ACIAR FST/2009/062 Development of advanced veneer and other products from coconut wood to enhance livelihoods in South Pacific communities

Producing rotary-peeled coconut veneer

July 2015

Queensland Government

Authors

Robert McGavin, William Leggate, Gary Hopewell, Joh Fehrmann, Henri Bailleres, Chris Fitzgerald and Susan House, Department of Agriculture and Fisheries, Queensland.

Table of contents

Table of figures

Acknowledgments

The manual: *Production of rotary-peeled coconut veneer* was supported by the Australian Centre for International Agricultural Research (ACIAR) and developed from the knowledge achieved through the project: *Development of advanced veneer and other products from coconut wood to enhance livelihoods in South Pacific communities* (*FST/2009/062).* The project was undertaken in collaboration with ACIAR, the Queensland Government Department of Agriculture and Fisheries (DAF), the University of Tasmania (UTAS), the Secretariat of the Pacific Community (SPC), the Fiji Ministry of Fisheries and Forests, Samoa Ministry of Natural Resources and Environment, and Solomon Island Ministry of Forestry.

The DAF research team was led by Mr Rob McGavin and included Dr Henri Bailleres, Gary Hopewell, Rod Vella, Fred Lane, Joh Fehrmann, Chris Fitzgerald, Eric Littee, Dan Field, Rica Minnett and William Leggate.

The authors acknowledge the material they have drawn on from several publications and web resources. These are listed in the ‘More Information’ section at the end of the manual.

Glossary and abbreviations

These definitions are drawn from several sources listed in 'More information'.

ADHESIVE – A substance that is used to stick materials to each other through surface attachment.

AS/NZS – Australian and New Zealand Standards

BACK – The veneer ply on the back side of the panel.

BOND - to glue together, as veneers are 'bonded' to form a sheet of plywood. Pressure is applied to keep mating parts in proper alignment.

CHECKS

> SEASONING CHECKS – Small slits running parallel to the grain of wood, caused chiefly by strains produced during seasoning.
>
> LATHE OR PEELER CHECKS – Fractures on the loose side of the veneer sheet developed as a result of stresses occurring during peeling.

CLIPPER – A machine used to cut the veneer ribbons or sheets into specified widths.

CORE – The inner part of a veneered panel or plywood between the face and back veneers.

CREEP – Slow and continuous deformation of a material with time and use.

CROSS BAND – A veneer sheet or panel in which the veneer grain directions are parallel to the shorter panel dimension. It is also defined as the inner layer with a grain direction that is at right-angles to the outermost plies.

DEFECT, OPEN – Open checks, splits, joints, knotholes, cracks, loose knots, gaps, voids or other openings interrupting the smooth continuity of the wood surface.

DENSITY - The weight per unit volume, in kilograms per cubic metre (kg/m^3).

DISCOLOURATION – Stains in wood substances. Common veneer stains include sap stains; blue stains; stains produced by chemical action caused by the iron in the cutting knife coming into contact with the tannic acid of the wood, or chemical reactions between extractives in wood and glue or finish discolorations. Areas of colour differing from the average colour of the surrounding piece or from the colour normally associated with the piece and occurring in either streaks or patches.

DURABILITY - The natural ability of the heartwood to resist decay (as a result of fungal attack) in high risk conditions (for example, low ventilation or high moisture). In Australia, a four-class system is used: Durability Class 1 being most durable and Durability Class 4 least durable with separate ratings for in-ground and above-ground environments.

EMC – Equilibrium Moisture Content.

EWPs (ENGINEERED WOOD PRODUCTS) - Wood products manufactured by bonding together wood strands, veneers, lumber or other forms of wood fibre to produce a larger and integral composite unit with superior performance characteristics. These high performance building components achieve predictable and reliable performance characteristics with the efficient use of natural resources.

FACE VENEER – A term used to describe better quality veneers that are used to cover the visible surfaces of a panel.

FUNGAL DECAY- Decomposition of wood by fungi.

GLUE LINE - The adhesive joint formed between veneers in a plywood panel or between face veneers and core in a composite panel (primary glue line), or between lumber and wood structural panel parts in an assembly such as a component (secondary glue line).

GRADE - Refers to the letter-graded quality of veneers used in plywood manufacture (N, A, B, C-Plugged, C and D), or to particular panels, e.g. A-A.

GRADING – Classifying veneers according to quality standards.

GRAIN – The direction, size, arrangement and appearance of the fibres in timber and veneer: the natural growth pattern in wood. The grain runs lengthwise in the tree and is strongest in that direction. Similarly, grain usually runs the long dimension in a panel of plywood or OSB, making it stronger in that direction.

GRAIN SLOPE – Expression of the angle of the grain to the long edges or the length of the veneer.

GRAIN TEAR-OUT- Gouges in veneer surface.

HARDWOOD/SOFTWOOD - Regardless of weight or hardness, 'hardwoods', e.g. red cedar, are technically defined as those woods having vessels (pores), while 'softwoods', e.g. hoop pine, are defined as those not having vessels.

HEARTWOOD - The non-active core providing support to a tree often distinguishable from the sapwood by its usually darker colour and greater resistance to decay in many species.

HOLE - A hole that extends partially or entirely through the piece and attributable to any cause.

INNER PLIES - All plies of a plywood panel except face and back.

INSECT ATTACK- Deterioration caused by borers or termites.

JOINT - The seam produced by jointing the edges of veneer sheets together.

KNIFE ANGLE – The angle between the knife face and a horizontal plane (when the billet is peeled at various diameters). It is also called slope angle.

KNIFE, LATHE – used to cut the veneer from the peeler billet as the billet is held in the lathe.

KNIFE MARK- Marks on the surface of a veneer usually caused by a chipped blade resulting in a raised strip along the veneer surface.

LAYER - In plywood, a layer consists of one or more adjacent plies having the wood grain in the same direction.

LONG-BAND – A veneered sheet or panel in which the veneer grain directions are parallel to the long panel dimension.

LOOSE SIDE OF VENEER – The side of the sheet that was in contact with the knife while the sheet was being cut. It contains cutting checks (lathe checks) because of the bending of the wood at the knife edge.

LVL (LAMINATED VENEER LUMBER) - A composite of wood veneer sheet elements with wood fibres primarily oriented along the length of the member. LVL is one of several types of EWP.

MC - MOISTURE CONTENT – The proportion of moisture in wood, expressed as a percentage of its oven dry weight

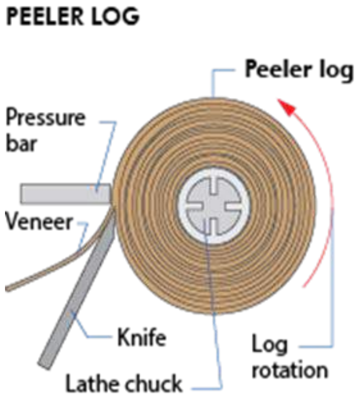
MLW – MULTILAMINAR WOOD - Large blocks composed of multiple layers of veneers glued together.

NOSE BAR – A bevelled or roller bar mounted parallel with the tip of the lathe knife and designed to compress the veneer block into the cutting edge of the lathe knife.

PATCHING - A wooden or plastic composite patch or plug used to replace voids removed from veneer.

PEELER BILLET – Synonym for peeler log. A billet used to produce veneer. Peeler billets are debarked, then lathe-turned against a long knife blade that removes a thin continuous ribbon of veneer then clipped to size, dried, graded, repaired and laminated into plywood panels or LVL billets.

Source: http://www.wooduniversity.org/glossary



PLYWOOD is made from peeled veneer layers that are bonded by adhesive. Peeled veneer layers are arranged perpendicular to each other.

PLY – layer of veneer or single veneer in a panel.

PRE-CONDITIONING – Preparing a peeler billet (using heat and wetting agents) for peeling.

PRODUCT STANDARD - An industry product manufacturing or performance specification.

QUALITY CONTROL - Quality control (QC) is best described as a system of process and product monitoring that aims to ensure implemented procedures, protocols and measurements are being followed to produce a consistent product of the required quality.

RECOVERY

GREEN VENEER RECOVERY provides a useful measure of the maximum recovery, taking into account log geometry (sweep, taper, circularity) and lathe limitations (e.g., peeler core size). Green veneer recovery disregards internal log quality. Green Veneer Recovery is expressed as a percentage of billet volume.

GROSS VENEER RECOVERY provides a useful measure of the maximum recovery of dried veneer that meets the relevant quality specifications. This recovery includes the losses accounted for in green veneer recovery but also includes additional losses from visual grading (i.e., veneer that failed to meet grade) and the drying process (e.g., veneer shrinkage, splits). Gross Veneer Recovery is expressed as a percentage of billet volume.

NET VENEER RECOVERY provides a useful measure of process efficiency, as it identifies the saleable product, taking into account the product manufacturing limitations. Net veneer recovery includes the losses accounted for in gross veneer recovery but also includes the additional losses due to the trimming of veneer before, during, and after product manufacture. Net Veneer Recovery is expressed as a percentage of billet volume.

GRADED VENEER RECOVERY for an individual grade can be calculated using the same method as for net veneer recovery but using the veneer volumes that meet the specific grade (e.g. A, B, C, or D grades in accordance with AS/NZS 2269.0:2012 Plywood –

Structural – Specifications). Graded Veneer Recovery is expressed as a percentage of billet volume.

REPAIRS - Any patch, plug or shim in a veneer. A patch is a sound wood insert or synthetic material to replace a defect in veneer. ‘Boat’ patches are oval shaped with sides tapering to points or small rounded ends. ‘Router’ patches have parallel sides and rounded ends. ‘Sled’ patches are rectangular with feathered ends. A plug may be a circular or dogbone shaped wood patch or a synthetic filler of fibre and resin to fill openings and provide a smooth, level, durable surface. A shim is a long narrow wood or synthetic repair not more than 3/16 inch wide. Various other shapes of plugs or patches may be encountered.

ROTARY VENEER – A veneer produced when a billet mounted in a lathe is rotated against a cutting blade. This method of peeling is used to produce veneers for manufacturing products such as plywood, LVL, multilaminar wood and other EWPs.

ROUGHNESS - Unevenness of the surface of the veneer or plywood.

SCRATCH - A surface split or gouge that does not penetrate through, from one side to another, on a veneer sheet.

SEASONING (DRYING) - Drying timber to a moisture content range appropriate to the conditions and purposes for which it is to be used.

SHRINKAGE - A change in dimensions occurring as the wood dries from a 'green' (wet) to a seasoned (dry) condition. Shrinkage can occur in three directions: radial, tangential and longitudinal.

SLICED VENEER – Veneer produced by thrusting a log or sawn flitch into a slicing machine that shears off the veneer in sheets.

SMOOTH, TIGHT CUT – Veneer carefully cut to minimise peeler or slicer checks.

SPINDLED LATHE - The traditional method of rotary veneer production. This type of lathe uses spindles or ‘chucks’ to hold the billet in position and to rotate the billet against the knife. This method has proved very reliable and a very effective way to produce high quality veneer, even at very high production speeds.

SPINDLELESS LATHE - Spindleless lathes, as the name suggests, have no spindles. Rotary drive is provided through powered backup rollers and often with support from a driven roller nose bar. While spindleless lathes still produce peeler cores, their diameters are often smaller (in the order of 20–50 mm) than those for a spindled lathe.

SPLIT - A separation of the fibres in the direction of the grain and extending through the thickness of the veneer

TIGHT SIDE – The side of a veneer sheet that was furthest from the knife as the sheet was being peeled and contains no lathe checks.

UNIT SHRINKAGE - Percentage of change in dimensions with each one percent change in moisture content (below about 25% moisture content).

VENEER-BASED PRODUCTS – Products made from peeled or sliced veneers. Examples of veneer-based products produced from peeled veneers include plywood and Laminated Veneer Lumber (LVL).

VENEERS - Thin sheets of wood of uniform thickness (usually1–4 mm), created by peeling (peeled veneer) or slicing (sliced veneer) from logs for use in plywood, face decorative veneers, laminated veneer lumber (LVL), veneer multilaminar blocks, etc. A thin sheet of wood laminated with others under heat and pressure to form plywood, or used for faces of composite panels. Also called ply.

VENEER COMPOSING - Veneer composing means to dock and butt join random-width veneers and sections freed from defects and combine them in a full size sheet for plywood panel production.

WAVINESS - Waviness in the veneer. Waves can split and overlap during pressing into veneer-based products.

About this manual

This manual describes best practice for the production of rotary veneer. The manual is focused on the production of coconut palm rotary veneer (or cocoveneer), however also presents more general information on rotary veneering from more traditional forest resources.

These technical guidelines are based on the research outcomes of the ACIAR project *Development of advanced veneer and other products from coconut wood to enhance livelihoods in South Pacific communities* (*FST/2009/062).*

The manual focuses on the manufacturing of veneer derived from rotary peeling, rather than slicing.

Where possible, emphasis is placed on relevance to the Pacific region's coconut resource, although much of the manual will also be useful for guiding more traditional forest log conversion by rotary peeling in other countries, including Australia.

The manual is divided into 10 chapters. Each chapter discusses different aspects of rotary veneer processing.

Chapter 1 provides a summary of the best practice steps for processing coconut logs into veneers.

Chapter 2 provides an overview of rotary veneer product types and uses. It also highlights the advantages of veneer processing compared to solid wood processing.

Chapter 3 summarises the key wood properties and processing characteristics of coconut palms that influence veneer production.

Chapters 4, 5 and 6 describe recommended best practice methods for rotary-peeled veneer manufacture from the log grading stage to veneer drying.

Chapters 7, 8 and 9 summarise veneer grading, quality control and veneer recovery.

The field of rotary peeling is vast and no single publication could adequately cover all aspects in detail. The manual is intended to provide information and recommendations relevant to the main subject areas of interest.

While the manual attempts to describe best practice recommendations for rotary-peeled veneer production from coconut logs covering a wide range of scenarios, it is impossible to cover all situations. Specific recommendations will ultimately vary depending on equipment type, plant layout, level of investment, scale of operation, resource, labour, product, market and economic considerations. For example, optimal lathe settings will be strongly influenced by lathe type and target product.

It is also important to highlight that although the manual provides general recommendations, veneer product manufacturers and veneer users should also seek specific expert assistance.

1 Overview

1.1 Manufacturing veneer-based products from rotary-peeled coconut palm stems

1.1.1 Definition of rotary veneer

Traditionally, a veneer is a thin layer of wood usually 1–4 mm in thickness, removed from a log using a rotary peeling process. For the purposes of this manual, veneer is also a thin layer of coconut removed from a coconut stem using a rotary peeling processes and is called ‘cocoveneer’. Cocoveneer thicknesses usually range between 2.5 and 6 mm. Other forms of veneer such as sliced or sawn veneers are not discussed.

The process of rotary veneer production is to remove a continuous thin ribbon of veneer or cocoveneer from a peeler billet periphery using a knife that is positioned parallel to the grain. The billet is rotated against the knife using a drive mechanism that varies in design and approach, depending on the technology being used.

1.1.2 Uses of rotary veneer

Rotary-peeled veneers can be used in structural and appearance applications.

Common structural applications for rotary-peeled veneers include structural plywood, form ply for concrete construction, packaging, and laminated veneer lumber (LVL). Decorative uses for rotary-peeled veneer include architectural uses, furniture and joinery.

1.1.3 General advantages of veneer-based wood products

Significant advantages of veneer-based products compared to solid wood products include:

- Increased yield and value from forest resources. Rotary-peeled veneers provide an opportunity to use lower-quality and different log resources that are not suitable for traditional, sawn products. Additionally, recovery rates are usually much higher from a rotary peeling process compared to sawing, especially with small diameter log resources.
- More predictable performance, faster production and a greater range of possible product dimensions. Rotary peeling allows material to be produced with much greater lengths, widths and thicknesses compared to that possible with sawing.
- Randomisation of varying properties and qualities (including defects). Unlike sawn timber products, in veneer-based products varying properties and qualities can be much better controlled and where appropriate spread throughout the product. This permits log resources with varying qualities to be more successfully converted into veneer-based products that are suitable for structural and appearance applications.
- Versatility and suitability for diverse applications and all building types ranging from detached domestic housing to multi-residential and commercial buildings.
- Greater stability under cyclical environmental conditions. For example, plywood’s alternating grain direction construction (each layer is at right angles to adjacent veneers) means that movement within the plane of the panel is minimal. The axial alignment of the grain in one sheet of veneer restrains the tangential movement in adjacent veneers. Unlike solid wood products, shrinkage and strength properties are similar in both planes.

- Greater control over the variability of properties and gradients within the final product compared with sawn products. Veneer-based products can be engineered to suit different structural and appearance applications.
- Ability to span wide supports and they have good creep resistance. Their ability to withstand large racking forces can make them the preferred building material choice in areas that experience extreme weather events (e.g. earthquake or cyclone prone regions).

1.1.4 Coconut stems are highly suited to veneer-based products

Until recently, attempts to processing coconut stems into rotary veneer have been largely unsuccessful. This has been mainly due to the spindles or chucks of traditional lathes being unable to successfully transfer the forces between the turning spindles and the low density, soft inner part of the coconut stem. This prevents the billet from correctly rotating allowing veneers to be produced. However, technological advances in peeling equipment have provided spindleless veneering approaches that have enabled the problem to be largely overcome. The development of this technology has been primarily focused on the processing of very small and young plantation hardwood logs, however it can be successfully adapted for the processing of coconut stems.

1.1.5 General overview of the process and best practice steps.

The section below summarises key recommendations for optimal conversion of coconut stems into rotary-veneer-based products. The recommendations are general only and applicability will depend on many factors including:

- Individual plant equipment, scale of operation and layout
- Specific raw material (resource), product and market factors
- Available finances, labour and other economic considerations.

Veneer-based product manufacturing typically involves three main stages: Veneer manufacture (billet storage, handling and peeling); veneer clipping, drying and up-grading; and product manufacture (lay-up, pressing and finishing) (Fig. 1.1). Recommended practices for stages one and two are outlined below. Details of stage 3 are not included in this manual.

1.1.5.1 Stage 1: Veneer manufacture

Grading, sorting and handling logs

- Select logs that meet required specifications - appropriate quality and size.
- Sort logs into batches based on quality and size.
- Minimise time between harvesting and processing to avoid degrade.
- Store logs off the ground and protect where necessary from drying out and biological attack from insects and decay.
- Cut logs to billets of appropriate length before peeling.

Debarking, pre-conditioning and round-up

- Debarking (or removal of the cortex layer) and rounding up may be undertaken before or after pre-conditioning. Rounding-up produces cylindrical billets in preparation for veneer peeling.
- Pre-conditioning (heating) billets is necessary prior to peeling, particular when peeling coconut stems which have mid to high density zones on the billet periphery. Failure to pre-condition correctly will lead to high lathe loadings, poor quality veneer and unsuccessful peeling. A temperature of 80–90°C is suitable, particularly for mid to high-density coconut.
- Ensure billets are kept free of stones, dirt and other debris in order to avoid damage to peeler knives and other equipment.

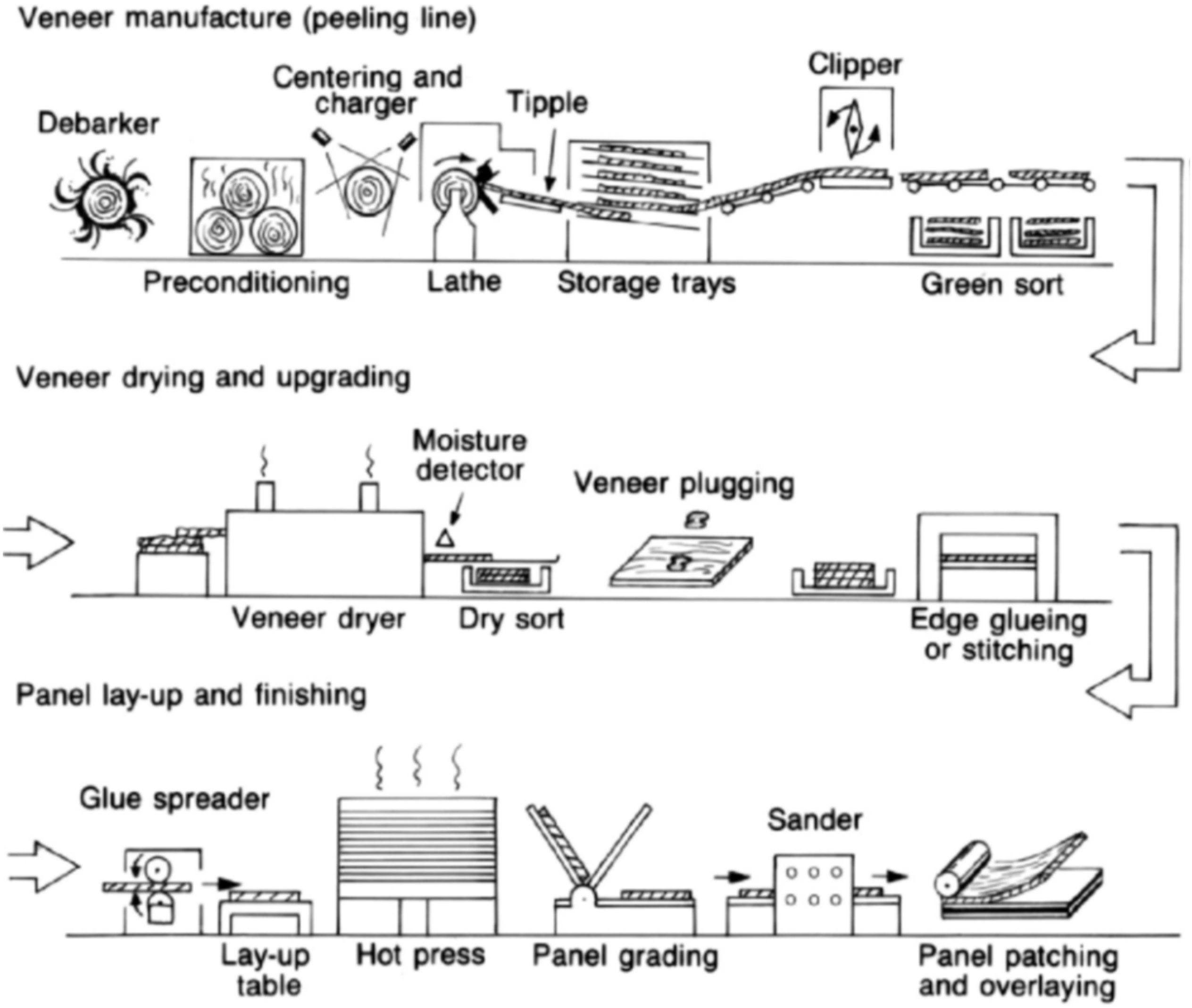


Figure 1.1 The three stages of product manufacture.

Source: Walker, J.F. (2006) Primary Wood Processing. Principles and Practice. 2nd Edition, p.399.

Peeling

- Choose lathes compatible with log resource characteristics, target products, available supporting infrastructure, labour and other economic factors. Spindleless lathes are necessary for rotary peeling coconut stems due to the incompatibility of spindles and the low density, soft core of the coconut stem.

- Adopt a lathe set up appropriate for the resource and target products. Optimal settings are determined by a range of conditions and parameters including the lathe capacity, supporting infrastructure (e.g. billet pre-treatment), log size, log quality, log densities, speed of production and actual veneer quality requirements (including target thickness and thickness tolerance).

1.1.5.2 Stage 2: Veneer clipping, drying and upgrading

Clipping and sorting

- Choose a clipping strategy that recovers the highest amount of accurately sized veneer with acceptable quality.
- Sort the veneers, where appropriate, according to quality, sizes and target end-product.

Drying

- Separate veneers that will dry at significantly different rates e.g. it might be necessary to separate cocoveneers into several density batches.
- Determine target moisture content according to adhesive, product and market requirements.
- Dry the veneers as soon as possible after peeling to avoid degrade (e.g. by moulds, veneer distortion or buckling).
- Dry to target moisture content as quickly as possible and with minimum levels of degrade.
- Re-dry veneers that do not meet moisture content requirements.

Grading and sorting

- Grade the veneers according to the requirements of relevant standards and/or requirements of customers.
- Where necessary, edge-join veneers prior to product manufacture to boost recovery and utilisation of part sized veneers.
- Sort the veneers according to end product requirements. For example, quality, sizes, colour, density etc.

Storage

Ideally the storage area should be dry and enclosed thus providing protection from the weather and extreme UV radiation. There should be adequate air circulation.

Veneers should be stored flat and the stacks need to be evenly supported, kept clear of the ground and protected, to avoid damage.

The surface of stacks should be kept free of contaminants e.g. dust, oil and adhesives. This can be achieved by wrapping in plastic, which can also protect the products from significant changes in moisture content.

Quality control

Adopt a quality control system that includes procedures, protocols and assessments to ensure that veneers adhere to the requirements of relevant standards and/or customer expectations.

This page left blank intentionally

2 Rotary-peeled products: advantages and uses

2.1 Rotary-peeled veneer product uses

Traditionally rotary-peeled veneers are most commonly used in structural applications. However, they are also used in the manufacture of architectural and decorative products. Rotary-peeled veneer is usually 1–4 mm in thickness from traditional wood resources and 2.5–6 mm thick for cocoveneers. Sliced veneer on the other hand is used for high-value decorative applications in interior design such as lining, shop-fitting and furniture (Fig. 2.1). Sliced veneer is often figured and highly coloured and the process is geared to maximise recovery by slicing very thin sheets that are adhered to a substrate. Sliced veneer is usually less than 1 mm thick. Sliced veneer operations are generally much smaller in scale than the high-volume rotary veneer facilities. Sliced veneer may not be possible from coconut stems.

Although there are some veneer products made from single sheets of rotary-peeled veneer such as ice-cream sticks (Fig. 2.2) and coffee stirrers, most veneer is used as feedstock to manufacture products such as panels or beams.

The opportunities for products using cocoveneer are yet to be fully explored.

Figure 2.1 Sliced veneer used in shop fitting.

(Photo: Kennedy's Classic Aged Timbers)

Figure 2.2 Rotary-peeled hoop pine has been used for ice-cream sticks.

2.1.1 Plywood panels

Plywood is a major traditional use of rotary-peeled veneer and is comprised of layers of veneer known as plies, glued together with the grain of adjacent plies alternating by 90° (Fig. 2.3).

The high-volume uses for rotary-peeled veneers that are made into panels are:

- structural plywood for sheathing and bracing
- form ply for concrete construction
- plywood flooring, usually covered with carpet, tiles or solid timber overlay
- plywood for noise barriers along highways
- marine ply for boat building applications
- bridge decks
- soffits and fascias
- plywood box beams
- webs in I-beams and trusses
- exterior residential cladding
- sign boards

- truck, trailer and horse float trays and beds
- shipping container flooring
- stair treads and risers
- train, bus and tram floors
- wall and ceiling lining
- kitchen and laundry benches
- walkways
- aircraft components.

Figure 2.3 Cocoveneer plywood.

Figure 2.4 Decorative hoop pine plywood flooring and fit-out.

Decorative uses (Figs. 2.4) for plywood include:

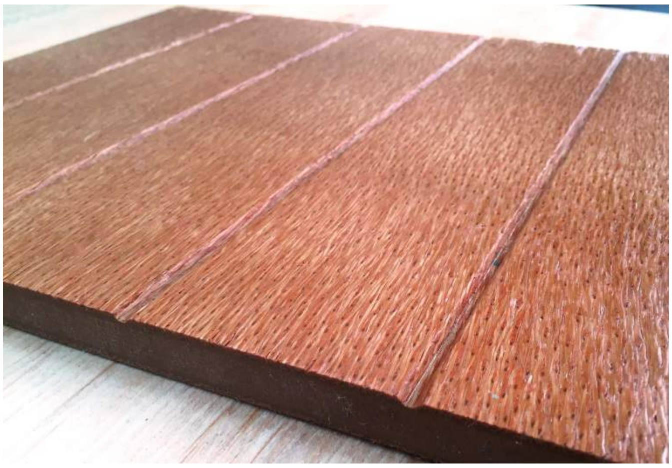
- architectural fit-outs, e.g. feature walls and ceilings in shops and lifts.
- furniture components.
- decorative flooring.

2.1.2 Novel hybrids

A range of facings can be used over plywood for special applications in architecture projects. For example, in addition to high quality veneers, aluminium, galvanised iron, copper, stainless steel, fibreglass and carbon-fibre have all been used as a facing over plywood for specialty applications.

Blending forest resources, for example cocoveneer faces combined with softwood or hardwood core veneers provides the opportunity to maximise the best properties of the different materials and therefore can assist in gaining maximum recovery and value from each resource.

Other reconstituted wood-based products can also be combined with rotary-peeled veneer to form a composite panel combining the advantages of both materials, for example veneer-faced medium density fibreboard (MDF) (Fig. 2.5). Likewise sawn wood or cocowood can be blended with veneers to produce a range of products including engineered flooring (Fig. 2.6).



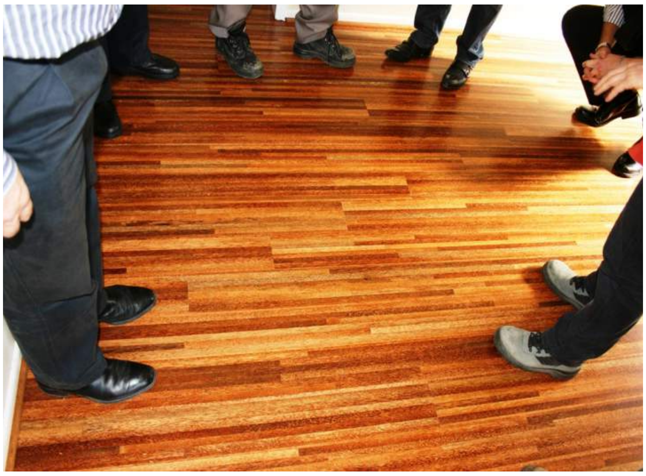


Figure 2.5 VJ style wall panelling made from cocoveneer and medium density fibreboard.

Figure 2.6 Engineered flooring combining sawn coconut and plywood.

2.1.3 Laminated veneer lumber (LVL)

Laminated Veneer Lumber is a solid wood substitute manufactured from rotary-peeled veneers adhered in parallel layers to form a beam (Fig. 2.7). This product has made in-roads to many markets as a substitute for sawn timber or steel in load carrying beam applications such as:

- lintels and headers over windows, doors, verandahs and other openings in construction
- sub-floor framing as joists and bearers
- internal framing
- furniture
- bridge components

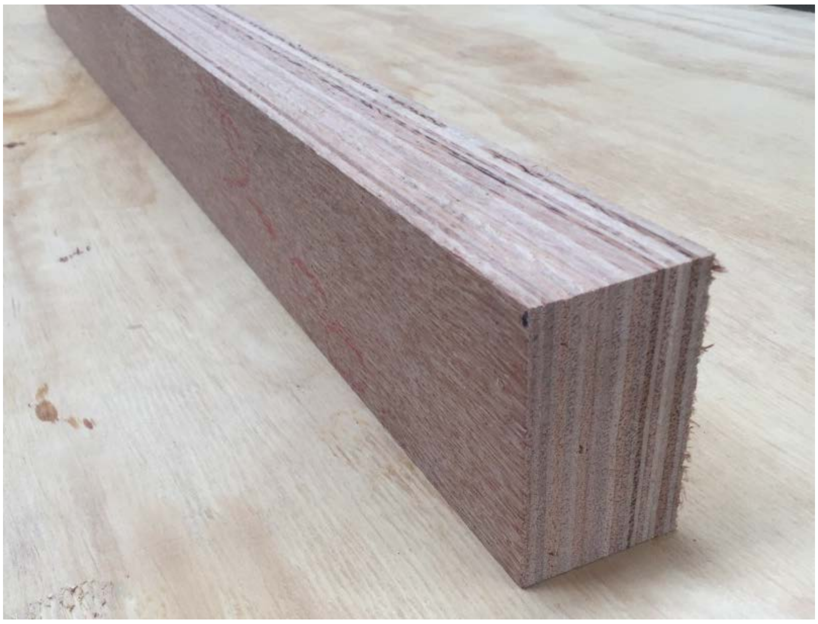


Figure 2.7 Cocoveneer laminated veneer lumber (LVL).

2.1.4 Multilaminar wood (MLW)

MLW is a material made of superimposed layers of veneer first spread with adhesive and then pressed so as to form a block from which sliced veneers or sawn pieces are obtained, mainly for decorative purposes. The construction strategy is usually similar to that of LVL. Various effects, colours, forms and patterns can be achieved by mixing qualities, bleaching or dyeing veneers, using different glue types with varying colours, block moulding and also slicing or sawing the blocks at different angles (Fig. 2.8 and 2.9).

Figure 2.8 Detail of a cocoveneer multilaminar block.

Figure 2.9 Sawn section from cocoveneer multilaminar block.

2.1.5 Fit for purpose

Not all logs delivered to a rotary peeling mill are suitable for all products and the grade quality of the logs and of the dried veneer quality will determine the suitability for possible applications and products.

From the research undertaken in the ACIAR project *FST/2009/062 Development of advanced veneer and other products from coconut wood to enhance livelihoods in South Pacific communities* (*FST/2009/062)*, cocoveneer achieved relatively low mechanical properties (stiffness) compared with many existing commercial wood species. This may limit its suitability for many structural products in current markets unless careful grading techniques are used, or the cocoveneer is blended with other forest resources or specific markets can be identified that have lower mechanical quality requirements (or at least low MoE). However it is suitable for applications where appearance qualities are prioritised.

2.2 Advantages of veneer-based wood products

The concept of rotary peeling a log to produce veneer as an alternative to sawing boards arose due to the significant advantages the process provides. Improved recovery is foremost, with typical recovery from rotary peeling estimated at double that achievable by sawmilling similar quality and sized logs. This is largely because the peeling process does not produce sawdust or wood chips, unlike log conversion by sawing. This has a significant effect on the potential return on investment to the processor.

Veneer can be rapidly dried (pre-shrunk for downstream processes such as gluing and to prevent performance issues in-service) compared to the time required to dry solid wood products, which means potential energy cost savings and less inventory and storage issues.

Developments in the engineering of veneer-based products during the past century have resulted in materials that are stable and straight, and can be manufactured in a wide range of sizes to a consistent quality. In sawn timber, the grade quality and therefore piece value is limited by the major defect, whereas the manufacture of veneer-based products allows for randomisation of defects to attain the best grade possible and enable supply of a consistent and homogenous product (Fig. 2.10).

Figure 2.10 Veneer-based construction products- stable, consistent and strong.

Another important and valuable advantage of veneer-based wood products is their stability under cyclical environmental conditions. For example, plywood’s alternating grain direction construction (each layer is at right angles to adjacent veneers) means that movement within the plane of the panel is minimal. The axial alignment of the grain in one sheet of veneer restrains the tangential movement in adjacent veneers. Unlike solid wood products, shrinkage and strength properties are similar in both planes.

Veneer-based wood products generally have the ability to span wide supports and they can have good creep resistance. Their ability to withstand large racking forces can make them the preferred building material choice in areas that experience extreme weather events (e.g. earthquake or cyclone prone regions).

More specific to coconut, one of the key advantages of rotary peeling over sawing processes is the ability to recovery much higher volumes of the higher density zone on the outer part of the stems. The higher density coconut is favoured for its darker colour, more attractive visual appearance, increased hardness and increased mechanical properties. A significant portion of this zone is unable to be recovered using sawing processes but can be recovered with rotary peeling.

This page left blank intentionally

3 Material characteristics of coconut palm stems

This chapter describes key characteristics of coconut palm stems that influence veneer processing. Research conducted during the ACIAR co-funded project *FST/2009/062* and its predecessor *FST/2004/054 Improving value and marketability of coconut wood* has provided valuable data on the wood properties and characteristics of coconut palm wood and veneer (cocowood and coconeer). This chapter summarises the results of this work.

3.1 Cocowood and cocoveneer

Industrial coconut plantations are characterised by palms up to 25 m high with breast height diameters between 25 and 35 cm. The palms are tree-like monocots and their stems can be used as a wood substitute.

The term 'wood' is generally understood to refer to the material derived from the stems (and sometimes branches) of forest trees: hardwoods (dicotyledonous angiosperms, flowering plants); and softwoods (gymnosperms, cone-bearing plants). In both of these types of trees, radial growth originates in the vascular cambium resulting in incremental increases in girth and height. After the secondary wall has formed in cells there is no increase in cell dimensions or cell wall thickness.

Coconut palms are botanically classified as monocotyledons and have very different physiological growth processes, structural composition and therefore different material attributes compared to woody dicots and gymnosperms. The radial growth of a palm stem is limited after a relatively short establishment period and all subsequent growth occurs axially. Palms don't contain a vascular cambium, i.e. the vascular system is totally closed, doesn't give rise to a secondary vascular cambium, and the cells stay alive, continuing to change over the life of the palm.

Coconut palms have neither heartwood nor annual growth rings and lack branches (and therefore contain no knots in processed material). Senile palms (>80-years old) are markedly heterogeneous with a soft, low density central core and hard, dense, ring of peripheral tissue. Nevertheless, the stems of coconut palm can be processed using similar equipment and tools to traditional woody materials and have long been used for many similar applications.

3.2 Anatomy of the coconut palm

The stem of a coconut palm is covered with a cortex which provides a similar function to the protective bark layer on trees but with the additional function of anchoring the palm fronds (leaf bases) (Fig. 3.1). The central cylinder is composed of irregularly scattered vascular bundles embedded in parenchymatous ground tissue (Figs. 3.2, 3.3 and 3.5). The ground tissue contains specialised tannin cells holding polyphenols and raphide sacs and can include random strands of pectin. Each vascular bundle consists of xylem, phloem, axial parenchyma and sclerenchyma fibre elements. The bundles are architecturally arranged in a multi-helix up the stem. The helical pathways rotate approximately ¼ of the stem circumference per 15 cm length along the stem (Fig 3.4). This architecture can result in twist distortion and low strength in sawn boards of cocowood.

Figure 3.1 The hard cortex covering a coconut palm stem.

Figure 3.2 Many vascular strands in the high density zone are leaf traces, anchoring the palm frond to the stem.

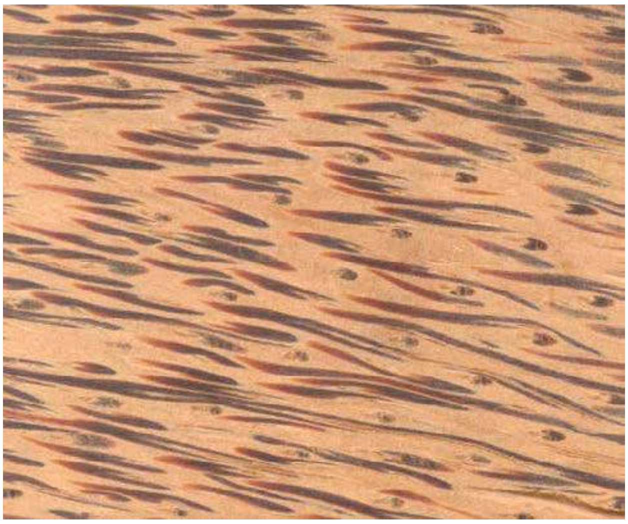


Figure 3.3. Longitudinal surface of sawn cocowood showing the vascular bundles (dark lines) embedded in parenchymatous ground

Figure 3.4. A split coconut palm disc exposing the triple helix structure.

The diameter of the bundles decreases both from the base longitudinally towards the growing top and from the core radially to the cortex of palm stems, though the range of variation in fibre wall thickness is larger in the longitudinal axis. Cell lengths are shorter in the higher density outer wood than in the central core. Fibre walls are essentially comprised of several layers, the wall thickness of which increases with age. There is no radial parenchyma tissue in coconut palm wood.

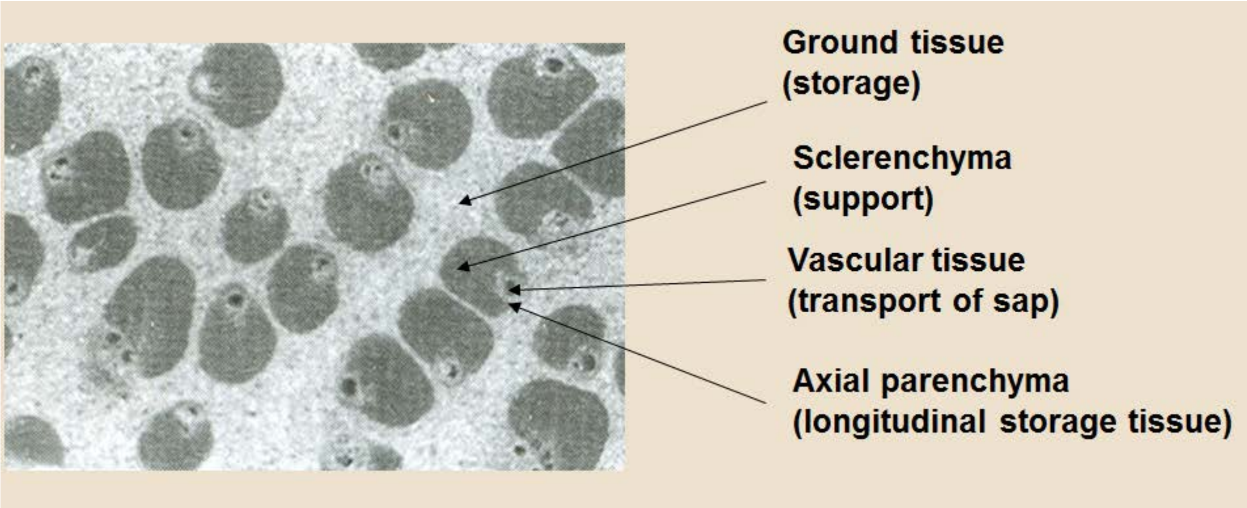


Figure 3.5. End grain of cocowood showing the vascular bundles (dark shapes) in transverse section; the light grey background tissue is comprised of parenchyma and occasional pectin strands.

3.3 Coconut palm density and hardness

Density is the mass per unit volume of a material. In the wood industry, density is expressed in kilograms per cubic metre (kg/m^3), usually at a specified moisture content such as 12% (air-dry density). The inner core zone of coconut palm stems is characterised by very low density, between 100 and 400 kg/m^3. The intermediate zone has medium density material usually between 400 and 600 kg/m^3. The outer-wood has very high density, above 600 kg/m^3 and often between 800 and 1,170 kg/m^3 (Fig 3.6). Figure 3.7 provides an example of the profile of density within a stem.

Figure 3.6. Cross-section of a coconut palm stem showing the frequency of vascular bundles increasing radially from the centre to the periphery, corresponding to increasing density.

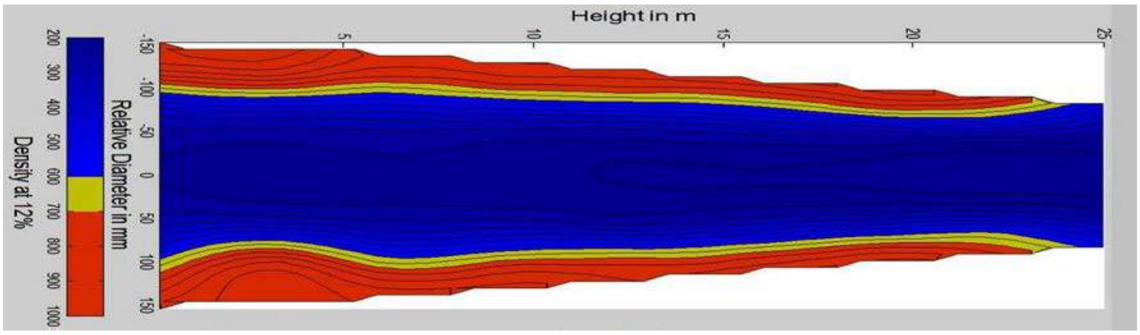


Figure 3.7. Air-dry density profile for coconut palm 'wood' (not to scale).

Hardness is an expression of a material's resistance to indentation. The Janka method provides a quantitative technique to compare hardness values for different woods and was used in earlier ACIAR research undertaken by DAF to determine values for cocowood. An outer ring of hard cocowood (approximately 1/5th of the radius) provided Janka hardness values between 4 kN up to 13 kN which is within the recommended range for applications requiring resistance to indentation such as flooring and benchtops.

Despite comprising a high proportion of log volume, much of this material is lost to waste if processed using traditional sawmilling equipment, whereas rotary peeling can maximise recovery of this valuable part of the palm stem.

A correlation has been demonstrated to exist between hardness and density, and it was shown that the relationship between these two parameters was comparable to normal wood (cocowood Janka hardness:cocowood basic density $R^2 = 0.77$).

Tall varieties of coconut palm older than 60 years have a higher proportion of high density fibre than younger palms. Air-dry density and hardness data are presented in Table 3.1 which includes common Queensland commercial timbers for comparison to cocowood.

Table 3.1. Density and hardness (air-dry, 12% moisture content) for cocowood and common woods.

Trade name	Air-dry density (kg/m^3)	Janka hardness (kN)
cocowood	100 - 1,020	1 - 13
white cypress	675	6.5
spotted gum	950 – 1,010	10
hoop pine	520 - 560	3.4

3.4 Coconut palm moisture content

Moisture content in the timber industry is expressed as a percentage and indicates the proportion of water to the oven-dry weight of wood material. The moisture content of coconut palm stem material at the time of harvest varies markedly and can range from 50% to over 400%. Moisture content increases with rising stem height from the base to the palm fronds and from the periphery radially inwards to the core. This pattern is strongly correlated with the proportions of parenchymatous ground tissue which holds more water than the vascular bundles. The combination of high moisture content and tropical conditions provides an environment inductive to mould and fungal contamination and harvested logs need to be processed rapidly to minimise degradation by discolouration or decay.

3.5 Coconut palm shrinkage and collapse

An advantage of coconut palm over normal wood is that the anisotropy coefficient for shrinkage (tangential shrinkage to radial shrinkage) is 1 for the former compared to a range between 1 and 2 for normal wood. This can be explained by the absence of radial parenchyma in woody monocots. The presence of rays in woody dicots probably contributes to their anisotropy where shrinkage in the tangential plane can be up to double that in the radial plane.

In coconut palm, shrinkage generally increases with an increased proportion of vascular bundles per unit volume. Shrinkage from green to air-dry (12% moisture content) is approximately 4% in both tangential and radial planes for cocowood, compared to approximately 6% (tangential) and 4% (radial) for spotted gum (*Corymbia* spp.) a high volume commercial timber in Queensland.

Unit shrinkage is the percentage change in dimension associated with each 1% change in equilibrium moisture content. Unit shrinkage data for high density cocowood ranges from 0.32-0.38% tangentially and 0.24-0.30% radially.

The low density central portion of the stem is prone to cell collapse during drying.

3.6 Coconut palm mechanical properties

Two of the key material mechanical properties of interest to product designers, specifiers and engineers are the Modulus of Elasticity (MoE) and the Modulus of Rupture (MoR). The former denotes a material's dimensional response under stress and is measured by bending tests or the resonance method to determine deflection. MoR is the measure of the ultimate short-term load-carrying capacity when the load is applied slowly and provides an indication of suitability of a material for structural applications.

DAF tested nearly 500 sawn specimens using the resonance method to determine MoE of cocowood. The results showed a range between 2 and 25 GPa across all densities providing an average of 12 GPa at a moisture content of 8%.

For MoR testing, just over 120 sawn specimens were tested providing a range of results from 28 to 205 MPa with an average for the test population of 97 MPa. It was found that results for some high density cocowood samples were comparable to published MoR data for conventional structural hardwoods from the *Eucalyptus* genus.

Veneer mechanical properties are yet to be established.

4 Log and billet specifications, grading and pre-processing

4.1 Log specification and grading

A successful veneer operation depends on three main criteria:

- a supply of suitable logs.
- proper processing techniques.
- good sales and marketing.

To produce suitable veneer, the logs must have appropriate wood and log characteristics. This is where log grading is of prime importance. The desired wood and log characteristics, in turn, depend on the end-use specifications for the veneer. Ultimately, the relative importance of any one characteristic (beneficial or non-beneficial) in a veneer log depends on how the veneer will be used.

In order to trade veneer logs, a transferable and comparative grading system is generally established. This allows stakeholders to have confidence in the supply of graded veneer logs to meet their manufacturing and quality requirements. The purpose of grading veneer logs is to sort material into groups that match the best utilisation and price/value category. This price/value relationship is set generally by the aesthetics and physical properties of the logs. Most veneer peeling processors buy logs based on log volume and log quality.

Factors affecting the veneer quality from coconut logs include age, density profile, colour, diameter, form, decay, mechanical damage and insect damage. A good knowledge of veneer quality requirements provides a better understanding of how forest qualities will impact the yield of veneer-quality logs.

While a log grading system for coconut peeler logs is yet to be established, the importance and value of a log grading system is recognised and will be necessary as the cocoveneer industry matures.

4.1.1 Grading a peeler log

Log grading systems exist for many traditional wood species and although they can vary substantially between countries, the principles are essentially the same in that they:

- identify grade limiting defects
- measure and/or assess those defects
- identify grade enhancing characteristics
- determine log size and shape characteristics e.g. diameter, length, sweep, taper
- assign a grade to the log.

Grading a peeler log destined for veneer production entails evaluating the log quality and hence the quality of the veneer that can be peeled from that log. Log grading is often based on a visual assessment of specific log features that are set out for each grade classification. Ideally, the grading rules should be simple to understand so they can be applied quickly and accurately.

4.1.2 Grade defects and grade enhancing characteristics

While peeler log grading systems are well developed for traditional wood species, these will not be directly transferrable to coconut peeler logs. For example, coconut logs have an absence of knots and also a very low occurrence of log splitting which are common defects included in traditional wood peeler logs. Coconut peeler logs may have some additional grading rule requirements for density, colour and mould/discolouration. Some synergies potentially exist with log size, shape, decay, insect attack etc.

4.1.3 Grading a eucalypt peeler log – Australian example

Each State forest agency in Australia has developed specifications for the logs sold within its jurisdiction. Sales between private growers and wood processors either use the same grade definitions or others derived from the specifications developed by the State agencies. Although the general principles are the same throughout Australia, the precise definitions of grades may vary.

Forestry Tasmania has specifications for grading regrowth and eucalypt plantation peeler logs that are destined for veneer production (Table 4.1).

Table 4.1 Peeler log specifications for eucalypt regrowth and eucalypt plantation in Tasmania.

Grade factors	Criteria
Length	Minimum length is 3.4 meters. A minimum length of 2.2 m can be accepted if suitable arrangements can be made for handling and transporting them.
Small end diameter (SED)	Minimum of 18 cm.
Large end diameter (LED)	Maximum 70 cm.
Knots and limbs	• For logs with an SED < 35 cm, the max. diameter of any knot or limb is 10 cm. • For logs with an SED ≥35 cm the max. diameter of any knot or limb is 20 cm. There is no limit to the number of knots or limbs allowed as long as they do not exceed the maximum diameters.
Bumps	• A log may contain no more than one significant bump in each one (1) metre of log length. • A log may contain any number of bumps that are not significant bumps.
End-splitting	The end of the log may contain minor cracks no more than 5 mm in width.
Scars and borers	• A log may contain scars, provided that they are sound and that there is no evidence of any rot beyond the scar itself. • A log may contain evidence of borers.
Roundness	• Neither end of the log can have a major axis that is more than 20% greater than the minor axis at the end. • A log with an irregular or 'fluted' circumference is not allowable.
Sweep	• For logs < 5.4 m in length, the max. permissible sweep is 25% of the SED. • For logs ≥ 5.4 m in length, the max. permissible sweep is 50% of the SED.

Logs must be crosscut cleanly at each end perpendicular to their length. All protrusions, limbs and knots are to be trimmed flush with the log surface.

4.1.4 Grading a hardwood peeler log – Vietnam example

Vietnam is currently in the advanced stages of introducing a standardised veneer log grading system for small diameter hardwood peeler logs. The development of grading system in Vietnam was supported by the ACIAR project *FST/2008/039 Enhancement of production of acacia and eucalypt peeled and sliced veneer products in Vietnam,* led by DAF.

The proposed peeler log grading system for Vietnam incorporates two grades; grade A and grade B, where grade A is of higher quality. For a log to meet grade A classification, all grade criteria must meet grade A classification. For instance, if one criterion meets class B then the log is classed as a grade B log. If a log displays a criterion outside either the grade A or grade B classification, it is considered a reject log, not fit for peeling. Special consideration may be given to reject-logs, depending on the company and client specifications. Table 4.2 sets out a summary of the proposed peeler log grading system for Vietnam.

Table 4.2 Proposed grading system for hardwood peeler logs in Vietnam.

Criteria	GRADE A	GRADE B
Knot	max. diameter ≤ 10 cm	unlimited
Bend	max. 3% - no multiple bends	max. 4% - no multiple bends
Total end-split	total split ≤ 10% log length	total split ≤ 20% log length
Holes/insect holes	max. diameter ≤ 5 cm	max. diameter ≤ 20 cm
Decay	not permitted	permitted
Mould	not permitted	permitted
Metal objects	not permitted	not permitted

A log is assigned the grade that is the lowest grade encountered for each criterion. The metal object criterion is included to prevent peeling logs that have imbedded metal objects such as nails, fencing wire etc. Peeling logs with imbedded metal objects can cause severe damage to the lathe and injury to machine operators.

There is no minimum diameter and/or log length proposed in the log grading specifications because this is subject to the limitations of machinery and should be specified separately by the independent processor or log buyer. For example, log specifications will vary depending on whether the lathe is spindled, spindleless or a hybrid type.

4.2 Log storage and handling – pre-processing

Ideally, logs should be processed as soon as possible after harvesting. Timely log processing is especially important for coconut peeler logs to maintain log quality.

Logs should be transported to the log or holding yard as soon as possible after felling to minimise peeler log degradation by insects, mould and decay. Once in the log yard, the logs must be stored in a way that alleviates defects associated with shrinkage, splitting, end-checking, and further exposure to wood decaying fungi, bacteria and insects (Fig. 4.1).

Figure 4.1 Harvested coconut logs waiting to be processed in a log storage yard.

Veneer logs can be kept in good condition for potentially several weeks (if necessary) as long as they are suitably stored. With poor storage conditions, logs can deteriorate due to drying; development of mould/ stain; attack by insects; development of undesirable odours or increased porosity due to attack by bacteria. Mould, staining and decay can become developed quite quickly in coconut logs.

Much of the risk of log quality degrade is related to the weather the stored logs are exposed to, and the impact that this has on log drying rates. Wet weather and low temperatures are more favourable for maintaining log quality than are hot, dry temperatures, although some wood fungi thrive in sustained wet conditions. Shrinkage defects may be minimal during cold, cloudy and wet conditions and many fungi (moulds and rot-forming) and wood destroying insects are inactive below 0°C. Insects and fungi cannot survive in very cold, anaerobic conditions but anaerobic bacteria can. A combination of hot and humid conditions, such as that in the Pacific region, can also be ideal for fungal and insect attack.

4.2.1 Effective log yard storage for coconut logs

Best practice for coconut logs waiting to be processed in the log yard includes:

- processing logs quickly, to minimise storage time.
- logs are stored on bearers, off the ground in well drained areas, cleared of grass and plant growth, and free from dirt, stones and other contaminants that can cause processing problems.
- logs are sorted according to receipt date, size, grade, intended veneer products.
- there is sufficient space for loading and unloading logs.
- the log storage area remains trafficable in all weather conditions.
- the logs are adequately protected from harsh weather conditions.
- care is taken when handling the logs to prevent mechanical damage.

- Workplace Health and Safety (WPH&S) practices are adhered to including log pile stability, and that any necessary personal protective equipment (PPE) is worn.
- the first logs into storage should be the first out.

Log drying rates can be reduced by:

- end-sealing the logs
- water spraying (water storage) the logs (Fig. 4.2)
- storing end-sealed logs closely together
- covering logs with a shade cloth or storing in the shade
- being cognisant of the log orientation in relation to the wind and sun
- using wind breaks if wind is an issue.

If the logs need to be stored for long periods, additional measures could include:

- a sprinkler system (incorporating re-cycled water) may be appropriate but not always possible.
- a spray treatment of a registered chemical fungicide.
- a spray treatment of a registered chemical insecticide.

Figure 4.2 Using water sprays in a hardwood log storage yard to prevent excessive, rapid drying and to deter insect and fungal attack.

4.3 Debarking

The protective, outer layer of a tree is the bark. The equivalent layer in coconut stems is called the 'cortex'. This prevents the loss of moisture and inhibits insect attack and decay organisms. It also offers protection to the stem from damage (e.g. mechanical, fire, etc). The bark (or cortex) often includes grit and extraneous materials that can damage knives or cause rapid blunting.

The removal of bark, termed debarking or sometimes barking, in peeler logs from traditional wood species is relatively easy and is undertaken at the time of harvesting, at the commencement of storage or immediately prior to processing. In small operations, this may be undertaken manually with a bar or axe (Fig. 4.3, Fig. 4.4), however the most common method is to use mechanical debarking systems.

Figure 4.3 Debarking hardwood billets using the back of an axe.

Figure 4.4 Removing bark from hardwood billets with the cutting face of the axe.

When to debark depends on several factors. Debarking in the forest at the time of harvesting has many advantages. It reduces the volume of waste material transported from the forest to the veneer mill. The bark is also much easier to remove immediately after harvesting. Removing the bark may render the billets less susceptible to insect attack, depending on the insect species. Leaving the bark in the forest can also benefit the soil nutrient cycle. On the other hand, retaining the bark can partially protect the billet from mechanical damage; and also reduce drying while the billet is transported and stored. Delays in debarking can cause the bark to tighten, making it more difficult to remove, especially with manual methods.

By comparison, the removal of the cortex layer from a coconut peeler log is much more difficult. Undertaking the process manually is extremely slow and challenging. The application of traditional mechanical debarking systems is unknown but expected to also be problematic.

It is not uncommon for operations using spindleless veneer lathes to rotary peel traditional wood species, to use these lathes to debark billets immediately before peeling. This is the most appropriate approach for removing the cortex of coconut peeler logs.

This approach is relatively easy and requires minimal capital investment. However, debarking using a lathe frequently damages the veneer knife (e.g. chipping and dulling) which results in reduced veneer quality, machine down-time (due to additional knife replacements) and increased knife sharpening.

Many spindleless lathe manufacturers now make dedicated debarkers that are based on the spindleless lathe system (Fig. 4.5). This prevents premature damage to the veneer lathe and boosts productivity. These debarkers usually have a basic design and are more robust than the lathe. Debarking using this method can also provide a rounding-up function as well, preparing the billet for immediate peeling.

Figure 4.5 Spindleless lathe debarker

4.4 Log pre-conditioning

Depending on the species being peeled and the required peeled quality, a practice termed billet (log) pre-conditioning can be employed. Pre-conditioning is highly recommended for rotary peeling coconut logs and is critically important as the density increases above approximately 600 kg/m^3. Pre-conditioning involves heating without drying the billet. For this reason saturated steam or hot water (soaking and/or spraying) is used as a heating medium (Fig. 4.6). While normal practise when pre-conditioning traditional wood species is to ensure the full radial depth of the log is heated, with the wide range of density across the radius of coconut peeler logs, it may only be necessary to ensure the higher density outer log zone is pre-conditioned. In fact there may be a disadvantage in heating the lower density inner part of coconut logs as over softening may occur resulting in failed peeling. For this reason, using steam to heat rather than hot water soaking may prove more appropriate.

The decision to pre-condition or not and to what target temperature becomes an individual business decision based on the following potential advantages and disadvantages:

Potential advantages:

- reduced energy requirements for the peeling process
- reduced loading on the veneer lathe (reduced wear and tear, maintenance)
- improved veneer quality (smoothness, tightness)
- ability to recover veneer from high density logs
- reduced veneer thickness variation
- reduced knife damage and wear (chipping, blunting)
- veneer colour modification (which could also be a disadvantage).

Potential disadvantages and risks include:

- can lead to over-softening, particularly in the lower density core resulting in premature peeling failure (e.g. billet collapse)
- can be an expensive operation requiring specialist heating equipment
- heating mediums (especially hot water) and hot billets can be a safety hazard
- veneer colour modification (which could be an advantage)
- pre-conditioning is the slowest part of the peeling process. It can be logistically difficult to have sufficient pre-conditioned stock ready for peeling to keep pace with the potential productivity of the lathe.

The following is a guide to desirable target temperatures for rotary peeling:

- coconut stems (<600kg/m^3 density): approximately 50–70°C
- coconut stems (>600kg/m^3 density): approximately 70–90°C
- softwoods: approximately 50–60 °C
- hardwoods (500 to 700kg/m^3 density): approximately 50–70°C
- hardwoods (>700kg/m^3 density): approximately 70–90°C.

Figure 4.6 Coconut peeler billet pre-conditioning using a steam chamber.

Billet temperature can be checked during peeling with the use of an infra-red thermometer (Fig. 4.7).

Figure 4.7 An infra-red, non-contact thermometer measures wood temperature safely.

There are a number of factors that influence the time period required to pre-condition billets. These include:

- density (higher density wood generally requires longer heating times)
- billet moisture content
- pre-treatment method (steam versus water)
- infrastructure capacity
- billet diameter
- veneer quality requirements.

4.5 Log round-up

Ideally, billets presented to the lathe should be cylindrical or as close to cylindrical as possible Fig. 4.8). Ovality, taper, sweep and bumps affect the peeling process, particularly by lowering productivity and increasing wear on machinery. They also have a negative impact on recovery so it is desirable to trim or round up the log.

Log round-up makes the subsequent peeling more efficient, but the process doesn't necessarily continue until a perfect cylinder is attained. The operator decides when to stop the round-up phase by estimating where it is worth-while to recover short lengths and/or narrow width veneers.

Figure 4.8 Cylindrical coconut logs after round-up, and ready for peeling.

Ideally, the round-up process is done using a separate machine before moving the log to the main veneer lathe. This ensures that grit is removed, which will extend the life of the knife on the main lathe and also provides better quality veneer surfaces.

As a rule of thumb, the round-up lathe should peel the log until approximately 50-75% of its surface is dressed.

4.6 Log positioning

To maximise recovery using spindled lathes, spindles need to be positioned as close as possible to the geometric central axis of the billet. The objective of locating the geometric centre of the billet is to ensure that the maximum diameter cylinder is provided as the starting point for peeling and that the log is positioned along an optimum centreline with respect to the knife that theoretically will provide the highest recovery.

The opportunity to improve veneer recovery through optimised billet positioning is not possible with spindleless technology. Billet positioning using this technology is influenced by the external dimension and shape of the billet.

This page left blank intentionally

5 Rotary peeling

The process of rotary veneer production is to remove a continuous thin ribbon of wood from the periphery of a peeler billet using a knife that is positioned parallel to the grain. The billet is rotated against the knife using a drive mechanism that varies in design and approach, depending on the technology being used. In close proximity to the knife is a nose bar (or pressure bar) which applies a localised zone of compression (just prior to the point of cutting) that helps improve veneer quality (Fig. 5.1).

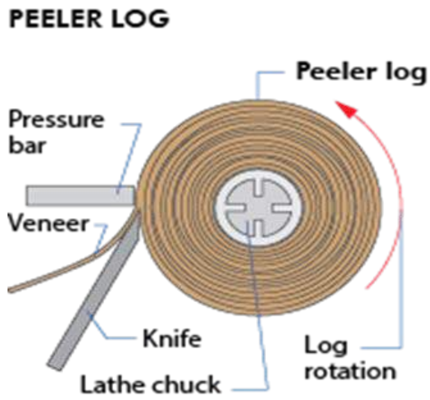


Figure 5.1 Illustration of a typical rotary peeling process

(http://www.wooduniversity.org/glossary)

5.1 Rotary peeling methods

Traditionally, the rotary veneer industry received premium quality logs ensuring that billets were large in diameter and high in quality. To match the resource, rotary veneer lathes and other associated processing equipment were designed and built to be large and robust. To accommodate the changes in available resource and to improve efficiency, technology has evolved in several key areas. While initial development was focused towards improving efficiencies through increasing production speeds, in the last decade or so, much focus has been on improvements in resource recovery through minimising waste and systems that better accommodate smaller diameter and sub-optimum quality billets.

5.1.1 Spindled lathes

The traditional method of rotary veneer production is using a spindled lathe (Figs. 5.2, 5.3). This type of lathe uses spindles or 'chucks' to hold the log in position and to rotate the billet against the knife. This method has proved very reliable and a very effective way to produce high quality veneer from traditional wood species, even at very high production speeds.

This technology is not suitable for coconut stems as the spindles are not able to provide sufficient holding forces due to the very low density core in the coconut peeler logs. Failure to provide sufficient holding capacity leads to 'spin outs' where the spindles lose grip on the billet and the billet cannot be peeled further.

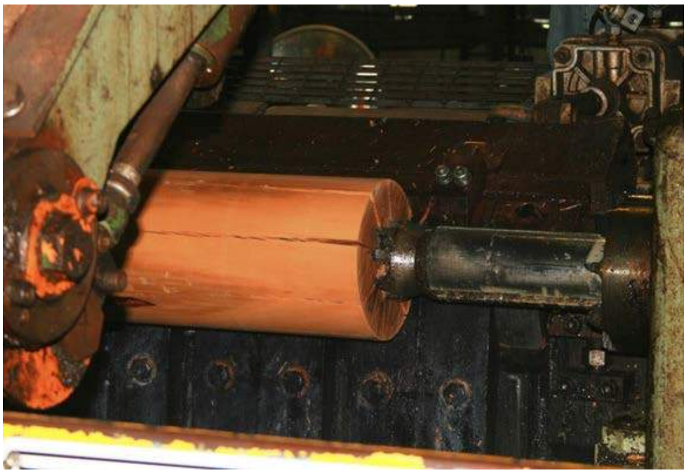


Figure 5.2 An example of a spindled lathe.

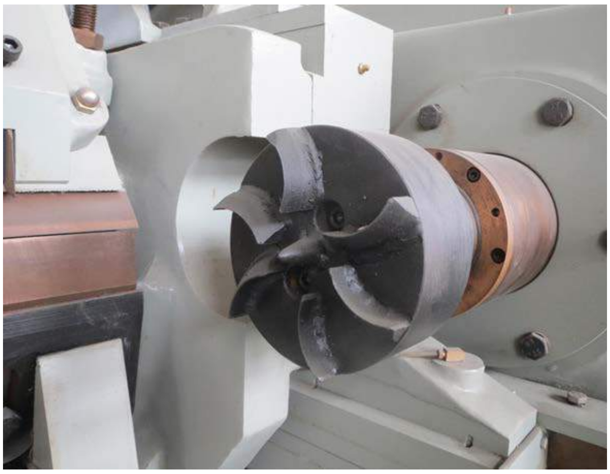


Figure 5.3 'Chucks' or 'spindles' on a spindled lathe.

5.1.2 Hybrid systems

An alternative to the classical spindled lathe approach has been developed by Meinan, a Japanese company. Similar to a spindled lathe, spindles are used to position the billet and provide rotary drive, however the spindles are completely retracted once the billet diameter is close to the spindle diameter. Additional drive is provided through a sectional nose bar that contains a series of spiked gang roll segments. Two in-feed brace rolls (similar to backup rolls) are used, and which are combined with the gangi roll to allow the peeling process to continue after the spindles have retracted. This allows further processing until the peeler core is released at diameters below 75 mm. These lathes are well suited to large-scale, high-throughput operations.

While this technology has not been trialled with coconut peeler billets, it wouldn't be expected to be appropriate given the reliance on spindles during the early stages of peeling.

5.1.3 Spindleless

Spindleless lathes were originally designed and developed primarily for further processing of peeler cores produced from conventional spindled lathes. While the approach has existed for decades, the commercial adoption remained very low due to their reputation of producing poor veneer quality, mainly due to veneer thickness variation. Spindleless lathes are also referred to as 'chuckless lathes' or 'centreless lathes'.

In the last decade or so, spindleless lathes have developed quickly and have been widely adopted in some countries prompted by the rapidly growing availability of small diameter forest resources, particularly from young fast-grown hardwood plantations. While spindleless lathes were originally developed to process further the already pre-rounded peeler cores, many of the spindleless lathe operations that exist are successfully using the lathes to directly process small-diameter unrounded billets (Figs. 5.4).

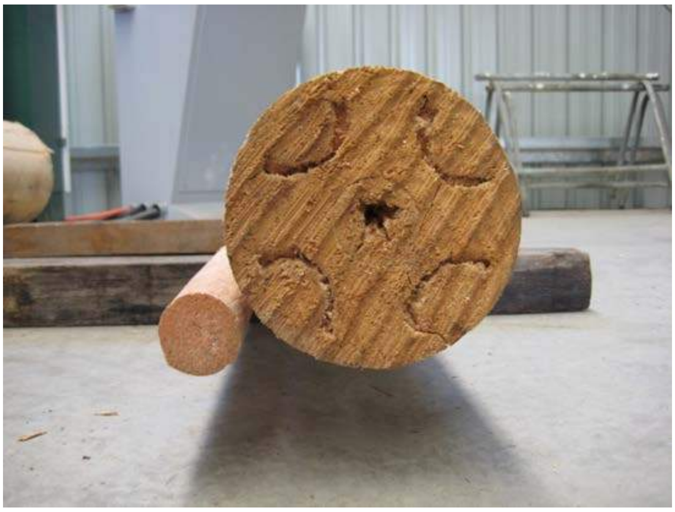


Figure 5.4 An example of a spindleless lathe.

Figure 5.5 A 45 mm coconut peeler core (left) produced from a spindleless veneer lathe, compared with a 130 mm hoop pine peeler core produced from a standard, commercial spindled lathe.

Spindleless lathes, as the name suggests, have no spindles. Rotary drive is provided through powered backup rollers and often with support from a driven roller nose bar. While spindleless lathes still produce peeler cores, their diameters are often in the order of 20–60 mm. Figure 5.5 illustrates a peeler core produced from a standard rotary veneer lathe and a coconut peeler core produced from a spindleless veneer lathe.

Without the reliance on spindles to hold the billet in position through a relatively concentrated zone, spindleless lathes are proving to be very successful in processing logs with qualities very different from that previously accepted. This processing approach enables coconut peeler logs to be successfully processed where more traditional approaches have failed (Fig. 5.6).

Figure 5.6 Coconut log being peeled with a spindleless lathe.

5.1.4 Optimal lathe settings

The quality of the veneer is heavily influenced by the lathe settings. Optimal settings are determined by a range of conditions and parameters including the lathe capacity, supporting infrastructure (e.g. billet pre-treatment), species, log size, log quality, speed of production and actual veneer quality requirements (including target thickness and acceptable thickness tolerance).

Some of the common variables for lathe settings include knife angle, knife grind angle, knife height, pitch angle, nose bar position (horizontal and vertical), nose bar design and feed rate.

For spindled lathes, there is widely available documentation supported by many decades of research that provides lathe settings specific to commercial timber species and target veneer qualities. The vast majority of published settings and approaches to improve veneer peeled qualities are largely transferable between spindled lathe manufacturers and models.

For hybrid lathes, such as Meinan, documented settings are usually provided by the supplier and are very specific to the individual operation.

While a very large number of spindleless lathes now exist, documented lathe settings remain largely non-existent. In addition, the vast majority of spindleless lathe designs have targeted simple designs with minimal capacity to change many settings. This means the opportunity to optimise settings to suit a particular operation, are often limited. There are also several variations to lathe design and operational methods resulting in major differences in lathe settings between manufacturers and models. For example, while nose bar designs on spindled lathes are relatively similar, a much larger range of designs commonly exist on spindleless lathes, although they are almost always a roller style. Diameters however can be in the range of 30 mm to 150 mm, power driven or free spinning, segmented or full width, smooth or grooved. The design of the nose bar, along with other design features, has a large influence on optimum setting including position of the knife height and knife angle.

The feed rate is also very different on a spindleless lathe compared to a spindled lathe. With the latter, the knife carriage is moved towards the spindle at a uniform rate relative to the billet rotation. The rate of advance influences the veneer thickness per log revolution. With a spindleless lathe, there are two common approaches, both of which move the billet towards the knife. The first approach uses hydraulic pressure against the driven feed roller to move the billet towards the knife. The other approach uses a screw driver (similar to the mechanism that moved the knife carriage on a spindled lathe) to move the feed rollers toward the knife. While the latter probably has better control, both approaches provide a source of veneer thickness variation, especially if a wide variation in wood properties exists within the billets being peeled.

Another major difference between spindled and spindleless lathes is the control of the knife angle relative to the billet surface. On spindled lathes, the knife carriage changes the knife angle during peeling as the billet diameter is decreased to maintain an optimal angle. With the exception of a couple of very recent spindleless lathe models, the knife angle is set and then remains constant during the peeling operations. This means that the optimum settings are potentially compromised for a significant part of the billet peeling.

The large range of spindleless lathe designs and the capacity to influence settings explains why optimum lathe settings are not published. Although some basic lathe operation principles apply, optimum lathe settings are required to be developed specific to models, the resource being processed and the target end-product.

This page left blank intentionally

6 Veneer clipping and drying

6.1 Clipping

Veneer clipping is usually done as part of the peeling operation. As the veneer ribbon leaves the lathe, it is transported along a conveyor straight to a clipper that clips the veneer, parallel to the grain, into smaller, more manageable veneer sheet widths. Alternatively, the veneer ribbon is coiled or rolled immediately after the lathe and is moved to a separate clipping station. The clipping operation can then be conducted totally independently of the peeling operation. Regardless of the approach, any clipping strategy should aim to recover the highest amount of veneer that contains the qualities demanded by the target end-products (Figs. 6.1–6.3).

Figure 6.1 Veneer sheets being clipped manually with guillotine in Vietnam.

Figure 6.2 Veneer being coiled in preparation for a separate clipping operation.

The simplest clipping systems are manual operations that utilise hand operated guillotines. These are slow by comparison and rarely adopted given the availability of relatively cheap, more automated systems. The next level of technology utilises a mechanical clipper system, normally activated on a time based interval. This means that the sheet width is determined by the speed that the veneer ribbon is traveling through the clipper and the time interval between the clipper knife being activated.

Often with these operations, the clipper knife is fixed to a rotating shaft meaning that the knife blade clips the veneer at each revolution. This is a simple, low capital cost approach that is much more efficient than hand operated guillotines; however it provides minimal opportunities to maximise the recovery of specific grade qualities. This is because the clipping strategy doesn't consider veneer quality (e.g. defects such as splits etc.) and focuses on veneer width only. This approach can result in a low grade recovery as unacceptable defects remain in the veneer sheets. While these defects can be removed during follow up processes, this can lead to less than desirable and variable veneer sheets widths, and added costs.

Figure 6.3 Veneer ribbon ready for clipping.

Advanced systems incorporate veneer scanning technology that can be programmed to detect and measure defects within the veneer as it travels between the lathe and clipper. Using this information, unacceptable defects (e.g. wane) can be limited to narrow strips of veneer, which can be clipped out and rejected. The remaining veneer ribbon is clipped to sheet widths that best suit the final end-product. This approach maximises the recovery of veneer with acceptable qualities, operates at speeds that equal the lathe operating speeds, and also produces more accurately-sized veneer sheets.

6.2 Drying

The main motivation for veneer drying is to remove moisture so that the veneers are prepared for adhesive application and product manufacture. To prevent mould, veneer distortion (e.g. buckling) and other degrade, drying soon after clipping is preferred. Practical objectives are to dry with low cost, short drying time and to achieve appropriate quality.

Veneer drying approaches have evolved over time. The simplest approach is to air-dry veneers (Fig. 6.4). This is the lowest capital cost option however little control over drying time and quality exists. While there are various types of mechanical drying systems developed, the most common form of veneer dryer in larger commercial operations is the conveyer-type jet-box drier (Fig. 6.5). With this system, veneers are fed along a conveyor system into the drier and passed through a series of chambers where hot air is blasted across the veneers to remove the water. Temperature and conveyor speeds are adjusted to ensure the veneer exits the drier with the appropriate moisture content and with a suitable quality. A number of moisture monitoring systems are commercially available that identify under-dried veneers at the drier exit, allowing these veneers to be separated and re-dried.

The most important and common form of avoidable degrade during veneer drying is out-of-range and uneven moisture contents. The target moisture content and acceptable range both between veneers and within a veneer depends mainly on the adhesive being used to manufacture the final product, but also species and the manufacturing process being adopted has an influence. A common target moisture content is 6% with a range of 3–10%.

Other drying induced defects include buckling, splitting and surface modification. All these drying defects affect the veneer recovery, and the aesthetics and mechanical qualities of the final product.

These defects generally become more common if excessively high temperatures are reached and also if the veneer has been over or under-dried.

The variables that effect drying time are veneer thickness, initial moisture content, drying temperature, air velocity and relative humidity. Air-drying may take several days or weeks whereas a jet-box drier can dry veneer within minutes.

Cocoveneer can be dried following similar practices and protocols used for traditional wood veneer species.

Figure 6.4 Air drying veneer sheets in Vietnam.

Figure 6.5 Cocoveneer dried using a jet-box veneer dryer.

This page left blank intentionally

7 Veneer grading and upgrading

The need for a transferable and comparative method (grading rules) to allow veneer to be traded requires a grading system that will allow stakeholders to have confidence in the supply of graded veneers to meet their manufacturing and quality requirements.

The veneer sheets are graded so that they can be sorted into categories that reflect their best use and price/value. This price/value relationship is set by the aesthetics and physical properties of the veneer.

The standards or rules for grading veneer may be set by individual countries. These standards are for grading veneer suitable for different uses such as for face veneer, substrate veneer, plywood, laminated veneer lumber (LVL) and formply. Manufacturers may also use non-standard veneer grading rules to classify the veneer quality to suit customer's requirements, as well as the wood species, type of veneer or the planned use.

The grading system applies a set of rules (grade criteria) to classify material into different grade classes. Grade criteria can include natural veneer defects or features; or process-induced defects caused when peeling or handling the veneer. Grade classes are usually assigned either a letter (A, B, C etc.) or number (1, 2, 3, etc.), where the best grade class is 'A' or '1'and subsequent grades reflect lower quality veneers.

While many veneer grading systems exist which have been developed for traditional forest resources, a new or modified veneer grading system may be necessary to suit the uniqueness of cocoveneer.

7.1 The process of veneer grading

7.1.1 Visual

When grading veneer sheets, the grader assesses the sheet visually, comparing the apparent qualities and imperfections against a fixed set of rules (applicable grading standard). The predominant defect/feature will then determine in which category the sheet is going to be placed, and determine its useability.

7.1.2 Automated

In high-end production lines, companies usually install equipment to fully automate the grading process from beginning (green ribbon) to the moment the sheet is ready to be glued (dried). The equipment can provide automated inspections to grade veneer sheets consistently for sorting into categories and for optimising the clipping of veneer ribbons from the lathe.

A camera scans the veneer as it passes, determining every defect type and position, using this information to grade the veneer to specifications that can be tailored to the current production requirements. Quite often a touchscreen display/interface will allow operators to select production grading requirements easily and to view grading results during the process. In addition, the grading results will be logged to a database to monitor production data efficiently.

7.1.3 Clipper optimisation

The veneer ribbon from a peeled log can be continuously scanned to determine how it should be clipped to produce the best quality yield, while removing as many defects as necessary. The clipper blade is controlled directly by the system, diverting clipped defects to waste, while good sheets are cut to accurate dimensions with minimal defects.

7.1.4 Sorting

Veneer sheets leaving the dryer are scanned to determine the grade based on visual and structural quality specification, and ensuring that the sheet dimensions meet accepted tolerances. Results can be printed onto the sheet, and the sheet is directed to allocated stacker bins.

7.1.5 Characteristics to grade

Given the veneer qualities and characteristics of cocoveneer are in many ways very different to veneer from traditional wood species, it is possible that many existing veneer grading systems will not be effective in efficiently separating the range of qualities that cocoveneer produces. Veneer characteristics that need to be considered when grading cocoveneer will depend on the end-product being targeted, and may include:

- Density – a large range in density exists in cocoveneer.
- colour – a range of colours exist in cocoveneer (Fig. 7.1).
- roughness - unevenness in the surface of the veneer.
- splits - a separation of the fibres in the direction of the grain and extending through the thickness of the veneer (Fig. 7.2).
- brittleness – the veneers resistance to degrade when handled (e.g. splitting).
- fungal decay - fungal decay is the decomposition by fungi (Fig. 7.3).
- holes and tear-out - a hole extending partially or entirely through the piece and attributable to any cause.
- flatness - excessive waviness or buckling in the veneer caused by compression. During pressing, the waves could split and overlap, affecting product quality (Figs. 7.4, 7.5).
- wane – the natural log surface remaining in the veneer (Fig. 7.6).
- insect tracks - deterioration caused by borers or termites.

Figure 7.1 Example of cocoveneer colour range.

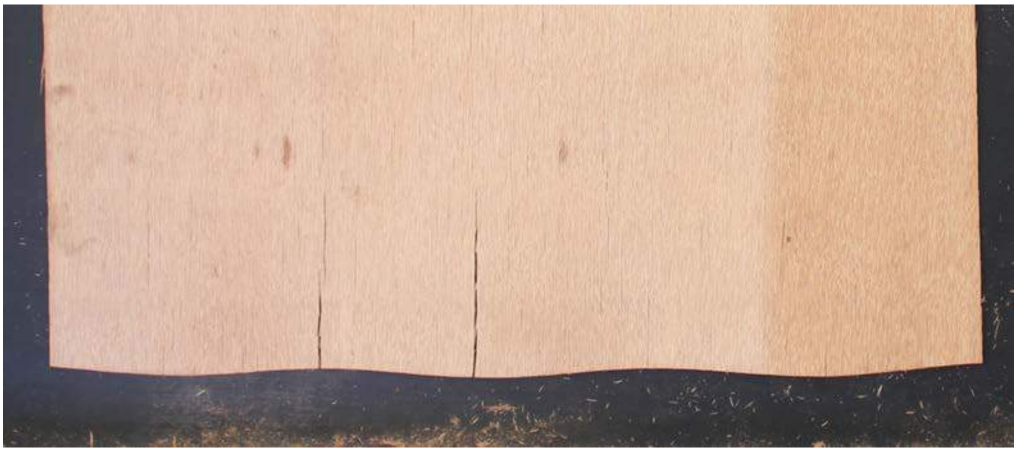


Figure 7.2 Splits.

Figure 7.3 Fungal decay.

Figure 7.4 Waviness in hardwood veneer.

Figure 7.5 Waviness can cause an overlapping when pressed flat.

Figure 7.6 Wane.

7.1.6 Australian and New Zealand Standard 2269.0:2012

The Australian and New Zealand Standard AS/NZS2269.0:2012 is an example of an existing industry standard which provides minimum performance requirements and specifications for manufacturing structural plywood that are acceptable to users, specifiers, manufacturers, and building authorities in Australia and New Zealand. The standard is applicable to both hardwoods and softwoods, and may also have relevance to cocoveneer.

There are five (5) veneer grades specified for plywood: A, S, B, C and D. The grades are described by general descriptions of each grade category follow:

7.1.6.1 A-grade veneer

A high quality appearance grade veneer suitable for clear finishing. This appearance grade quality should be specified for the face veneer in plywood where surface decorative appearance is a primary consideration (Fig. 7.7).

7.1.6.2 S-grade veneer

Similar specifications to A-grade veneer, but some characteristics (not permissible for grade A) are allowed when specified as a decorative feature: knots, holes, discoloration, hobnails, and other characteristics as agreed between manufacture and customer.

7.1.6.3 B-grade veneer

An appearance grade suitable for high quality paint finishing. This face veneer quality should be specified for applications requiring a high quality paint finish (Fig. 7.8).

7.1.6.4 C-grade veneer

Defined as a non-appearance grade with a solid surface. All open defects such as knot holes or splits are filled. Plywood with a quality C-grade face is designed specifically for applications requiring a solid non-decorative surface. An example is plywood flooring that will be overlaid with a decorative flooring surface (Fig. 7.9)

7.1.6.5 D-grade veneer

Defined as a non-appearance grade with permitted open imperfections. Plywood manufactured with face veneer quality D-grade is the lowest veneer appearance grade. It is designed specifically for structural applications where decorative appearance is not a requirement e.g. structural plywood bracing (Fig. 7.10).

7.1.6.6 F-grade veneer

Defined as reject grade. Sheets not meeting the minimum requirements of the above grades (Fig. 7.11).

Figure 7.7 Example of the visual quality of A-grade hardwood veneer.

Figure 7.8 Example of the visual quality of B-grade hardwood veneer.

Figure 7.9 Example of the visual quality of C-grade hardwood veneer.

Figure 7.10 Example of the visual quality of D-grade hardwood veneer.

Figure 7.11 Example of the visual quality of F-grade hardwood veneer.

7.1.7 Upgrading - veneer patching

A larger proportion of better grade veneer can be recovered by upgrading. This can be done by patching: cutting out (punching out) defects and inserting a precisely-fitting patch in the veneer sheets. Automated systems feed the veneer to the router, cut out the defects, press in the patches and secure them with a hot-melt adhesive. These machines can be linked to automatic defect-detectors that automate the process (Figs. 7.12–7.14).

Figure 7.12 Veneer patching.

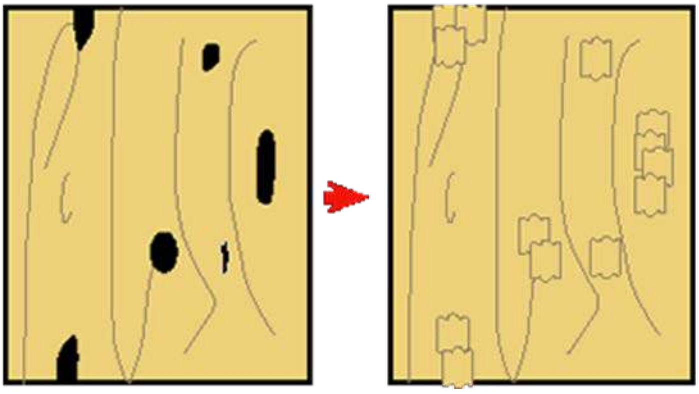


Figure 7.13 The principle of veneer patching.

Figure 7.14 Semi- (left) and fully-automated veneer patching.

7.1.8 Upgrading - veneer composing

Veneer composing means to dock and butt-join random-width veneers and sections freed from defects to produce full size sheets for product manufacture. Composing is an efficient process that improves veneer recovery, handling, labour costs and increases veneer quality as well final product quality. Composing improves flexibility in producing veneer sheets as well as specially-sized products, and is applied to manufacture face veneers and core veneers.

Traditionally, composing veneer sheets and edge-jointing options include the use of tape, glue, string or a combination of glue and string. For example fibreglass strings pre-coated with hot-melt adhesive can be applied to the veneer in a number of places using a heated roller. Full sheets of jointed veneer can be readily handled as single pieces.

Green veneer can be edge-stitched/sewn (splicing) using either a zig-zag or looper stitch (Fig. 7.15). A polyester thread is usually used as it shrinks by about the same amount as the veneer when dried.

Figure 7.15 Veneer splicing.

Figure 7.16 Veneer taping.

Product lay-up can be done manually with random-width cross-plies, two-piece centres and full sheets for faces and backs. However, the advantage of jointed veneers is to minimise the risk of overlapping and creating gaps and voids as a result of careless handling and positioning (Fig. 7.16).

Advanced veneer composer machines (Fig. 7.17) are able to combine and streamline the following individual steps to produce full size sheets in a semi or fully automated process:

- electronic thickness detection
- cutting individual sections
- joining sections using hot melt or non-melt adhesives.

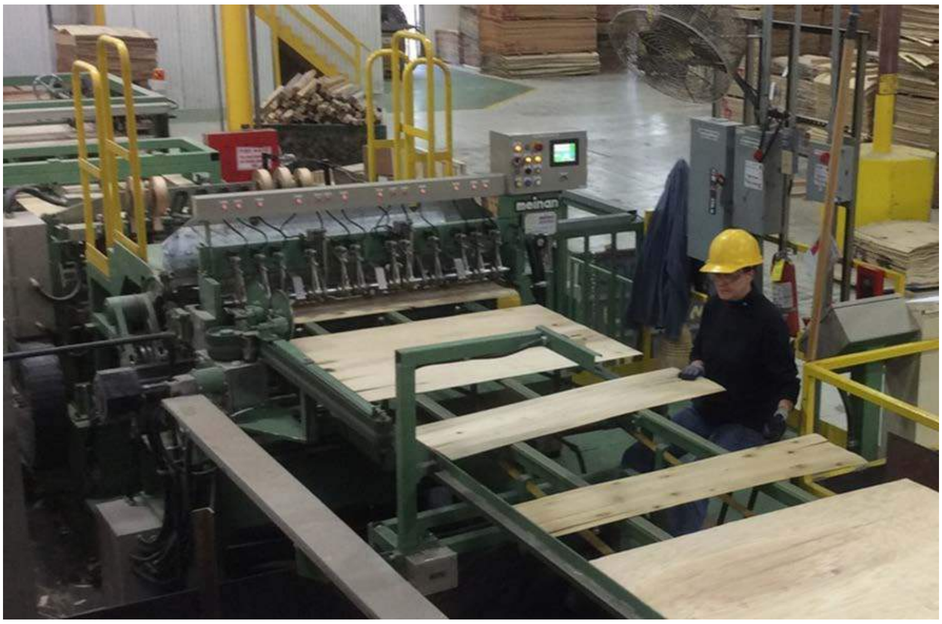


Figure 7.17 Meinan green veneer composer.

This page left blank intentionally

8 Veneer quality control

Quality control (QC) is best described as a system of process and product monitoring that aims to ensure implemented procedures, protocols and measurements are being followed to produce a consistent product of the required quality.

Optimised QC systems have a positive impact on the quality of the finished products and help to reduce manufacturing costs by:

- reducing rejects and downgraded products
- reducing repair and reprocessing costs
- increasing recovery and reducing waste
- increasing productivity.

8.1 Quality control for veneer production

With regard to manufacturing marketable veneer, the quality of the veneer is determined to a considerable extent by the precise set-up of the lathe. The challenge lies in selecting the correct settings (initial) and retaining these settings during the operation. In producing quality veneer, the objective is to:

- maximize the veneer recovery
- produce long and straight veneer ribbons
- minimize buckling and waviness
- minimize veneer breakage/splitting
- produce a smooth surface
- achieve uniform thickness.

QC systems are necessary to monitor veneer quality and correct the manufacturing process if necessary. The following paragraphs will help to identify such quality control markers, provide explanations and definitions in regards to their respective relevancy and establish procedures to overcome issues with manufactured veneer.

8.2 Ribbon tracking / straightness

8.2.1 Straight-tracking

The ribbon leaves the lathe in a true straight line onto the conveyer belt (which runs perpendicular to the rotation of spindle) if the knife remains with its edge exactly parallel to axis of billet rotation, and therefore produces a consistently, cylindrically-shaped peeler core (Fig. 8.1). A straight-tracking ribbon will inevitably produce a peeler core with the same circumferences at each end and its centre.

8.2.2 Mis-tracking

The ribbon has a tendency to track in an arc to either the left or the right side of the conveyer, depending on the source of misalignment (Fig. 8.2). The effect of mis-tracking becomes accentuated as the core diameter is approached and might only be barely noticeable when peeling large diameter billets.

Figure 8.1 Examples of straight tracking.

Figure 8.2 Examples of mis-tracking.

8.2.3 Disadvantages

The conveyer movement is designed to take the ribbon away from the lathe in a straight line and mis-tracking can cause splits along the concave edge of ribbon. The ribbon might break or split uncontrollably into unfavourably-sized sections, thus reducing the overall veneer recovery. Depending on the severity of the arc, the recovery rate might be reduced even further and the clipper can also jam.

8.2.3.1 Action

Mis-tracking indicates the need to realign the lathe settings (e.g. knife, nosebar, rollers). Measurements of peeler core diameters, veneer thickness variation and straightness of the resulting veneer ribbon will indicate the effectiveness of these adjustments. Multiple adjustments and fine tuning might be necessary to achieve straight–tracking.

8.3 Flatness (waviness & buckling)

A veneer ribbon is considered flat if the ribbon sits even/parallel with the conveyer belt and exhibits minimal gaps between veneer and belt's surface. The presence of buckling in a freshly peeled veneer ribbon indicates sub-optimal lathe settings. The specific position/occurrence of buckling within the ribbon is linked to/indicates potential sources of misalignment or incorrect setting of the knife, nose bar or rollers.

8.3.1 Effect of moisture on veneer buckling/waviness at the drying stage

Upon entering the dryer, buckled veneer are flattened, causing further stress on already-stretched edges and ultimately create split veneers (Fig. 8.3).

In the case where certain areas of veneer dry at different rates, differential shrinkage and associated differential tension occurs. Theses tensions can be the primary cause leading to buckling and splitting in dried veneer.

Growth stresses and reaction wood within logs can also cause buckling and splitting in veneers. The following methods can be used to minimise the occurrence of splitting and buckling:

- avoid over-drying
- moderating drying temperature over the last half of the drying cycle
- maintaining humidity as high as practicable over the last half of the drying cycle.

Buckling and waviness can also be accompanied by thickness variation.

Figure 8.3 Buckling and splitting on opposite edges of the veneer ribbon.

8.4 Veneer thickness variation

If all peeling parameters are optimised (e.g. adequate billet pre-treatment, lathe settings), the ribbon thickness should be uniform and close to its intended nominal thickness.

Variation in thickness for green veneer is best monitored by using a handheld, dial thickness gauge (Fig. 8.4). To minimise variation/induced bias/human error during measurements, it is important for the operator to calibrate the gauge and use the same method for each assessment.

Figure 8.4 A Kafer hand-held dial gauge thickness checker.

Thickness measurements should be randomly taken along both edges of the veneer sheets and on sheets along the veneer ribbon.

A similar approach can be applied to determine variation in thickness for dried veneer sheets.

Uniformity in thickness (within and between veneer sheets) directly affects the manufacturing process, and ultimately, the quality of the final product. In order to achieve efficiency in gluing and sanding, close control of product thickness and minimal variation is required.

Excessive variation can cause the following problems and poses the risk of producing an inferior product:

- There is variation in the amount of adhesive spread on veneers when using an automated glue spreader. For instance, thinner veneers will tend to have more glue spread on their surface than thicker veneers with the same machine set-up.
- There is localised, inadequate pressure distribution during the cold and hot-press stage.
- Overall thickness variation during manufacturing can result in undesired variation in the product thickness.

8.4.1 Thickness tolerances

Several veneer quality standards exist internationally that outline allowable thickness tolerances for rotary veneer produced from traditional veneer species. While they vary slightly, each allows a maximum tolerance of approximately 5% of the nominal dried veneer thickness. One of the key drivers for maintaining a low thickness tolerance in veneer is to reduce the thickness tolerance in products manufactured from the veneer.

Cocoveneer may require an alternative approach to accommodate the density variation that is produced between veneer sheets during rotary veneer processing. With standard processing protocols developed for traditional wood species and using a spindleless lathe with factory settings, a larger than traditionally acceptable range of veneer thicknesses could be expected. A strong correlation between veneer sheet density and veneer sheet thickness tolerance would also be expected.

In addition, the impact that veneer thickness has on the end product thickness after manufacturing will also be influenced by density, with varying densities expected to perform differently during product pressing where large forces are used during pressing. Targeting a low thickness tolerance over the possible density range that coconut palms can produce, may result in an unacceptable thickness tolerance of products after manufacture (i.e. low density veneer will compress more than high density veneer).

Research currently being undertaken by DAF seeks to better understand the impact of variable properties (e.g. density) on veneer thickness pre and post product manufacture. This research will guide suitable processing approaches whereby target veneer thickness may vary depending on density. Other control measures include thickness sorting as part of the veneer grading process.

8.5 Tightness and looseness

Veneer is characterised by the presence of small checks or fissures roughly parallel to the grain commonly referred to as ‘lathe checks’. These checks form on the side of the veneer that is in direct contact with the knife as the veneer passes between the knife and the nosebar as it is being cut from the billet, unrolled from the billet and flattened out (Figs. 8.5, 8.6).

The knife side of the veneer is the loose side and the nosebar side is the tight side. Veneer that has many deep lathe checks is 'loose-cut' veneer while one having shallow checks is 'tight-cut'. Lathe checks will affect the veneer quality significantly; and a balance is required between tightness and looseness.

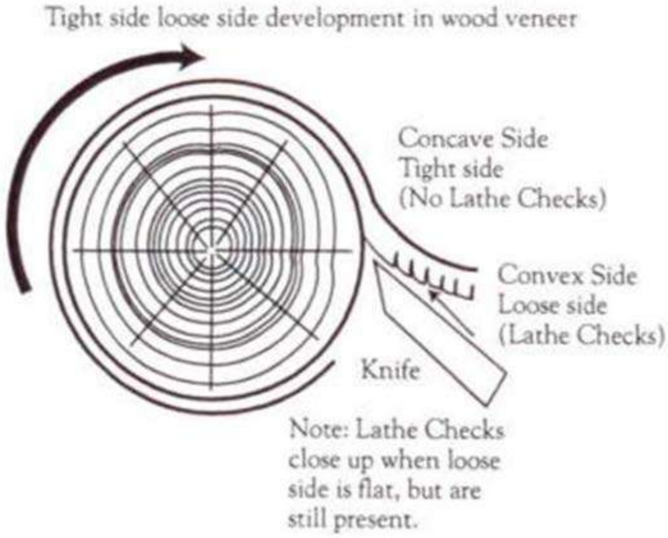


Figure 8.5 The development of lathe checks during peeling. ***Source: Columbia Forest Products,***
http://archive.constantcontact.com/fs058/1102117931485/archive/1102890340140.html

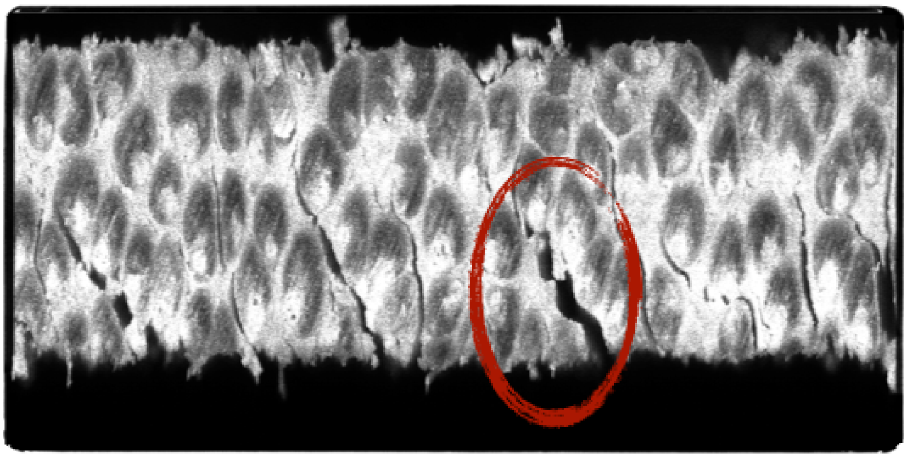


Figure 8.6 Peeler checks in cocoveneer.

Veneer with the optimal tightness only has small and fine peeler checks, and has little tendency to curl, buckle or split during drying and handling. Less peeler checks provide greater strength across the grain and tight-cut veneers are less likely to rip/split during manual handling.

Tight veneers are associated with superior weathering properties and exhibit less finishing faults. However, veneer that is too tight can cause pressing problems if the veneer hasn't dried flat.

Deep peeler checks significantly increase the surface area (up to 3 times) creating a condition that leads to excessive absorption of adhesive and/or finish material and distorted reflection of light (relevant for appearance grade).

8.6 Surface roughness

Surface roughness can be described as overall surface smoothness and the absence of excessive peeler checks and splits in veneer.

Rough surfaces might require intensified sanding (increase in operating costs and material wastage) and can be responsible for increased amounts of adhesive.

Roughness originates from splitting ahead of the knife edge during the peeling process due to cleavage action of the knife. The direction of splitting in relation to the cutting path determines the degree of severity of roughness. Roughness will develop when the split runs to the billet side. The development of roughness is also dependent on and intensified by the characteristics of the peeler billet (e.g. inherent lines of weakness such as fibre direction).

8.6.1 Influence/relevance of pre-treatment

As discussed in Section 4, veneer billet pre-treatment or conditioning commonly involves the heating of the billet prior to peeling. For most species, especially those in the higher density ranges, billet conditioning has significant advantages including smoother veneer surfaces with reduced lathe checking, improved gluability, improved veneer strength and reduced knife wear. However, over-heating can result in surface roughness of the veneer, due to over-softening. This can be a challenge with coconut given the massive density range that can occur within a billet.

Optimal lathe settings, combined with appropriate pre-treatment of the billet appear to be the best method to minimise surface roughness.

8.6.2 Influence/relevance of the nosebar

Without a nosebar, the veneer can split away from the billet ahead of the knife and the surface of the veneer would be very rough. The nosebar compresses the wood perpendicular to the grain so that the veneer is cut at the knife and the knife edge itself defines the surface of the veneer. The nosebar pressure is achieved by reducing the gap between the nosebar and the knife so that it is less than the thickness of the veneer being cut.

If the nosebar opening is too large the veneer will be compressed insufficiently and will be loose and of uneven thickness. If the nosebar opening is too small the veneer will be compressed beyond the elastic limit for the wood and it will be very tight and over compressed: it will not recover to its nominal thickness. Further, the power required to peel a billet increases steeply as the nosebar pressure is increased.

With spindleless lathes, nosebar settings also heavily influence target veneer thickness. In addition, many spindleless lathes have a powered roller nosebar which reduces frictional drag and clears slivers that stick in the gap. Roller nose bars have proved very beneficial for peeling coconut.

8.7 Moisture content

After peeling the veneer is too wet to glue and needs to be dried. Historically veneer was dried down to 2–5% moisture content, but today target moisture contents have been raised to 6–12% and even 15%.

Even with excellent control, the moisture content of dried veneer varies quite widely, so it is essential to monitor the moisture content of individual sheets as they emerge from the dryer and to mark and segregate out the under-dried material for subsequent redrying. Over-drying not only reduces throughput and increases dryer costs, but it causes unnecessary shrinkage of veneer, makes it more brittle and liable to degrade, and can cause gluing problems during product manufacture.

Better utilisation of the dryer is achieved by batching veneer to take account of large variations in initial moisture content and density.

Veneer moisture content must be suitable for the adhesive being used. Minimal variation is required within the veneer sheet as well as between the sheets used to make the product. The two, most commonly-used methods of quickly measuring moisture in timber products are with a resistance meter or with a capacitance meter.

8.7.1 Resistance meters (Pin meters)

A pin-type moisture meter uses two or more pins that penetrate into wood at a desired depth (Fig. 8.7). Direct current travels out from one pin into the wood and is picked up by another pin measuring the resistance to a current. Dry wood allows only little current to pass whereas wood with higher moisture content permits more. The meter reads how much resistance there is to the current and correlates the resistance to wood moisture content. Generally, this type of meter becomes less accurate as the MC increases and has limited application above 20% MC. Pin-type meters can be more effective in determining the moisture gradient within wood (difference between shell and core moisture content) compared to other types of meter.

Figure 8.7 A hand-held resistance moisture meter.

8.7.2 Capacitance meters (EMF meters)

These meters measure the moisture content of wood without penetrating the wood with pins. A sensor emits electrical waves that create an electromagnetic field (EMF). This field behaves differently, depending on how much moisture is in the wood and the wood density. EMF meters are based on the Capacitance method, but a properly designed meter will take many more factors into consideration. EMF meters measure the capacity of wood to store energy (capacitance), the amount of power the wood absorbs from the field (power loss) or the woods resistance to the field (impedance). However, a EMF meter is less effective in measuring the moisture gradient within wood. They are easy to use however and don't damage the veneer surface.

Table 8.1 compares the two types of moisture meters and the influence of physical factors and various features.

Table 8.1 Factors affecting types of moisture meter.

Factor	Capacitance (EMF)	Resistance (Pin)
Temperature	No	Yes
Chemicals	No	Yes
Wood orientation	No	Yes
Moisture gradient	Yes - in some types (but less effective than resistance meters)	Yes
Wood species	Yes*	Yes**
Wood density	Yes*	No
Surface texture	Yes	No

**Certain EMF moisture meters correct this either digitally or using a lookup table*

***Some pin meters may correct this using a lookup table.*

Handheld resistance moisture meters provide quick access to moisture content information and are relatively easy to use in small scale operations and are especially useful to determine MC of sheets outside the production line.

Commercial plants producing veneer on a large scale often install ‘in-line moisture analysers’ as part of their production line (Figs. 8.8, 8.9). These moisture analysers use the capacitance method and measure the veneer moisture content in real time on the conveyer. They are often combined with automatic visual grading detectors and form an essential part of a highly automated process. The figures show the principle of in-line moisture analysis and the moisture analysers in the commercial environment.

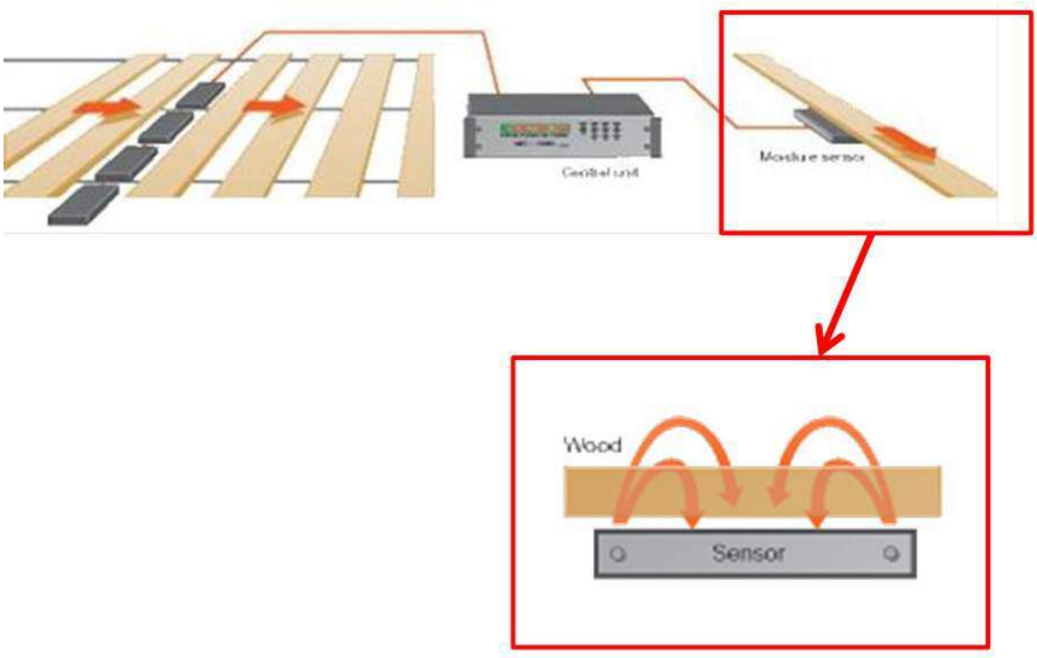


Figure 8.8 Commercial in-line moisture measurement for timber products.

Figure 8.9 Examples of industry in-line moisture measurements of veneer.

This page left blank intentionally

9 Veneer recovery

The calculation of veneer recovery is important to provide guidance on the efficiency of the veneering operation, to compare and evaluate forest resources, and to establish fundamental economic information. There are many different methods to calculate veneer recoveries and it can be often confusing to compare between reported recovery values as the methods used are often not sufficiently detailed. It can also be very valuable to calculate recoveries in a number of different ways to enable the extraction of valuable information such as the identification of where losses are occurring within the process.

Four recovery calculation methods are provided, including green veneer recovery, gross veneer recovery, net veneer recovery, and graded veneer recovery.

Green veneer recovery provides a useful measure of the maximum recovery, taking into account log geometry (sweep, taper, circularity) and lathe limitations (e.g. peeler core size). Green veneer recovery disregards internal log quality. Green veneer recovery for a batch of veneer billets (GNR as %) can be calculated as follows,

$$GNR = \left(\frac{L \times \sum_{veneer}(GT_{mean} \times GW)}{\sum_{billet} V}\right) \times 100 \qquad (1)$$

where GT_{mean} is the average green veneer thickness (m), GW is the green veneer width (m, perpendicular to grain) as measured prior to clipping and excluding any major defects (i.e., wane or undersize thickness) that are present at the beginning or end of the veneer ribbon, L is the veneer length (m, parallel to the grain) and V is the billet volume (m^3).

Gross veneer recovery provides a useful measure of the maximum recovery of dried veneer that meets the relevant quality specifications (e.g. AS/NZS 2269.0:2012). This recovery includes the losses accounted for in green veneer recovery but also includes additional losses from visual grading (i.e., veneer that failed to meet grade) and the drying process (e.g. veneer shrinkage, splits, etc.). Gross veneer recovery (GSR as %) is calculated as follows,

$$GSR = \frac{L \times \sum_{veneer}(DT_{mean} \times GRW)}{\sum_{billet} V} \times 100 \qquad (2)$$

where DT_{mean} is the mean dry veneer thickness (m), GRW is the width (m, perpendicular to grain) of dried veneer that meets the grade requirements (e.g. A, B, C, and D grades in accordance with AS/NZS 2269.0:2012), L is the veneer length (m, parallel to the grain) and V is the billet volume (m^3).

Net veneer recovery provides a useful measure of process efficiency, as it identifies the saleable product, taking into account the product manufacturing limitations. Net veneer recovery includes the losses accounted for in gross veneer recovery but also includes the additional losses due to the trimming of veneer before, during, and after product manufacture. The loss incurred when veneer sheets are reduced in width to the final product size is known as a trimming factor. While this varies between operations, an example is provided of a trimming factor of 0.96. This corresponds to reducing the veneer sheet width perpendicular to the grain from 1,250 mm to 1,200 mm. In the following example, the veneer sheets are also reduced in length (parallel to the grain) from 1,300 mm to 1,200 mm. For this example, that relates to the manufacture of 1200 mm x 1200 mm final product, the net veneer recovery (NR as %) can be calculated as follows:

$$NR = GSR \times 0.96 \times \frac{1200}{1300}$$
$$thus \;\; NR = GSR \times 0.88615 \quad (3)$$

Graded veneer recovery for an individual grade can be calculated using the same method as for net veneer recovery but using the veneer volumes that meet the specific grade (e.g., A, B, C, or D grades in accordance with AS/NZS2269.0:2012).

This page left blank intentionally

10 Resources

Contacts

Australian Centre for International Agricultural Research (ACIAR) www.aciar.gov.au

Queensland Department of Agriculture and Fisheries (DAF), Forest Products Innovations. www.daf.qld.gov.au Tel: +61 7 3277 9334. Email: robbie.mcgavin@daf.qld.gov.au

Cocowood – Exploring the potential of coconut wood, www.cocowood.net

More information

ACIAR Research project FST/2008/039 *Enhancement of production of acacia and eucalypt peeled and sliced veneer-products in Vietnam and Australia*. http://aciar.gov.au/project/fst/2008/039 and several, unpublished, technical reports.

ACIAR Veneer Value. FST/2008/039 project website. http://veneervalue.com/en/home/homepage.html [*accessed May 2015*].

Aeschlimann P. (2009). Preliminary research of key topics concerning the use of coconut wood as flooring material. Degree thesis Unversity of Applied Science School of Architecture, Civil and Wood Engineering Biel Switzerland.

Agelo Cremona www.angelo-cremona.com [*accessed May 2015*].

APA The Engineered Wood Association Wood University. Glossary. http://www.wooduniversity.org/glossary [*accessed May 2015*].

Australian Timber Database. http://www.timber.net.au/ [*accessed May 2015].*

Baldwin, R.F. (1995) Plywood and Veneer-Based Products. Manufacturing Practices.

Bootle, K.R. (2004) Wood in Australia. Types, properties and uses. 2nd Edition.

Corkhill, T. 1979. The Complete Dictionary of Wood. Dorset Press, 655 pp.

Columbia Forest Products Newsletter May 2009, Vol. 2. Lathe checks in rotary-peeled veneer. http://archive.constantcontact.com/fs058/1102117931485/archive/1102890340140.html [*accessed May 2015*].

Department of Agriculture and Fisheries, Queensland. Wood properties of timber trees https://www.daf.qld.gov.au/forestry/using-wood-and-its-benefits/wood-properties-of-timber-trees [*accessed May 2015*].

Dranibaka, S. (2008). Some technological properties of coconut wood that affect processing techniques of high quality flooring products. Masters Thesis (in. prep.) Southern Cross University.

DYAS EU, a.s. Terminology. http://www.dyas.eu/en/about-us/information/46-terminology [*accessed May 2015*].

Engineered Wood Products Association of Australasia (EWPAA). Plywood and LVL Production Course. Course Notes.

James, RN (2001) Defining the product- log grades used in Australia. Rural Industries Research and Development Corporation Publication No.01/161, 30 pp.

Lutz, JF (1977) Wood veneer: log selection, cutting and drying. U.S. Dep. Agric., Tech. Bull. No. 1577, 137 pp.

Mahnert, K-C. (2009). Evaluation of basic physical and anatomical properties of cocowood with regard to processing purposes. Masters Thesis, Institute of Wood Technology, Göttingen, Germany.

Schram. A. (2003) A complete guide to hardwood plywood and face veneer.

Standards Australia (1997) *AS/NZS 4491:1997*. *Timber—Glossary of terms in timber-related Standards*. SAI Global Limited. www.saiglobal.com

Standards Australia (2000) *AS/NZ 1080.3:2000. Timber—Method of test—Method 3: Density*. SAI Global Limited. www.saiglobal.com

Standards Australia (2012) *AS/NZS 2269.0:2012: Plywood—Structural—Specifications*. SAI Global Limited. www.saiglobal.com

Troughton, G (2001) Veneer drying manual. Special publication SP-45. Forintek Canada Corp

Tschupp, R (2009). Secondary machining properties and appropriate flooring design development for coconut palm wood. Thesis, Bern University of Applied Sciences School of Architecture, Wood and Civil Engineering, Switzerland.

Walker, J.F. (2006) Primary Wood Processing. Principles and Practice. 2nd Edition.

Wengert E and Meyer D (1994) Guidelines for grading hardwood logs. Forestry Facts No. 74. Department of Forest Ecology and Management, School of Natural Resources, University of Wisconsin, 6 pp.

Wood Moisture Solutions. Moisture Meter Technology. http://www.moisturemeters.com/moisture-meter-technology/ [*accessed May 2015*]

11 Notes