Advancing Enhanced Wood Manufacturing Industries in Laos and Australia

Engineered Wood Product Production Training Manual

Collated by Adam Redman

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VALTIP3

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Chapter 1: Veneer processing

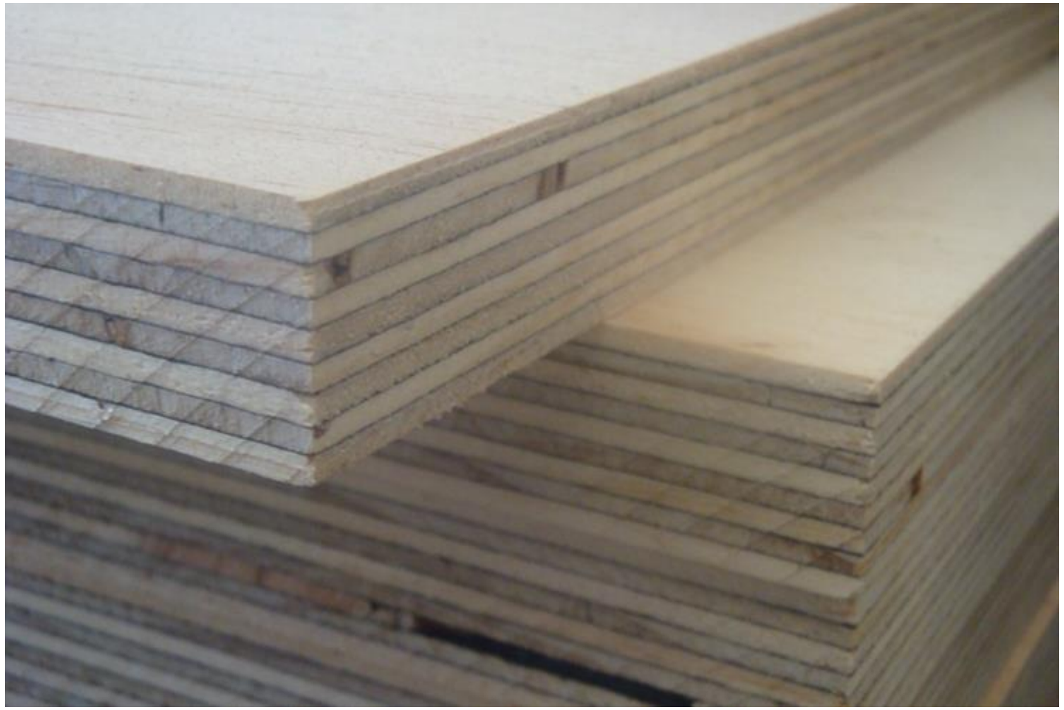
Adam Redman

Potential advantages
- High recovery
- Recovery of better qualities
- Segregation opportunities
- Overcome drying challenges
- Faster throughput

Important considerations
- Only produces feedstock
- Technically more complex
- Adhesive systems
- High infrastructure costs
- Scale

Example of veneer-based products

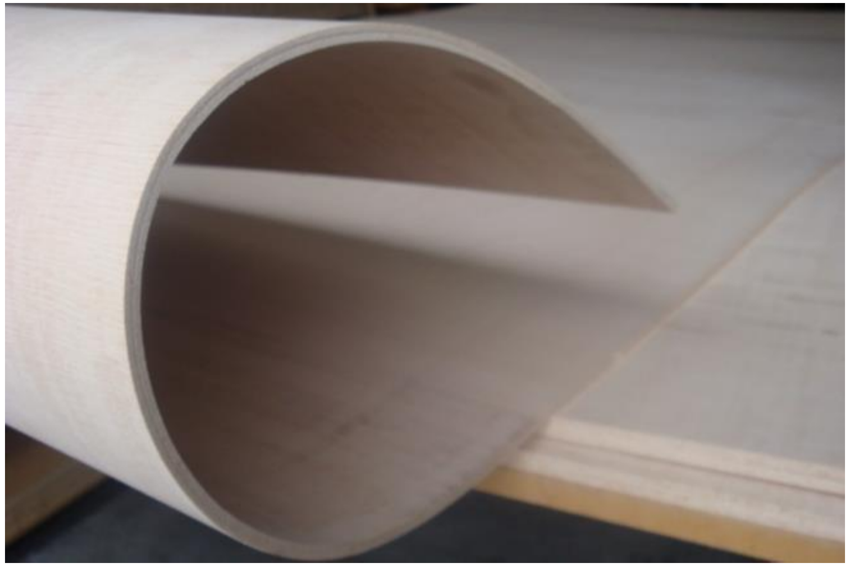
- Plywood
- Laminated veneer lumber
- Other……



Example of veneer-based products

- Structural
- Decorative

Example of veneer-based products



Overview

Three major production phases:

1. *Veneer manufacture*
2. *Clipping, drying and grading*
3. *Panel/product manufacture*

Overview

Veneer manufacture steps:

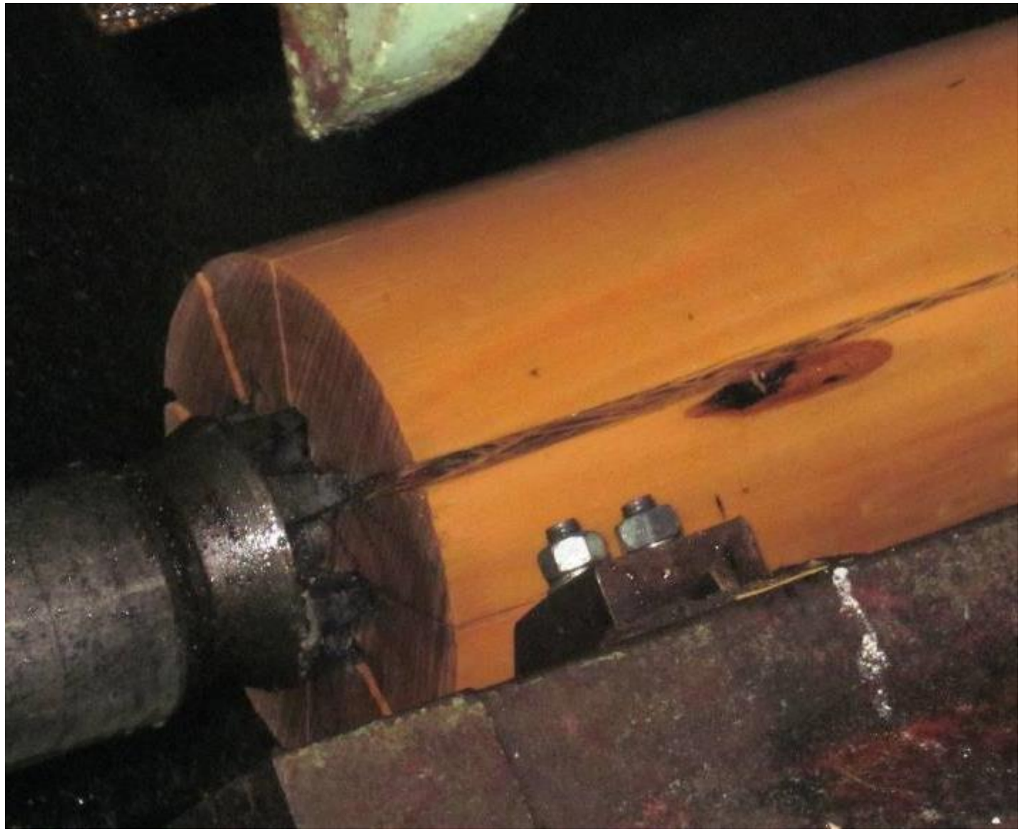
1. Debarking

2. Pre-conditioning

3. Scanning

4. Roundup

5. Rotary peeling



Debarking

• Removal of the fibrous bark
• Reduce the presence of dirt, sand and rocks
•Performed by hand, in a dedicated debarker or roundup lathe, peeling lathe (?)

Pre-conditioning

- Heating the billet without drying
- Softens the wood including hard knots
  - Easier to peel
  - Improves veneer quality
  - Easier on machinery (e.g. power, knife wear)

- Steam and water or hot water
- Softwoods 50 degrees C
- Hardwood 70+ degrees C

Billet Roundup

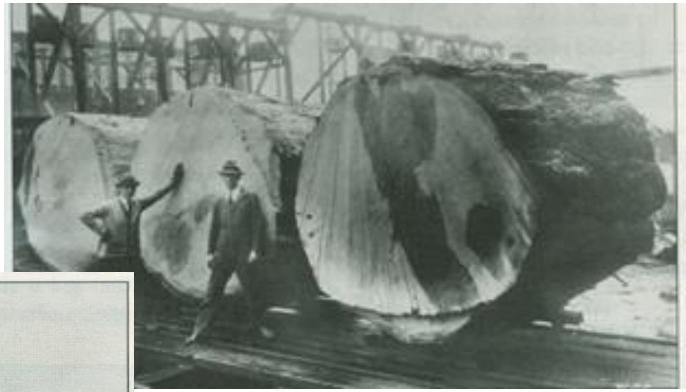
Roundup:

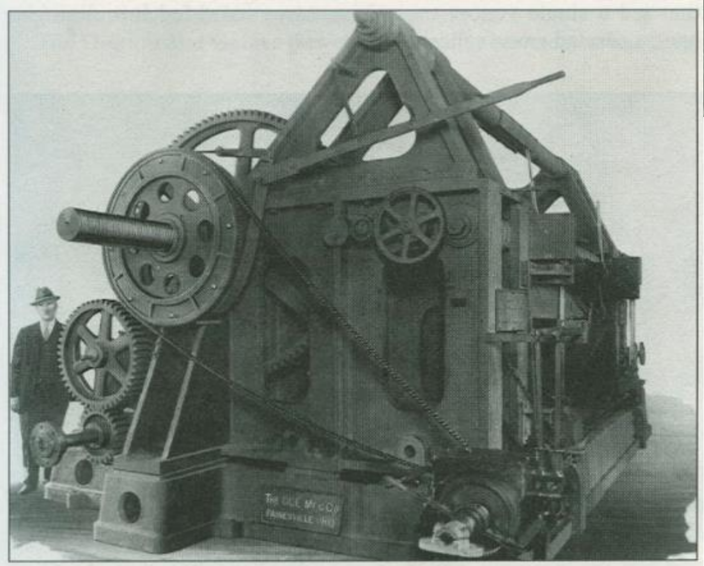
- **Aim to remove at least 50% of the natural billet surface**
  - **removes any foreign matter**
  - **provides a cylinder by removing branch stubs, sweep, ovality etc.**

- **Can be separate machine**
  - **generally simpler and more robust**
  - **protect peeling knife etc**

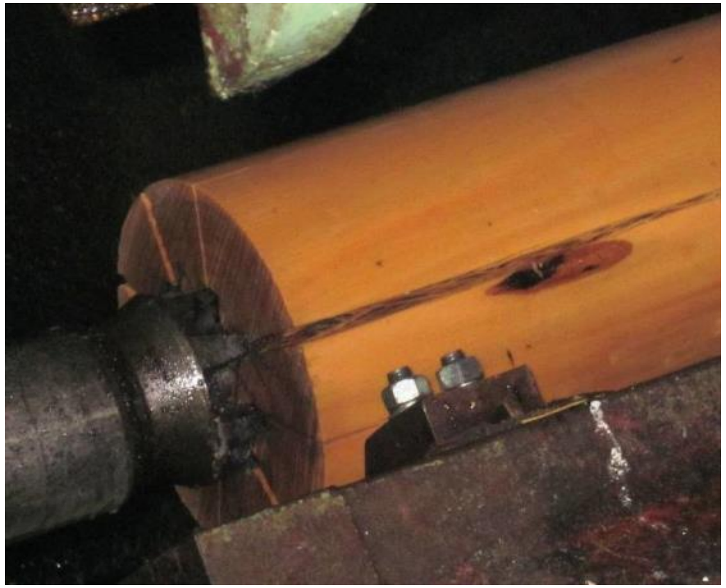
Rotary veneer processing

- **Range of technologies**
  - **Traditional spindled systems**
  - **Spindleless systems**
  - **Hybrid systems**





An early rotary veneer lathe. *Photo courtesy of Coe Mfg Co.*

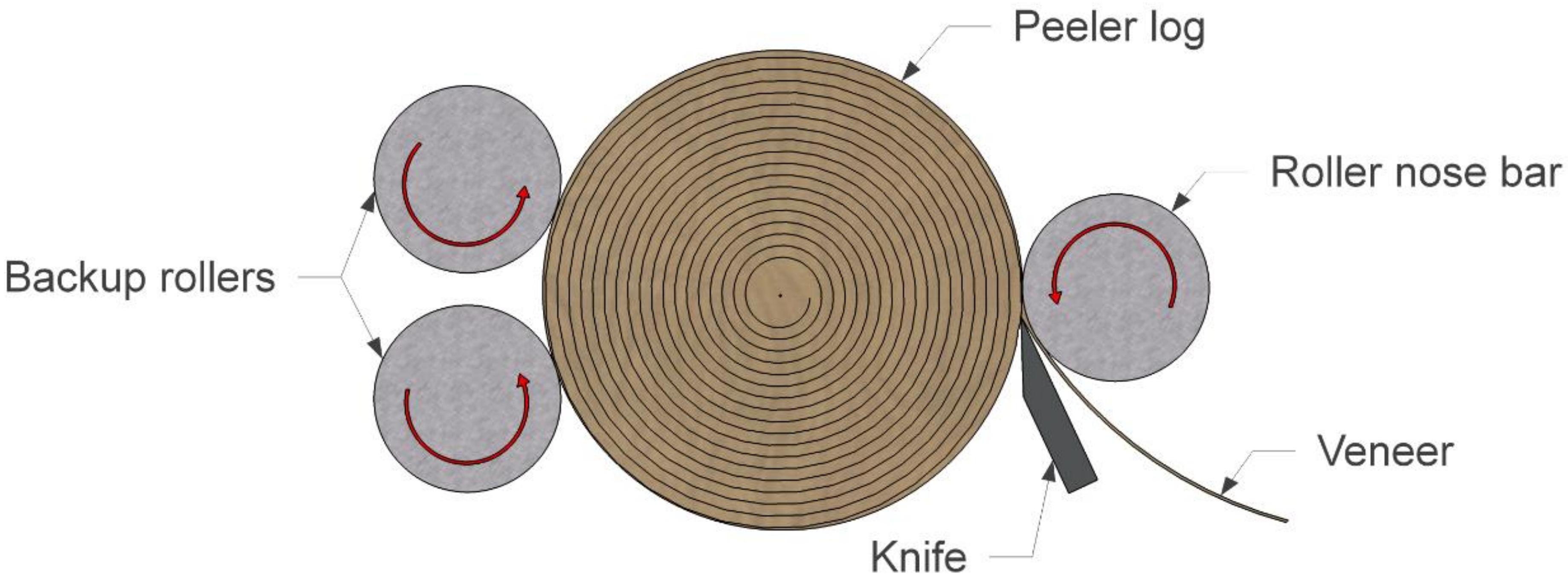


Rotary veneer processing

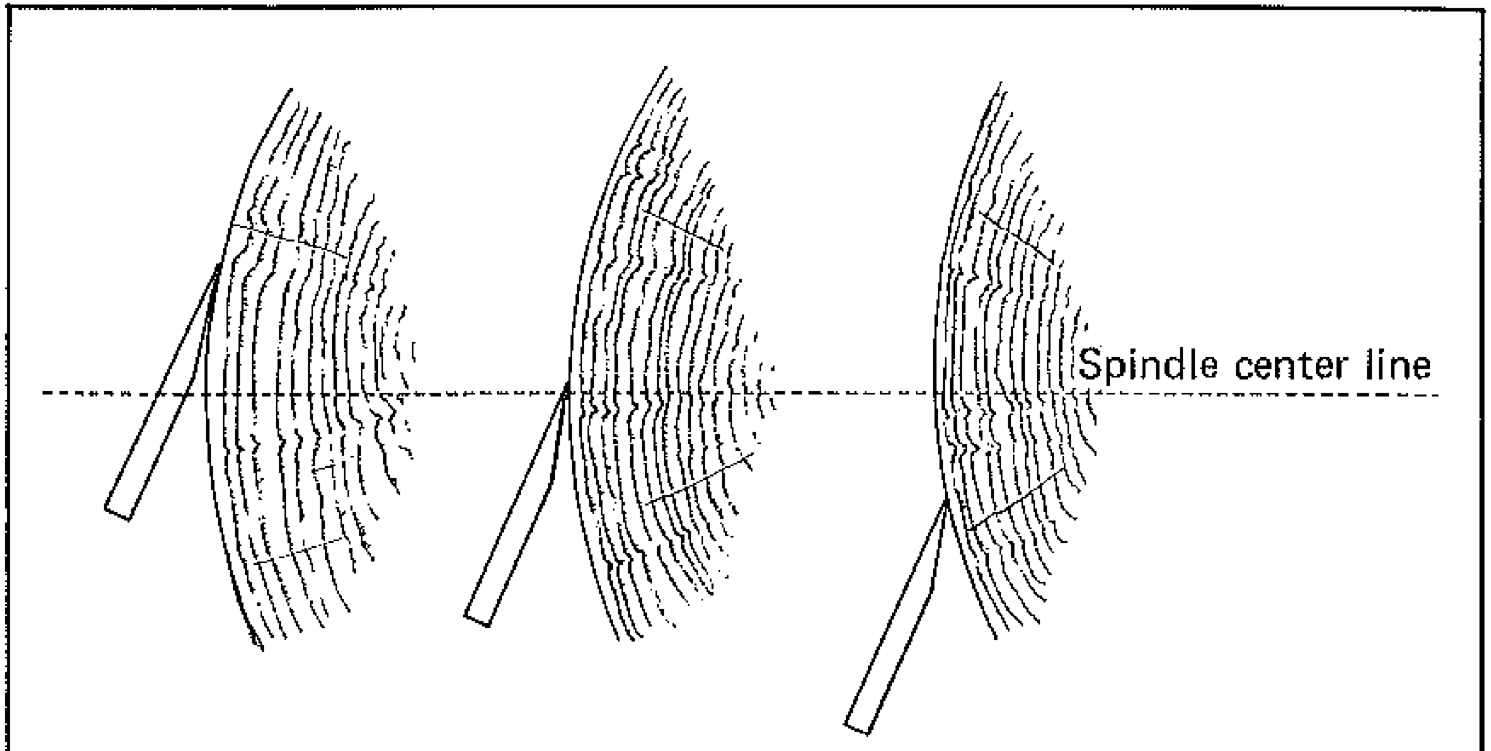
DAFF research spindleless veneer lathe

- 1.3 m billet length
- 400 mm max billet diameter
- 45 mm core diameter
- 0.8 to 3 mm veneer thickness

Rotary veneer processing



Knife height impact on cutting angle



Source: McCombe and Gottstein 1961, fig. 9.

FIGURE 8.2. Relationship between knife height and cutting angle. Setting knife above spindle center line decreases knife cutting angle. Setting it below spindle center line increases the knife cutting angle.

Impact of billet diameter on cutting angle

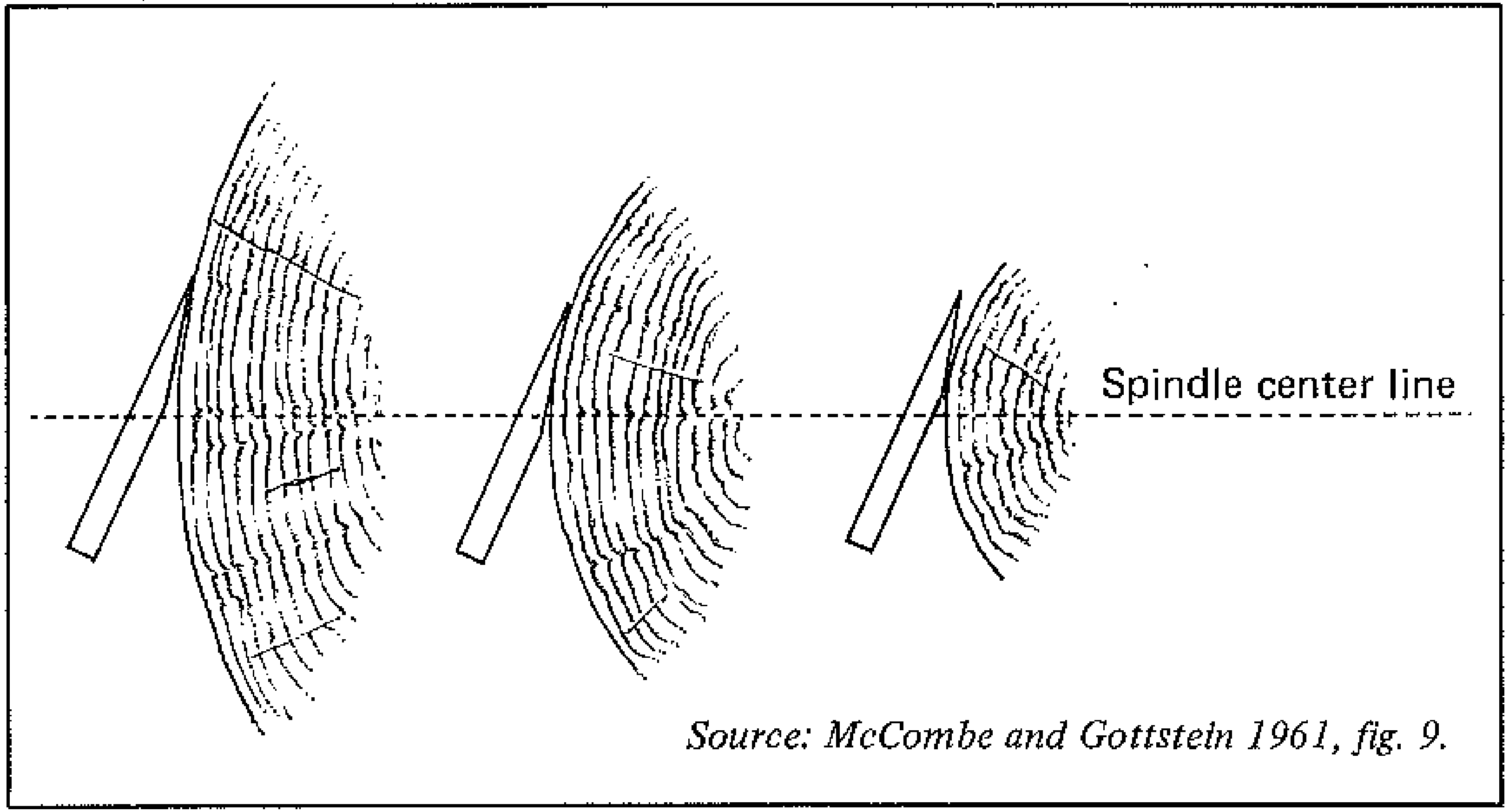


FIGURE 8.3. When knife is set above, rather than on, spindle center line, knife cutting angle changes as peeling diameter decreases.

Optimal lathe settings

- Traditional spindled systems well described in open literature
- Hybrid systems, described and supported by manufacturer only
- Spindleless systems not described at all
    - Need to reference factory default settings and then develop optimal settings

Quality Assessment

- **Ribbon tracking**
- **Veneer thickness variation along the grain**
- **Veneer thickness variation across the grain**
- **Tightness and looseness**
- **Surface roughness**
- **Flatness**

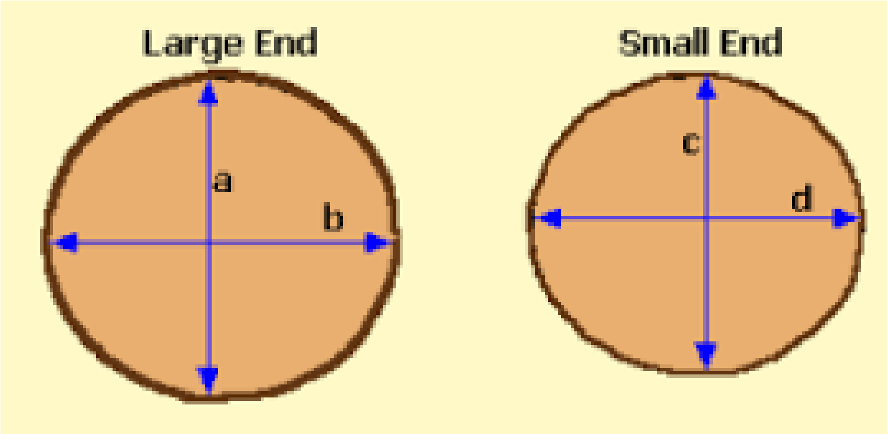
Veneer recovery

$$\textbf{Green recovery}\ (\%) = \frac{\text{Total } \textbf{green} \text{ veneer volume}}{\text{Log volume}} \times 100$$

$$= \frac{\text{Average } \textbf{green} \text{ ribbon thickness} \times \text{length} \times \text{peeled log length}}{\pi \times (\text{SEDUB} + \text{LEDUB})/4)^2 \text{ x peeled log length}} \times 100$$

Where **SEDUB** is the log **small**-end-diameter under-bark

and **LEDUB** is the log **large**-end-diameter under-bark



Veneer recovery

$$\textbf{Dry recovery}\ (\%) = \frac{\text{Total } \textbf{dry} \text{ veneer volume}}{\text{Log volume}} \times 100$$

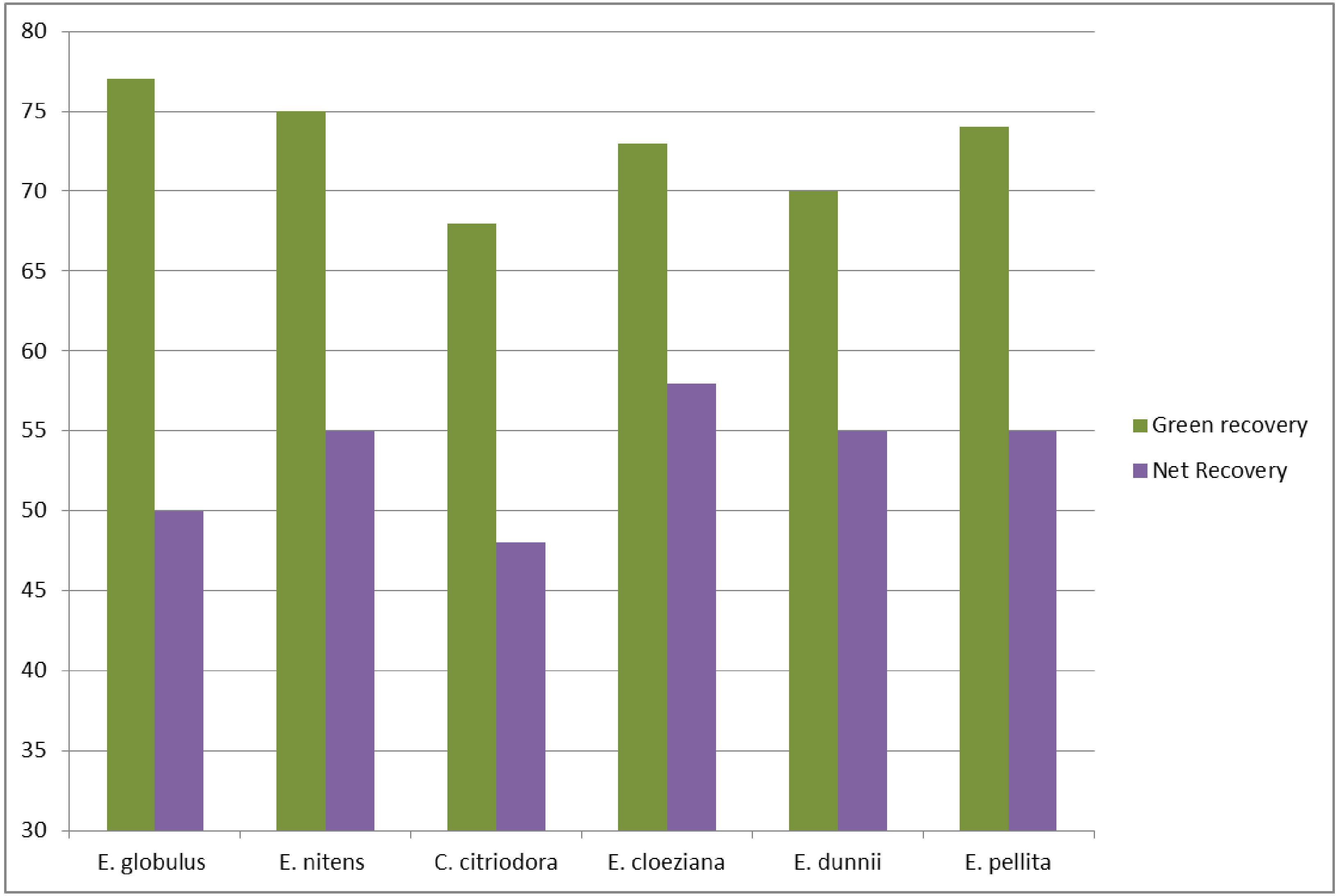
$$= \frac{\text{Average } \textbf{dry} \text{ ribbon thickness} \times \text{length} \times \text{peeled log length}}{\pi \times (\text{SEDUB} + \text{LEDUB})/4)^2 \text{ x peeled log length}}$$

Veneer recovery

$$\textbf{Saleable recovery} = \frac{\text{Total } \textbf{dry} \text{ veneer volume } (\textbf{excluding out of grade veneer})}{\text{Log volume}} \times 100$$

$$= \frac{\text{Average } \textbf{dry} \text{ ribbon thickness} \times \text{length} \times \text{peeled log length } (\textbf{ex. out of grade veneer})}{\pi \times (\text{SEDUB} + \text{LEDUB})/4)^2 \text{ x peeled log length}}$$

Veneer recovery - example



Chapter 2: Veneer drying

Adam Redman

Introduction

- Veneer dryer types
  - Air drying
  - Steam dryer
  - Jet box dryer
  - Radio frequency dryer
  - Vacuum dryer
- Drying time variables
  - Thickness
  - Moisture content
  - Drying Temperature
  - Air velocity
- Drying defects
  - Non uniform moisture content
  - Splitting buckling and loose knots
  - Surface modification – over drying
  - Collapse

Air drying

Very little control over drying conditions, and final moisture content

Usually needs further drying as some glues require low moisture content

Slow can take a few days

Air dried sheets should be arranged vertically in racks off the ground

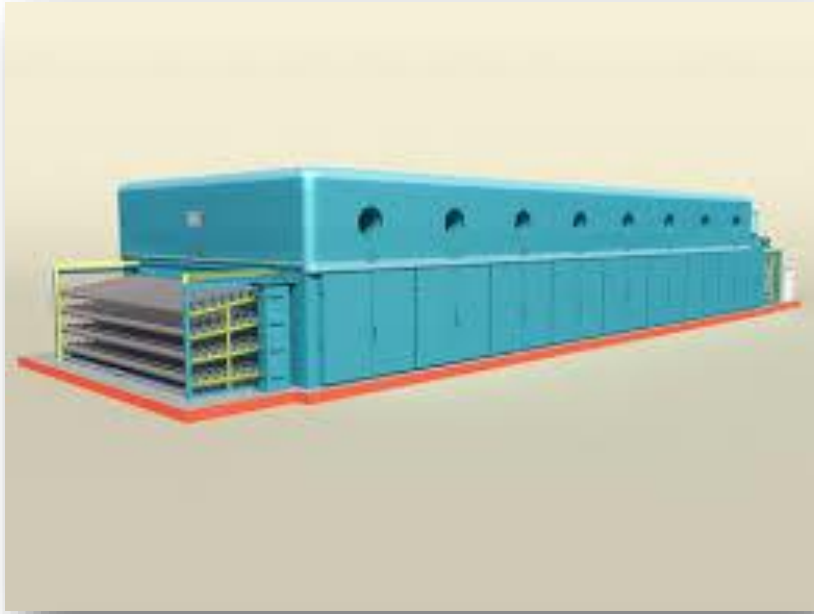
Steam dryer

Often used as a final dryer after pre air drying

Takes minutes/hours to dry depending on thickness

Requires steam input - boiler

Jet box dryer



For large fast production

Veneer dries in minutes depending on species and thickness

Multi-compartment conveyer

Usually hotter infeed and cooler outfeed

Air flow in the for of a air jet perpendicular to the veneer

Typical drying time for some Australian eucalypts using a jet box dryer

Final MC around 4-8 %

Thickness (mm)	Species	Maximum DBT 150°C	160-165°C
		Drying time (minutes)	
2.54	Flooded gum (plantation)	14-15	10-11.5
	Other*	16-17	11.5-13
3.2	Flooded gum (plantation)	18-19	13.5-16
	Other*	20-22	16-17.5
* Other	scribbly gum (E.signata), flodded gum - non plantation (E. grandis), blackbutt (E. pilularis), Sydney blue gum (E. saligna).		

Radio frequency drier

Usually used in smaller factories

Fast drying similar to jet box

Heat supplied by radio frequency generator

Dependent on electricity so can be expensive in places where electricity price is high

Veneer dries in minutes depending on species and thickness

Vacuum dryer

Expensive dryers

Used mostly for very thin <= 1.5 mm veneer

This thin veneer is dried in one big block and can take a few hours

Thin veneer tends to warp when using other forms of drying so vacuum drying works well as the veneer is constrained in a block

Drying time variables

- **Veneer thickness**

Drying time increases with thickness. If thickness is doubled so is drying time up to 4 mm (Troughton, 2001)

- **Moisture content**

Drying time increases with initial veneer moisture content (MC)

Drying time variables

- **Drying temperature**

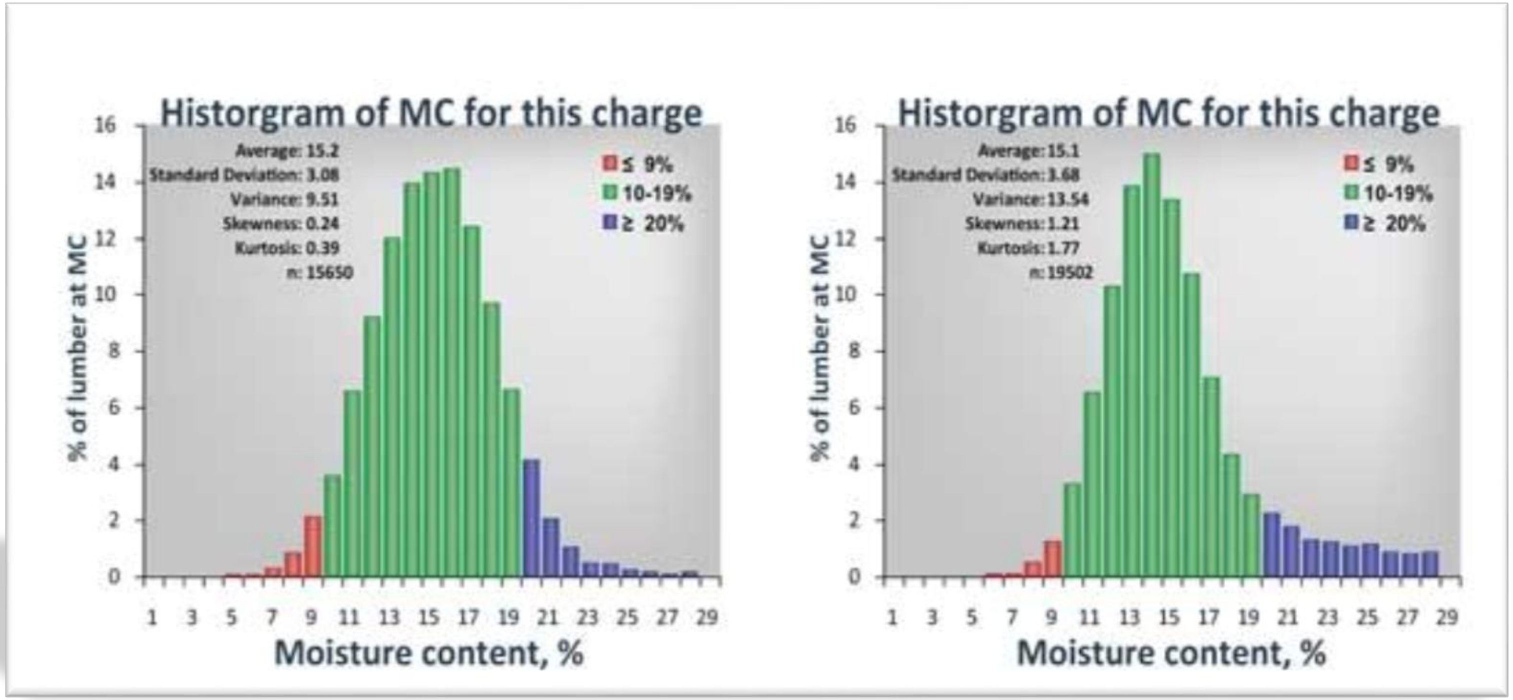
If it takes 10 minutes to dry veneer at 150°C, it takes roughly half that time at 210°C and approximately one quarter of that time at 310°C. Most current dryers operate at temperatures ranging from 150°C in steam-heated drying systems to 260°C in gas-heated dryers.

- **Air velocity**

Faster air velocities on the surface of veneer usually result in faster drying times. The drying time is three times shorter from approximately 1 m/s to 8 m/s.

Veneer drying defects

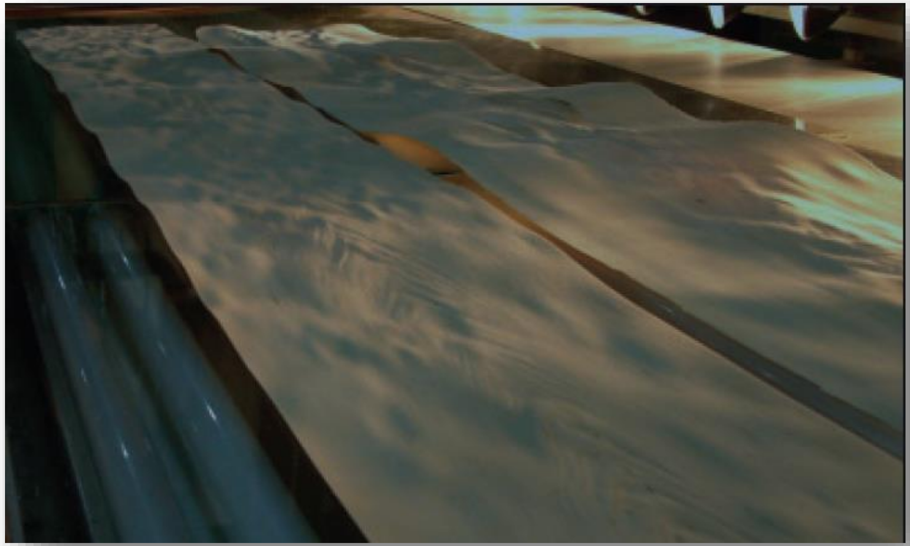
- Non uniform final moisture content



A common target MC in Australia is 6% with a variation of 3-10%

Splitting

Waviness



Loose knots

Measuring moisture content

- Oven dry method always most accurate.

- oven dry method

$$Moisture\ content\ (MC) = \frac{Sample\ weight\ (W) - Oven\ dry\ weight\ (ODW)}{Oven\ dry\ weight\ (ODW)}$$

103°± 2°C

Measuring moisture content

- Jet box driers use resistance brushes on the outfeed to measure MC and control the kiln conditions

Measuring moisture content

- Capacitance meter

Measures to approximately

1 mm depth

Density must be known

Chapter 3: Veneer grading

Adam Redman

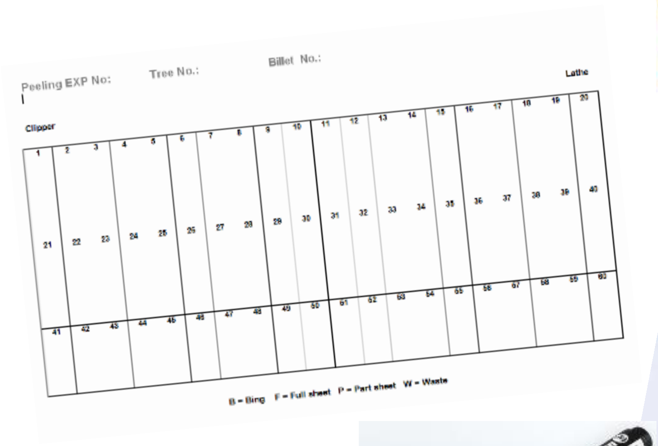
Veneer grading - objectives

- Provide a fair price for veneer
- Give the buyer quality confidence
- Sort material for best in-service use
- Grading separates veneer timber into quality groups, providing a way in which buyers and sellers can agree on value

Veneer grading

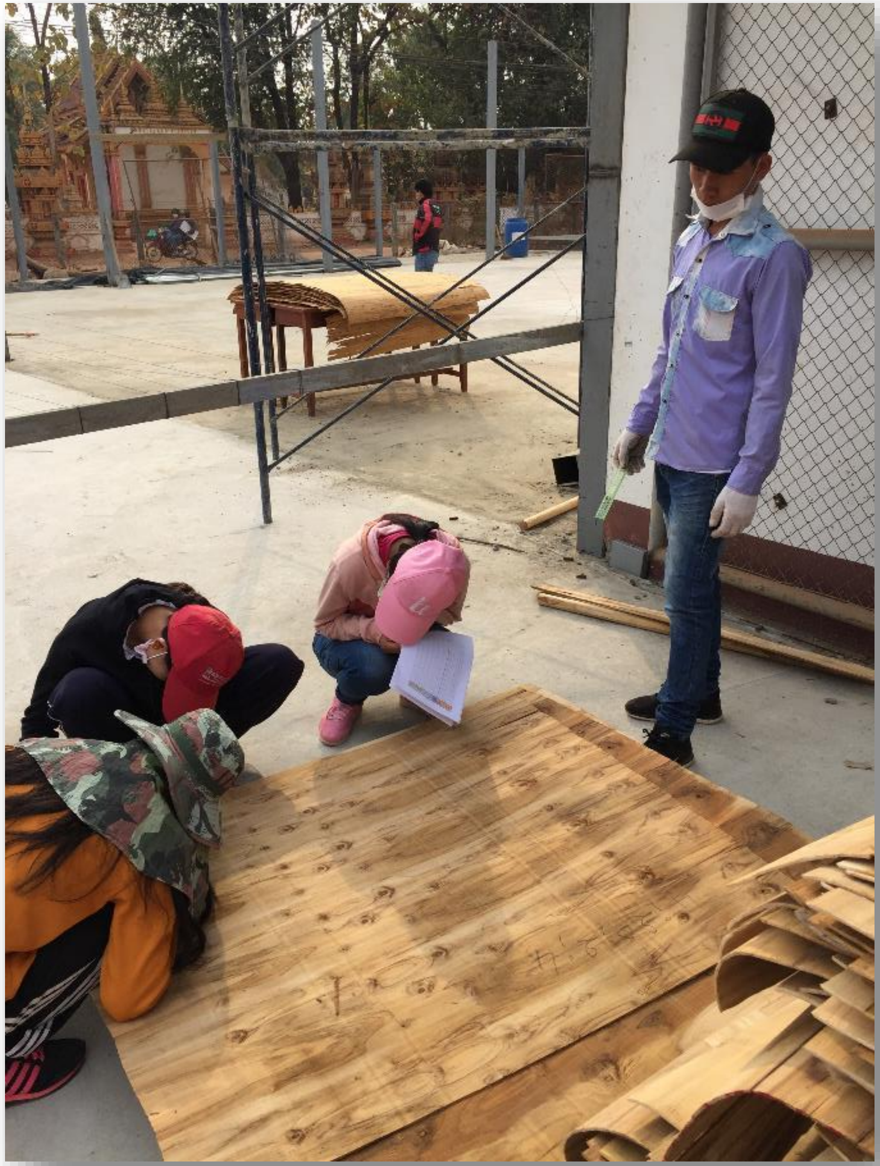
- Veneer grading systems vary internationally however their application is the same:
  - Identify grade limiting defects
  - Measure the defects
  - Determine size and species requirements
  - Assign grade

- Tools required
- Measuring tape,
- marking template,
- crayons/markers/pens,
- Ribbon record sheets (printout)



Veneer grading

- Ideally veneer grading systems should be:
  - Simple
  - Easy to understand
  - Able to be applied rapidly



Veneer grading

- Key veneer characteristics that will be assessed during hardwood veneer grading are:
  - Thickness – grade tolerances are specified
  - Features
    - Sound knots
    - Loose knots
    - Pin knots
    - Holes
    - Splits
    - Bark/gum pockets
    - Insect attack
    - Discoloration
    - Grain tear-out
    - Scratches
    - Knife mark
    - Decay

Veneer grading

- Characteristics included in the standard but not assessed are:
  - Joints
  - Patching

    manufacturing processes

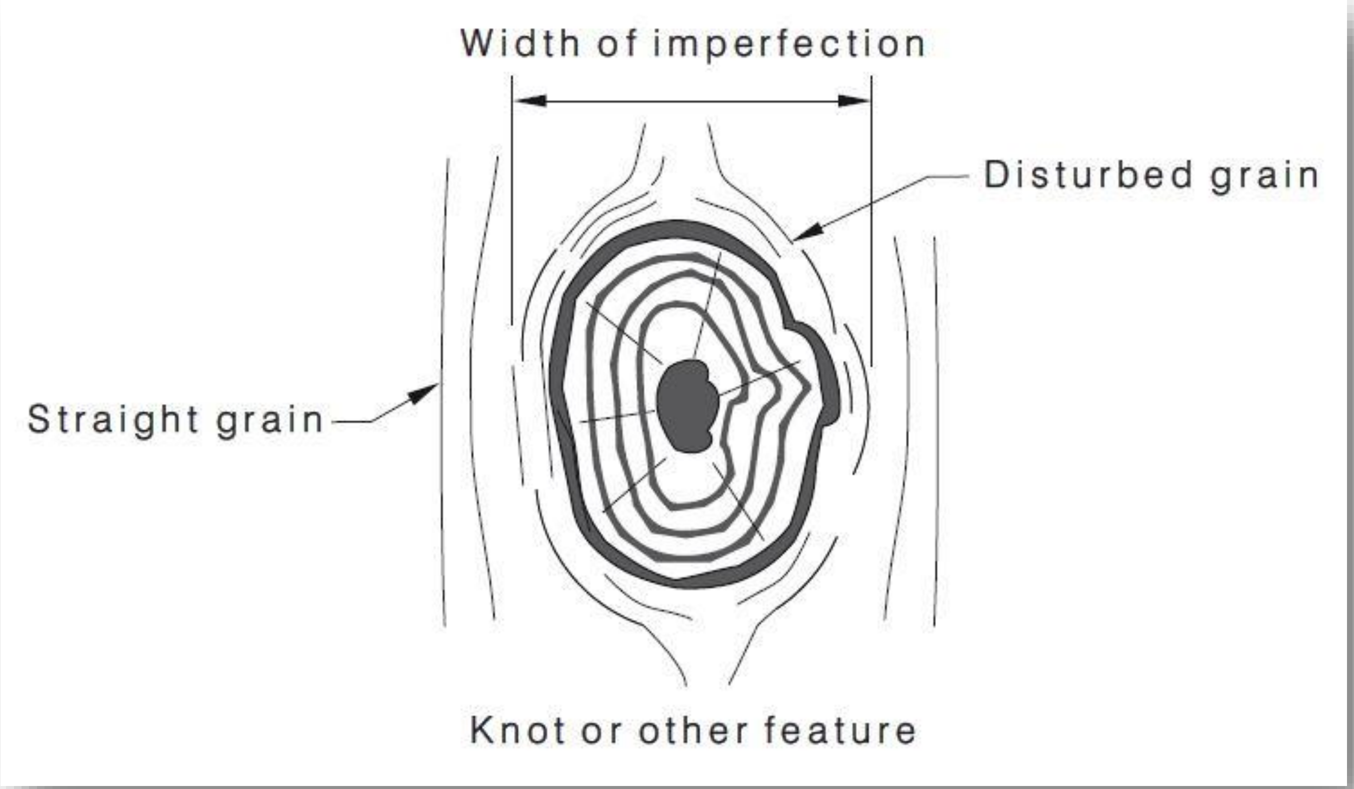
  - Resin pockets – softwood characteristic

Veneer grading

- Features are important because they affect the:
  - Quality and value of the veneer
  - Appearance
  - Performance in service

Features – how to measure

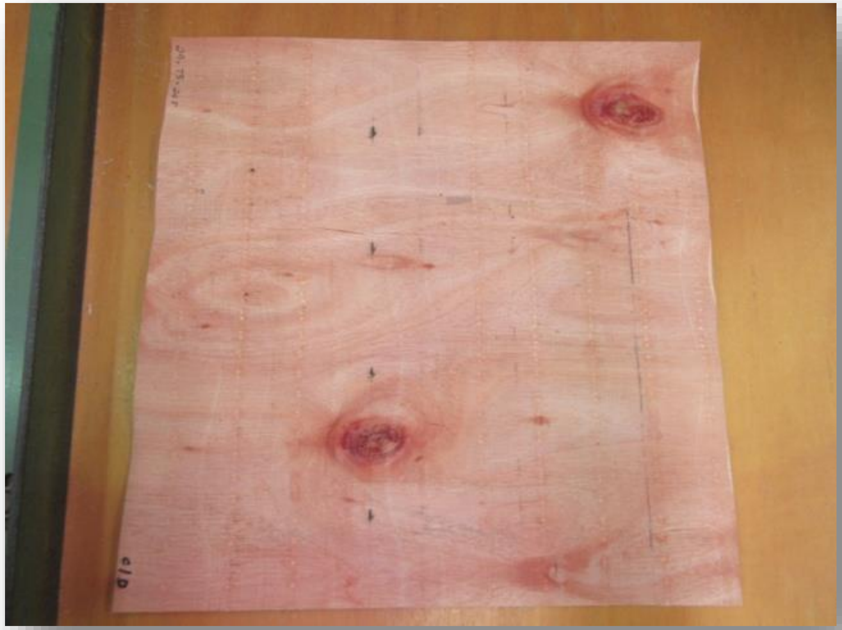
- Features measured in width direction (perpendicular to the grain)



- Some features are measured in the length direction or as an area

Features – how to measure

- Sound or tight knots



- measure width
- measure number / m^2

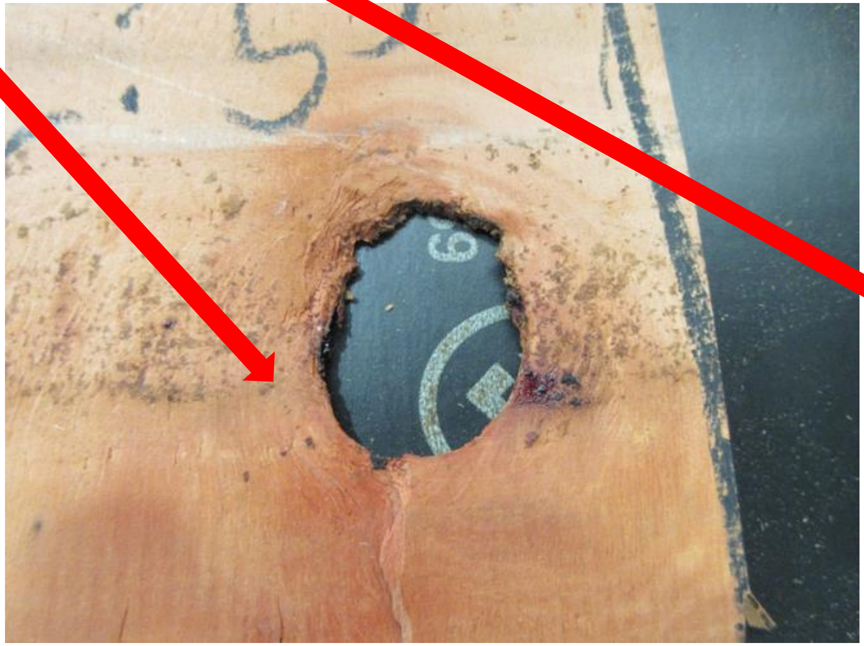
Features – how to measure

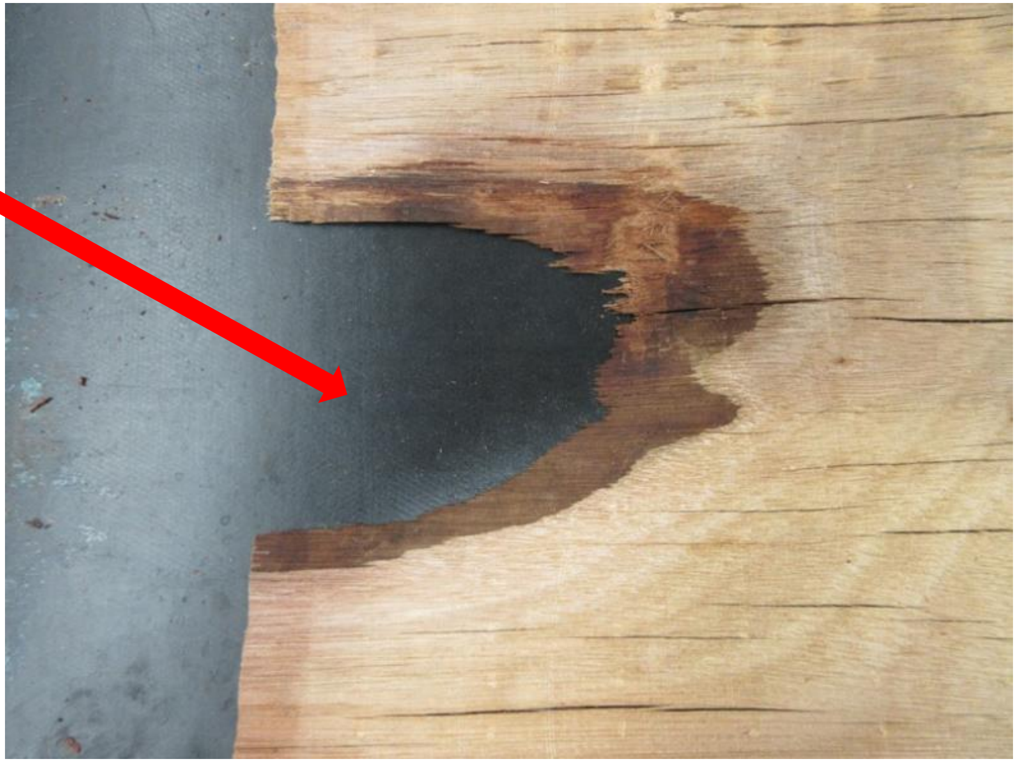
- Loose knots

- measure width
- measure number / m^2

Features – how to measure

- Holes – knot holes or wane usually. Not insect holes.





- measure width
- measure number / m^2

Features – how to measure

- Splits

- measure width
- measure length
- measure number / m width

Features – how to measure

- Bark/gum pockets

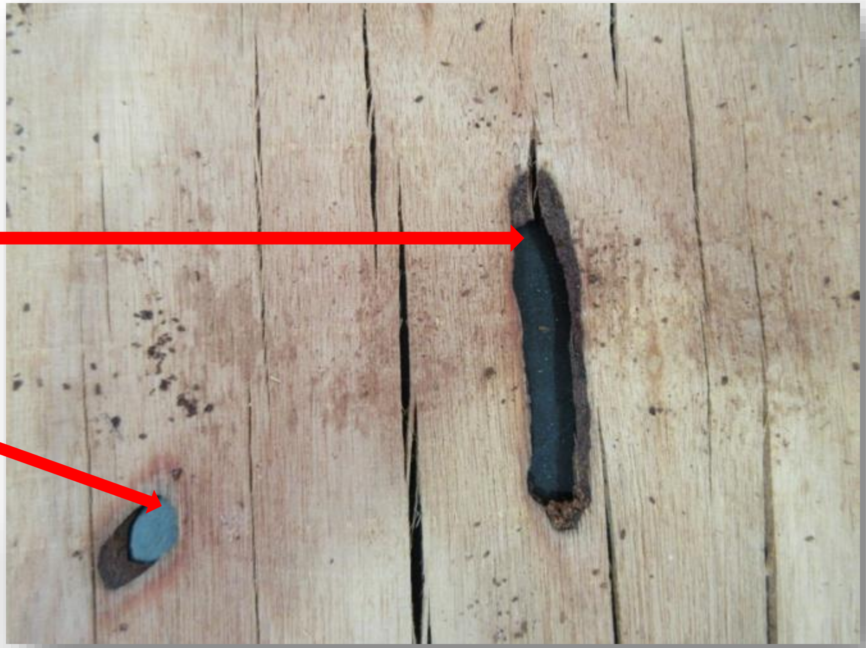
- measure width
- measure length
- measure number / m^2

Features – how to measure

- Insect tracks and holes

horizontal hole

vertical hole



Insect track

- measure width (vertical)
- measure width and length (horizontal)
- measure number / m^2

Features – how to measure

- Discoloration

- measured visually
- measure % of sheet area

Features – how to measure

- Grain tear-out

- measured visually
- subjective measurement

Features – how to measure

- Pin knots = sound knot less than 5 mm diameter

- measure diameter (width)

Features – how to measure

- Scratches

- measure sheet area affected
- measure depth – through sheet or not?

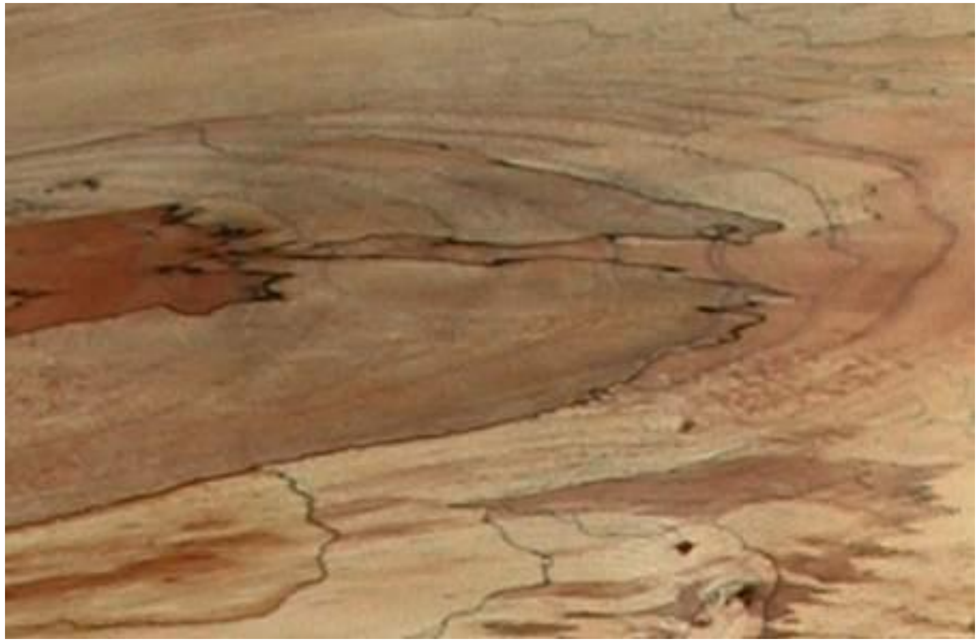
Features – how to measure

- Knife mark

- measure visually and by hand feel

Features – how to measure

- Decay



  - measure by presence
  - subjective investigation of strength affected

Thickness tolerance

Nominal thickness range (mm)	Thickness tolerance (mm)
0.55 – 0.65	± 0.03
0.66 – 1.00	± 0.04
1.01 – 1.60	± 0.06
1.61 – 2.00	± 0.08
2.01 – 3.20	± 0.10

Training guide

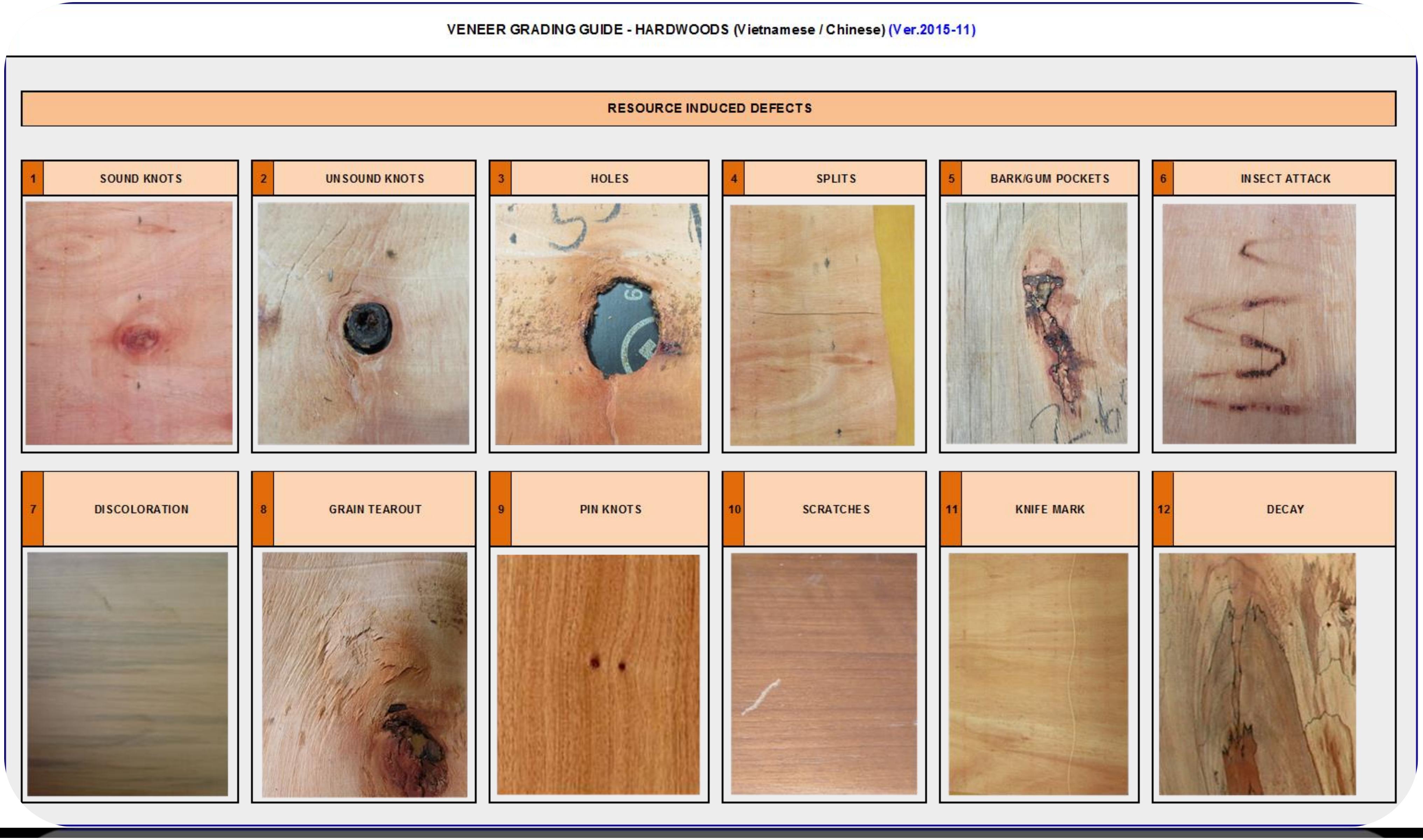
VENEER GRADING GUIDE - HARDWOODS (Vietnamese / Chinese) (Ver.2015-11)

RESOURCE INDUCED DEFECTS

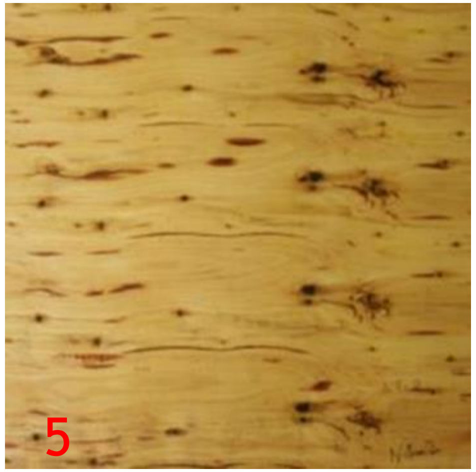
Grade	1 SOUND KNOTS	2 UNSOUND KNOTS	3 HOLES	4 SPLITS	5 BARK/GUM POCKETS	6 INSECT ATTACK
1	≤ 5 mm wide ≤ 5 / m^2 no knot splits	≤ 4 mm wide ≤ 2 / m^2 < 2 mm OK	not allowed	≤ 1.5 mm wide ≤ 2 / m sheet width ≤ 200 mm sheet length	not allowed	vertical ≤ 2 mm diameter vertical ≤ 3 / m^2 horizontal not allowed
2	≤ 50 mm wide	≤ 6 mm wide ≤ 2 / m^2 < 4 mm OK	≤ 5 mm wide ≤ 4 / m^2 < 2 mm OK	≤ 1.5 mm wide ≤ 4 / m sheet width ≤ 400 mm sheet length	not allowed	vertical ≤ 2 mm diameter vertical ≤ 8 / m^2 horizontal ≤ 2 mm wide ≤ 10 mm long horizontal ≤ 15 / m^2
3	no limitations	≤ 15 mm wide ≤ 4 / m^2	≤ 8 mm wide ≤ 8 / m^2	≤ 3 mm wide ≤ 4 / m sheet width ≤ 600 mm sheet length	≤ 4 mm wide ≤50 mm long < 2 / m^2	vertical ≤ 4 mm diameter vertical ≤ 15 / m^2 horizontal ≤ 3 mm wide ≤ 15 mm long horizontal ≤ 15 / m^2
4	no limitations	≤ 30 mm wide	≤ 20 mm wide	≤ 5 mm wide if > 5 mm - repair	no limitations	vertical ≤ 5 mm diameter vertical ≤ 15 / m^2 horizontal ≤ 3 mm wide ≤ 50 mm long
5	no limitations	no limitations	≤ 20 mm wide	≤ 5 mm wide if > 5 mm - repair	no limitations	no limitations
C1	no limitations	≤ 3 mm wide	≤ 3 mm wide	≤ 2 mm wide ≤ 2 / m sheet width ≤ 10 % sheet length	not allowed	no limitations
C2	no limitations	≤ 25 mm wide	≤ 25 mm wide	≤ 3 mm wide ≤ 30 % sheet length	no limitations if bond quality OK	no limitations

Grade	7 DISCOLORATION	8 GRAIN TEAROUT	9 PIN KNOTS	10 SCRATCHES	11 KNIFE MARK	12 DECAY
1	not allowed	very slight	≤ 2 mm wide	not allowed	not allowed	not allowed
2	≤ 5 % sheet area	slight	no limitations	≤ 1 % sheet area don't go through	very slight, **can not** be felt by hand	not allowed
3	≤ 30 % sheet area	OK if surface not rough	no limitations	≤ 2 % sheet area don't go through	slight, **can not** be felt by hand	not allowed
4	no limitations	no limitations	no limitations	no limitations don't go through	slight, can be felt by hand	permitted if sheet strength OK
5	no limitations	no limitations	no limitations	no limitations don't go through	slight, can be felt by hand	permitted if sheet strength OK
C1	no limitations if bond quality OK	no limitations	no limitations	≤ 3 % sheet are don't go through	not allowed	not allowed
C2	no limitations if bond quality OK	no limitations	no limitations	≤ 5 % sheet area, don't go thr	slight, **can not** be felt by hand	permitted if sheet strength OK

Training guide



Grade examples



Chapter 4: Principles of structural wood adhesives

Simon Dorries

Principles of Structural Wood Adhesives

EWP's Have the following in common

- WOOD (solid timber laminates, veneers, strands, flakes, fibres, chips etc)
- ADHESIVE - generally structural thermosetting adhesives
- STRUCTURALLY RATED - F grade, span rated, Published Characteristic structural properties

DESIRABLE PROPERTIES OF STRUCTURAL WOOD ADHESIVES

1. STRENGTH

THE COHESIVE STRENGTH OF THE ADHESIVE MUST BE AT LEAST EQUAL TO THE PARENT WOOD.

(DESIGN AROUND WOOD ELEMENTS ONLY)

WHEN TESTED 50% WOOD FIBRE FAILURE

Responsible Wood

Responsible Wood

2. DURABILITY

DEPENDS ON:

1. ENVIRONMENT
2. CHEMICAL NATURE OF THE ADHESIVE

MUST BE EQUAL TO THE INTENDED SERVICE LIFE OF THE PRODUCT

SHOULD HAVE A SHORT TERM DURABILITY TEST

Responsible Wood

3. CREEP RESISTANT

THE ADHESIVE MUST REMAIN RIDGED AND NOT CREEP WHEN SUBJECTED TO LONG TERM LOADS

Responsible Wood

4. GAP FILLING

THE ADHESIVE MUST BE ABLE TO BRIDGE GAPS BETWEEN LAMINATES AND RETAIN SUFFICIENT COHESIVE STRENGTH

5. WATER PROOF

THE ADHESIVE SHOULD NOT REACT WITH WATER EITHER AS LIQUID WATER OR IN THE FORM OF WATER VAPOUR.

RESISTANT TO CYCLIC CHANGES TO EQUILIBRIUM TIMBER MOISTURE CONTENT

Responsible Wood

6. NON- SHRINKING

THE ADHESIVE SHOULD NOT SHRINK DUE TO CHANGES IN MOISTURE CONTENT OR TEMPERATURE AND HAVE LONG TERM STABILITY

Responsible Wood

7. NON- BRITTLE

THE ADHESIVE MUST ACCOMMODATE THE NORMAL HYGROSCOPIC MOVEMENT OF TIMBER

TYPES OF ADHESIVES

Responsible Wood

TWO BROAD CATEGORIES OF ADHESIVES

1. **THERMOSET- Once cured a form a ridged glueline that will not replasticise if reheated.**

DO NOT CREEP - STRUCTURAL ADHESIVES

eg. formaldehyde based adhesives

2. **THERMOPLASTIC -replasticise when heated. eg. PVA**

CREEP UNDER LONG TERM STRESS

Chapter 5: Adhesives and plywood production

Rod Vella

Topics

- Plywood production
- Plywood bond classes in Australia
- Testing



Types of adhesives

- Urea formaldehyde (UF)
- Melamine formaldehyde (MF) & Melamine urea formaldehyde (MUF)
- Phenol formaldehyde
- Phenol resorcinol formaldehyde (PRF) & Resorcinol formaldehyde (RF)
- Polyvinyl alcohol adhesives (PVA)
- Polyurethanes (PUR)

Panel production

Preparation

- Veneer drying and conditioning
- Adhesive selection
  - Determination of adhesive spread rates
  - Determination of pressure
  - Determination of press time
- Veneer layup

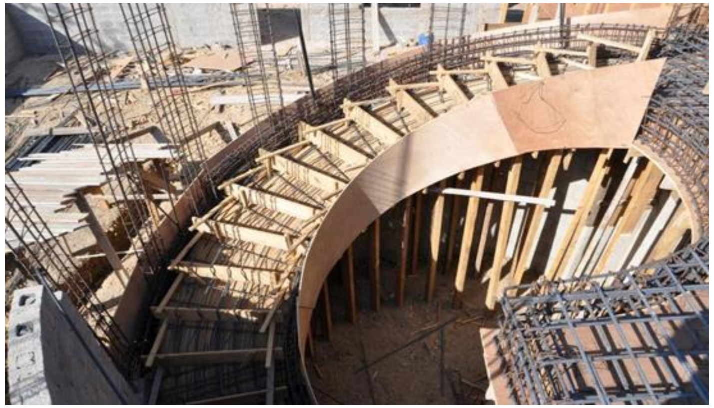
Panel production

- Adhesive application
- Open assembly time (OAT)
- Prepress
- Closed assembly time (CAT)
- Hot press
- Storage

Bond classes and uses

A bond

B bond



C bond

D bond

Testing

AS/NZS 2098 – Methods of test for veneer and plywood.

10 standards

1. Moisture content
2. Bond quality (chisel test)
3. Bond quality and strength – scarf joints
4. Dimensions and shape
5. Resistance of glue lines to micro-organisms
6. Depth of peeler checks
7. Density
8. Water absorption and thickness swell
9. Structural properties
10. Formaldehyde emissions

Chapter 6: Trouble shooting for faulty bonds

Simon Dorries

Basics of bond formation in formaldehyde based adhesives

Responsible Wood

Identify the type of bond failure

Establish the likely causes/s of failure

Confirm the course of failure (quality control records)

Implement corrective action plans

Responsible Wood

MOST COMMON BOND FAILURE CATEGORIES

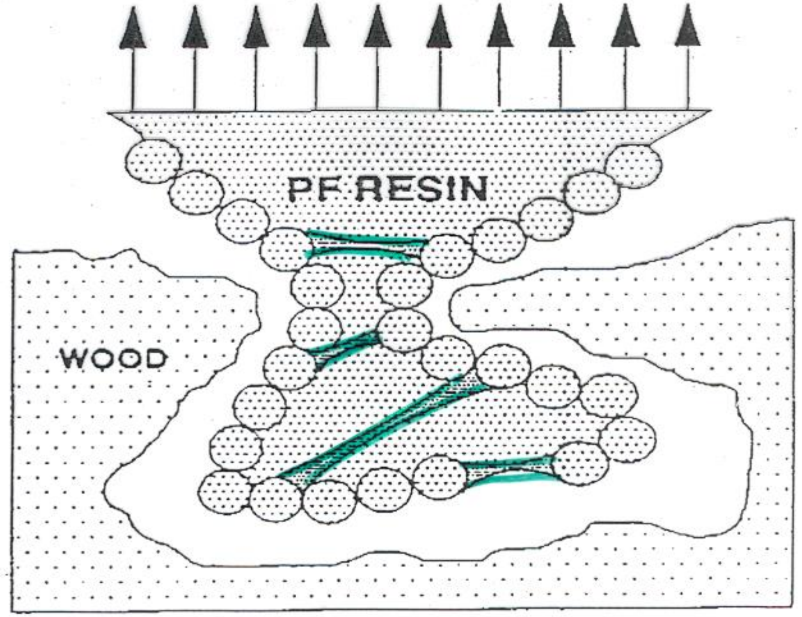
1. OVER PENETRATION OF ADHESIVE
2. ADHESIVE DRY OUT
3. THICK AND THIN VENEER (VENEER THICKNESS VARIATION)
4. PRECURE OF ADHESIVE
5. UNDERCURED ADHESIVE
6. SURFACE INACTIVATION/CASE HARDENING

Responsible Wood

EXTRACT

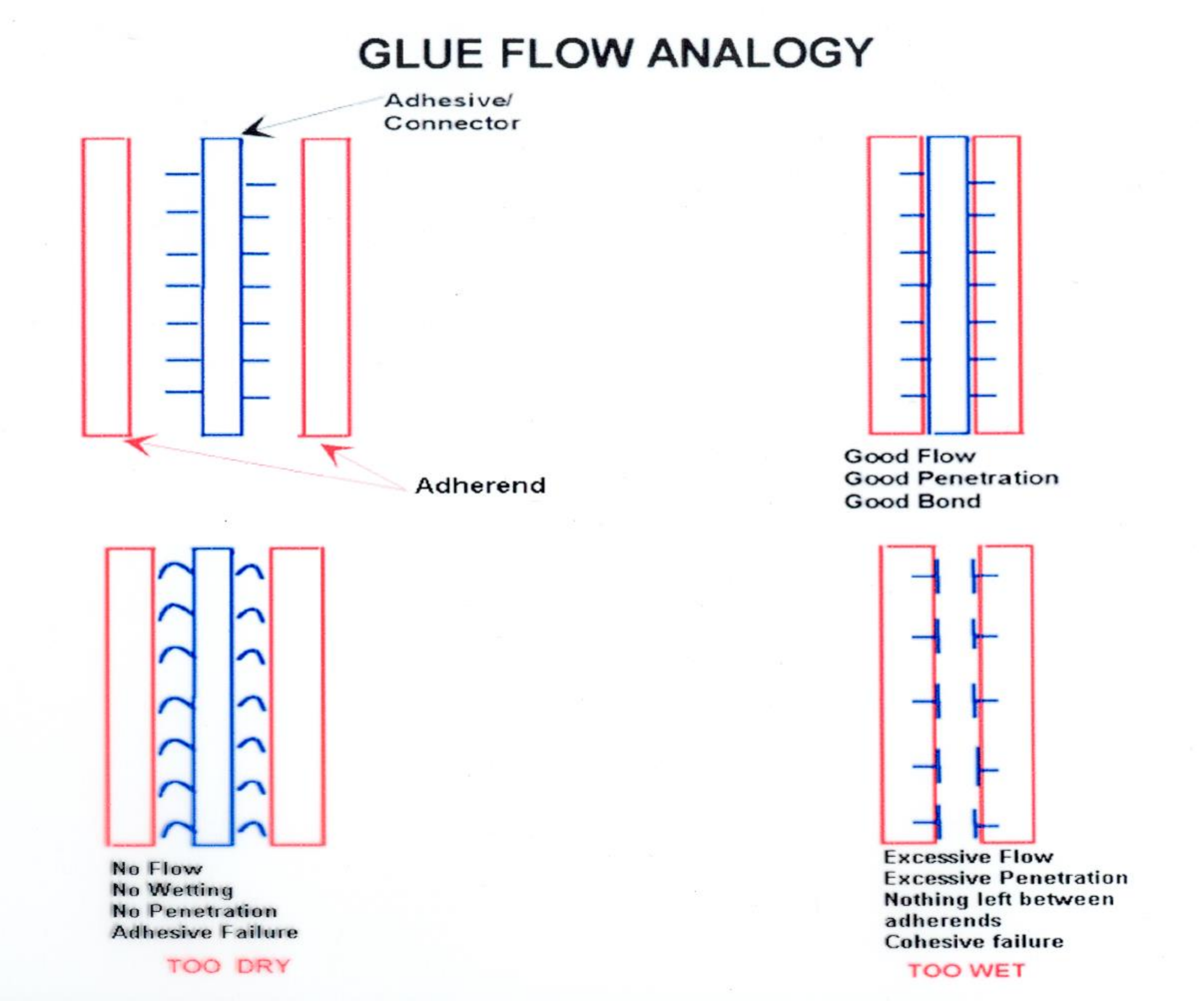
CSIRO/PAA PLYWOOD PRODUCTION COURSE

Y.YASAKI



PF Gets Physically "Stuck"
Only Mechanically Bonded

Responsible Wood


GLUE FLOW ANALOGY
Adhesive/
Connector
Adherend
Good Flow
Good Penetration
Good Bond
No Flow
No Wetting
No Penetration
Adhesive Failure
TOO DRY
Excessive Flow
Excessive Penetration
Nothing left between
adherends
Cohesive failure
TOO WET

LARGE PERCENTAGE OF FAILURES ASSOCIATED WITH GLUE FLOW EITHER —

EXCESSIVE → OVER PENETRATION OF ADHESIVE

OR

INSUFFICIENT → ADHESIVE DRY OUT

GLUE FLOW $\propto$ GLUE LINE MOISTURE CONTENT

Responsible Wood

OVER PENETRATED BONDS EXCESSIVE GLUE FLOW

IDENTIFICATION

1. GOOD TRANSFER SPREAD TO UNSPREAD VENEER
2. LITTLE OR NO ADHESIVE LEFT IN GLUELINE MAINLY FILLER
3. OVER PENETRATION OF GLUE INTO VENEER
4. UTLIMATELY A BLOWN SHEET

CAUSES

1. TOO HIGH INITIAL MOISTURE CONTENT
2. TOO HIGH A GLUE SPREAD

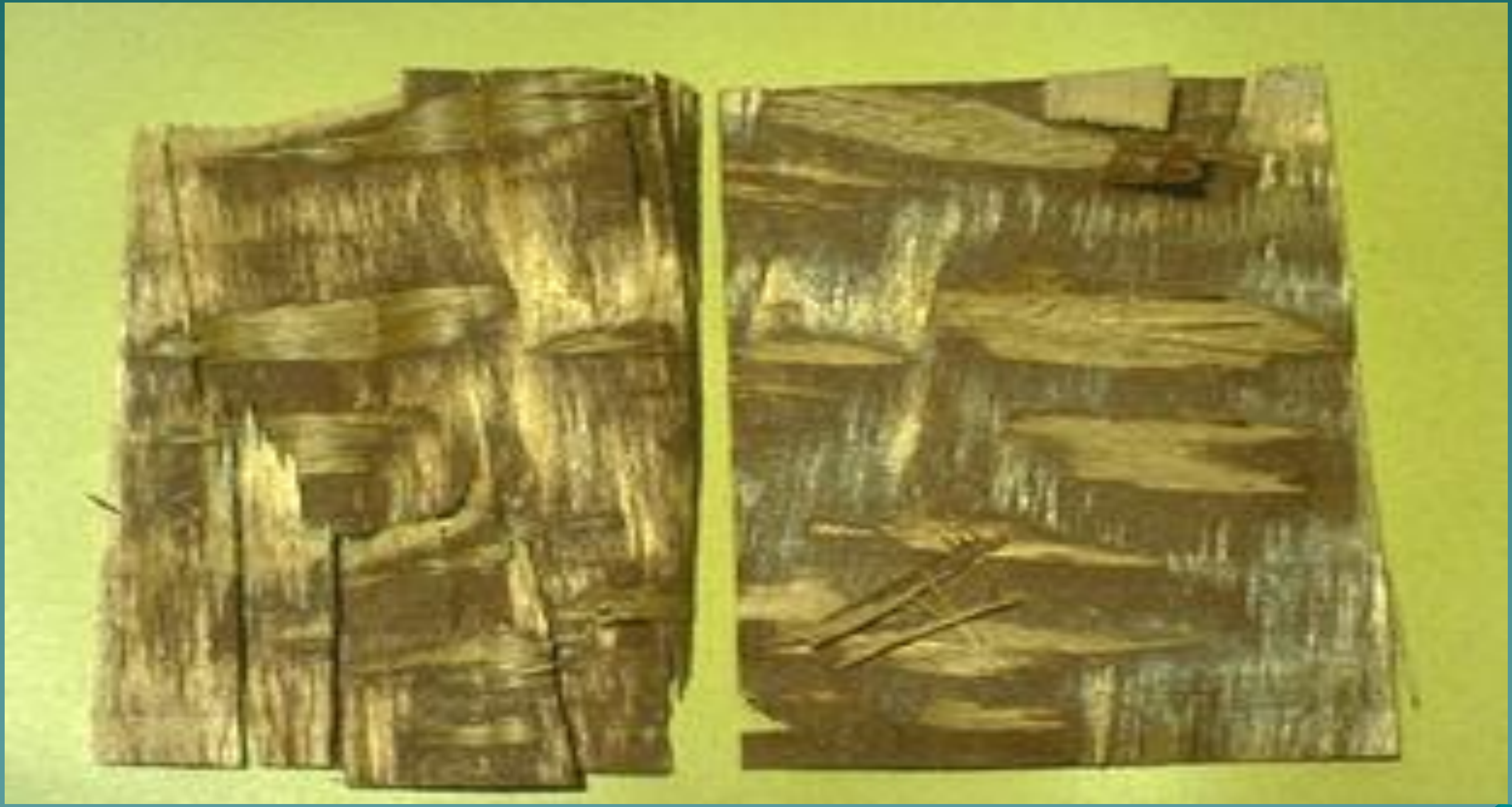
2A. TOO LOW PRESS TEMPERATURE

3. TOO SHORT AN OPEN ASSEMBLY TIME RELATIVE TO AMBIENT CONDITIONS OF TEMPERATURE & HUMIDITY
4. A COMBINATION OF THE ABOVE CAUSES
5. UNDERCONDENSED RESIN

CHECKLIST

1. WAS VENEER MOISTURE CONTENT ABOVE SPEC.?
2. HAD ASSEMBLY TIME BEEN SHORTENED DRASTICALLY?
3. WAS GLUE SPREAD LEVEL ABOVE SPEC.?
4. WAS VISCOSITY TOO LOW?
5. WERE SOLIDS TOO LOW?
6. WAS IT A COLD/WET DAY? IF SO WERE ALLOWANCES MADE?
7. CHECK PREPRESS TRANSFER & GRIP

Responsible Wood



‘DRY OUT’ LACK OF GLUE FLOW

IDENTIFICATION

1. NO PENETRATION OF GLUE INTO VENEER
2. PLENTY OF GLUE ON SPREAD VENEER
3. LITTLE WETTING OF UNSPREAD VENEER
4. SPREADER ROLL MARKS VISIBLE ON SPREAD VENEER

CAUSES

1. TOO LOW A VENEER MOISTURE CONTENT
2. TOO LOW A GLUE SPREAD
3. WARM VENEERS
4. TOO LONG AN OPEN ASSEMBLY PRIME RELATIVE TO AMBIENT TEMPERATURE & HUMIDITY
5. TO HIGH A VISCOSITY
6. A COMBINATION OF THE ABOVE

CHECKLIST

1. WAS VENEER MOISTURE CONTENT BELOW SPEC?
2. WAS VENEER BEING FED TO THE SPREADER DIRECT FROM DRIER OR SPLICER?
3. HAD OPEN ASSEMBLY TIME BE LENGTHENED?
4. WAS IT A HOT/DRY DAY?
5. WAS THE GLUE SPREAD BELOW?
6. WERE GLUE SOLIDS AND VISCOSITY WITHIN SPEC.?
7. CHECK PREPRESS TRANSFER & GRIP

Responsible Wood

TROUBLESHOOTING FOR FAULTY BONDS (A STARTING POINT)

DATE

SAMPLES MONTH

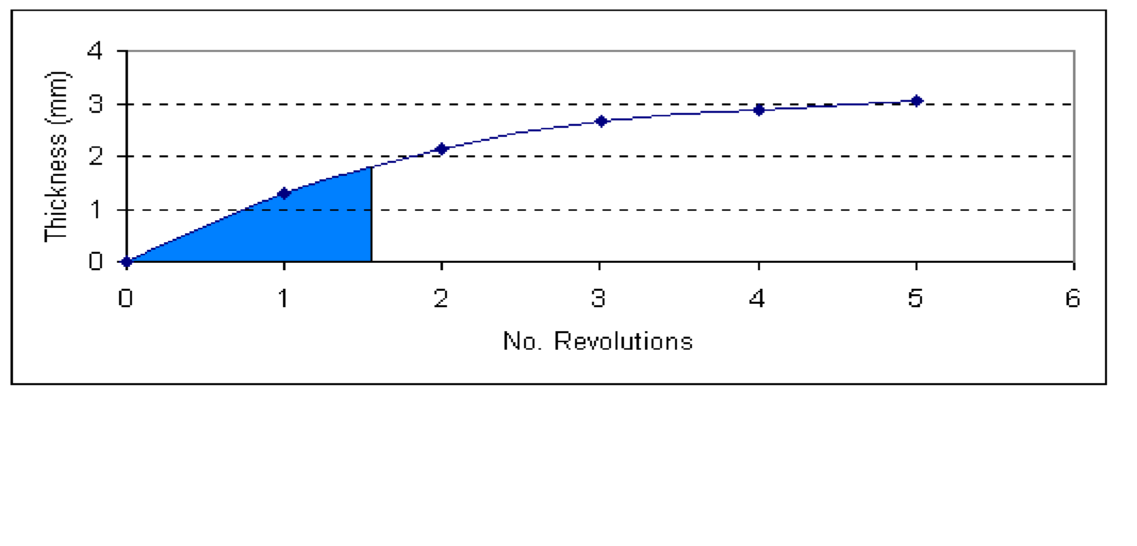
SAMPLE NO.

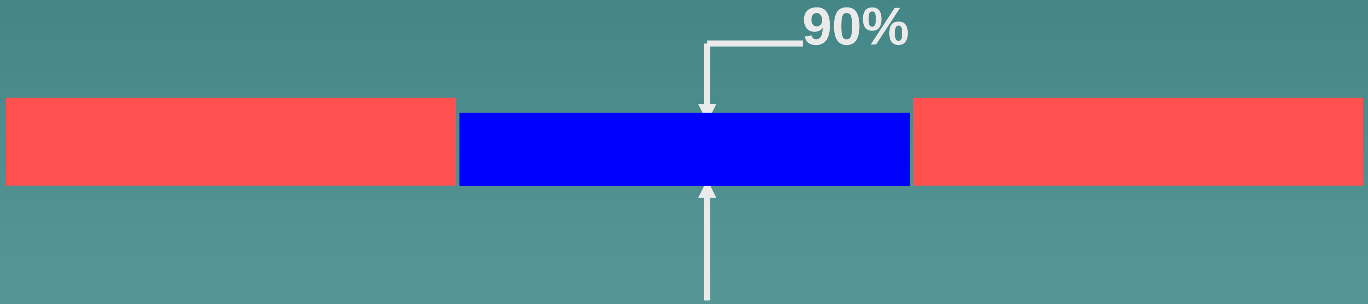
DRY BOND ______________ **AV.**

		YES	NO
1	TRANSFER?		
2	IS THE GLUE IN THE GLUELINE?		
3	IS THERE PENETRATION?		
4	ARE THE FACES WORSE THAN MIDDLE?		
5	ARE THERE SPREADER MARKS?		

COMMENT

Responsible Wood





THICK AND THIN VENEER

(SIZE AND THIN)

Responsible Wood

"THICK AND THIN VENEER"

IDENTIFICATION

1. NO TRANSFER IN FAILED AREA FROM SPREAD TO UNSPREAD VENEER
2. NO PRESSURE IN FAILED AREA BUBBLED AND BRITTLE GLUE
3. NO GLUE PENETRATION OR WETTING
4. PLENTY OF ADHESIVE ON SPREAD VENEER
5. A TYPICAL PRECURE/DRY OUT

5A. SPREADER ROLL MARKS VISIBLE

6. USUALLY DISTINCT CUT OFF LINE GOOD TO BAD BOND NEAR A JOINT

CAUSES

1. DISTINCT STEP BETWEEN TWO ADJACENT VENEERS
2. NO PRESSURE
3. NO CONTACT
4. PRECURE IN THAT AREA

CHECKLIST

1. WAS JOINTED AND SPLICED VENEER BEING USED
2. WERE MULTIPIECE CENTRES BEING LAID
3. WAS ROUND UP VENEER SEGREGATED. CHECK THICKNESS
4. WAS LATHE PEELING THICK AND THIN
5. SPLICED VENEER CHECKED FOR THICKNESS VARIATIONS

AUSTRALIAN FORESTRY STANDARD EST. 2003

Setting the standard for sustainable forest management for more than 10 years

PRECURED GLUE LINES

IDENTIFICATION

A UNPREPRESSED

1. NO GLUE TRANSFER OR WETTING
2. NO GLUE FLOW OR PENETRATION
3. PLENTY ADHESIVE ON SPREAD VENEER
4. SPREADER ROLL MARKS
5. BUBBLED AND BRITTLE GLUE

B PREPRESSED

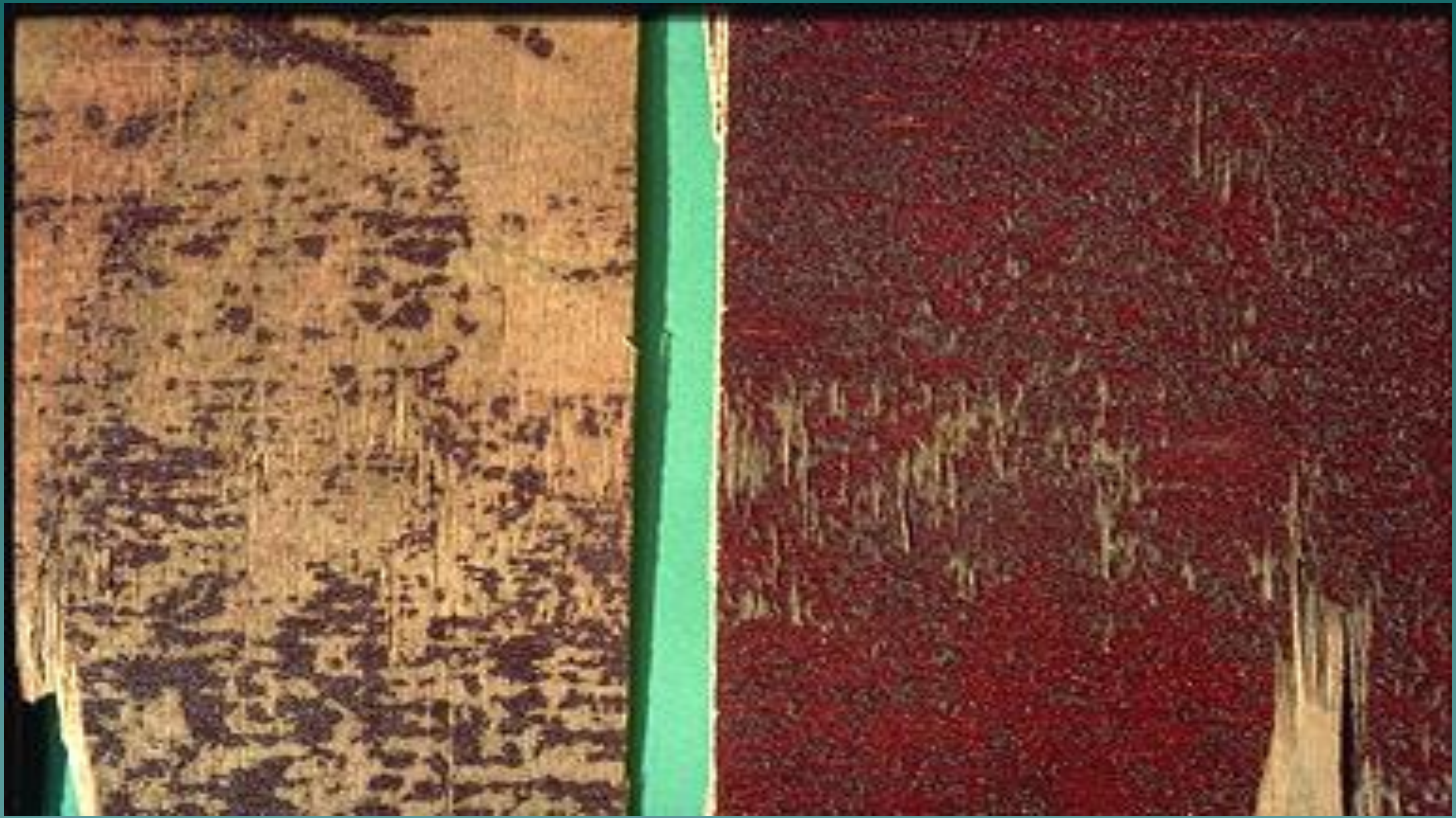
1. GOOD TRANSFER
2. POOR FLOW AND PENETRATION
3. PLENTY ADHESIVE ON BOTH SURFACES
4. CURED JOINT. ADHESIVE HARD TO SCRAPE OFF
5. BUBBLED AND BRITTLE GLUE

CAUSES

NO PRESSURE OR INSUFFICIENT PRESSURE AT TIME WHEN GLUE CURES

CHECKLIST

1. USUALLY HUMAN ERROR OR MACHINE MALFUNCTION
2. WAS THERE A PRESS LOADING MALFUNCTION?
3. WERE THERE HYDRAULIC PROBLEMS? SUFFICIENT PRESSURE 1.0-1.4MPa
4. WERE PRESS OPERATIONS SLOW?
5. WAS PRESS CLOSED SUFFICIENTLY QUICKLY AFTER LOAD? 45sec – 1min



UNDERCURED GLUELINES

IDENTIFICATION

1. GOOD TRANSFER SPREAD TO UNSPREAD VENEER
2. PLENTY OF ADHESIVE ON BOTH SURFACES COHESIVE FAILURE
3. A FAILURE WITHIN ADHESIVE
4. "WET THUMB TEST" SHOWS SOME STICK
5. OUTER GLUELINES GOOD, INNER GLUELINES POOR

CAUSES

INSUFFICIENT TEMPERATURE/TIME

MINIMUM TEMPS

PHENOLIC 135 - 140°C

M.U.F. 125 - 130°C

U.F. 120°C

CHECKLIST

1. WAS PLATEN TEMPERATURE UP TO SPEC.?
2. WAS THERE A BOILER BREAKDOWN?
3. ARE THERE COLD SPOTS IN THE PLATENS?
4. IS THE CONDENSATE BEING REMOVED PROPERLY?
5. WAS THE PRESSING TIME BELOW SPEC?

Responsible Wood

SURFACE INACTIVATION/CASE HARDENING

IDENTIFICATION

1. DISTINCT AREA OF ZERO BOND SURROUNDED BY GOOD BOND
2. IN THE AREA OF POOR BOND NO WETTING OR GLUE TRANSFER
3. NO GLUE PENETRATION
4. LOOKS SIMILAR TO DRY OUT OR PRECURE

CAUSES

1. OVER DRYING VENEER AT EXCESSIVELY HIGH TEMPERATURE ABOVE 180°C
2. SURFACE WETABILITY GREATLY REDUCED
3. ADHESIVE PENETRATION REDUCED DRAMATICALLY/NO FLOW/NO BOND

CHECKLIST

1. DRIER TEMPERATURE AT STAGE OF DRYING WHEN VENEER MOISTURE CONTENT 5-8%
2. CHECK WETABILITY
3. INSPECT VENEER FOR DISCOLOURATION (BROWN TINGE IN PINUS)

Responsible Wood

Chapter 7: Adhesives and EWP production

Rod Vella

Topics

- What are Engineered wood products (EWP’s) ?
- EWP Applications
- Which adhesive?
- Testing

Engineered Wood Products

Veneer based

- Multilaminar wood (MLW)
- Plywood
- Laminated veneer lumber (LVL)

Particle based

- Particle board
- Oriented strand board (OSB)
- Medium density fibre board (MDF)

Timber based

- Glue laminated timber (Glulam or GLT)
- Cross laminated timber (CLT)






Veneer based EWP

MLW

- Single orientation veneer
- Decorative
- Internal applications

Plywood

- Alternating orientation
- Structural and non structural applications
- Internal & external applications
- Thickness variability

LVL

- Single orientation
- Structural and non structural applications
- Internal & external applications
- Thickness variability

Timber based EWP

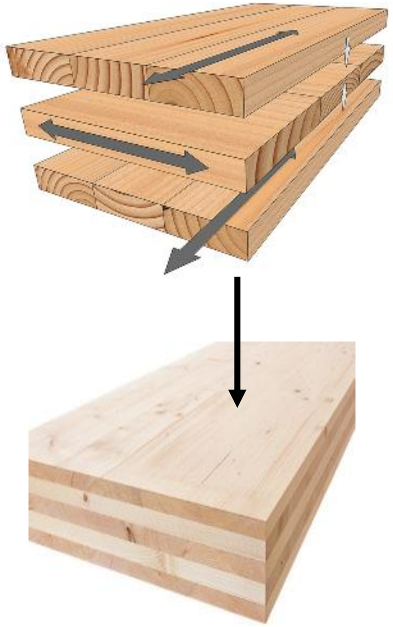
Glulam

- Large elements manufactured from smaller pieces of timber.
- Structural and non structural applications
- Internal or external use.
- Size and shape variation depending on requirements



CLT

- Timber cross laminated to manufacture panels
- Improved structural properties
- Structural use only
- Internal and external use




Particle based EWP

Particle board

- Wood chips, sawdust and shavings
- Flooring, Interior lining, furniture manufacture
- Interior use

OSB

- Wood flakes – cross oriented layers
- Structural and non-structural
- Strength/performance similar to plywood

MDF

- Wood fibres
- Mainly internal use
- Structural and non-structural
- Furniture production, flooring, wall lining and high moisture areas

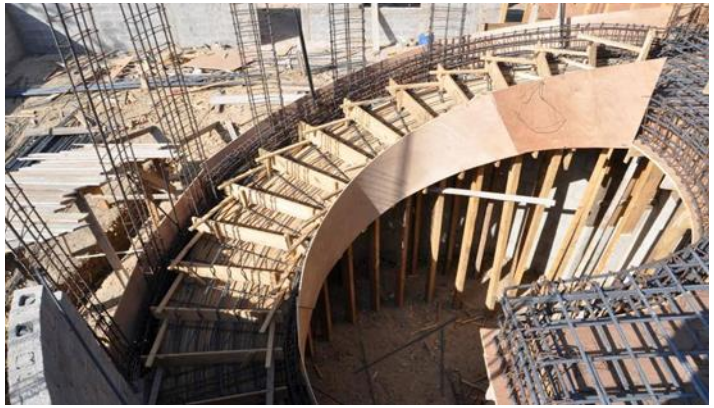
Adhesives

- Which adhesive?
  - What is the product?
  - Final uses and applications?
  - Exposure conditions?
  - Structural or non-structural?
  - Manufacturing considerations?
  - Costs?

Bond classes and uses – veneer based panels

A bond

B bond



C bond

D bond

Adhesive types and service classes – Timber EWP

Adhesive types

- Type 1 – Structural in all service classes
- Type 2 – Only used for service classes 1 and 2

Service classes

- Service class 1 – interior/low moisture
- Service class 2 – interior/high moisture
- Service class 3 – Exterior exposure to all environmental conditions

Testing

AS/NZS 2098 – Methods of test for veneer and plywood. Method 2: Bond quality of plywood (chisel test)

AS/NZS 1328 - Glue laminated structural timber – Part 1 : Performance requirements and minimum production requirements

AS/NZS 4357 – Structural laminated veneer lumber – Part 2: Determination of structural properties – test methods

AS/NZS 1859 – Reconstituted wood based panels

Chapter 8: Production of sliced veneers and products

Prof. Barbara Ozarska

Fine design does grow on trees

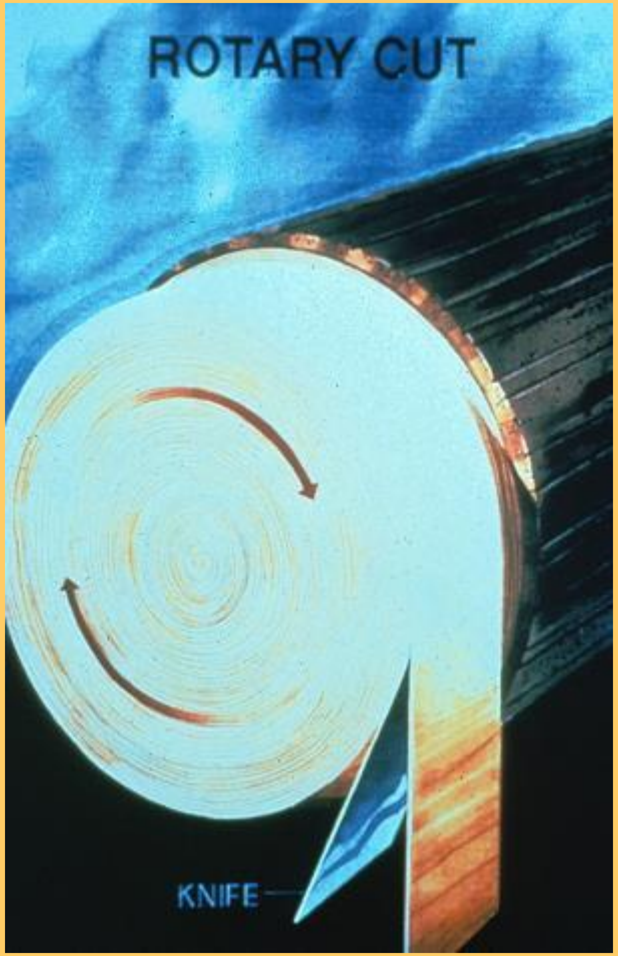
- **Beautiful with infinite variety!**
- **Every tree is unique to itself.**
- **Frugal use of precious resource.**
- **Real timber – not made from petro-chemicals.**
- **Renewable & sustainable.**
- **Timeless beauty and lasting quality.**

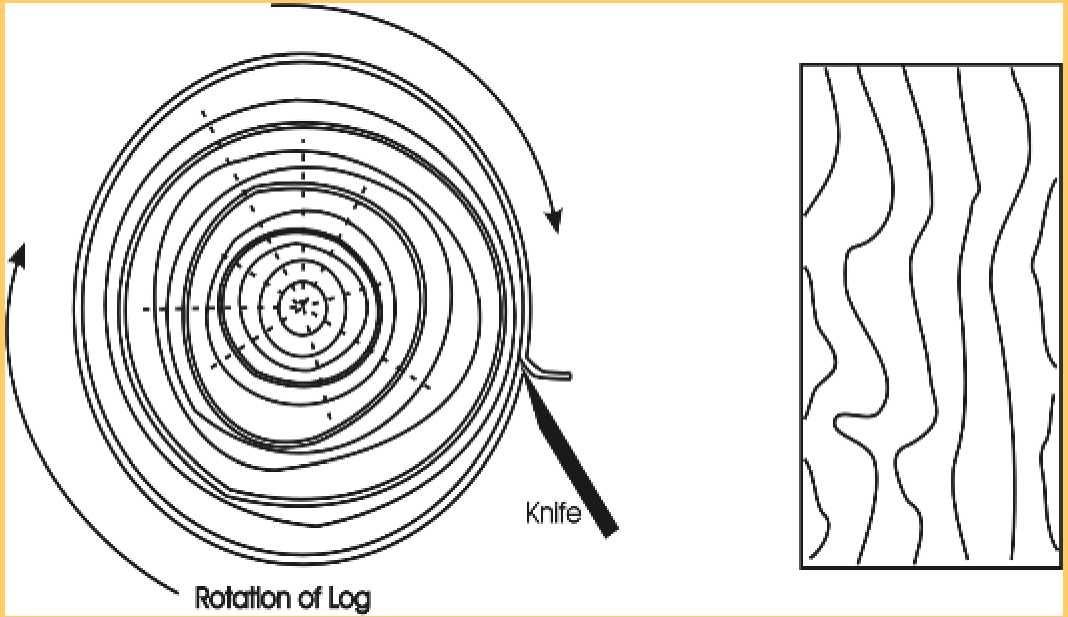
Types of veneers

A veneer is a thin slice of wood with its thickness determined by the end use. There are two major classifications of veneers:

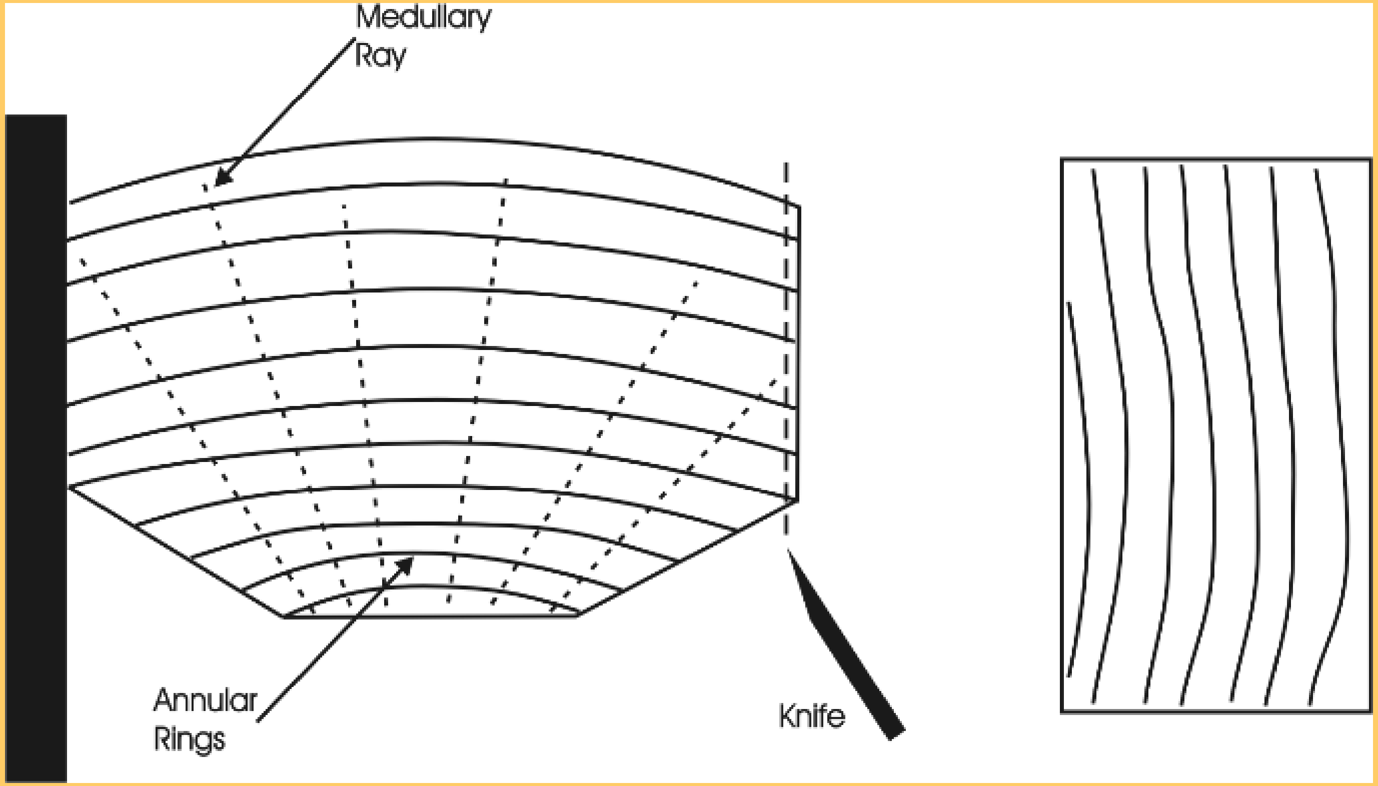
- Constructional: peeled, used mainly for plywood and laminated veneer lumber (LVL).
- Decorative: sliced, produced to display aesthetic surface appeal.

Peeling - Rotary Cut





Veneer slicing



Uses of decorative veneers

- **High value appearance products such as furniture and cabinets.**
- **Architectural applications.**
- **Panelling.**
- **Profile-wrapped mouldings.**

Advantages of using veneered panels in wood products

- **More economical use of figured wood: the maximum surface area obtained from suitable materials.**
- **Veneered panels are less prone than solid figured timber to shrink, check and warp.**
- **Limitless design possibilities.**
- **Utilization of highly figured timber showing unusual and beautiful effects due to grain irregularities.**

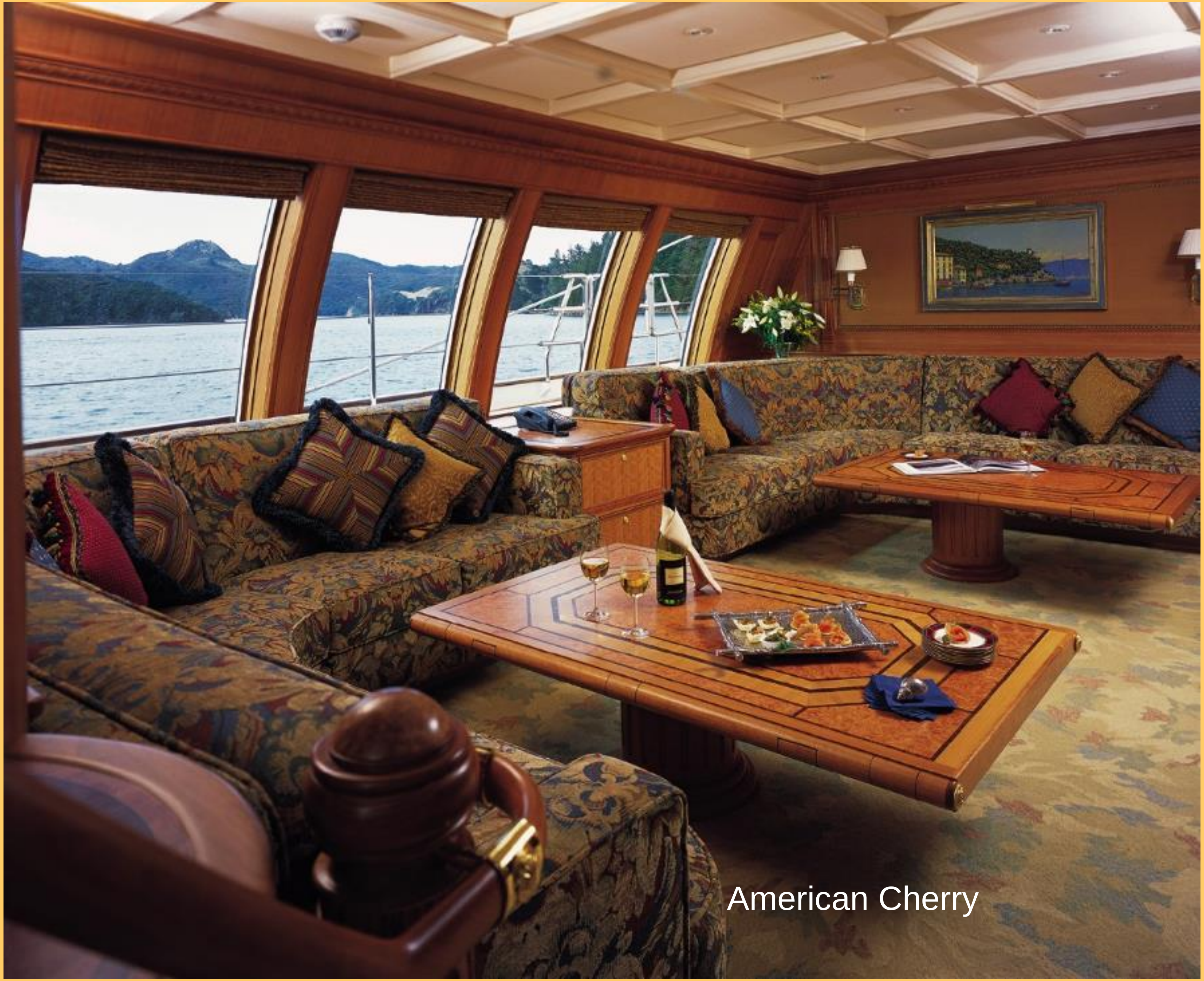
Veneering

Look at the following examples!

Huge range of colours & finishes!

Real timber!


American Cherry


American Cherry


American Walnut


Zebrano Veneer

Quarter Cut Japanese Sen


Quarter Cut Tasmanian Oak


Crown Cut Tasmanian Oak


Hoop Pine

- **Timber veneer is real timber, cut fine - not something made from petro-chemicals.**
- **So it is a renewable, sustainable resource.**
- **It has been used since the time of the Pyramids, and the timeless beauty of antique furniture testifies to the lasting quality of the veneering art.**
- **WHERE DOES IT COME FROM?**

Logging

Production Shots courtesy:
General Woods & Veneers – USA
& Gunns Veneers – Tas.

Log Selection

Production of flitches

Logs selected for veneer production are usually checked with a metal detector. They are de-barked and cut to the desired length into flitches.

In Australia, they are usually 2.4m to 3.9m long.

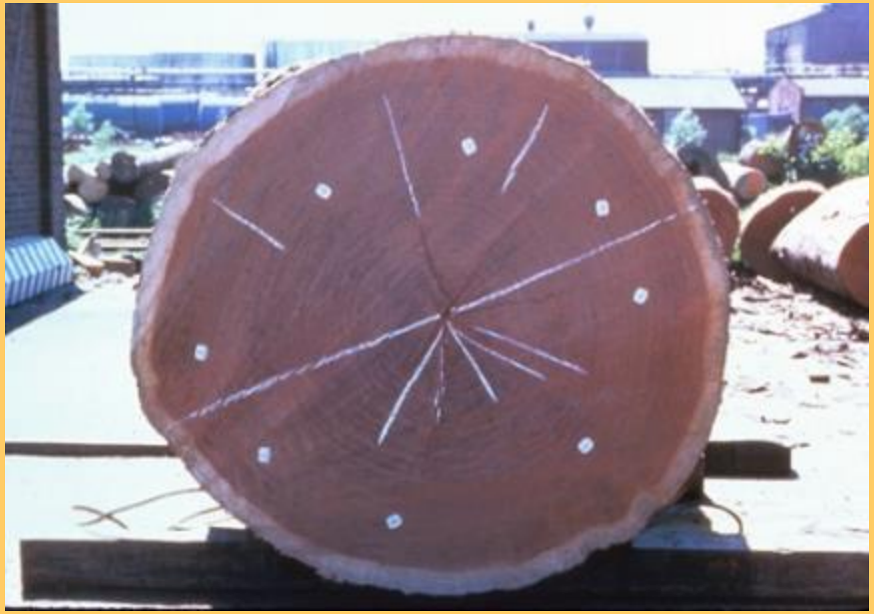
The flitches can be squared up with a saw.

Flitching a Log

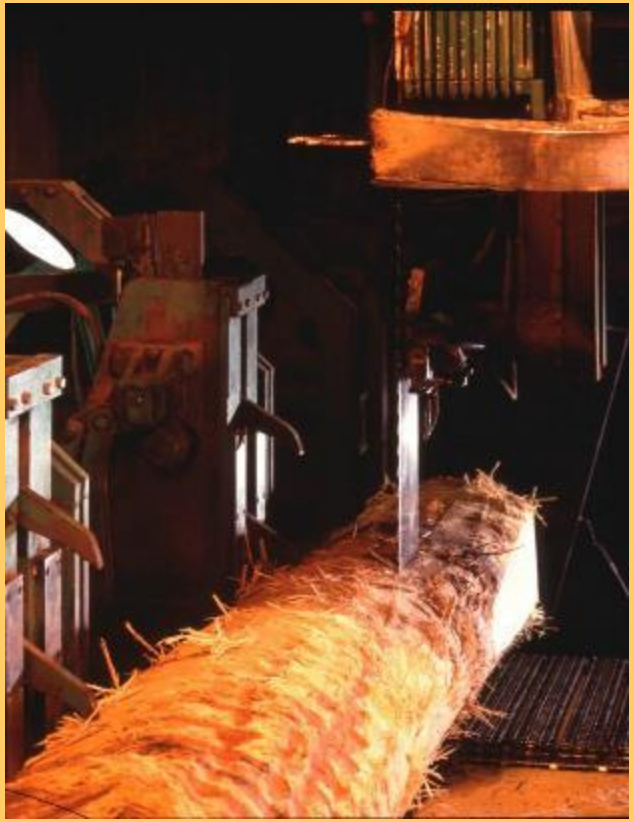
A. Lengths are determined.

B. Size of flitches

C. Type of cuts



Debarking the log



Flitching at the sawmill

Flitch sawed and ready to produce veneer

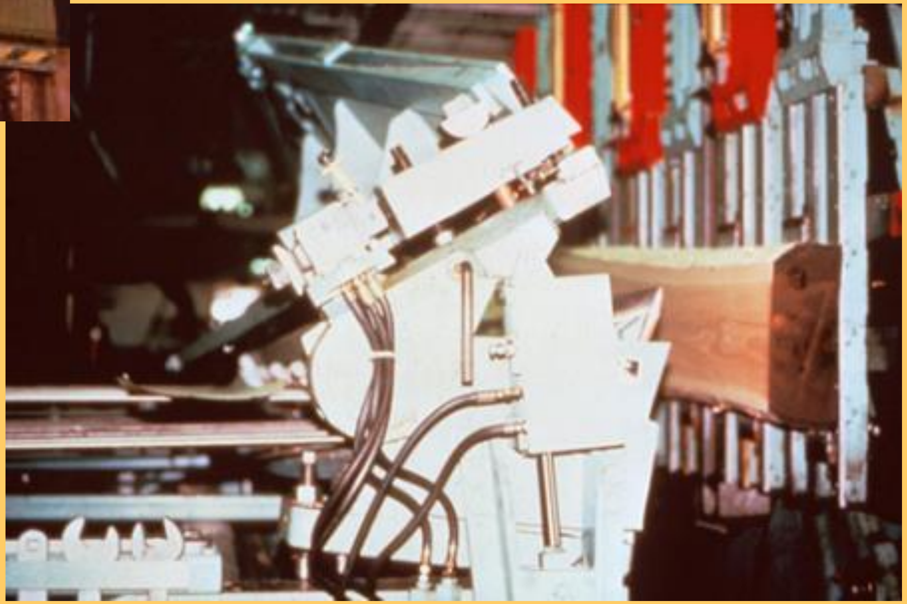
Cooking Vats

- Softens wood for slicing
- Possible color changes

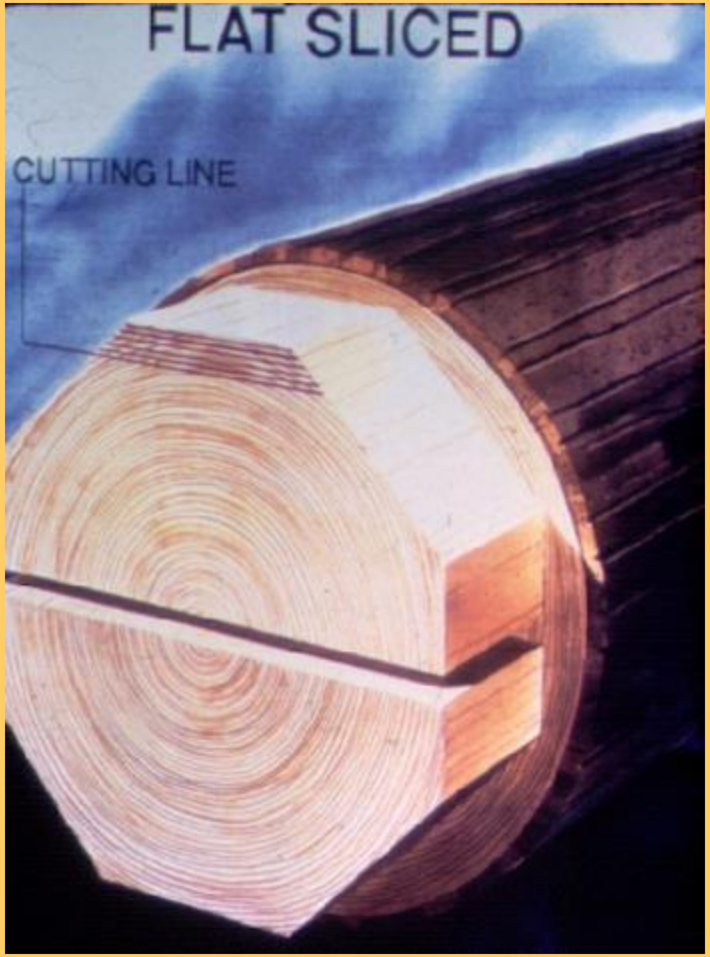
Softening flitches for slicing

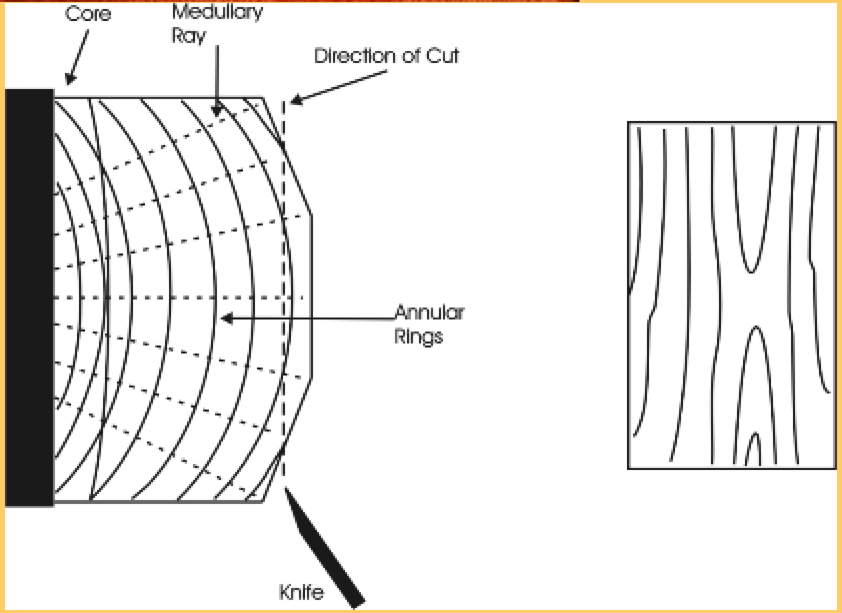
- The flitches are heated in water vats or steamed to soften the wood,
- The temperature usually varies between 50º and 90º C and the heating time between 24 to 36 hours. However, some high-density species need to be heated for many days.

Slicing Veneer

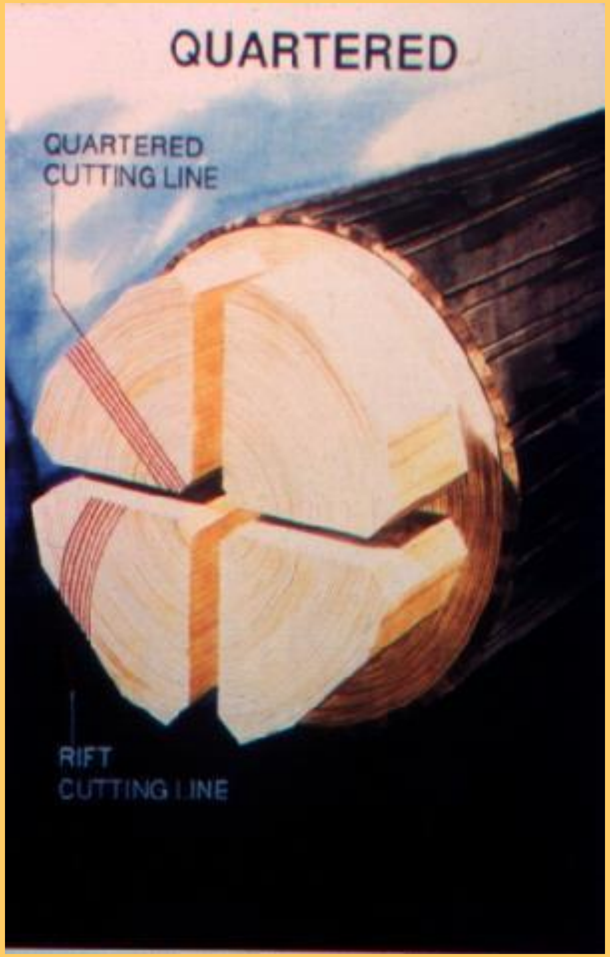


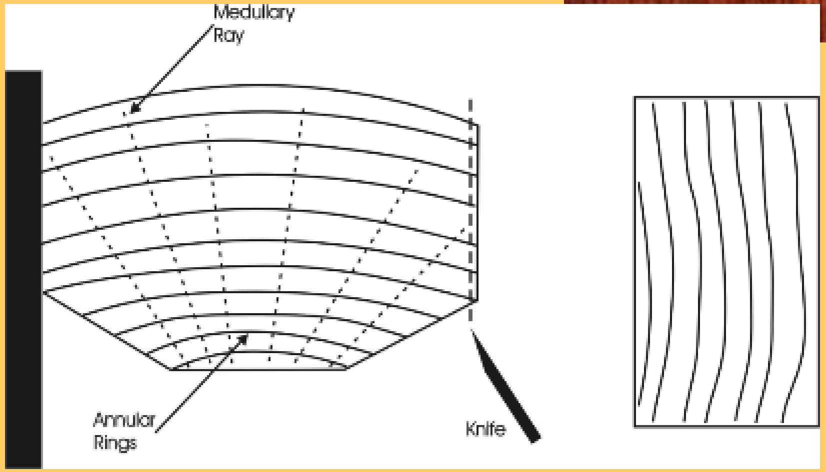
Flat Cut - Crown Cut



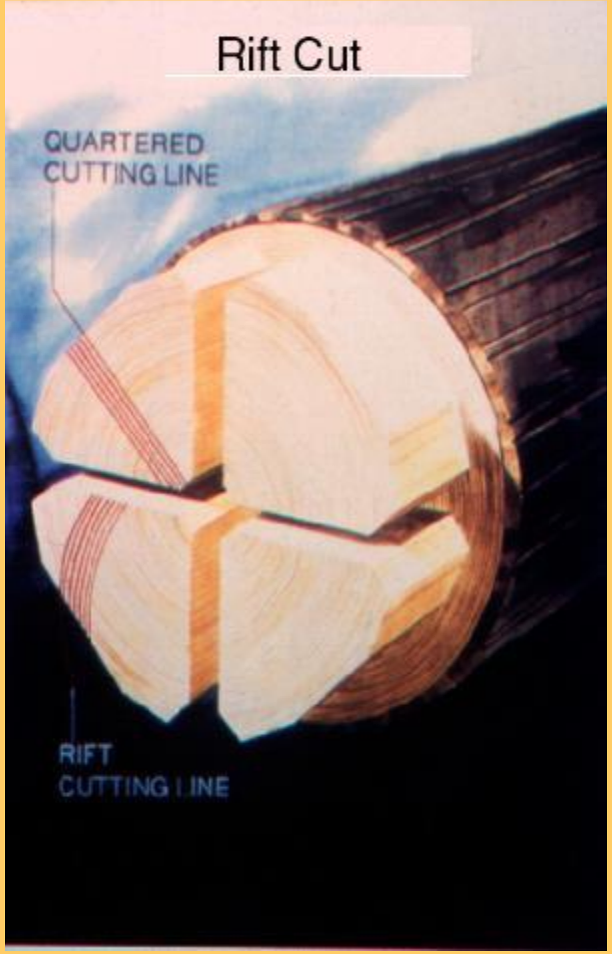


Quarter Cut

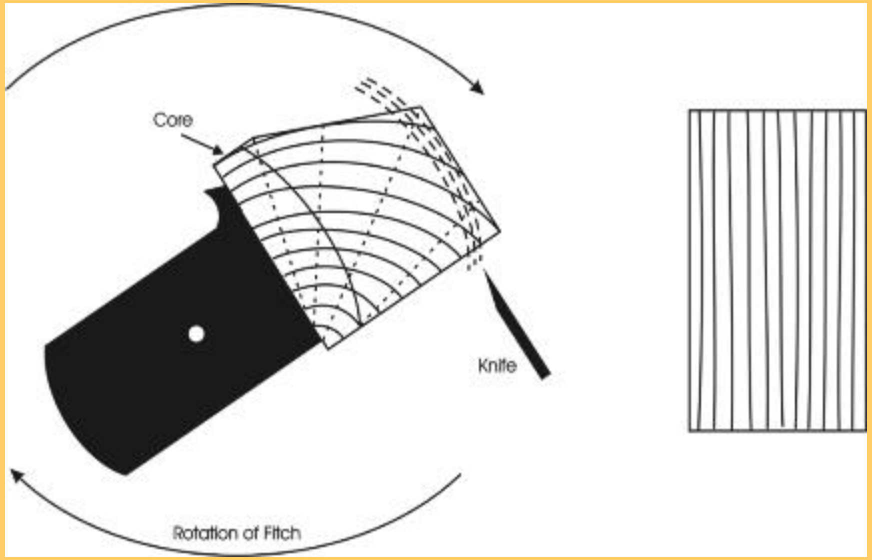

QUARTERED
QUARTERED
CUTTING LINE
RIFT
CUTTING LINE


Medullary
Ray
Annular
Rings
Knife

Rift Cut

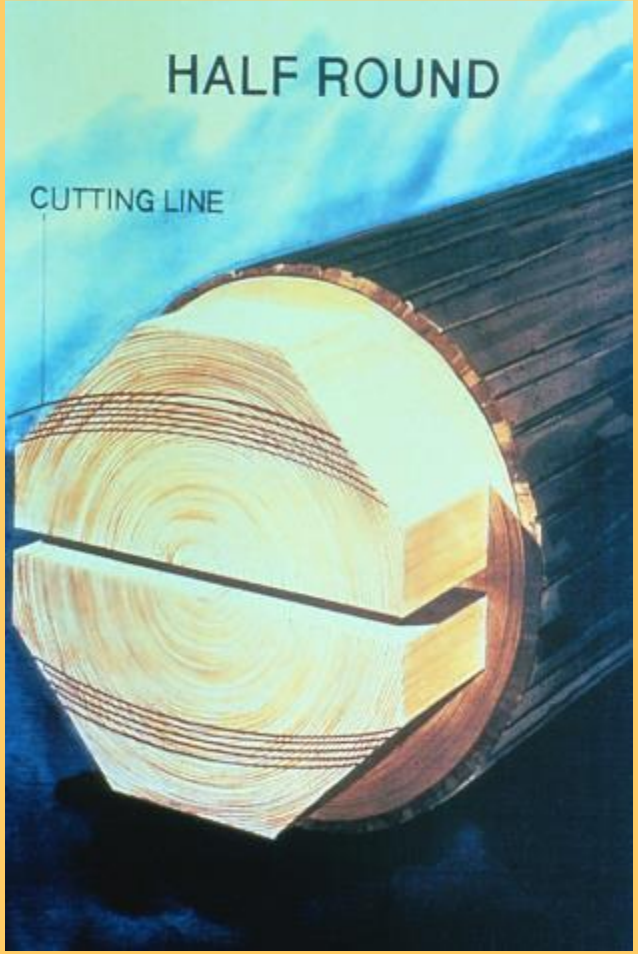


Rift Cut
QUARTERED
CUTTING LINE
RIFT
CUTTING LINE



Core
Knife
Rotation of Flitch

Half Round, or
Staylog Semi Rotary Slicing



Staylog Slicing
Gunns - Somerset


veneer leaves
being packed
sequentially

Drying Veneer

Input to Veneer Drier – Veneers suspended by air pressure = flat veneers

Gunns Veneers - Boyer

Clipping Veneer

Veneer Grading and Measuring

Imported Veneer

Veneer ready for inspection

Veneer Selection

Review Your
Resources

Define Your
Requirements

Consult Your
Suppliers

Panel Manufacture

Veneer is adhered to various substrates:

- Particleboard – strong, stable, inexpensive
- Medium Density Fibreboard – particularly for moulded and exposed edges
- Plywood – Very stable & tough
- Blockboard – Solid core doors

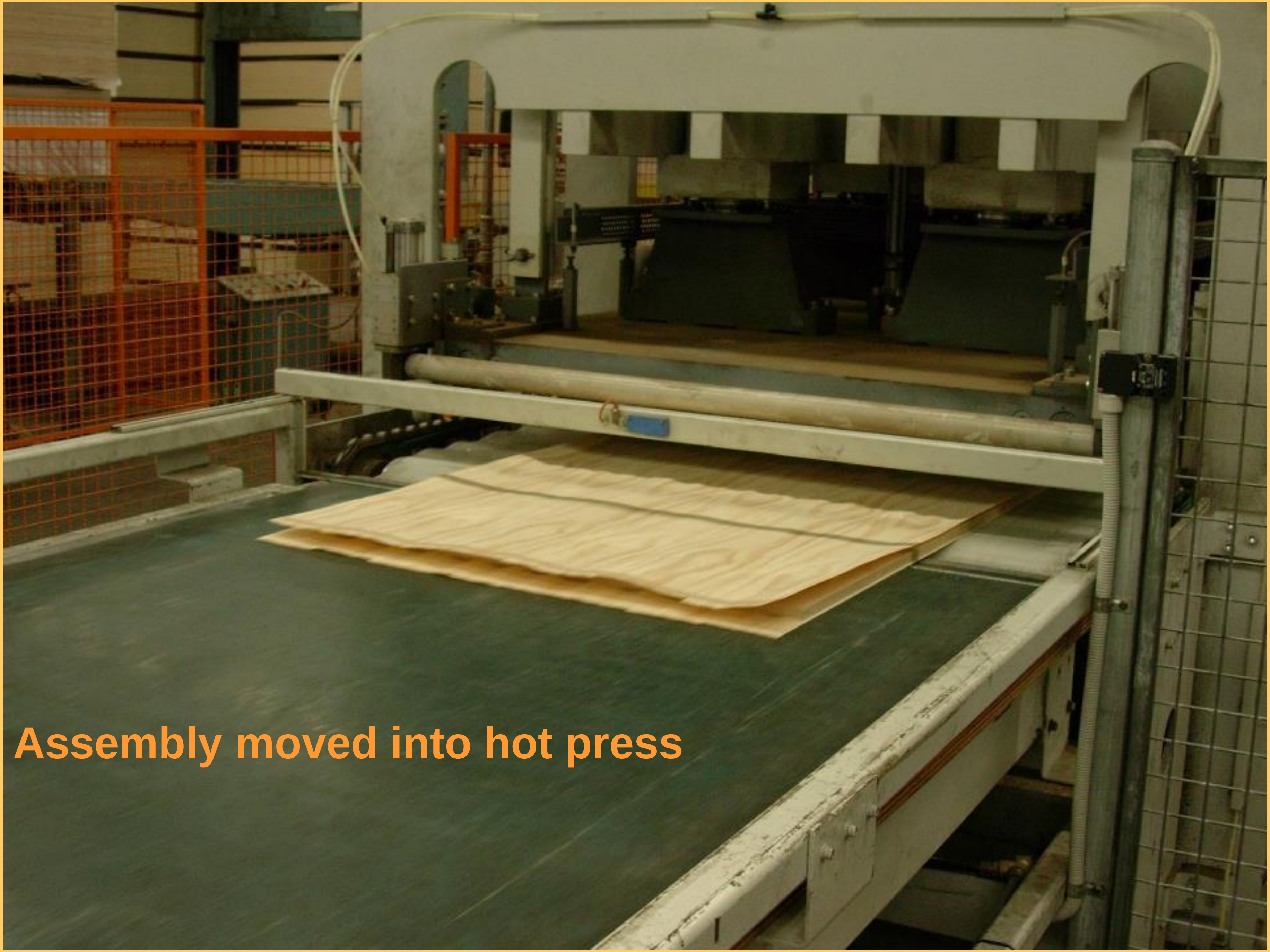
Pressing:

Adhering veneer layons in a hot press.

Substrate passes through glue ‘spreader’ – adhesive spread on both sides


Spread substrate placed on back veneer

Face veneer placed on top of spread substrate



Assembly moved into hot press

After hot pressing panel exits the hot press

Veneered pack ready for trimming & sanding

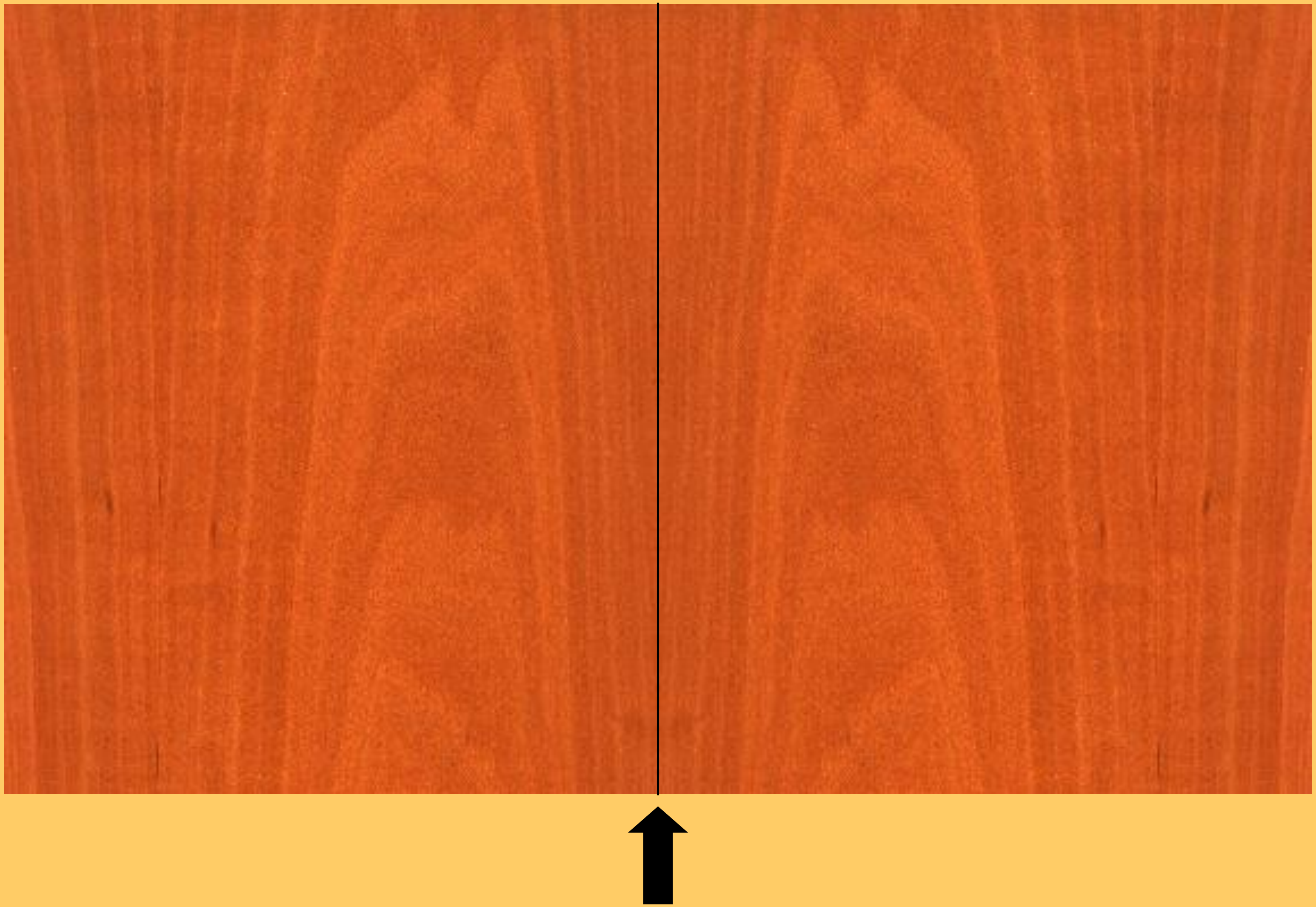
Leaf Matching
Common Types of Veneer Layons

Book Match

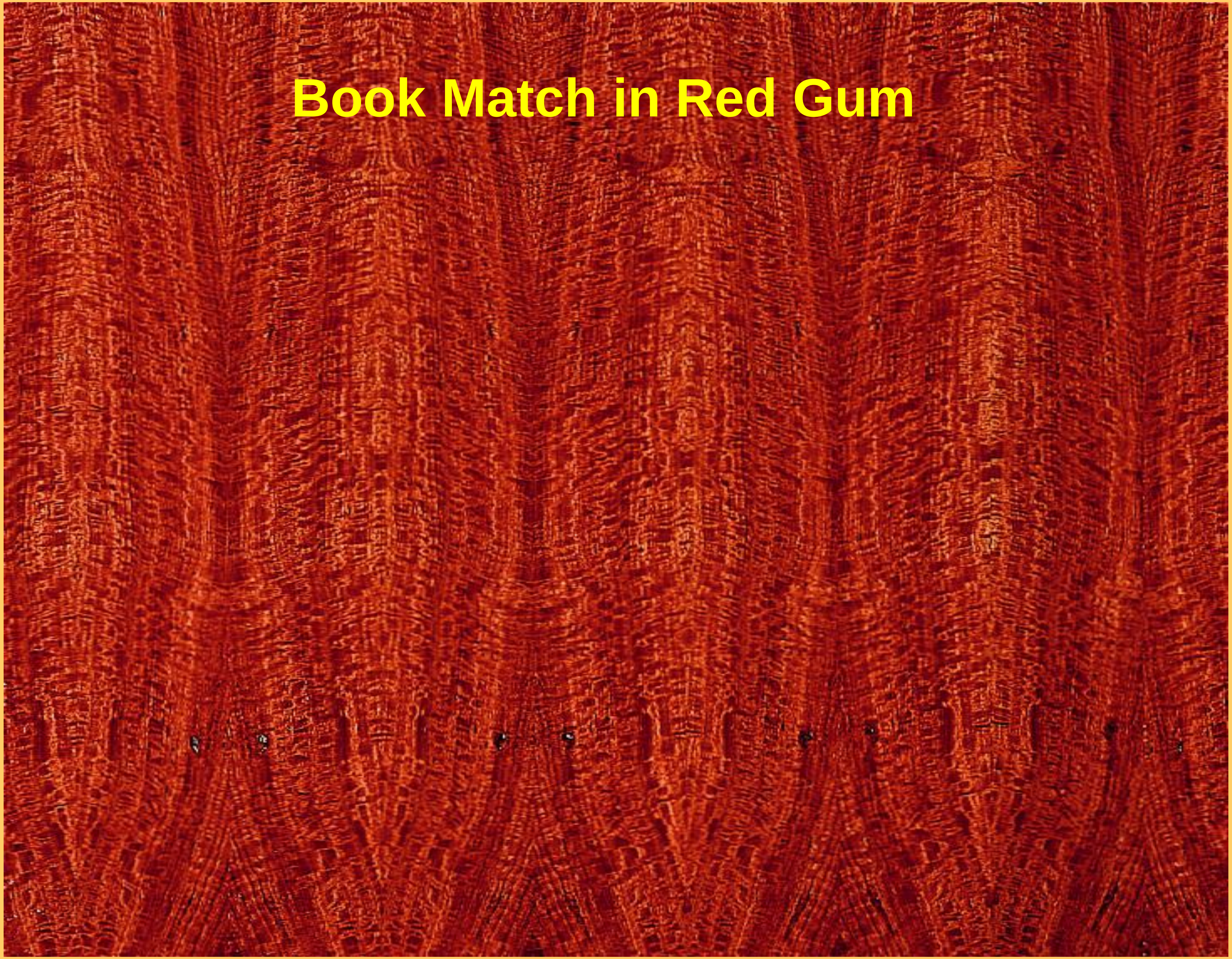
Slip Match

Random Match

Book Match



Book Match in Red Gum




Slip Match in Red Gum

Panel Matching

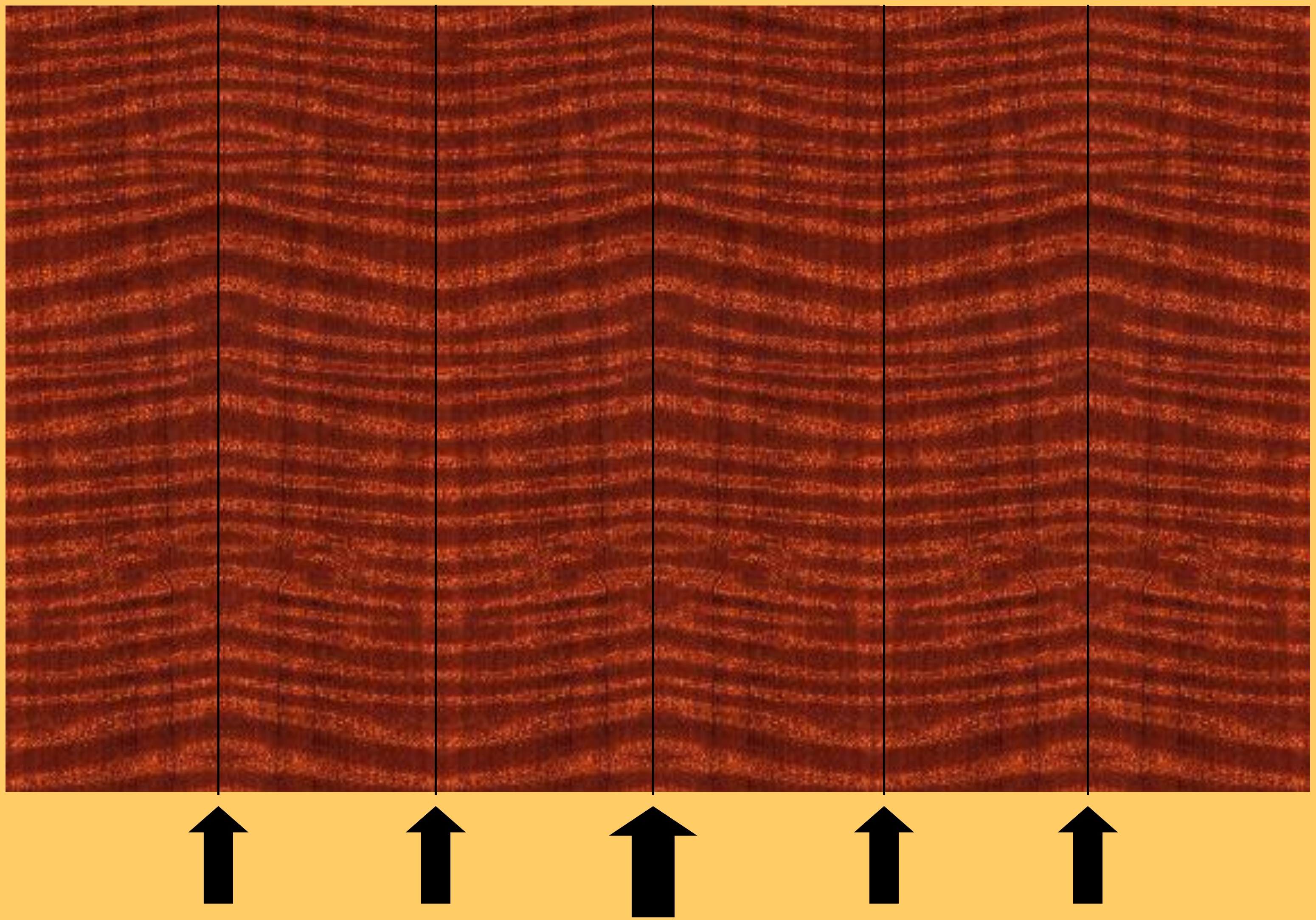
Centre Match

Balance Match

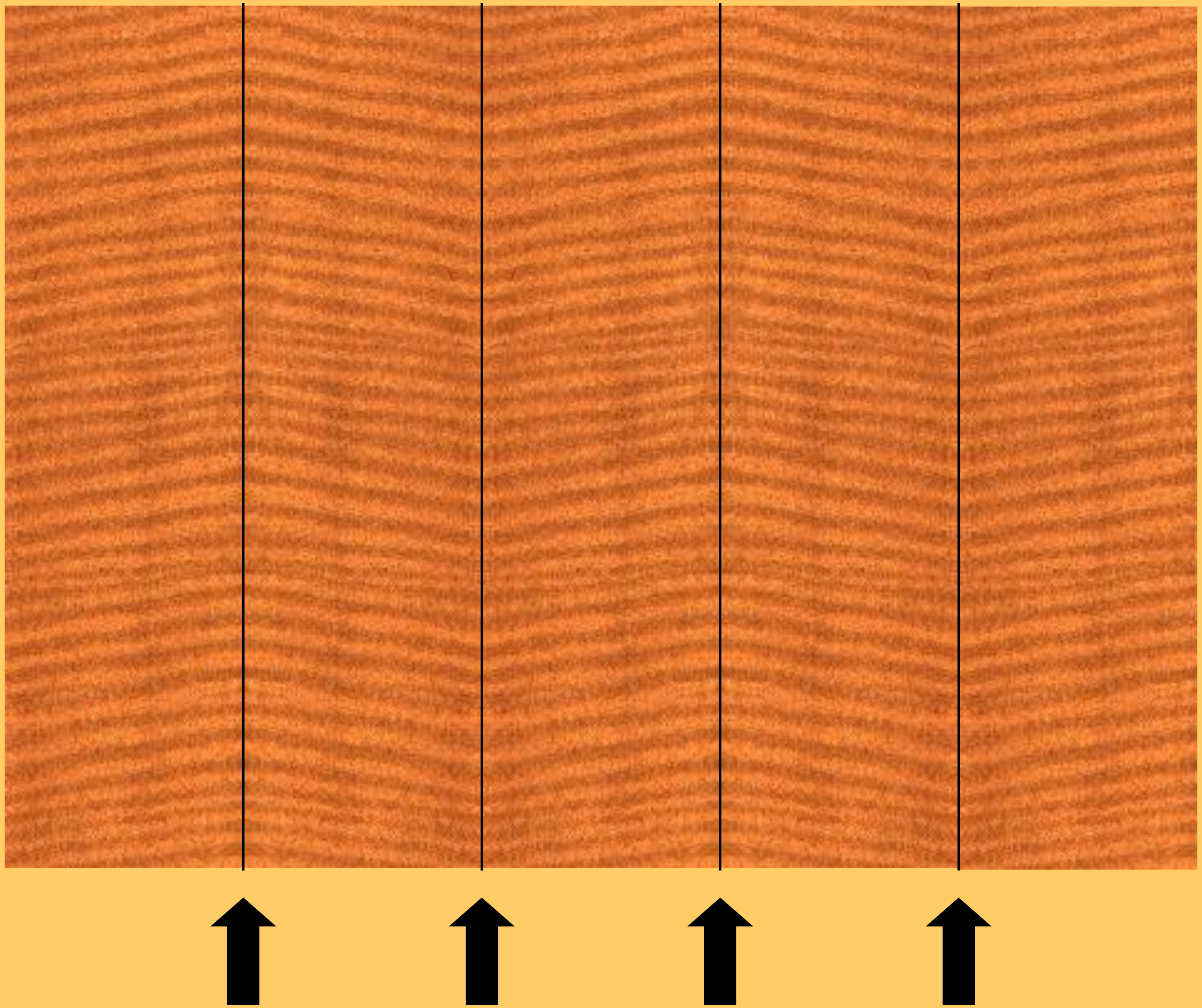
Running Match

End Match

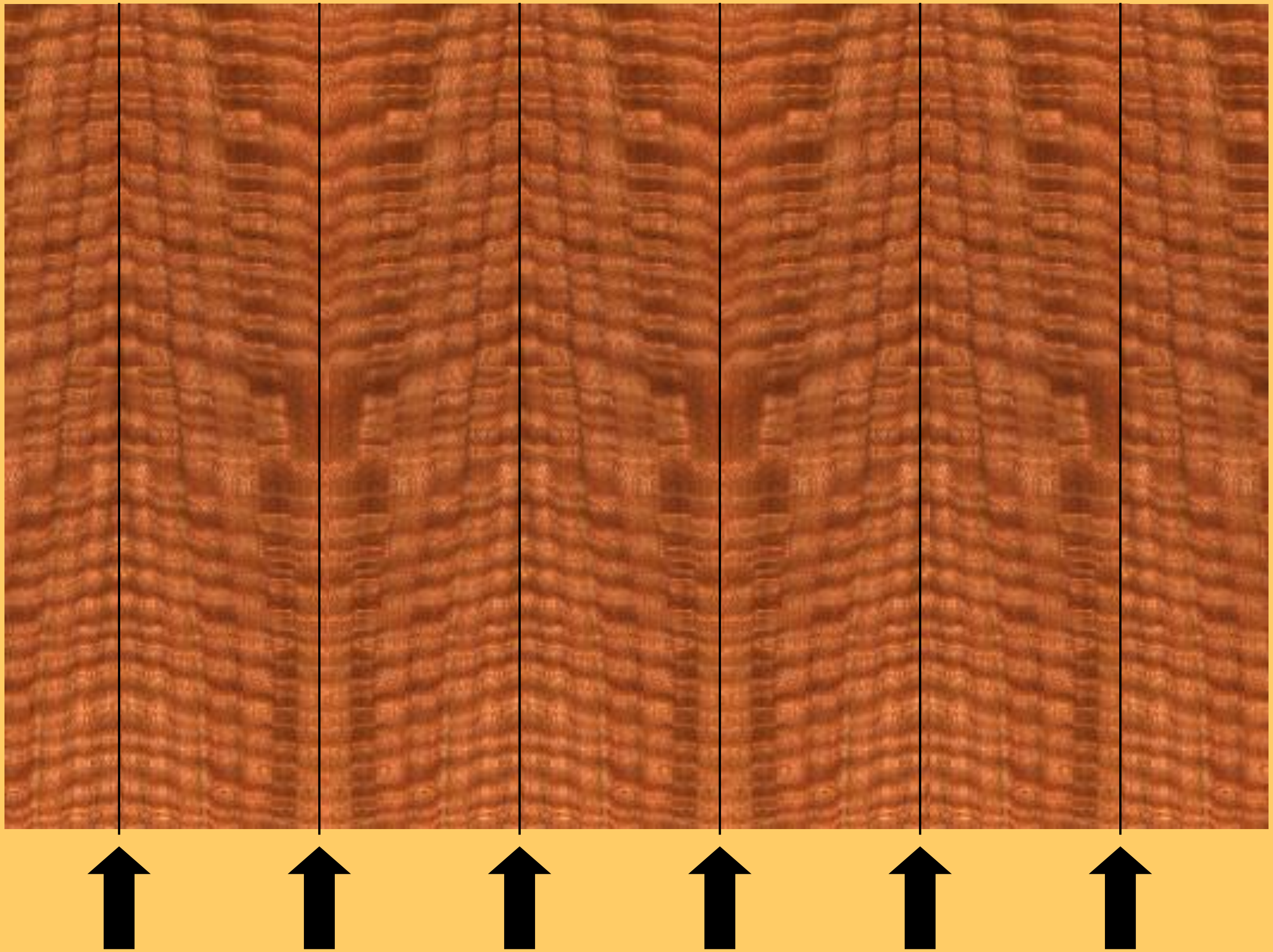
Centre Match



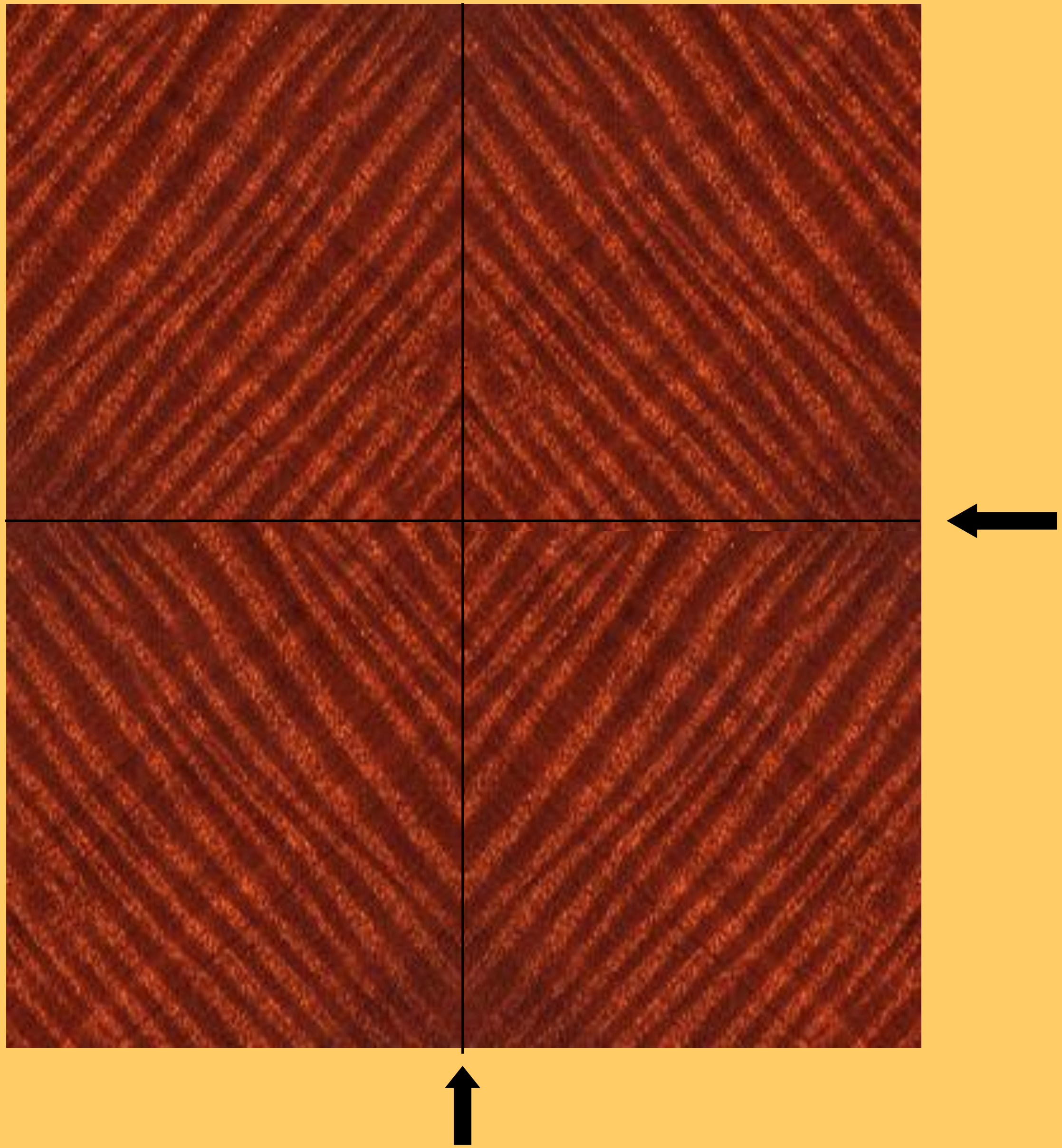
Balance Match



Running Match



End Match / Diamond



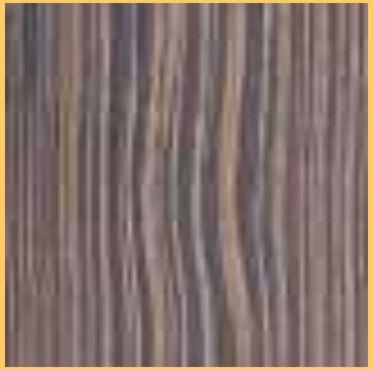
“V” Match

Herringbone Match

Reconstructed Veneers

- These veneers are made from natural veneers sliced from plantation and managed-forest timbers, which are dyed and then re-glued in moulds to form "grain" patterns.
- Final re-slicing produces unique and innovative veneers that have excellent consistency.
- The result is a wide range of colours and patterns, designed to meet the individuality of modern designers

Reconstituted Veneer



Fit Out Using Reconstructed veneers

Finishing/Polishing

- Veneered products require a protective coating or lacquer to protect them.
- It is very important that the selection of finish is suitable for the end use application of the finished piece of furniture, etc.

- **Veneered products should be sanded smooth.**
- **Care should be taken to round sharp edges since this causes finishes to thin**
- **Surface should be free from marks, indentations, etc., as polishing will highlight**
- **After sanding, ensure that the surface is clean**
- **Oil, wax and other contaminants also need to be removed before a finish is applied**

Traditional Finishes

They still can provide the best solution for particular applications as an alternative to the following general purpose finishes:

General Coating Systems

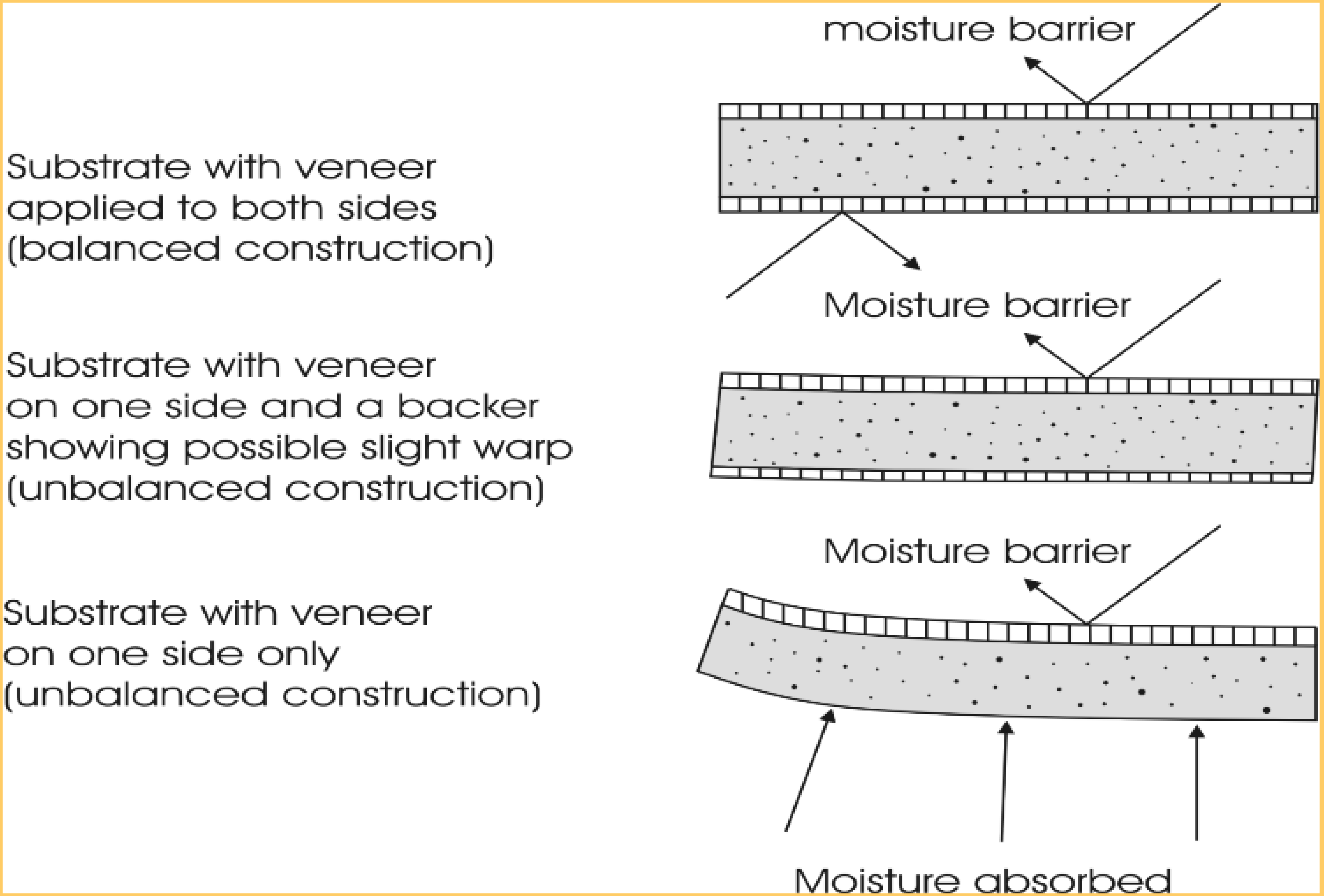
- Nitrocellulose Lacquers – simple, easy to use, fast drying, economical
- Pre-catalysed Lacquers - improved mar and scuff resistance, fast drying, medium water and solvent resistance
- Acid catalysed Lacquers - high build, superior mar and scuff resistance
- Polyurethane Coatings - excellent - chemical solvent and water resistance, high build, excellent mar and scuff resistance

A high quality (and probably more expensive) lacquer will help achieve a high quality result

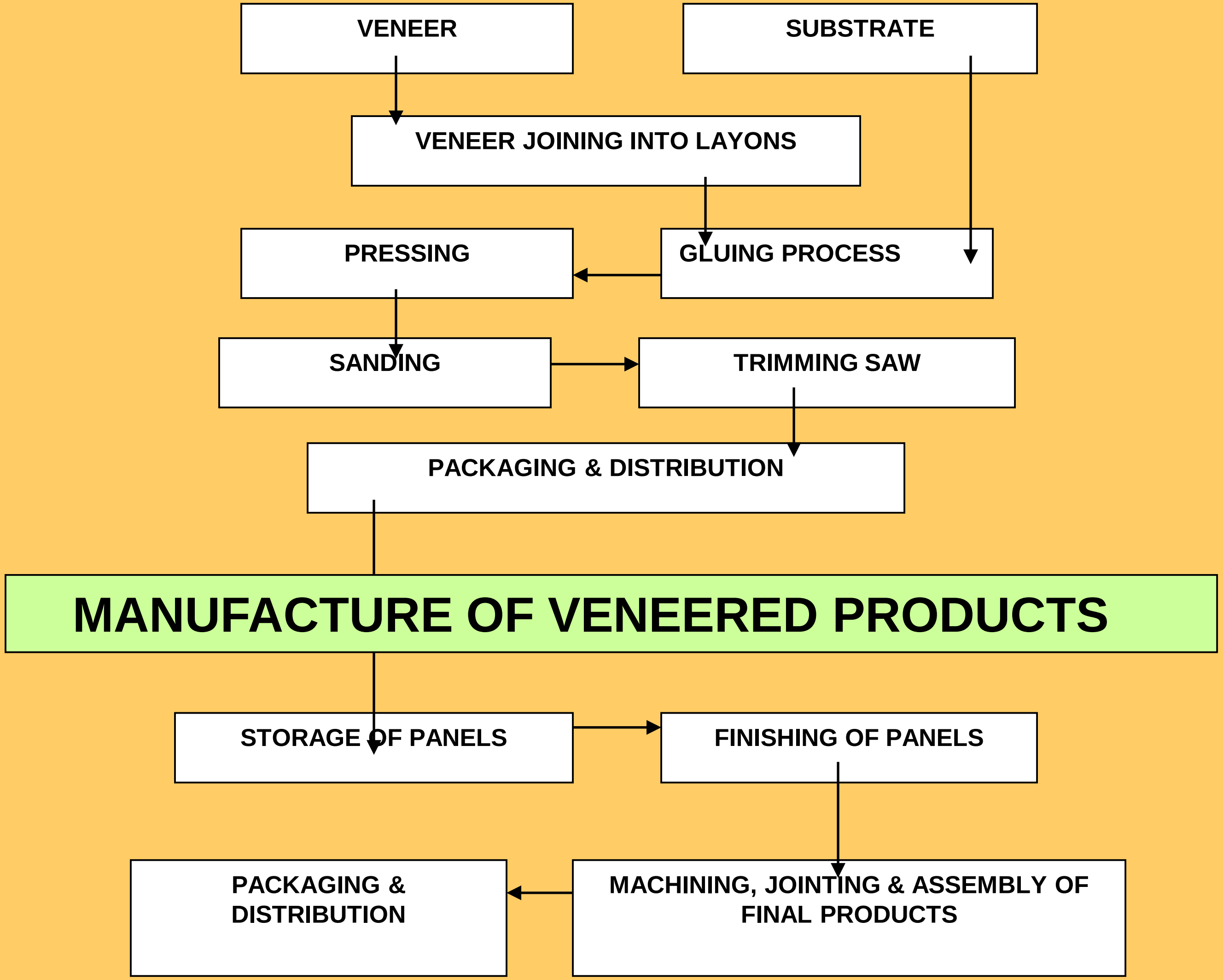
More sophisticated systems such as UV cured roller coating lines are available for volume production


Veneered Table Top
Matching Timber Edging
Veneer Edging an Alternative
Tasmanian Blackwood

Veneer panel construction



MANUFACTURE OF VENEERED PANELS



Eucalyptus regnans, obliqua & delegatensis – 75% of eucalypt veneers

Eucalypus regnans

Eucalyptus obliqua (Messmate)

Nothofagus cunninghamii (Myrtle)



Atherosperma moschatum

(Black heart sassafras)

***Eucalyptus camaldulensis* (River red gum)**

***Acacia melanoxylon* (Blackwood)**

Methods of Production of Sliced Veneers in Australia

- **Crown cut & Quarter cut veneers.**
- **Veneer thickness: 0.6 mm.**
- **Heating parameters:**
  - **temperature: 45^0C – 65^0C**
  - **heating time: 10 – 24 hours**
  - **Higher temp and longer time are used for high density species.**
- **Vertical slicers and staylog lathe.**
- **Drying temperature: 140^0C - 190^0C.**



Veneer Requirements and Standards

- AS/NZS 1859
  - Parts 1 and 2: substrate materials
  - Part 3: Decorative overlaid wood panels.

- AS/NZS 4266.32: Reconstituted Wood Based Panels – Methods of Test.

Australian Research Studies on Decorative Veneers

- Production and use of high density Victorian hardwoods for the production of sliced veneers.
- Veneers from younger timber resources.
- Dyeing veneers.
- Causes of veneer discolouration and prevention methods.
- Development of "The Manual on Decorative Wood Veneering Technology" www.fwpa.org.au

Research Studies (continued…)

- **Veneer colour matching and defect recognition system using machine vision technology.**
- **Surface activation of veneers to improve the adhesion of glues and coatings.**
- **Development of alternative heating methods for softening logs and flitches prior to peeling and slicing.**
- **Microwave drying of veneers.**

http://www.jahroc.com.au

http://www.jamel.com.au/




Chapter 8: Agricultural fiber panel production

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Presentation's content

- Why Agricultural fibers are used for panel production?
- Factors have influences on panels' properties
- Type of adhesives used in wood based panels.
- Australian standards for testing properties of panels
- Sharing the results of the effects of particle sizes on the mechanical and physical properties of particleboards made from cotton stalks
- Questions and Answers

Background


Millions hectares of forest have been lost in recent decates
More wood & wood based panels needed
POPULATION
More food required
Millions tons agricutural residues are generated annualy

The estimates of agricultural fibers Globally

Crops	The estimated crop residues (million metric ton) Source: (FAOSTAT 2017) and calculation base on mean ratio by(Lal 1995)])			
	1990	2000	2010	2014
Cotton	78.5	77,7	100.3	109.7
Rice Paddy	777.8	898.3	1,052	1,112
Sorghum	85.2	83.8	90.7	103.4
Soy beams	108.5	161.3	265	306.5
Sugarcane	263.3	314	423.2	471
Wheat	887	877.5	962.8	1,093

Utilisation of crop residues

A small portion of Agricultural residues has been used as fuel

Most of them are

- burnt at feld leading to
  - air pollution
  - soil erosion and decrease in soil biological activity
- incoporated into the siol → providing an ideal leaving place for pests

Therefore, if this waste can be used as an alternative material for wood based panels it can address

- shortage of wood materials (reducing pressure on forest resource)
- enviromental pollution
- soil problems

Factors influence boards' properties

Furnish

Most of particleboard consists of more than 90 percent lingo-cellulose material on a dry weight basic. Therefore, the characterization of this raw material has a significant influence on the properties of final products.

The properties of wood furnish that have effects on properties of particleboards:

- Density
- Acidity
- Extractive content

The effect of furnish density is expressed by compaction ratio (panel density/ wood furnish density). The boards with having the same densities, MOR and MOE Improved with increasing compact ratios.

Particles ‘s size

Aspect ratio S

$$s = \frac{l}{d}$$

l : The length of particles
d: The thickness of particle

Aspect ratio is one of the major factors that has a significant effect on properties of particleboard.

When the aspect ratio <150, the increase in aspect ratio will lead to

- Increase in MOR and MOE
- Dimensional stability Improve
- Decrease in internal bond strength (IB)

When aspect ratio > 150, the influence of aspect ratio on the properties of particleboards is insignificant

Mat Moisture Content

The mat moisture content is an extremely critical factor not only for the total press time but also in the development of the vertical density gradient.

- Moisture content at the surface speeds up heat transfer to the core which allows resin react more quickly than provided the heat moved by conduction through the wood and air spaces.
- Surface moisture content reduces the compressive strength on the wood that leads to increasing the density surface layers and decreasing density in core layer for a given average board's density. Consequently, the MOR and MOE of board will increase and the internal bond strength (IB) and screw withdraw will decease.
- Excessive moisture content migrates into core layer, the longer press cycle is require to remove moisture through the edges in order to prevent delamination.

In order to reduce the detrimental effects and retain advantage effects of moisture content, the non-uniform distribution of moisture content through the mat thickness could be applied with higher moisture content in the surface and lower moisture content in the core.

Press closing rate

- Higher initial pressures result in the platens closing to stops more quickly than that of lower initial pressures.
- The press closing rate and moisture content of mat are both important factors in the vertical density gradient formation.
- Faster closing rate could be expected to increase vertical density gradient and improve the bending strength. Nevertheless, it has detrimental influence on internal bond and screw holding strength

Pressing time and temperature

In the progress of the manufacture of particleboards, pressing time and temperature are considered as extremely important parameters. Hence, they have to be carefully controlled to ensure:

- The temperature at the core area reach the requirement level to cure the adhesive
- But without subjecting the board surface to high degradative temperature

This is Be cause the temperature distribution in the thickness direction is non-uniform leading to curing of the resin does not occur uniformly.

Type of adhesives using in wood based panels

Urea formaldehyde (UF), Melamine formaldehyde (MF) and phenol formaldehyde (PF) are the most commonly used resins in the particleboard industry.

- UF is a cost-effective non-transparent thermal-setting resin due to its high reactivity, water solubility. However, it has low moisture resistance, especially at high temperature. Consequently, UF resin is usually limited for the manufacture of products for interior only.
- MF is more resistant to moist environment than that of UF but MF is relative more expensive than UF and PF.
- PF is fist completely synthetic polymer to be commercialized and it is the major adhesive utilized for wood panels that used in exterior applications as a result of its resistance to moist environments. However, the dark colour is a disadvantage. What is more, it requires lower moisture content of wood in comparison with many other adhesives.

In addition to UF, MF and PF, polymeric diphenyl dimethyl isocyanate (pMDI) is very useful for manufacturing composites, especially in the core layer, which is lower in temperature and higher moisture content than are face layers. Moreover, composites bonded with pMDI have basically good water resistant properties as well as it has good boding to difficult surfaces such as wheat straw.

Process of panels production

Test standards

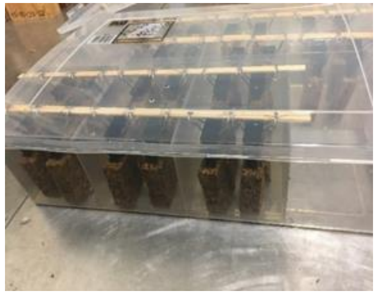
1. Modulus of elasticity/ Modulus of rupture (MOE/MOR): AS/NZS4266.5:2004 Reconstituted wood based panels- methods of test. Method 5: Modulus of elasticity in bending and bending strength.

2. Internal bond (IB): AS/NZS4266.6:2004 Reconstituted wood based panels- methods of test. Method 6: Tensile strength perpendicular to the plane of the panel (internal bond strength).

3. Swelling: AS/NZS4266.8:2004 Reconstituted wood based panels- methods of test. Method 8: swelling in thickness after immersion in water.

4. Density: AS/NZS 4266.4: 2004 Reconstituted wood based panels-Methods of test. Method 4: Density

Test results



Properties of homogenous particleboards made from different particles sizes

Properties	Units	Number of samples	Panel with particles of 6 mm	Panel with particles of 8 mm	Panel with particles of 10 mm	Panel with particles of 20 mm	STD particleboard requirements
MOR	Mpa	9	11.143 (1.852)	11.733 (2.051)	9.944 (1.988)	9.258 (1.495)	13
MOE	Mpa	9	1500.898 (167.845)	1612.867 (267.590)	1381.732 (195.344)	1300.467 (244.901)	1700
IB	Mpa	9	0.649 (0.077)	0.659 (0.094)	0.458 (0.108)	0.580 (0.079)	0.35
TS after 2 hours	%	9	18.022 (1.283)	10.83 (3.073)	19.556 (4.188)	13.231 (2.129)	-
TS after 24 hours	%	9	28.745 (2.393)	25.366 (2.739)	33.326 (7.078)	28.543 (9.617)	-
Density	g/cm^3	9	0.759 (0.016)	0.756 (0.017)	0.759 (0.022)	0.753 (0.019)	

Standard deviation is presented in parenthesis