Natural and manufactured timber

Functionality

There are many opportunities for using wood when designing and making prototypes. Wood is typically used when making items of furniture and for providing structure to a design. The properties of wood vary considerably.

**Balsa**, for instance, is light in weight, soft and relatively weak, but is very easy to work, which makes it ideally suited for use as a modelling material.

**Teak** is a strong hardwood and contains a natural oil that makes it an excellent choice for use in garden furniture.

**Oak** is a very strong material that has a very decorative grain known as ‘figuring’, which makes it suitable for manufacturing high-quality furniture.

Aesthetics

Different types of timber are available in a wide variety of colours. **Sycamore** is a very pale cream-coloured timber; **mahogany** has a deep red colour; **ebony** is very black.

**Burr walnut** is a special timber that has very distinctive markings and is used by high quality car manufacturers to make their dashboards.

**Bird’s eye maple** is a hardwood that is used by manufacturers of musical instruments to make bass guitars.

The colour of timber can easily be changed by staining or painting. Timber can be given a varnish finish, which will give it a matt, satin or shiny gloss look.

Timber is relatively easy to shape into interesting and unique forms by sawing, planing and sanding. Very creative curved forms can be produced by laminating and steam bending.
Types of natural timber

Natural timber is categorised into two groups: hardwoods and softwoods.

<table>
<thead>
<tr>
<th>Hardwood</th>
<th>Properties</th>
<th>Common uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jelutong</td>
<td>A close-grained timber with a pale colour</td>
<td>Pattern making</td>
</tr>
<tr>
<td></td>
<td>Medium hardness and toughness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Easily worked</td>
<td></td>
</tr>
<tr>
<td>Beech</td>
<td>A hard, strong, close-grained timber with a light brown colour</td>
<td>Furniture, children's toys, workshop tool handles</td>
</tr>
<tr>
<td></td>
<td>Prone to warping and splitting</td>
<td>and bench tops</td>
</tr>
<tr>
<td></td>
<td>Can be difficult to work</td>
<td></td>
</tr>
<tr>
<td>Mahogany</td>
<td>A strong and durable timber with a deep reddish colour</td>
<td>Good quality furniture, panelling and veneers</td>
</tr>
<tr>
<td></td>
<td>Available in wide planks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fairly easy to work but can have interlocking grain</td>
<td></td>
</tr>
<tr>
<td>Oak</td>
<td>A hard, tough, durable, open-grained timber</td>
<td>Timber-framed buildings, high quality furniture,</td>
</tr>
<tr>
<td></td>
<td>Can be finished to a high standard</td>
<td>flooring</td>
</tr>
<tr>
<td>Balsa</td>
<td>A very lightweight, soft and easily worked timber</td>
<td>Model-making, floats and rafts</td>
</tr>
<tr>
<td></td>
<td>Pale in colour</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weak and not very durable</td>
<td></td>
</tr>
</tbody>
</table>

Finishes for natural timber

Natural timber products usually require a finish to be applied to them before they can be used. A finish has two main functions: it protects the natural timber and it enhances its appearance.

- **A wood stain** changes the colour of the timber but offers little protection. Many colours are available to choose from when using wood stain.

- **A wood preservative** allows natural timbers to be used outdoors in products such as fences and sheds. It gives protection against the weather and can also be coloured.

- **A varnish** finish gives protection against weather when used outdoors and can also be coloured. Varnishes that are used indoors are typically used as a
clear protective coating that enhances the natural look of the wood.

- **Oil** finishes such as Danish oil are used indoors. They give a shine to the surface of the wood but offer only low-level protection.

- **Painting** changes the colour of wood and gives it protection from the weather. Again, a variety of colours are available as well as Matt, Gloss and Satin.

**Natural and manufactured timber**

**Primary sources**

Trees are our primary source of all timber-based materials and are grown in forests throughout the world. Britain was once covered in forests but now, mainly due to the needs of agriculture, we import most of the timber we use.

Softwoods come mainly from the cool northern parts of Europe, Canada and Russia.

Hardwoods are grown in central Europe, West Africa, Central and South America. Whether you are using a natural timber such as pine or oak, or a manufactured board such as plywood or MDF, they all started life as a tree.

**The world distribution of forests**

The length of time it takes for a tree to reach an age when it can be cut down (felled) and used commercially as timber varies depending upon the type of wood. A pine tree grows relatively quickly, taking only around 30 years to be commercially usable, whereas exotic hardwood trees can take considerably longer.

Once a tree reaches maturity it can then be felled. This is a mechanised process involving sophisticated logging machinery. A tractor carries a special adapter that can cut the tree, strip off the branches and slice the logs into manageable lengths. This operation is carried out in minutes by the driver from the comfort of their cabin. The logs are then transported to the saw mill, where they are converted into usable planks.
Manufactured timber

Manufactured boards are commercially produced sheets of timber that offer advantages over natural timber:

They are available in much larger sheets than solid timber (2440 x 1220mm).

- They have **consistent properties** throughout the board.
- They are **more stable** than natural timbers, meaning they are less likely to warp, shrink or twist.
- They can make use of lower grade timber, so can have environmental benefits.
- They can be **faced** with a veneer or a laminate to improve their aesthetic appearance.
- Due to their consistent quality, they are **well suited to CNC machining** and volume production.

Manufactured boards fall into two categories. Laminated boards are produced by gluing large sheets or veneers together, (eg Ply Wood), and compressed boards, as the name suggests, are manufactured by gluing particles, chips or flakes together under pressure. (eg MDF or Chipboard)

Plywood

Plywood is a laminated board made up several veneers of wood glued on top of each other. Each layer is laid at a 90ÅÅ angle to the last, so that the grain alternates in direction.

There are always an odd number of layers so that the two outside surfaces always have the grain running in the same direction. This arrangement of layers gives plywood a consistent strength across the whole board. The adhesive used to produce plywood is a formaldehyde resin.

Where the plywood is going to be visible in use, it is common to find that the outside veneers are made from a more expensive wood, such as birch or oak. Due to the very nature of the material, veneer-faced boards will differ in appearance from one to the next. While impossible to specify its appearance, timber merchants will use a plywood grading system to help with appropriate selection. ‘A grade’ plywood will be blemish-free and of high quality, whereas ‘D grade’ plywood will have knots and/or repair patches visible.

One of the advantages of plywood over other manufactured boards is its stiffness, as this means that it is hard to bend into other shapes. You will, however, often see plywood in bent forms.
In these cases, the glued veneers will have been compressed in a shaped mould as they dried.

**Medium-density fibreboard**

Medium-density fibreboard (MDF) is a compressed board that is manufactured from fine fibres of wood combined with a synthetic adhesive (usually formaldehyde resin). The MDF pulp is compressed between two heated plates, where the adhesive bonds the fibres together. MDF makes use of low-grade softwood and hardwood timber, along with the waste created from other wood manufacture processing.

Care should be taken to limit the dust produced when working with MDF as it can cause respiratory issues due to the size of the fine particles.

The surface of MDF boards is smooth, which makes it easy to apply a high quality paint finish. The edges of the board are fibrous and so need additional sealing before painting.

The MDF pulp is compressed to one-fortieth of its original thickness, which is why MDF is denser than other manufactured boards. In addition to standard board, MDF is also available in a range of specialist versions, including moisture-resistant board, fire-resistant board and flexible MDF. Flexible MDF has a series of small grooves known as kerfs cut into one side of the material that allow the board to bend around a radius. This particular form of MDF is often used in shop-fitting applications.

MDF is also commonly faced with a veneer to improve its aesthetics. Common veneered or faced boards include oak-faced, ash-faced and beech-faced. Faced MDF can be single- or double-sided and adhesive veneer-edging tape of the corresponding material can be applied with an iron or edge-banding machine to improve the aesthetic of the otherwise exposed MDF edge.

**Common uses of MDF include** flat-pack furniture, decorative mouldings and shop interiors.

Kerf Bending MDF, where a pattern is cut into the board, using a laser cutter or saw, allowing it to bend and create interesting patterns or finishes.
Chipboard

Chipboard, sometimes referred to as ‘particle board’, is a manufactured board that is made up of large flakes or chips of timber glued together under pressure.

Chipboard is cheaper to produce than MDF and plywood, but is not as strong or durable. It is commonly used in applications where cost is a more important factor than strength or aesthetics. It can be faced with a laminate or plastic film, as the unfinished surface is usually rough. Many popular chipboard applications have been superseded by MDF.

Common uses of chipboard include kitchen work surfaces, kitchen cupboards and flooring.

Hardboard

Hardboard is a very low-cost board often used as a backing for products such as wardrobes and drawer bottoms. It is made from wood pulp that has been compressed and heated to produce a tough board with one smooth surface and one meshed surface. This is cheap to buy and not very strong, it is usually quite thin and flexible.

Manufactured boards

Manufactured boards are readily available in large standard-sized sheets of 2440 x 1220mm.

They are also available in a variety of thicknesses ranging from 3mm up to 38mm. The thickness of plywood and MDF generally increases in 3mm increments (6mm, 9mm, and so on), whereas chipboard and hardboard board come in a more limited range of thicknesses.

Flexible plywood is one of the thinnest manufactured boards available, at 1.2mm, and MDF kitchen work surfaces one of the thickest, at 38mm.

Most manufactured boards are flat, smooth and far less prone to the problems of twisting, warping and splitting than natural timbers. Unlike natural timber, most manufactured boards do not need any additional machining or preparation before they can be worked with.

Natural timber

Natural timbers (hardwoods and softwoods) are generally supplied in planks, boards, strips and
squares. These often come rough sawn straight from the sawmill but it's common for the timber merchant to then plane the wood to give it a smooth surface. Timber can be either planed both sides (PBS) or planed all round (PAR), also referred to as planed square edge (PSE). It is worth remembering that the planing process removes around 3mm from each side of the plank, therefore timber advertised as nominally PAR 100mm would actually be 94mm.

Planed timber is more expensive than rough sawn, but it provides you with a more accurately sized material.

In addition to the square-edged forms, timber is also available in a variety of shapes and decorative mouldings. These can be used in many areas but are commonly found in framing applications and architraves. They are manufactured using a spindle moulder and a series of specialised cutters. The waste timber removed can be used in the production of manufactured boards.

The most common timber moulding shape is dowel. It is supplied in a range of sizes, from 2mm diameter up to 75mm diameter and in lengths up to 2400mm.

**Veneers**

All of these timber stock forms are available in both hardwood and softwood depending on the intended application.

Timber can also be supplied as large thin sheets know as veneers.

These are commonly used to face the external surfaces of manufactured boards such as plywood and MDF. Veneers can also be layered up, glued together and clamped in a shaped former to form curved products.

Veneer is available in a variety of thicknesses and can either be manufactured by rotary peeling, which is used for plywoods, or slicing, which is more decorative and used in furniture.

Rare hardwood trees are often processed into veneers as it is one of the most efficient conversion processes, using as much of the original trunk as possible.
Social factors

Developments in the production of manufactured boards and automated machining processes have influenced how we buy products such as furniture. Previously, furniture would be handed down through generations of a family and there was little opportunity to buy new products.

Today, flat-pack furniture is readily available and more affordable, allowing people to change the look of their home on a regular basis.

Environmental factors

Natural timber is considered to be the most environmentally friendly material as it is renewable, reusable and recyclable, and has less negative impact on the environment when being processed from trees to its stock form.

Manufactured boards are less environmentally friendly, as they have undergone additional processes that involve using extra energy and adhesives.

Some manufactured boards, such as MDF, also produce fine particles of dust when being machined/sanded. This fine dust can be harmful if inhaled and has been linked with cancer.

Using good-quality materials and finishes can extend a product’s life so that fewer replacements need to be made. This is better for the environment than making many products that need to be thrown away after only a short life.

Biodiversity

The forests are a very biodiverse environment. This means that not only are forests an area where trees are grown but that they also provide a habitat for many types of plants and wildlife. Many types of animals, birds, insects, grasses and flowers live within the forest and rely on it for their existence. Some of these species are now endangered and they, and their forest environment, must be protected or they will become extinct.

Paper and timber production requires large areas of forest to be felled, which can take years to grow back and leads to deforestation in many areas around the world. This has led to an increase in endangered forests and the many species of animals that inhabit them.

Deforestation can lead to global warming and to certain species of animals and plants becoming extinct. Choosing ethically sourced timbers, such as those from FSC-managed forests, can reduce the damage to the environment and the lives of those living nearby.
Costs involved in the design of products

Timber products

When designing a product from timber it is important to consider the costs associated with all elements of its manufacture. This includes the initial purchase of the rough sawn timber and the costs associated with machining the material to the desired size before shaping and fabrication can take place. It is not sufficient simply to calculate the cost of the individual elements as there will have been waste material produced throughout the manufacture.

With some materials such as metals and polymers this waste material can be recycled or reused, reducing the overall cost of the item, but this is harder to achieve with timber-based products.

Depending on the type of product, a manufacturer may also have to take into consideration the cost of fixtures and fittings such as cam locks, hinges or handles.

We will consider the cost implications of two products that have been manufactured in different ways.

<table>
<thead>
<tr>
<th></th>
<th>MDF storage unit</th>
<th>Bespoke oak dining table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
<td>Constructed from MDF, delivered to the workshop by a local supplier.</td>
<td>Manufactured from oak selected from the timber yard by the designer.</td>
</tr>
<tr>
<td>Fabrication</td>
<td>CNC routed panels that are joined using PVA adhesive.</td>
<td>Hardwood planks that are planed all round and biscuit-jointed together using a resin-based adhesive; shaped by hand with a profile.</td>
</tr>
<tr>
<td>Components</td>
<td>Drawer sliders, Screws to join the legs.</td>
<td>Screws to join the legs.</td>
</tr>
<tr>
<td>Finish</td>
<td>Surface preparation by hand before being sprayed with a cellulose paint.</td>
<td>Surface preparation by hand before receiving several layers of polyurethane oil.</td>
</tr>
<tr>
<td>Assembly</td>
<td>Sold as a one-piece product with no customer assembly needed.</td>
<td>Transported in parts and assembled at the customer’s home.</td>
</tr>
<tr>
<td>Delivery</td>
<td>Transported to the distribution centres and stores by road, rail and sea; shipped assembled in corrugated cardboard and expanded polystyrene packaging.</td>
<td>Delivered by road direct to the customer’s home; transported in parts and assembled on delivery.</td>
</tr>
</tbody>
</table>

The MDF storage unit is clearly a cheaper product than the bespoke dining table, primarily due to the significantly lower costs associated with using manufactured timber over a natural hardwood, but also due to the scale of manufacture that is possible when using CNC machinery to cut and shape component parts.

Automated production, although costly to establish, quickly produces significant savings over manual workers. A company that is batch producing an item is also likely to have greater purchasing power than a lone manufacturer. This means that it can buy components and materials in bulk.

**KEY POINTS**

- Natural timbers are available **in many different colours, from very pale white to dark brown almost black.**
- Different timbers have different grain patterns that can be aesthetically pleasing.

Figure 4.30 An MDF storage unit and a bespoke oak dining table
• Hardwoods and softwoods have different functional properties; some are hard and durable while others are light and flexible.

• Applying a finish to timber increases its durability and can enhance its appearance.

• Timber is grown in forests throughout the world.

• Natural timber is classified into two categories: hardwood and softwood.

• Different timbers have different properties: hardwoods are generally hard and softwoods are generally soft.

• Manufactured timbers are manmade and have several advantages over natural timbers:
  - they are available in larger sheets; they have a smooth surface; they are generally flatter and more stable

• The properties of a timber directly affect the function of a timber-based product.

• Natural timber is available in a wide variety of colours and grain styles.

• Natural timber is generally considered to be an environmentally friendly material, but some manufactured boards contain adhesives that mean they are hard to recycle.

• Timber is a readily available product that comes in a variety of regular sections and sizes.

• The cost of timber varies but the true cost must be taken into consideration.

• The Forest Stewardship Council (FSC) ensures that one or more trees is planted for everyone felled to ensure timber is sustainable.

• The common sizes, shapes and profiles that timber is supplied in are known as stock sizes.

• Manufactured boards are available in sheet form and in standard sizes and various thicknesses.