acceptable, so the response is Y. The estimated conditioning time is printed out but can be overridden if it differs sharply from mill practice. The unit of measure of throughput changes to cubic feet. It is printed along with the estimated number of vats that are required for this amount of wood.

```
ARE DEFAULT VALUES OK FOR BLOCK CONDITIONING (Y/N) Y

        SPEC.  GRAV              .45    MOIST. CONT           73.73
        ST. DEV. HRT            5.00    ST. DEV. SAP          18.00
        STEAM  TEMP           175.00    TARG. TEMP           125.00
        AIR/LOG  TEMP          45.00

TO REDO THESE VALUES TYPE N.    TO CONTINUE HIT NEW LINE _

        9.1 hours
IS ESTIMATED COND. TIME OK? IF NOT, TYPE N: _

        VAT  LENGTH            80.00    VAT  HEIGHT           16.00
        #  LOADERS              2.00    LOADER HP            200.00

        # VATS          OUTPUTS(CFT/HR)
        9.12                  4486.37

---------------------------------------------------------------
TO REDO THESE VALUES TYPE N.    TO CONTINUE HIT NEW LINE _
```

Screen 6

The next section is the lathe (Screen 7). Many parameter values are changed, so the initial response is N. After the values are entered, the program indicates that two lathe shifts are sufficient to handle the volume. The average peeltime (including charging and roundup) is 14.4 s and 448 blocks are processed per hour. (This is not quite true. The program treats the two shifts as if they occurred simultaneously. Since they do not, the actual number of blocks per hour is 224.) The veneer output is 3,738 ft^3. The decline in volume from the vat is due to spur losses and the core residues.

```
ARE DEFAULT VALUES OK FOR LATHE (Y/N) N
IS LINEAR POSITIONING USED TO DRIVE CARRIAGE? 0 = NO 1 = YES (def: 0) _
SPECIFY WHETHER BOLT IS PREROUNDED 0 = NO 1 = YES (def: 0) _
SPECIFY AVERAGE SPUR WIDTH (def:.80 in.): _
SPECIFY TARGET VENEER THICKNESS (def:. 1000 in.):. 129
SPECIFY ST. DEV. OF THICKNESS (def:.0060): .007
CORE RADIUS (def: 2.15 in.): 2.65
CHARGE TIME (def: 3.00 Seconds): 4.0
SPECIFY TARGET VENEER SHEETSPEED (def: 425.): 745
SPECIFY MAX. LATHE RPM (def: 400.): 350
SPECIFY WHETHER POWERED NOSEBAR IS USED 0 = NO 1 = YES (def: 0) _
NOTE: SPINOUT AND PLUGUP RATES SHOULD BE CONSISTENT WITH
NOSEBAR TYPE
SPINOUT RATE (def: .0200): .08
AVERAGE RADIUS SPINOUT CORE (def: 3.60 in.): 4.7
SPECIFY LATHE DOWNTIME RATIO (def:.0700): .06
SPECIFY PLUGUP RATE FOR BLOCKS (def:.0625): _
     VEN. THICK            .129     CORE RADIUS         2.650
     ST. DEV. VEN          .007     SPUR WIDTH           .800
     TARG SHT SPD       745.000     MX LATHE RPM       350.00
     SPINOUT RATE          .080     SPINOUT CORE        4.700
     DWNTIM RATIO          .060     PLUGUP RATE          .060
     CHARGE TIME          4.000

     # LATHES                    PEELTIME
        1.97                      14.42
     CUB FT/HR                   BOLTS/HR
     3738.03                     448.00
-----------------------------------------------------------------
TO REDO THESE VALUES TYPE N.   TO CONTINUE HIT NEW LINE _
```

Screen 7

In the clipper section (Screen 8), we assume that the higher grade veneers are segregated and sold to other mills for further processing. At the assumed processing speeds and green end downtime assumption (specified in the lathe section), the program estimates that two clipper shifts are about sufficient to handle the volume. The output drops to 2,914 ft^3. The loss is due to trash gate waste and clipper and fishtail loss.

In green veneer stacking (Screen 9), the assumed full sheet target width is 53.25 in. The program prints out the estimated cubic foot volumes of veneer stacked by heartwood and sapwood, and by full, half, random, and fishtail categories. The volumes by grade, in thousand square feet, are also printed.

```
ARE DEFAULT VALUES OK FOR CLIPPER (Y/N) N
SPECIFY IF B&BTR VENEER IS SOLD OR PROCESSED (S or P, def: S): _
SPECIFY ROUNDUP VENEER TRASH FRACTION (def:.5000): _
RIBBON SPEED - FULL SHEETS (def: 375. fpm): 400
RIBBON SPEED - ROUNDUP (def: 260. fpm): _
     RIB. SPEED FSH        400.00    RIB. SPEED RUP        260.00
     RNDUP TRSH FRAC          .50    B + VENEER IS      S

        # CLIPPERS                OUTPUT(CFT/HR)
            2.01                      2913.79

--------------------------------------------------------------
TO REDO THESE VALUES TYPE N.   TO CONTINUE HIT NEW LINE _
```

Screen 8

```
ARE DEFAULT VALUES OK FOR GREEN VENEER STACKING (Y/N) Y
FULL SHT WIDTH                53.25

              ** CUBIC FEET/HR **
                     FULL      HALF     RANDOM     FISHTAIL   TOTAL
     HEART        1086.16     81.46     129.74          .00  1297.36
     SAP           969.75    255.20     245.53       145.96  1616.43
     TOTAL        2055.91    336.66     375.26       145.96  2913.79

     B VEN. (MSF/H)  C VEN. (MSF/H)  D VEN. (MSF/H)  TOT VEN.(MSF/H)
          3.17            61.52           28.55            93.24

--------------------------------------------------------------
TO REDO THESE VALUES TYPE N.   TO CONTINUE HIT NEW LINE _
```

Screen 9

In the drying section, jet dryers are specified (Screen 10). With the stated parameters, the program calculates that 5.4 dryer shifts, or nearly two dryers operating three shifts per day (5-day basis) are needed. The residual dryer capacity can be used for redrying. The throughput drops to 2,546 ft^3/h. The difference between clipper and dryer outputs is due to shrinkage in veneer thickness and width.

```
ARE DEFAULT VALUES OK FOR DRYING (Y/N) N
SPECIFY AIR VELOCITY (def: 4000. fpm): 3500
SPECIFY DRYER TEMPERATURE (def: 360. deg. F): 370
SPECIFY MILL TEMPERATURE (def: 60. deg. F): _
SPECIFY DRYER DOWNTIME RATIO (def:.04): .08
SPECIFY FINAL MOISTURE CONTENT (def: 4.50 percent): _
SPECIFY HIGHEST ACCEPTABLE M.C. (def: 7.00 percent): 7.5
SPECIFY DRYER TYPE: Jet of Longitudinal (def: L): J
SPECIFY DRYER LENGTH (def: 100.0 ft): _
SPECIFY NUMBER OF DECKS (def: 4.): _
SPECIFY PERCENT HEAT LOSS THRU DRYER (def: 17.00 percent): _
SPECIFY RATE OF HEAT LOSS THRU EXHAUST (def: 40.00 percent): _
    AIR VELOCITY        3500.00    DRYER TEMP          370.00
    MILL TEMP             60.00    DOWNTIME RATIO         .08
    FINAL MST CONT         4.5     HIGHEST ACC MC        7.50
    DRYER LENGTH         100.00    NUMB. DECKS           4.00
    % LOSS DRYER          17.00    % LOSS EXHAUST       40.00

    SAP DRY TIME(M)        8.17    HRT DRY TIME(M)       3.47
        # DRYERS             OUTPUT (CFT/HR)
        5.41                      2545.71
____________________  ____  ______________________________
TO REDO THESE VALUES TYPE N.   TO CONTINUE HIT NEW LINE
IF FEEDRATE NEEDS TO BE ADJUSTED TYPE "F" _
```

Screen 10

For redrying (Screen 11) we assume that conventional dryers are used. The estimated dryer requirement is 0.4. Together with the primary dryer requirement, this means that the two dryers are essentially operating continuously throughout the day, 5 days per week.

In dry stacking (Screen 12), we specify the volume of veneer lost in primary drying. Total stacked veneer output is estimated at 2,437 ft^3 and the decline from the initial dryer throughput is due to primary and secondary dryer losses.

It is assumed that the mill unitizes its random and half-width sheets, so the use of a stringer is specified (Screen 13). Based on the assumed parameters, the program estimates that 3.07 stringers are required, or essentially one stringer operating continuously throughout the day.

```
ARE DEFAULT VALUES OK FOR REDRYING (Y/N) N
SPECIFY REDRYER (1 = CONVENTIONAL 2 = MICROWAVE) (def: 1): _
SPECIFY REDRY LOSS RATE (def:. 15): _
        REDRYING  (conventional)
    AIR VELOCITY            3500.00     DRYER  TEMP            370.00
    DRYER  LENGTH            100.00     NUMBER  DECKS            4.00
    HT  LSS  DRYER            17.00     HT  LSS  EXHST          40.00
    REDRY  LOSS                 .15

    #  REDRYERS              OUTPUT  (CFT/HR)
         .43                      328.85

TO REDO THESE VALUES TYPE N.    TO CONTINUE HIT NEW LINE _
```

Screen 11

```
ARE DEFAULT VALUES OK FOR DRY VENEER STACKING (Y/N) Y
       DRYING   DEGRADE            .02

TCYT VEN. (cu.ft.)      TOT. VEN.(M sft.)      DRYER   REJECT(cu.ft.)
    2436.8                  78.0                      50.9
-------------------------------------------------------------
TO REDO THESE VALUES TYPE N.    TO CONTINUE HIT NEWLINE _
```

Screen 12

```
ARE STRINGERS TO BE SIMULATED (Y/N) (def: N): Y
ARE DEFAULT VALUES OK FOR STRINGER (Y/N) N
SPECIFY STRINGER LOSS FACTOR (def:.02): .03
SPECIFY DISTANCE BETWEEN STRIPS (def:.20 ft): _
SPECIFY STRINGER SPEED (def: 82.00 fpm): 88
    STRINGER  SPEED          88.00     DIST  BETWEEN  SHT         .20
    STRINGER  LOSS             .03
    #  STRINGERS               OUTPUT  (CFT/HR)
         3.07                       708.11
  ________________________   _______________________
TO REDO THESE VALUES TYPE N.    TO CONTINUE HIT NEW LINE _
```

Screen 13

In the layup section (Screen 14), we specify relevant process parameters along with the contents of the glue mix. Based on the specified line speed, which is consistent with speeds on automated lines, 2.98 shifts are estimated to be required, or one line operating three shifts per day. Output is 2,403 ft^3/h. The difference from dry stacking is due to core losses in the layup line.

```
ARE DEFAULT VALUES OK FOR LAY UP (Y/N) N
SPECIFY CORE LOSS PERCENT (def: 1.00 percent) _
SPECIFY LAY UP LINE SPEED (def: 63.00 fprn) 78
SPECIFY NOMINAL PANEL THICKNESS (def: .50 in): _
SPECIFY ADHESIVE WASTE FACTOR, NET OF TRIM (def:.05): _
SPECIFY PANEL CONSTRUCTION (# PLIES) (def:5.00): 4
SPECIFY PEEL QUALITY: 1 = ROUGH; 2 = INTERMEDIATE; 3 = SMOOTH: (def: 2.) _
SPECIFY FACE GRADE (C) OR (P,c-plugged or better) (def: C) _
SPECIFY WHETHER HI-MOISTURE GLUE IS USED (0 = NO 1 = YES) (def: 0) _
SPECIFY WHETHER GLUE IS FOAMED (0 = NO 1 = YES) (def: 0) _
ARE DEFAULT VALUES OK FOR ADHESIVE COSTS OR MIX? Y OR N: N
***SPECIFY ADHESIVE MIX COMPONENTS (in lbs per 10,000 lb batch)
SPECIFY ADHESIVE (def: 6500.): _
SPECIFY RESIN SOLID CONTENT (def:.43): _
SPECIFY EXTENDER (def: 600.): _
SPECIFY FILLER (def: 700.): _
SPECIFY CAUSTIC SODA (def: 350.): _
SPECIFY BLOOD (def:.01): _
SPECIFY WATER (def: 1850): _
SPECIFY SOLID RESIN COST/LB. (def: $.33): .37
SPECIFY EXTENDER COST/LB. (def: $.12): _
SPECIFY FILLER COST/LB. (def: $.10): _
SPECIFY CAUSTIC COST/LB. (def: $.07): _
SPECIFY BLOOD COST/LB. (def: $.45): _
SPECIFY ROYALTY FEES, IF ANY (def: $.00/MSGL): _
                    LAY UP
          COMPONENTS PER 10000 LB. BATCH
    ADHESIVE              6500.00   EXTENDER               600.00
    FILLER                 700.00   CAUSTIC SODA           350.00
    BLOOD                     .01   WATER                 1850.00
    RESIN SOLID CONT          .43   SOLID RESIN COST          .37
    EXTENDER COST             .12   FILLER COST               .10
    CAUSTIC COST              .07   BLOOD COST                .45
    ROYALTY FEES              .00   LINE SPEED              78.00
    GLUE SPREAD             37.35   ADHESIVE WASTE            .05
    NUMB. PLIES              4.00   CORE LOSS PERC.          1.00
    NOM. PAN. THK             .50   FACE GRADE                  C
    GLUE TYPE            LOW MOIS   RESIN APPLIC.        NON FOAM
           LAYUP STATIONS          OUTPUT (CFT/HR)
               2.98                    2402.73
________________________________________________________
TO REDO THESE VALUES TYPE N.    TO CONTINUE HIT NEW LINE _
```

Screen 14

The next section is pressing (Screen 15). Given the thickness of the panels, their dry MCs, and the press parameters, the program estimates the press time (time under heat and pressure) to be 5.35 min. This can be overridden if mill press schedules vary significantly for the type of glue used. The estimated throughput is 2,338 ft^3. This amount is smaller than layup throughput because of compression in the press. Square footage calculations are not affected, since they are based on nominal thickness. The effects of excessive compression show up in the proportion of panels that fall below thickness limits and have to be sold at lower mill grade prices. The program estimates that 6.0 press shifts are required to handle this volume, or about two presses operating three shifts per day.

Along with the number of presses (Screen 16), the program also calculates the number of trim saws needed to produce finished panels. Throughput calculations are based on a feed rate assumption of 22 panels per minute. Process steam needs are calculated along with potential heat available from bark and dry residues. If the energy requirement exceeds the energy availability, the difference is assumed to be made up by purchases of natural gas.

ARE DEFAULT VALUES OK FOR PRESSING (Y/N) N
SPECIFY PRESS PRESSURE (def: 175.): _
SPECIFY TIME TO LOAD/PANELS (def: 2.50 sec): 3.0
SPECIFY PRESS TEMPERATURE (def: 280. deg): _
SPECIFY PRESS OPENINGS/CYCLE (def: 24.): 32 SPECIFY NUMBER
PRESSURE CYCLES (def: 1): _
SPECIFY PANEL BLOW RATE (def:.02): _
PRESS TIME = 5.353030 minutes
IS ESTIMATED PRESS TIME OK, IF NOT TYPE N: _

PRESS PRESSURE	175.00	PRESS TEMP	280.00
PRESS OPENINGS	32.00	LOAD TIME/OPNG	3.00
NUMBER CYCLES	1.00	TARG PAN THICK	.50
PANEL BLOW RATE	.02		

# PRESSES	OUTPUT (CFT/HR)
5.99	2338.13

TO REDO THESE VALUES TYPE N. TO CONTINUE HIT NEW LINE
IF FEEDRATE NEEDS TO BE ADJUSTED TYPE “F” _

Screen 15

# TRIMMERS	OUTPUT (MSF/HR)
1.532	70.577

TOTAL BTU USAGE

BTU NEEDED	BTU AVAILABLE
184.622700	176.045 100

HIT RETURN TO CONTINUE _

Screen 16

Staffing requirements are specified in the next section (Screen 17). Forklift and maintenance crew sizes are estimated within the program based on the number of lathes and presses. If the calculated number of employees varies significantly from actual, it can be compensated for by specifying larger (or smaller) numbers in one of the other work centers requiring user input. Total work hours, including those of supervisors, are estimated at 156. Wages paid per hour, including fringe benefits, are estimated at $2,445. This is higher than the base wage multiplied by the number of hours because supervisors and skilled employees are paid more.

Value of cores is based on the estimated selling value of studs and chips (Screen 18). Values are calculated separately for target size cores and spinout cores. Spinout cores are assumed to be chipped and carry a value based on chip selling values. Based on the average core value, estimated revenue per hour is $462.

```
ARE DEFAULT VALUES OK FOR STAFFING (Y/N) Y
     HOURLY WAGE              14.50    NO. SUPERVISORS        9.00
     CREW/LATHE                2.00    STACKERS/LATHE         8.00
     CREW/DRYER                1.34    CREW/REDRYER           1.00
     STACKERS/DRYER            3.00    CREW/STRINGER          2.00
     CREW/LAYUP LINE           4.00    WHRS & SHIPPING        3.00

     TOT FKLFT CREW           15.92    MAINT. CREW           17.31
TOTAL EMP. HRS                     TOTAL WAGE/HR
      156.00                             2445.54
______________________________________________________
TO REDO THESE VALUES TYPE N.   TO CONTINUE HIT NEW LINE _
```

Screen 17

```
ARE DEFAULT VALUES OK FOR CORE VALUE (Y/N) Y
     STUD PRICE              160.00    CHIP PRICE            41.00
     TARG CORE VALUE           1.12    SPINCORE VALUE         1.98

              # OF CORES            REVENUE
                 412.16              461.92

TO REDO THESE VALUES TYPE N.   TO CONTINUE HIT NEW LINE _
```

Screen 18

Timber costs are based on the relationship of the value of the log of the specified diameter to the value of a standard log, in this case No. 2 sawlog grade Douglas Fir (Screen 19). Based on an average delivered cost of $320 per thousand board feet for No. 2 grade sawlogs, the delivered cost for 14-in. logs is estimated at $299 per thousand board feet, or $1.46 ft^3.

In the next section (Screen 20), cost of propane and electricity are specified. Diesel fuel and natural gas costs were specified at the log deck section.

```
ARE DEFAULT VALUES OK FOR TIMBER COSTS (Y/N) N
SPECIFY DELIVERED DOUG.FIR #2 SAWLOG COST
        (def: 310.00/MBF,SCRIBNER) 320
TIMBER COSTS FOR 14. INCH LOGS

COST/CU.FT      WOOD COST $/MBF
   1.46              298.77

TO REDO THESE VALUES TYPE N.   TO CONTINUE HIT NEW LINE _
```

Screen 19

```
ARE DEFAULT VALUES OK FOR FUEL & ELEC. COSTS (Y/N) Y
    PROPANE COST            .75        ELECTRICITY            .05
____________________________________________________
TO REDO THESE VALUES TYPE N.   TO CONTINUE HIT NEW LINE _
```

Screen 20

Overhead and depreciation costs are specified next (Screen 21). Operating and maintenance supplies are specified as fraction of direct labor costs. Insurance and property tax costs are based on the estimated annual expense. Capital recovery expense depends on the amount to be depreciated, the capital recovery period, and the annual interest rate (expressed as a fraction).

Revenues are specified for panels meeting grade, mill certified panels, blows and rejects, and B and better grade veneer (if B grade is assumed sold rather than processed within the mill) (Screen 22).

```
ARE DEFAULT VALUES OK FOR OVERHEAD & DEPRECIATION (Y/N) N
SPECIFY OP. SUPPLIES AS FRACTION OF DIR LAB COST (def:.13): _
SPECIFY MAINTENANCE SUPPLIES AS FRACTION OF DIR
     LAB COSTS (def:. 13): _
SPECIFY ANN. PROP. TAXES & INSUR. (def: $.25 mil): _
SPECIFY CAPITAL RECOVERY AMOUNT (def: $5.00 mil): 4.0 SPECIFY
CAPITAL COST (ANN. INT. RATE; def:.08 per year):_
SPECIFY CAPITAL RECOVERY PERIOD (def: 12 years): 10
    OP SUPPLY SHR                 MAINT SUPP SHR
           .130                         .125
    CAPITAL AMOUNT                ANN. INTEREST
          4.000                         .080
    RECOVERY PERIOD               PR TAX&INS($M)
         10.000                         .250

    TAX & INS/MSF                 DEPREC./MSF
         2.07                          4.95

TO REDO THESE VALUES TYPE N.   TO CONTINUE HIT NEW LINE _
```

Screen 21

```
ARE DEFAULT VALUES OK FOR REVENUES (Y/N) N
SPECIFY PRICE OF APA GRADE PLYWOOD / MSF (surface measure)
     (def: $190.00): _
SPECIFY PRICE OF MILL GRADE PLYWOOD / MSF (surface measure)
     (def: $155.00) 150
SPECIFY PRICE OF REJECT PLYWOOD / MSF (surface measure)
     (ckf: $65.00) 55
SPECIFY PRICE OF B-GRADE VENEER / MSF (.129 basis)
     (def: $55.00) _
    PRICE APA PLY       190.00   MILL PLY PRICE       150.00
    PRICE B+ VEN.        55.00   REJECT PLWD PR        55.00
    $/MSF(3/8) APA      $/MSF(3/8) MILL
        128.96                8.44

TO REDO THESE VALUES TYPE N.   TO CONTINUE HIT NEW LINE _
```

Screen 22

After the inputs have been supplied, the program calculates total costs, revenues, and profits (per thousand square feet, 3/8-in. basis). It prints out these results along with the estimated plywood recovery factor (Screen 23). It then asks if the user wants to save the results. If the response is Y, it asks for a file name. A name should be specified that is not already used. Next, a prompt appears for a file name to contain all the results for each diameter class (if only one diameter was specified, the saved results will be the same as for the previous file). Finally, it asks if the parameters specified in this run should be saved. To prevent having to input each assumption when running the program again, the user should type Y and direct the output to a file that can be referenced for future runs. It is not necessary to save assumptions when only a few parameters are changed. As before, care should be taken to indicate a file name that has not been used before.

```
****************************************************************
* COSTS/MSF  REVENUE/MSF  PROFITS  RECOV. FACTOR *
*   140.7        145.4        4.7        16.2     *
****************************************************************

***END OF PASS     1
DO YOU WANT DATA FOR THIS DIAM SENT TO A FILE? Y/N: Y
ENTER NAME OF OUTPUT FILE BASERUN
FILE BASERUN HAS BEEN WRITTEN
ENTER NAME OF AVERAGE FILE:
BASEAVE
WOULD YOU LIKE TO SAVE INPUTS? (Y/N): Y
PLEASE ENTER NAME OF INPUT STORAGE FILE - OWNDEFLT
```

Screen 23

Program Outputs

Table 2a contains the first page of the contents of the file saved as BASERUN. It is broken into five sections, some summarizing key process parameters, others summarizing key results.

The SPECIFICATIONS section references some of the key process assumptions supplied by the user, such as log diameter, debarker speed, peel thickness, and dryer temperature. It also contains some process variables estimate&within the model. Examples are peel time, redry percentage, glue spread, and gross compression loss (percentage difference in thickness of panel before and after pressing).

The INPUTS AND OUTPUTS PER HOUR section traces the material flow through each stage of processing and indicates calculated machinery and labor requirements. The NUM. SHIFTS column indicates the number of shifts required of each machine center. The standard is one shift per day. A value of two is equivalent to a requirement of two shifts per day for that machine, three is three shifts per day, and so on.

The COSTS section contains the estimated amounts of variable inputs required per “hour” of operation, where an hour has multiple shifts running simultaneously. Next to the required amount is the unit cost of each input and the cost of the item per unit of finished output.

The REVENUES section details the volumes of products produced, their unit prices, and revenues generated per unit of output.

The first line of the MARGINS section contains total costs, primary product revenues, and net margins per standard hour of operation. The product recovery factor, annualized output, and annualized margins are shown on the second line. Annualized data are based on 7 h per shift, 5 days per week, and 48.8 weeks per year. That is, to get the annualized equivalent of any hourly volume or value, it is multiplied by 1,708. The NET COSTS/MSF entry includes both variable and overhead costs (not shown on this table) less revenues for residues.

At the bottom, the estimated energy balance for the mill is displayed. If negative, the deficit is assumed to be made up through market fuel purchases.

Table 2b contains a line item display of estimated costs and revenues by each process center and cost category. The data are displayed in terms of dollars per square feet, surface measure, and dollars per square feet, standard 3/8-in. measure.

Table 3 displays relevant process and economic data for each log diameter. Since in this case only one diameter was specified, it repeats much of the information contained in Tables 2a and 2b. Table 3 was intended to aid overall process center utilization balancing when more than one log size is specified, since what balances one log size will not necessarily balance another. By checking the last column in the CENTER OPERATION, # SHIFTS block, the user can see if the specified process parameters achieved a reasonably balanced process center utilization. Several model iterations may be required to achieve such a balance.

Table 2a–PLYMAP base run output file

V1.3 PLYMAP OUTPUT FILE (1): D.FIR 3/3/89

----SPECIFICATIONS----

LOG LENGTH	34.80	feet	MAX CLIP SPEED	400.0	fpm
LOG DIAMETER	14.00	inches	DRIER TEMP.	370.0	deg
LOG COST	298.77	$/mbf	TARGET M.C.	4.5	percent
DEBARKER SPEED	65.00	fpm	REDRY M.C.	7.5	percent
CONDITIONING TIME	9.05	hours	DRIER DOWNTIME	.08	share
CORE RADIUS	2.65	inches	TOTAL REDRY	15.2	percent
SPINOUT CORE RAD.	4.70	inches	NUMBER OF PLIES	4.0	
SPINOUT FRACTION	.08		GLUE SPREAD	37.3	lbs/MSG
LATHE CHARGE TIME	4.00	seconds	LAYUP LINE SPEED	78.0	fpm
BOLT RNDUP. TIME	3.14	seconds	PRESS TEMP.	280.0	deg
TOTAL PEEL TIME	14.42	seconds	PRESS TIME	5.4	minutes
GR VEN THICKNESS	.129	inches	OPENINGS/PRESS	32.0	
THICKNESS VAR.	.007	inches	LOAD TIME/OPENG.	3.0	seconds
MAX RIBBON FLOW	745.	fpm	UNSAND PAN THICK	.485	inches
MAX LATHE RPM	350.	rpm	GROSS COMP.LOSS	5.0	percent

----INPUTS AND OUTPUTS PER HOUR----

STATION	LFT LOG LENGTH	CU.FT. WOOD	CU.FT. LOSSES	ITEM	MSF(3/8) VENEER	NUM. SHIFTS	MACHINE CENTER	LABOR REQD.
DEBARKING	3897.6		18625.1	LBS. BARK		1.0	DEBARKERS	2.0
SLASHING	3830.4		78.7	LOG TRIM		1.0	SLASHSAWS	1.0
CONDITIONING	3830.4	4486.4				9.1	VATS	3.1
PEELING INPUT	3830.4	4486.4				2.0	LATHES	3.9
PEELING OUTPUT		3738.0	748.3	CORE & SPUR				
CLIPPER INPUT		3639.3	98.7	TRASHGATE		2.0	CLIPPERS	2.0
CLIPPER OUTPUT		2913.8	725.5	CLIPPER & FISHTAIL		2.0		
GREEN STACKING			99.1	B+ VENEER	93.2			16.1
DRYING		2545.7	269.0	SHRINKAGE	81.5	5.4	DRIERS	10.3
REDRY OUTPUT		328.9	58.0	REDRY	10.5	.4	DRIERS	.4
DRY STACKING		2436.8	50.9	DRYER	78.0			23.4
STRINGING		708.1	21.9	STRINGER	22.7	3.1	STRINGERS	6.1
PLUGGING		.0			.0	.0	PLUGGERS	.0
LAYUP OUTPUT		2402.7	12.1	LAYUP	77.1	3.0	LAY UP	11.9
PRESS OUTPUT		2338.1	64.6	COMPRESSION	77.1	6.0	PRESSES	6.0
TRIM & SANDING		2139.7	198.5	TRIM	70.6	1.5	TRIMSAWS	3.1

---COSTS---

EMPLOYEE HOURS	156.0	HRS/HR	WAGES	14.50	$/HR	PER MSF (3/8)	34.11
DIESEL USAGE	33.5	G/HR	COST	1.25	$/GAL	"	.57
PROPANE USAGE	22.3	G/HR	COST	.75	$/GAL	"	.23
ELECTRICITY	5603.4	KWH	COST	.05	$/KWH	"	3.97
NATURAL GAS	85.8	THERMS	COST	.85	$/THRM	"	1.03
WOOD	44.9	CUNITS	COST	145.75	$/CUNIT	"	88.66
GLUE	6549.5	LBS	COST	12.01	$/100LB	"	11.14

----REVENUES----

PLYWOOD, APA GRADE	63.9	MSF/HR	PRICE	190.00	$/MSF	REV/MSF PAN	128.96
PLYWOOD. MILL CERT	5.3	MSF/HR	PRICE	155.00	$/MSF	REV/MSF PAN	8.72
PLYWOOD, BLOWS	1.4	MSF/HR	PRICE	65.00	$/MSF	REV/MSF PAN	.97
B VENEER, 3/8	3.2	MSF/HR	PRICE	55.00	$/MSF	REV/MSF PAN	7.19
TARGET CORES	412.2	NUM/HR	PRICE	1.12	$/CORE	REV/MSF PAN	6.26
CHIPS	10.9	TONS	PRICE	41.00	$/TON	REV/MSF PAN	6.08

---MARGINS---

NET COSTS/MSF	140.7 $	REVENUES/MSF	145.8 $	MARGIN/MSF	5.2 $
SF/CFT RECOVERY	16.2	PRODUCTION/YR	120.5 MMSF	MARGIN/YR	.62 $MIL.
BTUs AVAILABLE	176.0	BTUs NEEDED	184.6	EXCESS BTUs	-8.6 MILS.

Table 2b–Direct and overhead costs, revenues, and profit for PLYMAP base run

DIRECT & OVERHEAD COSTS FOR 4.-PLY .500 -INCH THICK PLYWOOD

	$/MSM	$/MSF(3/8)
DIRECT LABOR		
GREEN END	10.21	7.66
DRYING	11.91	8.93
VENEER PLUGGING	.00	.00
VEN. STRINGING	1.92	1.44
LAYUP & PRESS	6.85	5.13
TRIMMING	.96	.72
SHIPPING	.94	.70
TOTAL	32.79	24.59
MATERIAL COSTS		
WOOD	118.22	88.66
CORES (-)	8.35	6.26
CHIPS (-)	8.10	6.08
GLUE	14.86	11.14
TOTAL	116.62	87.47
PLANT OVERHEAD		
SUPERVISION	4.72	3.54
INDIRECT LABOR	1.19	.89
MAINT. LABOR	6.77	5.08
POWER & FUEL	7.73	5.80
OPER. SUPPLIES	4.26	3.20
MAINT. SUPPLIES	4.10	3.07
TOTAL	28.78	21.58
DEPRECIATION	6.59	4.95
TAXES & INSUR.	2.77	2.07
TOTAL COSTS	187.55	140.66
TOTAL REVENUES	194.45	145.84
PLANT PROFIT	6.91	5.18

Table 3–PLYMAP summary table for all diameters

V1.3 SUMMARY TABLE OF PLYMAP RUN FOR .50-INCH 4. PLY PLYWOOD 3/3/89

SPECIFICATIONS

DEBARKER SPEED fpm	RIBBON SPEED fpm	SPINOUT RATE	CLIPPER FULL fpm	SPEED RNDUP fpm	DRYING TIME SAP min	DRYING TIME HEART min	LAYUP SPEED fpm	PRESS TEMP. deg	PRODUCT PRICE $/MSF
65.0	745.	.08	400.	260.	8.2	3.5	78.0	280.	190.

			OUTPUT PER HOUR				
BLOCK SIZES (inches)	14.0	.0	.0	.0	.0	:	14.0
DISTRIBUTION (%)	100.0	.0	.0	.0	.0	:	100.0
COST ($/Cunit)	145.7	.0	.0	.0	.0	:	145.7
BOLTS (hrly rate)	448.0	.0	.0	.0	.0	:	448.0
GREEN VEN. RECOV.(%)	63.8	.0	.0	.0	.0	:	63.8
DRY VEN. RECOV. (%)	49.0	.0	.0	.0	.0	:	49.0
REDRY (%)	15.2	.0	.0	.0	.0	:	15.2
FINISHED PLY (msf, 3/8)	70.6	.0	.0	.0	.0	:	70.6
MILL CERTIF. (msf, 3/8)	5.3	.0	.0	.0	.0	:	5.3
MILL BLOWS (msf, 3/8)	1.4	.0	.0	.0	.0	:	1.4
GREEN B+ VEN (msf, 3/8)	3.2	.0	.0	.0	.0	:	3.2
			WORK CENTER, 0 SHIFTS				
LATHES	2.0	.0	.0	.0	.0	:	2.0
CLIPPERS	2.0	.0	.0	.0	.0	:	2.0
DRIERS	5.4	.0	.0	.0	.0	:	5.4
REDRIERS	.4	.0	.0	.0	.0	:	.4
PLUGGERS	.0	.0	.0	.0	.0	:	.0
LAYUP	3.0	.0	.0	.0	.0	:	3.0
PRESSES	6.0	.0	.0	.0	.0	:	6.0
			COST PER MSF(3/8)				
DIRECT LABOR:							
GREEN END	7.7	.0	.0	.0	.0	:	7.7
DRYING	8.9	.0	.0	.0	.0	:	8.9
VENEER PLUGGING	.0	.0	.0	.0	.0	:	.0
VENEER PREPARATION	1.4	.0	.0	.0	.0	:	1.4
LAYUP & PRESS	5.1	.0	.0	.0	.0	:	5.1
TRIMMING	.7	.0	.0	.0	.0	:	.7
SHIPPING	.7	.0	.0	.0	.0	:	.7
TOTAL	24.6	.0	.0	.0	.0	:	24.6
MATERIAL COSTS:							
WOOD	88.7	.0	.0	.0	.0	:	88.7
CORES (-)	6.3	.0	.0	.0	.0	:	6.3
CHIPS (-)	6.1	.0	.0	.0	.0	:	6.1
GLUE	11.1	.0	.0	.0	.0	:	11.1
TOTAL	87.5	.0	.0	.0	.0	:	87.5
PLANT OVERHEAD:							
SUPERVISION	3.5	.0	.0	.0	.0	:	3.5
INDIRECT LABOR	.9	.0	.0	.0	.0	:	.9
MAINTENANCE LABOR	5.1	.0	.0	.0	.0	:	5.1
POWER AND FUEL	5.8	.0	.0	.0	.0	:	5.8
OPERATING SUPPLIES	3.2	.0	.0	.0	.0	:	3.2
MAINTENANCE SUPPLIES	3.1	.0	.0	.0	.0	:	3.1
PROP. TAXES & INSUR.	2.1	.0	.0	.0	.0	:	2.1
DEPRECIATION	4.9	.0	.0	.0	.0	:	4.9
TOTAL	28.6	.0	.0	.0	.0	:	28.6
TOTAL COSTS:	140.7	.0	.0	.0	.0	:	140.7
TOTAL REVENUE:	145.8	.0	.0	.0	.0	:	145.8
PROFIT:	5.2	.0	.0	.0	.0	:	5.2
ANNUAL OUTPUT (MMSF)	120.5	.0	.0	.0	.0	:	120.5
ANNUAL PROFIT (MIL$)	.6	.0	.0	.0	.0	:	.6

Running Alternative Simulations

Once the system parameters have been made representative of mill conditions, the program can be used to analyze other economic or process assumptions. When considering changes to an existing process, it is important to determine which parameters will be affected and by how much. If the change involves a piece of machinery, for example, system changes should be developed in conjunction with the supplier (i.e., what are the performance levels the vendor is willing to guarantee?). If the modification involves a change in raw material utilization, what cost differences is the log buyer estimating? Capital costs incurred in the change, if any, should also be determined.

Once agreement is reached on the likely effects, then the program is ready to be run with the modified parameters. The resulting estimate of mill performance, when compared with the base run, gives an indication of the economic effects of the change. Sensitivity tests, in which economic rather than process assumptions are allowed to vary, can also be made to see how the modification fares under alternative scenarios. These analyses provide some guide to the risks incurred in making a change.

As an example, we assume that the lathe is currently equipped with a fixed nosebar. A supplier estimates that replacing the fixed nosebar by a powered nosebar would reduce the incidence of spinouts and plugups. Spinouts are guaranteed to drop to at least 0.04 from the current 0.08, while plugups are guaranteed to drop from 1 in 16 to 1 in 50 (0.0625 to 0.02). In addition, the average size of those blocks that do spin out is expected to decline from 4.7 to 4.0 in. The quality of the peel is guaranteed to stay unchanged. The in-place cost of the investment is $250 thousand with a projected life of 2 years.

The saved process parameters in the previous example were modified to reflect the above claims. The initial results indicated that with all other process parameters left unchanged, significantly more veneer would be produced than the clipper could handle. To stay within the clipper's limits, the number of blocks processed per hour was reduced by 1.6 percent in the debarker section. With fewer blocks to process, the peeling speed was reduced to 700 ft/min (Screen 24). Clipper utilization remained approximately the same as in the base run, but with more full-width veneer (which is clipped faster), clipper efficiency increased, resulting in greater veneer throughput.

ARE DEFAULT VALUES OK FOR LATHE (Y/N) N
IS LINEAR POSITIONING USED TO DRIVE CARRIAGE? 0 = NO 1 = YES(def:0) _
SPECIFY WHETHER BOLT IS PREROUNDED 0 = NO 1 = YES (def: 0) _
SPECIFY AVERAGE SPUR WIDTH (def:.80 in): _
SPECIFY TARGET VENEER THICKNESS (def:.1290 in.): _
SPECIFY ST. DEV. OF THICKNESS (def:.0070): _
CORE RADIUS (def: 2.65 in.): _
CHARGE TIME (def: 4.00 seconds): _
SPECIFY TARGET VENEER SHEET SPEED (def: 745): 700
SPECIFY MAX. LATHE RPM (def: 350): _
SPECIFY WHETHER POWERED NOSEBAR IS USED 0 = NO 1 = YES (def: 0) 1
NOTE:SPINOUT & PLUGUP RATES SHOULD BE CONSISTENT W/NOSEBAR TYPE
SPINOUT RATE (def:.0800): .04
AVERAGE RADIUS SPINOUT CORE (def: 4.70 in.): 4.0
SPECIFY LATHE DOWNTIME RATIO (def:.0600): _
SPECIFY PLUGUP RATE FOR BLOCKS (def:.0625): .02

VEN. THICK.	.129	CORE RADIUS	2.650
ST. DEV. VEN	.007	SPUR WIDTH	.800
TARG SHT SPD	700.000	MX LATHE RPM	350.000
SPINOUT RATE	.040	SPINOUT CORE	4.000
DWNTIM RATIO	.060	PLUGUP RATE	.020
CHARGE TIME	4.000		

# LATHES	PEELTIME
1.971	14.983
CUB FT/HR	BOLTS/HR
3747.539	440.800

TO REDO THESE VALUES TYPE N. TO CONTINUE HIT NEW LINE _

Screen 24

Capital expenditures were also factored in by changing the depreciable capital amount and the capital recovery period (Screen 25). The amount of depreciable assets was increased to $4.25 million, while the average capital recovery period was decreased to $9.53 years, the weighted average of the useful lives of the existing and the new equipment ((10 x 4 + 2 x 0.25)/4.25). All other inputs were unchanged.

The results of these changes are contained in Table 4. The annual margin is estimated at $0.78 million as compared to $0.62 million under the base run for an increase of $0.16 million. This indicates the approximate magnitude of the net improvement if the investment achieves the claimed performance levels.

```
ARE DEFAULT VALUES OK FOR OVERHEAD & DEPRECATION (Y/N) N
SPECIFY OP. SUPPLIES AS FRACTION OF DIR LAB COST (def: 13): _
SPECIFY MAINTENANCE SUPPLIES AS FRACTION OF DIR LAB
COSTS (def:.13): _
SPECIFY ANN. PROP. TAXES & INSUR. (def: $.25 mil): _
SPECIFY CAPITAL RECOVERY AMOUNT (def: $4.00 mil): 4.25
SPECIFY CAPITAL COSTS (ANN. INT. RATE) (def:.08 per yr): _
SPECIFY CAPITAL RECOVERY PERIOD (def: 10 yrs): 9.53
        OP SUPPLY SHR               MAINT SUPP SHR
             .130                        .125
        CAPITAL ($M)                ANN. INTREST
             4.250                       .080
        RECOV. PERIOD               PR TAX&INS($M)
             9.530                       .250

        TAX & INS/MSF               DEPREC./MSF
             2.057                       5.384

TO REDO THESE VALUES TYPE N.   TO CONTINUE HIT NEW LINE _
```

Screen 25

Table 4–PLYMAP alternative run output file

V1.3 PLYMAP OUTPUT FILE (1): D.FIR 3/6/89

----SPECIFICATIONS----

LOG LENGTH	34.80	feet	MAX CLIP SPEED	400.0	fpm
LOG DIAMETER	14.00	inches	DRIER TEMP.	370.0	deg
LOG COST	298.77	$/mbf	TARGET M.C.	4.5	percent
DEBARKER SPEED	64.00	fpm	REDRY M.C.	7.5	percent
CONDITIONING TIME	9.05	hours	DRIER DOWNTIME	.08	share
CORE RADIUS	2.65	inches	TOTAL REDRY	14.9	percent
SPINOUT CORE RAD.	4.00	inches	NUMBER OF PLIES	4.0	
SPINOUT FRACTION	.04		GLUE SPREAD	37.3	lbs/MSG
LATHE CHARGE TIME	4.00	seconds	LAYUP LINE SPEED	78.0	fpm
BOLT RNDUP. TIME	3.34	seconds	PRESS TEMP.	280.0	deg
TOTAL PEEL TIME	14.98	seconds	PRESS TIME	5.4	minutes
GR VEN THICKNESS	.129	inches	OPENINGS/PRESS	32.0	
THICKNESS VAR.	.007	inches	LOAD TIME/OPENG.	3.0	seconds
MAX RIBBON FLOW	700.	fpm	UNSAND PAN THICK	.485	inches
MAX LATHE RPM	350.	rpm	GROSS COMP.LOSS	5.0	percent

----INPUTS AND OUTPUTS PER HOUR----

STATION	LFT LOG LENGTH	CU.FT. --WOOD	CU.FT. LOSSES	ITEM	MSF(3/8) VENEER	NUM. SHIFTS	MACHINE CENTER	LABOR REQD.
DEBARKING	3835.0		18325.8	LBS. BARK		1.0	DEBARKERS	2.0
SLASHING	3768.8		77.4	LOG TRIM		1.0	SLASHSAWS	1.0
CONDITIONING	3768.8	4414.3				9.0	VATS	3.1
PEELING INPUT	3768.8	4414.3				2.0	LATHES	3.9
PEELING OUTPUT		3747.5	666.7	CORE & SPUR				
CLIPPER INPUT		3650.4	97.1	TRASHGATE		2.0	CLIPPERS	2.0
CLIPPER OUTPUT		2935.8	714.7	CLIPPER & FISHTAIL		2.0		
GREEN STACKING			99.9	B+ VENEER	93.9			16.1
DRYING		2564.9	271.0	SHRINKAGE	82.1	5.4	DRIERS	10.2
REDRY OUTPUT		325.6	57.5	REDRY	10.4	.4	DRIERS	.4
DRY STACKING		2456.2	51.3	DRYER	78.6			23.3
STRINGING		708.5	21.9	STRINGER	22.7	3.1	STRINGERS	6.2
PLUGGING		.0			.0	.0	PLUGGERS	.0
LAYUP OUTPUT		2422.0	12.2	LAYUP	77.7	3.0	LAY UP	12.0
PRESS OUTPUT		2356.9	65.1	COMPRESSION	77.7	6.0	PRESSES	6.0
TRIM & SANDING		2156.9	200.0	TRIM	71.1	1.5	TRIMSAWS	3.1

---COSTS--

EMPLOYEE HOURS	156.3	HRS/HR	WAGES	14.50	$/HR	PER MSF (3/8)	33.91
DIESEL USAGE	33.6	G/HR	COST	1.25	S/GAL	"	.56
PROPANE USAGE	22.4	G/HR	COST	.75	$/GAL	"	.23
ELECTRICITY	5636.6	KWH	COST	.05	$/KWH	"	3.96
NATURAL GAS	94.9	THERMS	COST	.85	$/THRM	"	1.13
WOOD	44.1	CUNITS	COST	145.75	$/CUNIT	"	86.55
GLUE	6602.1	LBS	COST	12.01	$/100LB	"	11.14

----REVENUES----

PLYWOOD, APA GRAD;	64.4	MSF/HR	PRICE	190.00	$/MSF	REV/MSF PAN	128.96
PLYWOOD, MILL CERT	5.3	MSF/HR	PRICE	155.00	$/MSF	REV/MSF PAN	8.72
PLYWOOD, BLOWS	1.4	MSF/HR	PRICE	65.00	$/MSF	REV/MSF PAN	.98
B VENEER, 3/8	3.2	MSF/HR	PRICE	55.00	$/MSF	REV/MSF PAN	7.18
TARGET CORES	423.2	NUM/HR	PRICE	1.12	$/CORE	REV/NSF PAN	6.38
CHIPS	9.7	TONS	PRICE	41.00	$/TON	REV/MSF PAN	5.34

----MARGINS----

NET COSTS/MSF	139.4 $	REVENUES/MSF	145.8 $	MARGIN/MSF	6.4 $
SF/CFT RECOVERY	16.6	PRODUCTION/YR	121.5 MMSF	MARGIN/YR	.78 $MIL.
BTUs AVAILABLE	174.6	BTUs NEEDED	184.1	EXCESS BTUs	-9.5 MILS.

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Appendix-List of Inputs

ADHWST	- Adhesive loss factor, net of trim loss; default is 0.05
AV	- Average forced air velocity inside dryer; default is 4000 ft/min
AVPROD	- Average plugger productivity in sheets per hour; default is 150
BLENGTH	- Average length of bucked blocks; default is 8.6 ft
BLPHR	- Number of long logs processed per hour; default is 50
BVENPR	- Price of B and better grade veneer; default is $55 per thousand square feet, surface measure
CAPITAL	- Amount of depreciable capital; default is $6 million
CHARGE	-Time from coredrop to knife contact with next bolt; default is 3 s
CLOADER	- Number of loaders used in moving bolts to and from vats (2)
CHIPS	- Selling price of chips; default is $40/BDU
CORE	-Target core radius; default is 2.15 in.
COSTBLD	- Blood cost; default is $0.45/lb
COSTEX	- Extender cost; default is $0.12/lb
COSTFIL	- Filler cost; default is $0.10/lb
COSTPF	- Solid resin cost; default is $0.33/lb
COSTSC	- Caustic soda cost; default is $0.07/lb
CPKWH	- Cost of electricity; default is $0.05/kWh
DDECKS	- Number of decks per dryer; default is 4
DEBFPM	- Effective debarker feedrate in ft/min; default is 112 ft/min
DIAM(I)	- Diameter of the ith diameter class
DIST	- Distance between infeeding strips of veneer to stringer; default is 0.2 ft
DEXHAUST	- Percent heat loss through dryer exhaust; default is 40 percent
DIESEL	- Cost of diesel fuel ($/gal; default is $1.25/gal
DLOADER	- Number of logyard loaders; default is 2
DLOG	- Delivered log cost
DLOSS	- Percentage heat loss through dryer; default is 17 percent
DRIERLT	- Dryer length; default is 100 ft
DRDOWN	- Operational dryer downtime ratio; default is 0.05)
DREJECT	- Rate of veneer loss in primary drying; default is 0.02
DTEMP	- Dryer temperature; default is 360°F
DTIMEL	- Lathe and green end downtime rate; default is 0.07
DTYPE	- Dryer type, jet (J) or longitudinal (L); default is J
FACE	- Face grade; C or C-plugged and better (If C-plugged or better is specified, then the model assumes the panels will be plugged and sanded. Otherwise, these work centers are skipped.)
FMC	- Dry veneer target moisture content; default is 4 percent
FPML	- Target veneer sheet speed; default is 425 ft/min
FSHFPM	- Clipper speed, full width sheets; default is 375 ft/min
FSHWDTH	-Target full sheet width; default is 53.25 in.
GLUADH	- Adhesive; default is 6,500 lb
GLUBLD	- Blood; default is 0 lb
GLUCAUS	- Caustic soda; default is 350 lb
GLUEX	- Extender; default is 600 lb
GLUFIL	- Filler; default is 700 lb
GLUH20	-Water; default is 1,850 lb
GLURESPC	- Resin solid content share of adhesive; default is 0.43

HP	- Average horsepower of logyard loaders; default is 200
HPC	- Average horsepower of vat loaders; default is 200
IFOAM	- Type of layup system; foam or other
IHIMOIS	- Type of glue mix used; low-moisture or high-moisture
IROUND	- Prerounding (0 is no (default), 1 is yes)
KANS	- Indicates whether A and B grade veneers are sold (default) or processed within the mill
LINPOS	- Type of carriage drive; default is mechanical
LODTIM	- Time to unload and load each press opening; default is 2.5 s
LUPFPM	- Layup line speed expressed as lineal feet of panels per minute; default is 63 ft/min
NBAR	- Nosebar type (0 is fixed or small roller (default), 1 is large diameter roller)
NSPECIE	- Species (Douglas Fir, white fir, ponderosa pine, or Southern Pine)
NUMCYC	- Number of pressure reductions during the pressure cycle; default is 1 (constant pressure during the cycle)
NUMDIAM	- Number of diameter classes (1, 2, 3, 4, or 5)
OPDRY	- Crew size per dryer, infeed; default is 1.34
OPDST	- Crew size per dryer, veneer stacking; default is 3
OPGST	- Crew size per green veneer stacking line; default is 8
OPLATH	- Crew size per lathe; default is 2
OPLUP	- Crew size per layup station; default is 4
OPRDR	- Crew size per redryer, infeed; default is 1
OPSHIP	- Crew size, shipping; default is 3
OPSTRING	- Crew size per veneer stringer; default is 2
OPSUPL	- Operating supplies as fraction of direct labor costs; default is 0.13
PCPBLW	- Panel blow rate; default is 0.02
PCTWi	- Percentage of logs in diameter class i (total must add to 100)
PLIES	- Number of plies in a panel; default is 5 (This number depends on nominal panel and veneer thicknesses, so care should be taken to specify a number that is consistent with those variables.)
PLUGRPB	- Peel plugup rate due to slivering; default is 0.0625, or 1 in 16
PLYAPAPR	- Price of panels that meet grade; default is $190 per thousand square feet, surface measure
PLYMILPR	- Price of mill certified panels; default is $155 per thousand square feet, surface measure
PLYREJPR	- Price of rejects; default is $65 per thousand square feet, surface measure
PPROPANE	- Propane cost; default is $0.75/gal
PROPEN	- Number of press openings; default is 32
PRPRSS	- Press pressure; default is 175 lb/in^2
PRTEMP	- Press temperature; default is 280°F
RATE	- Annualized interest rate to be applied against capital invested; default is 0.08
RDRYLSS	- Redry loss rate; default is 0.15
RDTYPE	- Redryer type; conventional is 1, microwave is 2
REDRYMC	- Highest acceptable moisture content; default is 8 percent
RPML	- Maximum lathe rotations per minute; default is 400 rpm

RUPFPM - Clipper speed, roundup veneer; default is 250 ft/min

RUPTRASH - Proportion of roundup veneer that is sent directly to be chipped; default is 0.50

RYLTY - Adhesive system royalty payment, if any; default is $0.00/MSGL

RYRS - Capital recovery period. Default is 10 years

SDEVHMC - Standard deviation of moisture content in heart veneer; default is 5 percent

SDEVSMC - Standard deviation of moisture content in sap veneer; default is 18 percent

SDEVVT - Veneer thickness standard deviation; default is 0.006 in.

SLASHFPM - Slasher saw throughput; default is same as debarker, 40 ft/min

SLOSS - Stringer loss factor; default is 0.02

SNDFDR - Sander feedrate; default is 144 ft/min

SPINCORE - Average radius of cores that spinout; default is 3.6 in.

SPINOUT - Spinout rate; default is 0.02

SPNTHK - Panel thickness after sanding; default is 0.47 in.

SPUR - Average spur width; default is 0.8 in.

STEAM -Temperature of heating medium; default is 175°F

STLNGTH - Average length of long logs; default is 34.8 ft

STRFPM - Stringer speed; default is 82 ft/min

STUDS - Producer price of studs; default is $160 per thousand board feet

SUPERV - Number of supervisors per shift; default is 9

TAX - Annual property tax and insurance costs; default is $0.25 million

TEMPAMB - Ambient temperature inside mill; default is 60°F

TEMPFI - Target temperature at 4-in. core; default is 125°F

TEMPIN -Temperature of wood entering vats; default is 45°F

THERMS - Cost of natural gas ($/therm); default is $0.65/therm

TPNTHK - Nominal panel thickness; default is 1/2 in.

VATH - Vat height; default is 16 ft

VATL -Vat length; default is 80 ft

VENRUF - Veneer surface quality; rough (1), intermediate (2), smooth (3)

VTHICK - Veneer thickness; default is 0.1 in.

WAGE - Average wage per hour, including fringe benefits; default is $14.5/h

WASTLU - Core loss factor; default is 1 percent

XMASUPL - Maintenance supplies as fraction of direct labor costs; default is 0.125

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