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Universität für angewandte Kunst Wien
University of Applied Arts Vienna

Design, Architektur und Environment für Kunstpädagogik

Wood in Practice

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Order of Content

Das persönliche Holzwerkstatt - Grundlagen Projekt

Diese Information ist an StudentInnen gerichtet, die ihr erstes persönliches Projekt in der Holzwerkstatt beginnen. Es wird ein Überblick geboten, der den Ausführenden helfen soll, ihre Ideen zu überdenken und die Realisierbarkeit der Umsetzung zu überprüfen, bevor sie sich endgültig für ein Projekt entscheiden.

Vor der Ausführung des persönlichen Projektes werden Vorlesungen abgehalten, um das Wissen der StudentInnen über Holz und seine Verwendungszwecke zu festigen. Es gibt auch eine Einführung in der Holzwerkstatt, die folgende Punkte beinhaltet:

- Sicherheit
- grundlegenden Gebrauch von Handwerkzeug
- Gebrauch von maschinellem Handwerkzeug
- Gebrauch von größeren Maschinen
- grundlegende handwerkliche Fähigkeiten
  - Verbindungen herstellen
  - Oberflächengestaltung
  - Bohren und Drechseln
  - Verwendung von Lacken und Klebern
  - Gebrauch von Furnieren

Die oben angeführten Tätigkeiten sollten binnen 2 Monaten abgeschlossen sein. Während dieser Zeit sollten die StudentInnen Researcharbeit über ihr angestrebtes persönliches Projekt gemacht haben. Die folgenden Punkte mögen in diesem Prozess hilfreich sein:

Künstlerischer Ausdruck/ Zweck des Designs

Verdeutlichung der Bedeutung des Objekts

Der künstlerische Ausdruck – obwohl offensichtlich - soll mit dem Zweck des Objekts in Einklang stehen, zum Beispiel eine Glühbirne erfüllt den Zweck einen Raum zu beleuchten und mit einem Lampenschirm wird ein künstlerischer Akzent gesetzt. Oder die Ausstrahlung von Ruhe könnte durch ein furnieretes, mit Aromaöl imprägniertes Lesezeichen erzielt werden.

Der Zweck sollte definierbar sein, muss aber nicht in direktem Zusammenhang mit dem unmittelbaren praktischen Gebrauch stehen. Zum Beispiel kann Materialresearch zu einem Objekt führen, das Aspekte aufweist, die Gebrauchsmöglichkeiten bieten, die nicht üblicher Weise mit diesem Material in Verbindung gebracht werden.

Auf jeden Fall soll das Ziel des Ausdrucks und Zwecks des persönlichen Projektes klar sein und die Planung soll im Projektvorschlag deutlich ausgewiesen werden, erst dann kann die praktische Umsetzung des Projekts beginnen.

Handwerkliche Fähigkeiten

Erlangen und Demonstration für eine ausreichende Basis

Thema

Einsatz des Ausdrucks und des Zwecks um eine künstlerische Botschaft zu transportieren

Die StudentInnen können das Design für ihr Objekt aus einem umfangreichen Themenkreis wählen, wie z.B. Natur, Heimat, Bedürfnisse, Selbsterfahrung

Präsentationsvorgaben

Die StudentInnen werden angehalten, ihr angestrebtes Projekt wahlweise unter Verwendung von Skizzen, Maßmodellen, technischen Zeichnungen oder CAD zu beschreiben.

Conclusio

Theoretisches und praktisches Know-how sind grundlegende Fähigkeiten, um das persönliche Projekt in der Holzwerkstatt zu vollenden. Diese Fähigkeiten sollten durch das abgeschlossene Projekt reflektiert werden.

Preamble

After a period of time working with wood the researcher became aware of a bond between him and the material. An ethereal conscious relationship was manifested in his appreciation of the material. To him it described, without expectation of reciprocation, the characteristics of a life. The following examples give insight as to how elements of wood could support such a rapport: stresses of growth during the life of the tree producing fanciful patterns known as 'flower' or 'flame'; hidden embodied deposits such as chalk adding variety to the subtle colours; diverse textures like glass to touch or the roughest sandpaper; the distinctive sound of a sharp blade running over a straight grained plank, with the shavings rustling in the hand plane before wafting to the floor; and the distinguishing aromas released when wood is cut. In this relationship the researcher found a friend within himself, a friend with which he was able to communicate.

After constructing projects using both hand tools and automated machinery he observed that this relationship was only apparent when he was in direct contact with the material. While he can understand those who describe the working of sophisticated systems of machinery as exhilarating, this process left him feeling alone.

Although the definition of a tree is somewhat opaque, the literature agrees that there is a minimum of 25,000 different species of tree. Oak has 240 different types alone!
5,000 of them are available from dealerships, although this number is diminishing in the wake of action against the felling of uncertified forests. Trees are the oldest form of building material for humans. Hugh Johnson (1976) argues that humankind has no greater debt and will again in the near future find reason to cherish and protect this source of food, energy and protection.

Today wood processing and use has become a science and there is much data to assist in choosing the correct wood for a project. Woods wear differently and when choosing the right wood there are many factors to consider such as, hardness, how regular or straight the grain is, the amount of natural oils within, tensile strength, flexibility and for what purpose the wood is to be used.
It is hoped the following notes will be useful in providing a general overview of some points which a woodworker will need to consider.

Chapter 1
Wood a living material

1.1 Softwood and hardwood

Contrasting softwoods from hardwoods
Reasons for the differentiation and relation to the construction of the timber

Softwood and hardwood are botanical terms and do not define the density of timber although it is true to say that the hardwood trees are usually denser than softwood trees. However, this should not be used as a guideline for differentiating between the two, as it is often not the case. For example, obeche, jelutong and balsa are soft in texture but nonetheless termed as hardwoods.

Softwood is an evergreen cone-bearing tree. It has needle-like leaves and is sometimes known as a 'plant with naked seeds'; it belongs to a group called gymnosperms. Hardwood has broad leaves and is usually deciduous, but evergreen varieties can be seen in cultivated gardens and parks.

Softwood has tracheid cells, about 3mm in length, i.e. longer than those of hardwood trees. Tracheid cells contain pits that store the tree's sap. They are located in the faster and softer growing summer wood, known as 'early wood' which contains a greater number of sap storing pits than those located in the more dense, slower growing winter grown wood, known as 'late wood'. The late wood's tracheid cell walls have fewer pits due to their denser and thicker consistency; these stronger cells provide the tree with its structural strength. The pits contained could be described as valves working to provide the tree with the correct volume of sap flow. This process works in conjunction with the method trees use to absorb the sun's rays.

Hardwoods have a different cell structure from softwoods. The sap flows through vessels which together form pipe-like pores that do not appear in softwoods. The cells are shorter at about 1mm and transport sap more efficiently. More often in hardwood trees the cells are sometimes arranged in horizontal bands called medullary rays. It is this formation which can give wood a characteristic 'flower, flame or figure'. The cell structure of the hardwood tree is more complicated than of softwoods; it has a fibre called 'stringing' which passes through the vessels, firmly tying them together. This is how hardwood trees are generally stronger and the wood, when used as a material, more reliable.

Reasons for determining whether a tree is a hard or softwood:

1. **Estimating the value of a crop prior to the trees reaching maturity:** A value is determined by either calculating a percentage between the time lapse since planting and how many years a tree will take to mature, or, where the tree's age cannot be proven, a value will be reached with the aid of measuring its girth with the knowledge of what this girth is likely be for a mature tree of the same type.
2. **Sustainability issues:** Judging the age provides forest inspectors with information needed to sanction the extent of an area (in cubic metres) which can be harvested.
3. **Processing:** The length of time required for seasoning (drying to a usable moisture content).

1.1.1 Hardwood/softwood differences relevant to use

Softwood:

- Will accept chemicals more readily
- Grows faster and matures quicker
- Usually provides a longer trunk (the portion of tree between the buttress, which consists of nearly all the usable area, it is immediately above the roots and preceding the crotch, the area where the first bough branches off)
- It is usually and typically less expensive
- Drying times are significantly shorter (due to its less complicated cell structure)
- Certain softwoods, such as yew, have greater elasticity
- The pine family is the most widely used wood. This is because of its speed of growth and resistance to insect attack, providing owners of plantations of this tree with a faster, reduced risk return on investment
- For solid wood purposes, softwood trees can be harvested from 60 to 100 years old; however, coppiced and younger trees are now being used for heating pellets and manufactured board production

Hardwood:

- Has more grain variation and is therefore more suitable for furniture construction requiring an aesthetic accent
- Is a generally more reliable material, making its shrinkage and expansion movements less likely to cause damage when installed (Shrinkage and expansion will be explained in the next chapter)
- Due to its stringing characteristics is stronger and more resilient, making it more suitable for certain products, for example, willow cricket bats, hickory axe handles or hornbeam drumsticks and billiard cues
- Is less susceptible to insect attack

1.2 Growth

Green areas of all plants contain chlorophyll; this green pigment is able to absorb energy from sunlight, a process called photosynthesis. All trees combine carbon dioxide from the air with water taken via the root system, from the ground. The green areas of all trees are exclusively the leaves, through which the carbon dioxide can pass. The result of this process is a manufactured sugar, which feeds the tree. This food is moved in a solution from the leaves to all parts of the tree through a layer situated under the inner bark, or phloem. This is used either immediately or after a period of storage, for the generation of new growth. A specialised cell layer called the cambium produces new wood; this lies between the sapwood and the phloem. During active periods of growth, the cambial cells in the cambium wood divide to produce new wood cells on the inside and phloem cells on the outside; thus new wood is called sapwood. As layers are produced they adhere and become part of the sapwood which provides the tree with material through which sap flow and food storage can occur (see figure 1a).

In areas of seasonal weather such as Europe, the tree will grow in increments. This will be faster in more favourable periods but slower, or will even suspend growth, in times of cold or drought, which is what makes growth rings visible. Dendrochronology, developed early in the 20th century, is a method of dating past climatic changes, through the examination of growth rings. However, where conditions are continually favourable for the tree, growth rings are not produced and in areas where climate changes are minimal growth rings are barely visible.

When a tree is older, the sapwood will be thicker, the cells in the innermost area of which will die and undergo a chemical change to become heartwood which may vary in colour; sometimes extreme visual differences will occur. Although this new and increasing area of the trunk is no longer living it has a vital role to play in supporting the tree’s ever increasing bulk and crown.

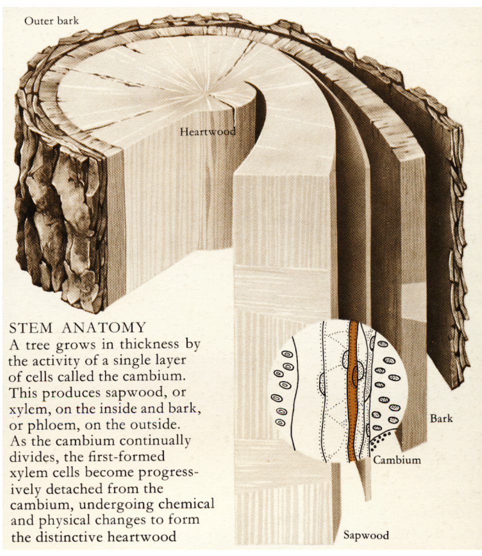


Figure 1a: Growth layers

Chapter 2

Working with wood

2.1 Timber shrinkage and expansion

Timber shrinkage and expansion have presented furniture designers and makers with a perpetual problem. A fully-grown tree will in the summer months take in hundreds of water per day, a plane tree for example as much as 500 litres. This water is pumped through its bulk to the leaves.

This section discusses some causes and considerations necessary to minimise the possible effects and impacts of material movement caused by reducing this moisture content once the tree is felled.

Depending on its use, wood when seasoned will have anything from one fifth to one twentieth of its original moisture content. In countries where there is a significant contrast between summer and winter, a tree will do most of its growing in the summer, at this time it will have its highest moisture content. In these areas of the world felling is carried out in the winter months when the tree's moisture content is at its lowest. Felling in these periods minimises the difference between the tree's natural state in nature and its final destination in the dry environment of a building, and the propensity for warping or splitting is therefore lessened.

To further reduce the likelihood of movement, the wood is seasoned in order to bring the moisture content to a usable percentage. After this process it will also be lighter, harder, stronger, more resistant to fungi and other diseases, less effected by ultra violet rays and generally more reliable to work.

In an ideal situation, timber should be dried until it reaches an equilibrium with the area of its intended installation.

Examples of moisture contents required:

- 20% Usually the maximum moisture content to avoid the occurrence of dry rot. However, certain woods are less susceptible to fungi and other attack due to their high oil content and can have a higher moisture content; examples are teak and cedar.
- 16 – 18% Outdoor furniture
- 12 – 14% General construction
- 10 – 12% Interior furniture
- 8 – 9% Timber to be installed in specially dry or monitored conditions

2.1.1 Drying wood and effects of inadequate or unsuitable drying

There are two main types of drying a plank of wood: air-drying and kiln-drying.

Air-drying has been used since ornate furniture was introduced into the home, but it is still in use today mainly because where space is available it is the least expensive method. Also, there are those who consider this method more reliable for initiating the drying process of very hard woods before completing the process either by placing the planks in the environment in which the wood will be installed or with kiln-drying. The length of time required to dry a plank depends on many factors, such as species, density and of course how thick the plank is; nonetheless, as an approximate guide, it takes about one year for every 25mm thickness for hardwood and about half that for most softwoods. The main disadvantage of using this method is that, depending on the relative humidity, it is possible to dry wood to only 14 – 16% moisture content, which for interior use is insufficient and would need further drying.

Kiln-drying is suitable for wood which will be used for interior purposes. Large rooms pump a mixture of warm dry air and steam throughout the room and the piled boards, which are stacked with air in between each one. The steam content, controlled by computer, is gradually reduced bringing the moisture content in the room down to a specified amount which depends on the requirement and species of wood. Once the room is full of the wood to be dried, the process will take only a matter of days. Due to the efficiency of this method, most wood is now dried this way. However, wood which has been dried at such speed is more likely to soak up moisture from the environment so more care is necessary when it is used.

Microwave (Radio Frequency Vacuum, RFV) drying is also today used to dry certain timbers. Douglas fir and other woods, which do not have a complicated cell structure, can be dried using this method. Hardwoods, however, generally have a more complicated cell structure that does not allow vapour to escape out at the speed which this method activates. In these cases a degrading of the wood known as honeycombing can occur.

Some of the effects of ineffective or insufficient drying

Cupping – across the width of a plank presenting a shallow cup shape

Bowing – this is a bending along the length of a plank. Some bowing is to be expected even in perfect drying conditions and provided these effects are not severe a correction can be made during the planing process.

Springing – a plank bending along its length edge. Cutting the edge straight can easily rectify this.

Twisting or warping – as the words suggest, one end of the plank has turned away from the rest of the plank.

End splitting – very common, split boards are generally sold as full price boards with the effected area removed from the price calculation.

Flaking – thin sections of wood disconnected from the bulk. It is not possible to ascertain how deep the problem lies and the complete plank may have to be discarded. The problem can be caused through stresses within the growing tree and present prior to felling.

2.1.2 Processes to minimise effects of timber movement

Ideally, the workshop where the object to be constructed is made will have a similar moisture content to the room where it is to be installed. This can be achieved with the use of sophisticated dehumidifiers. Care at all times should be taken in respect of the material's moisture content, for example if the journey from the workshop to its final destination is to be long or where the air is damp, shrink wrapping is recommended. Wood is a slow conductor which in the case of transportation is a great advantage; however, this also means that once wood has taken in a higher than recommended moisture content rectifying this may take a significant amount of time.

The various species of wood have different capacities for movement, for example mahogany has less than oak and idigbo less still. The area of the tree and the type of cut (see figure 1) has also to be considered. Variants are also not consistent between species but can be approximated by density.

Paint and lacquer will minimise moisture content fluctuation; however, there is no substitute for a skilful drying process. Timber which has been in use for some time or has had a longer seasoning period has a reduced tendency for movement.

Wood is a living material and therefore has an innate quality to adjust its water content according to the environment in which it is placed, it will do this until it is either destroyed or has disintegrated.

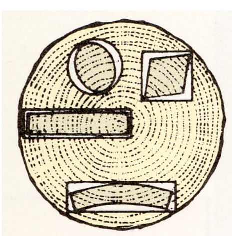


Figure 1: Varying results of the drying process

It is seldom that green timber is used for construction purposes, nonetheless there are occasions where timber, which has not been fully dried, can present an advantage. For example green oak used for a house frame will slowly twist and move, and in a relatively short period a house built in an old style will appear even more realistically old.

2.2 Veneers

Methods of production, decorative qualities and constructional uses

With modern glues, veneers are an excellent way of making an inexpensive substrate such as chipboard or medium density fibreboard not only attractive, but they can also protect the supporting material against moisture fluctuation because wood is generally slower in conducting moisture than man-made boards. Today, veneers are losing their stigma as an inferior product as more and more applications come onto the market. Veneered substrates are in certain circumstances a preferable method of construction, for example:

- For security considerations which need to be inconspicuous
- Lowering the risk of splitting for wider board construction
- Where moisture content equilibrium cannot be guaranteed
- Where a mixture of woods is required
- When weight is a consideration with the use of a lightweight substrate

The production of wood veneers requires considerable knowledge and experience. This starts with the log buyer who will determine without cutting the log how suitable it is for veneering. Once delivered to the sawmill, the technician will decide how the log would be most efficiently cut to yield the maximum amount of quality and/or specified veneers.

2.2.1 Methods of production

Cutting veneer

Wood to be used for veneers do not require undergoing a drying process but are cut 'green', nonetheless, will be felled in the winter when the tree sap content is at its lowest.

Veneers, with the exception of sheets cut from a burr, are cut from the length or the trunk of the tree. Before cutting starts, the bark is removed and the log controlled for elements which may damage the cutting equipment. These can include foreign elements such as nails or stones, which have become imbedded at the time of felling. The technician will also check for chalk and other elements the tree transported from the ground during growth which have become part of the tree.

Most woods are made sufficiently supple for veneer cutting by a process of soaking; however, some paler woods will be cut immediately after the bark is removed because otherwise they would be discoloured by this latter process. Depending on the type of veneer to be cut, soaking can take the form of immersing the entire log into water or first slicing the log into planks. Trees used for veneer production are usually fully grown, which, in the case of hardwoods, is from 120 to 200 years old and softwood approximately half this.

There are many ways of converting a log into veneers; these can be divided into three categories: saw cutting, rotary cutting, and flat slicing.

Saw cutting

Although this method was historically used for all veneers, modern saw mills use it today only where the wood veneer to be produced is valuable. Saw cutting is currently used for curls, burrs (see figure 2), difficult grained and thick-cut veneers. A burr is a growth on the tree, caused through the tree's natural defences to repair injury. Due to the way a tree constructs a burr inwardly from all sides these veneers are generally very decorative, rare and expensive. Curls are a grain pattern which is cut from the adjoining area between a branch and the larger part of the tree (see figure 4). Because of the special nature of burr and curl veneers, they are used mostly for quality bespoke furniture. Burrs are also manufactured through purposely injuring the tree, forcing it to repair itself with a burr.

Modern methods of cutting have made this method wasteful of material by comparison. A sawn cut veneer leaf will be from 1.1mm to 1.6mm thick and whereas the kerf (or thickness of blade) of a saw blade will be thicker.

Figure 2: Saw cutting

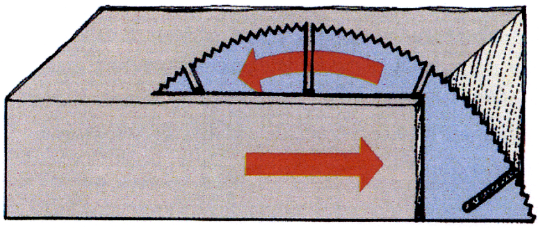


Figure 3: Burr wood
These highly prized veneers are cut from the end-grain of irregular outgrowths found on the trunks of many trees. They are commonly cut from elm, oak, ash, walnut (above) and other hardwoods.

Figure 4: Curl veneer
Veneer from the junction of a branch and the main trunk gives the attractive curl pattern. Beautifully figured veneers are also cut from the main root members of some trees. The sample above is mahogany.

Rotary cutting

This is a method of peeling a whole log which is set into a huge lathe (see figure 5). A continuous sheet is cut until practically the whole log is used. This is achieved with the help of a pressure bar which is pushed against the log, situated immediately above the knife (see figure 9). A continuous sheet is peeled off (see figure 5). The thickness of the veneer is adjusted by the distance that the knife is forward of the pressure bar. With each revolution, the knife is adjusted forward by the amount removed by the previous cut. The continuous tangential cut of this type is used for most plywood. When this method is used with softwoods, the results show a wavy pattern that has an unnatural appearance.

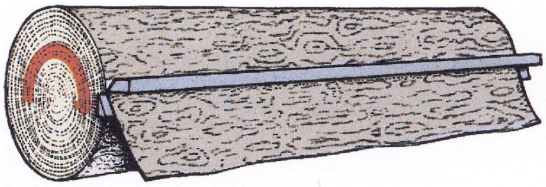


Figure 5: Rotary cutting

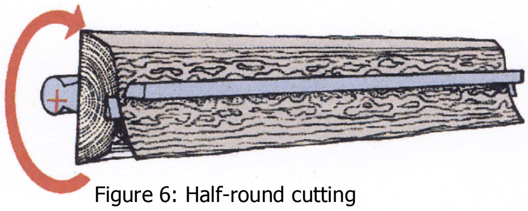


Figure 6: Half-round cutting
This is similar to off-centre cutting, and produces a figure similar to flat-sliced veneer.

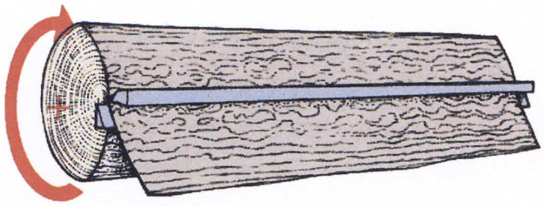


Figure 7: Off-centre cutting
This is a rotary-cutting method that produces a figure similar to that of flat-sliced veneer.

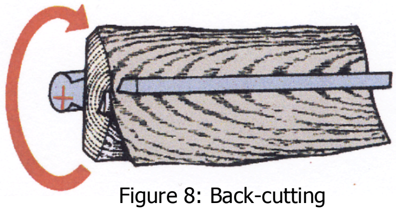


Figure 8: Back-cutting
This is a rotary method used for cutting decorative butt and curl veneers

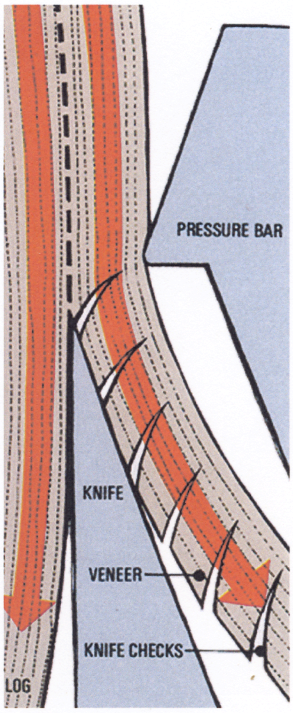


Figure 9: Pressure bar in relation to knife

Flat slicing

This method of veneer cutting is used where the log needs to be positioned manually according to its character, as chosen by the technician. The technician will initially rip saw the log into two halves before slicing (see figures 10 and 12). The cutting motion is similar to rotary cutting but, depending on the area sliced, this method can produce a very different grain effect. This method is also used for quarter-cut slicing, a method used to produce a closer grain. Maple cut with this method will often produce the attractive 'flame' associated with this material. This effect is produced by ray cells which run across the growth rings.

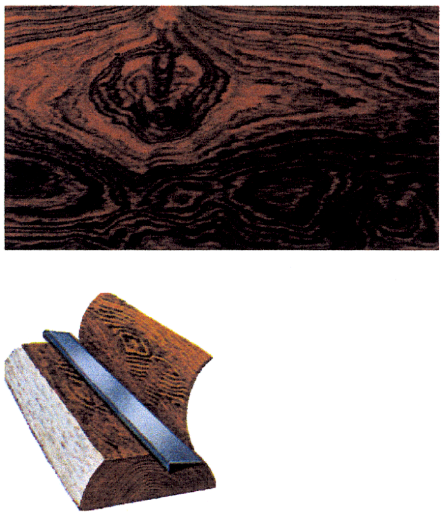


Figure 10: Flat-slicing
The half-log is softened in water or by steaming prior to cutting. Slices taken across the crown of the log expose the marbled heartwood, this often results with contrasting pale sapwood at the margins. The sample above is Rio rosewood.

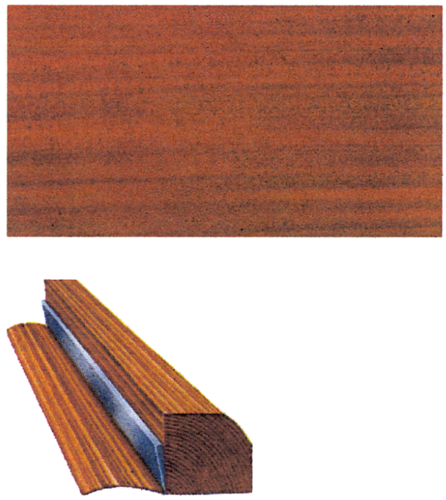
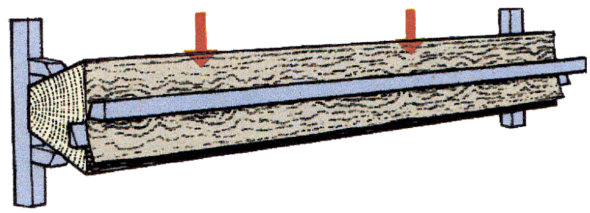


Figure 11: Quarter-cut slicing
After softening by soaking or steaming, the quarter log is mounted on a movable carriage which brings the section of log across a fixed knife-blade at a shallow shearing angle. The sample above is sapele.

Figure 12: Flat-sliced quartered
Quartered logs are sometimes cut tangentially to make flat-sliced veneers.



2.3 Grading

Once cut, veneer leaves are stacked in sequence. The sequence must at no time be lost. This is vital to the user when matching veneers that will be close to or touching one another. The leaves are then passed through a drying process before they are cut to width with a guillotine, which regulates their size. Certain species and all burr and curl veneers will remain at the size at which they were cut from the log.

In any single log there may be various grades of veneer. The more desirable veneers are known as face quality to be used for the side which will be seen, lower grade veneer is known as backing grade. Finally they are bound into bundles from 10 to 40 leaves and restacked in the order in which they were cut. They will then be stored in a cool dry environment before being sold.

It is vital that the reverse side is also veneered with a balancing veneer. This will usually be of backing grade as mentioned before. This is because the side to which veneer is being applied will shrink during the curing process causing distortion if the two sides are not balanced.

Chapter 3
Manufacture wood boards

3.1 Uses, advantages and disadvantages over solid wood

Increasing use and demand in the 20th century for manufactured wood boards has resulted in an ever-increasing variety of these materials. In the early 1980's a board made from wood pulp was developed which radically altered methods used for mass furniture production. 'Medium density fibre board' or MDF is now widely used in wood workshops throughout the world. There are three main categories of fabricated wood board: laminated, particle and fibreboard. These can be purchased in various standard sizes, which vary according to the country of sale. Boards are generally a more sustainable method of construction as their construction allows for far more of the tree to be usefully used. However, much board material is now manufactured in China and the far East, where, according to the Furniture Industry Research Association (FIRA, 2008), controls to meet European standards regarding the glues and materials used for board construction are not completely certain.

Advantages:
With the exception of blockboard (which to an extent has been replaced by MDF) wood boards have no lines of cleavage. This is beneficial when a wider section is required. Although wood boards are manufactured in varying widths, storage is significantly easier than with sawn solid timber because they can be efficiently stored in a vertical position. Although the straightness of their edges should be checked, they are usually straight, so the initial cut is less wasteful. Waste is further reduced as predetermined board sizes enable advanced segmentation calculation. Less attention is required in respect of moisture content as boards shrink and expand very little. Most boards can be finished with a variety of surfaces, for example, paint, tiles or lacquer. Boards also veneer very well with the result being a wider board which will have far less likelihood of splitting or other movement. Financially, most boards offer a reliable material at a fraction of the cost of solid hardwood.

Disadvantages:
These are mainly aesthetic. Manufactured boards generally require an additional surface such as paint or veneer and although MDF can be moulded, other boards generally require additional lipping of the edges. Because the shrinkage and contraction of manufactured boards is far less than that of solid wood, care must be taken when joining them to solid wood. However, provided the environment of installation has an average moisture content this can to an extent be overcome by using solid wood, which has been well dried.

It is extremely difficult to reduce their thickness and due to the glues used for their manufacture doing so will result in blades or sanding belts being quickly blunted. Repairing or re-finishing a damaged veneered board will not usually bring satisfactory results.

3.2 Laminated boards

Plywood

Plywood, in various forms was in use in ancient Egypt; however, the late 19th century witnessed the development of its current form. Nonetheless, plywood is the oldest of modern manufactured boards. Its main advantages are its strength and reliability. Exterior weather and boil proof (WBP) is constructed with phenol-formaldehyde, an extremely strong glue dark brown in colour. Its advantage over solid wood and indeed to an extent over other manufactured boards is its extreme tensile strength across its width and length. With the exception of structural (mostly used for formwork) plywood, this material has a smooth finish and is suitable for veneering. Plywood is often made of gabon which is one of the main timbers used in the plywood industry.

Plywood is manufactured in various forms and thicknesses some of which are mentioned below:

Stout hart plywood

This is a 3-ply board and is available in thicknesses from 4 - 9mm.

Drawerside plywood

This is the only plywood to have all the plies running in the same direction and is used for what its name suggests – the base of drawers where tensile strength is needed and where the framed board negates any consideration of splitting.

Multi-ply

Multi-ply can have any number of plies depending on the thickness of the board. This reliable board accepts veneer very well and when required is usually chosen. It is manufactured in various thicknesses ranging from 4 - 38mm. Running along its longest length, the plies used are approximately 2.5mm; however, the cross-banded plies will usually be thicker which provides the board with a uniform rigidity across its width and length.

Four and six ply

Although this is of a cross-ply construction, the inside plies run in the same direction as the outside faces, consequently the board offers a greater tensile strength in one direction. This material is generally used for building construction purposes.

Marine plywood

This is a high quality board, which uses graded plies and has no knots or voids. It is primarily used for boats and is generally made from mahogany and sapele.

Birch ply

This is the smoothest plywood; the best quality is derived from Finland while good but less expensive alternatives often originate from the Baltic states.

Blockboard

Blockboard has a particular advantage over MDF, which is its superior tensile strength. This is due to its construction, using solid strips of wood made from softwood, sandwiched between two outer plies. Thicknesses range from approximately 16 - 44mm. It is a stable material and veneers well; however, during the life of the material, due to shrinkage or expansion, the core strips can create an uneven surface causing the veneer to split or bubble.

Laminboard

This board is of similar construction to Blockboard but with thinner core strips which are often of greater density and made from ply or hardwoods. These strips must not exceed 7mm. The outer skins are made up of either three or five plies.

3.3 Particleboard

Chipboard

This board is generally used for interior work (although exterior grade can be obtained) where either the board cannot be seen or is covered with a veneer or decorative laminate. It is the least expensive of the boards mentioned here and requires a surface with 100% opacity. There are three types of chipboard:

Single-layer chipboard

Has a coarse finish and is generally used for flooring.

Three-layer chipboard

Has a core of coarse particles sandwiched between two outside layers of fine, higher density particles which contain a higher quantity of resin in the glue; this produces a smoother surface than a single layer, making it ideal for veneering.

Graded density chipboard

Has a finish similar to the three-layer board with one difference – there is a slow transition from the coarse to the finer particles.

MDF

Medium density fibreboard has only been widely used in recent years. For economic reasons it is generally constructed using coppiced wood, but can be made from fully-grown hard and softwood trees, which have been debarked and ground. It then looks similar to cotton wool. Formaldehyde glue is added before the mixture is pressed and dried. It has two smooth surfaces, which provide an excellent base for painting, and the board is consistent throughout. The core is softer than the outer edges but is dense enough to mould which when coated with a primer lacquer can provide a finish that can be painted. Delaminating can occur when fixing into the edges but with care, for example using a correct pilot hole, this can be avoided. Available also is bendy MDF; this, as the name suggests, can be bent into relatively tight curves. It is made by making many thin slits close together in a standard board's face leaving one good face.

Hardboard

This is high-density fibreboard, which is produced by placing wet fibres under high pressure and temperature. The sap resins, which are naturally found in wood, bond the fibres together. It is not water-resistant but can also be purchased as tempered hardboard, which is impregnated with oil and has some resistance to water and airborne moisture.

Fibreboard

This is a low-density fibreboard used as a heat insulation material, pin boards and for acoustic reasons in theatres.

Chapter 4
Wood bending

Laminating and steam bending are methods of producing curved or shaped wood components. These two methods, their processes and points of consideration are discussed in the following.

Methods of curving wood most commonly used are steam bending and laminating. Steam bending is the older of the two, but it is with the introduction of modern glues that the extremely strong and widely used method of building curves with the technique of laminating has been made possible. Laminating is not only widely used in the furniture industry, it is used by model makers, for decorative roof trusses, constructing bridges, and many other uses.

4.1 Laminating

Laminating is a process of cutting timber into thin strips and sandwiching them together with urea-formaldehyde glue. The strips are placed into a male and female mould prior to gluing and being pressed, in most cases under dry and very warm conditions. Strip thicknesses will vary according to the project but, depending on the elasticity of the wood being used, for smaller work or for sharper curves they should not exceed 3mm; there is no width restriction. Grain for all layers is placed running in the same direction maximising their bending properties and reducing the risk of warping.

All woods have a bending capacity and extent; some are naturally more pliable than others making them more suitable for tight curves. Some of the most commonly used woods used for bending are ash, beach, birch, elm, hickory, oak and walnut. The wood selected to laminate should be free from knots and shakes as these are likely to cause the wood to break or distort. Nonetheless, thinner, decorative and random grains can be used for the face laminates. Although efficient production demands the thickest strip possible, the thinner the strips used in construction the less ‘spring back’ there will be after curing. Urea-formaldehyde cures slowly and in so doing gives the assembler time to position all pieces prior to clamping. This glue also leaves the strips with a reduced likelihood of slipping against each other during the clamping process.

4.2 Steam bending

Steam bending requires surrounding the wood to be bent with flowing, very hot steam over a given period (approximately one hour for every 25mm of thickness). This has the result of making the wood’s fibres both far more stretchable and compactable than in other environments. Steaming for longer periods will not have the effect of making the timber more pliable, rather will create the risk of a breakdown of its fibres. This process makes a permanent bend, to the most extreme proportions possible, such as with the wheel-back chair (see figure 14). The method has great versatility and was even used for making doll's faces in the early 1900s.

Only straight-grained timber, which is free from knots and other weaknesses, should be considered for bending. Weaknesses of any kind within the wood are very likely to cause failure. Many woods can be steam bent but the most suitable and commonly used are: ash, beech, elm, hickory, oak, walnut and yew. Wood used for this purpose will have been seasoned in the usual way. Newly felled unseasoned timber will bend with less effort but the amount of water in the timber may generate extreme hydraulic pressures within the wood cells causing the cells to rupture and consequently inconsistently warp or distort the curve. Dry wood on the other hand will probably be too brittle, potentially causing the piece to break. An ideal moisture content for bending is 25%. Once the bend has been completed, the wood will require drying to equilibrium with the room in which it will be placed (10 – 12% for a domestic house). Subsequent moisture correction can be achieved by kiln or over a longer period in a room where the moisture content is regulated.

After steaming, timber should be immediately bent. This is done by hand over a former, or by mechanical means. The radius may be considerably decreased if a metal or leather strap is used to form the wood as this significantly reduces the risk of the wood fibres breaking out. The timber should be left in its formed position for 1 to 7 days, depending on the radius of the component, the thickness and the species.

4.2.1 Advantages of laminating over steam bending

A number of thin strips of wood bending independently provide the possibility of achieving a curve of relatively very low radius. Laminating has less trial and error and is more reliable than steam bending as any hidden faults or stresses in the wood (if not exposed on the wood's surface and purposely discarded) will not be adjacent to each other, therefore spreading the weakness within the component. Using this method it is also possible to produce random twists and bends.

4.2.2 Advantages of steam bending over laminating

The major advantage is that there will be no visible glue lines, which while they may be desired will often require much work to disguise. Steaming bending is less wasteful of material as here the saw kerf is reduced to either side of the material's edges. The colour of the wood will change after steaming which will give it a rich look; some woods are steamed purely for this effect.

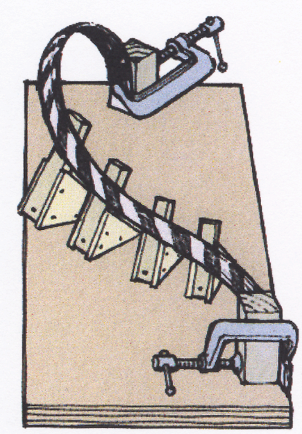


Figure 13: Free-form bend

Figure 14: Wheel-back chair

Chapter 5
Converting a log

By using modern technology, a tree today can be converted from a debarked tree into planks within a matter of minutes. This was not the case prior to the industrial age. It would previously have been done by hand using a pitsaw which was a long, wide bladed saw operated by two men; one would stand over the wood and would guide the saw, the other, more unfortunate man, would work under the log.

The main types of cut produced today are known as 'plain-sawn' and 'quarter-sawn' (see figure 15). Plain-sawn boards display a decorative and elliptical grain, and quarter-sawn a more flowery figure and because of this the latter is often used for musical instruments. Through and through sawn is a cheaper method of converting a log, but will produce a less even spread of grain which will greatly vary from one plank to the next adjacent plank. Consequently this method is generally reserved for cutting the less expensive woods used for building construction.

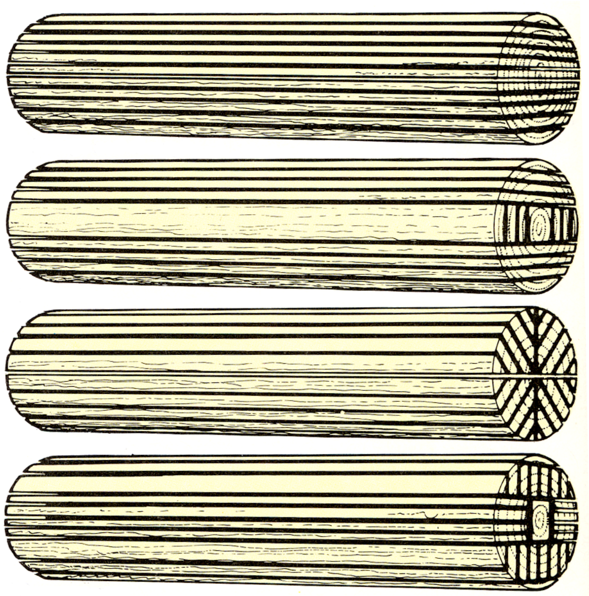


Figure 15: Main types of converting a log

Chapter 6
The balance of forests

Established forests are home to countless numbers of animals, birds and insects, that live in a delicately balanced state with the trees on which they rely. Seed eaters, for example, would have the capacity to destroy a complete forest; the forest is, however, protected by predatory animals and birds, which limit the number of insects and animals that live on seeds and nuts, thus dying trees *are* naturally replaced. Likewise, if the predators increase in numbers, creating an imbalance, they will, in a natural forest decline through shortage of food.

Species of wildlife are significantly different in deciduous forests from those of the coniferous forests. Broad-leafed trees support a greater variety of life; the oak, for example, has been found to support more than 200 insect species. Animals and birds, which prey on such insects will therefore fair far better in such surroundings than a coniferous forest. This is because a limited number of species can cope with the coniferous trees' resinous bark, narrow needle like foliage and tough seeds.

In our global society, this balance is often interrupted. The introduction of insect species in places foreign to their original environment have even caused the devastation of trees, which have not evolved the necessary defence. Quarantine laws have not had complete success in this regard. The bark beetles that carried to Britain in the 1970s the virulent strain of Dutch elm disease came from elm imported from Canada for boat building. Whereas the Canadian elms have developed defences against the insect, the British ones had not, causing near complete eradication of this tree in the British Isles.

Poisons are the most obvious solution, but these need to be continually reapplied and this often brings long-term, sometimes undesirable, side effects. Biological control offers a better remedy. In Australia, Monterey pines for example, suffered much damage from *Sirex* wood wasps, which were unknowingly imported from Europe. The wasps' numbers were significantly reduced to safe levels with the introduction of the European ichneumon fly, which is a natural and destructive parasite of the wood wasp.

Chapter 7
Wood in culture

Before the era of industrialisation, the working of wood would involve much of the craftsmen's time, often taking the equivalent of many years' working time for a team to complete a single piece of furniture. Consequently certain cultures would highly value such furniture. In Ancient Egypt for example, the richer citizens would often be buried with, among other precious artefacts, their furniture. This was so that they would be comfortable in the after world. Pieces of extremely ornate furniture have been excavated and tell us a story of how these craftsmen worked and the materials they used.

The art of veneering has been used at least since 3000 BC. Other techniques still used today have also been in use for thousands of years. The Egyptians, Romans and Greeks for example used mortise-and-tenon joints and wooden dowels, and glue made from the bones of animals was in common use.

In Europe, however, the Romans vastly reduced tree numbers; the diverse deciduous forests of Europe never recovered. The use of wood does not always involve the tree's death; many West African societies for example, plant large-leaved trees to provide shade, under which meetings are held. The trunks and protruding roots are gradually trimmed and worn down to provide comfortable seats and backrests – the living tree thus becomes the village's main item of furniture. Another example are 'hunting and gathering societies' such as the Aborigines or the Bambuti pygmies of central Africa who will pull a few branches down to form a simple bed. In New Guinea, headrests were made out of single branches from which lesser branches grew.

7.1 Sculpting wood

Wood offers a perfect medium with which to express a meaning and is often used by sculptors to not only carry a message but also to display a connection with an element of nature in beauty. Since the Renaissance, artists and craftsmen have carved into a block of wood for this purpose. It is a slow process requiring much patience; gradually the sculptor releases the form within the wood that he or she has imagined.

Chapter 8

Folklore of wood

(by Hugh Johnson)

Trees have played a central role in human's rituals from time immemorial and sacred overtones appear at all times. Human's earliest temples were simply clumps of trees, whether hidden in the depths of forests or growing prominently on some significant hillside. Prehistoric circular temples such as Woodhenge in southern England may have been built in imitation of these natural woodland temples and it is possible that the lofty pillars and vaulted roofs of later churches owe their origins to the natural forms of these distant forerunners.

Throughout the long history of religions, wood and trees appear constantly as sacred objects. This sacred character sometimes derives from a symbolic relationship which the trees bear to a spiritual force or being, but sometimes it expresses a sacredness belonging directly to the tree itself.

Spirits, whether dryads, the attendants of the goddess Artemis, or other nature spirits like the Nagas, the sacred cobras of India who bestow rain and fertility, are believed to dwell in tress and, in a natural development of the mythology, the tree has become so identified with the spirit that the two are almost inseparable.

Specific trees are worshipped as gods all over the world. The oak tree, sacred to the Druids, symbolized strength and offered protection. The cedar was revered in ancient Lebanon by Christians, Hebrews and Muslims alike, each for their own different reasons. Carried in the exodus from Egypt, the wood from the acacia tree was used by the Israelites to build their holy objects, the Tabernacle and the Ark of the Covenant. The Bo tree is sacred to Buddhists, because Gautama Buddha sat meditating beneath it until he found nirvana, and the Banyan tree is revered by Hindus, who believe that Brahma was transformed into one.

Rituals held on special occasions, particularly those marking climaxes in the annual cycle, like the spring equinox or the harvest, often employed, and still do employ, wooden objects, partly because wood is itself organic; its own cycle of growth makes it particularly appropriate to occasions which are linked to the natural seasonal cycle. The maypole and its attendant festivities – a familiar sight on English and Austrian village greens even today are remnants of the ancient spring fertility rites of pre-Christian Europe. In Ancient Rome, in spring, a pine tree symbolizing Attis, the lover of fertility goddess Cybele (and himself born of the almond tree), was carried to her temple on the Palatine Hill. Similarly, throughout northern Europe, youths would go out to the woods and bring home decorated tree branches, phallic symbols of many fertility rites, around which they would dance.

While many trees, and woods are believed to have sacred powers in their own right, many hundreds more have had powers attributed to them through the complex web of mythology and belief which ties humans to their natural environment.

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