ALL HANDS ON DECK

European work heritage in shipwright for present and future

# WORKSHOP MACHINING AND JOINING

# MODULE 2

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# (Module 2) Workshop machining and joining

## Objectives

At the end of this module, the student will be able to perform a mechanised job and carry out the assembly of workbench elements of the workshop

## Duration

35 hours

## Training content

### Practices

- To cut, edge and trim pieces of wood.
- To carry out the sectioning and squaring of boards.
- To plane and thicken pieces of wood.
- To profile parts.
- To machine connection assemblies between the components of each element of the main structure (frames, keel, keelson, stem and stern).

### Theory

- Wood sawing (sectioning, edging, trimming): Technology (parameters). Techniques. Saws, edgebanders (types, description, operation and basic maintenance), setting parameters.
- Cutaway of boards: Technology (parameters). Techniques. Squaring machines (vertical and horizontal) and other equipment for sectioning boards (types, description, operation and basic maintenance), setting parameters.
- Planning and thickening: Technology (parameters). Techniques. Surface and thickness planers (types, description, operation and basic maintenance), setting parameters.
- Profiling: Technology (parameters). Techniques. Spindle moulder, copier and moulder (types, description, operation and basic maintenance), setting parameters.
- Shipwright joints: Description, types, uses and techniques.
- Machining of shipwright joints: Technology (parameters). Techniques. Equipment (types, description, operation and basic maintenance), setting parameters.
- Drilling: Technology (parameters). Techniques. Simple or multiple drill, drill run, drill to insert fittings (types, description, operation and basic maintenance), setting parameters.
- Tuning of pieces. Purpose Techniques. Tools.
- Sharpening of manual tools. Purpose Techniques. Tools
- Sanding: Purpose. Techniques. Tools

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# Summary



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# Unit 1. Doing templates/sketches

In the past, in countries such as Spain, a shipwright could work without the blueprints of the ship; they submitted a simple sketch of the midship frame to the Administration to obtain the construction permit, at best, accompanied by a general schematic arrangement. This process changed in Spain, and it became necessary to submit a signed project by a recognised technician, specifying the main dimensions that must be met to obtain the construction permit.

Although this may not be a common practice, some shipwrights have drawn the blueprints themselves to define the hull shape and the division and distribution of the main elements of the structure.

Knowing the hull shape is fundamental to cut the parts that make up the structure. With this knowledge, templates can be made of the basic structure, namely the stem, the sternpost and the frames. These templates are laid out over the pieces of raw wood to trace the shape of the specific part and then proceed to its cut.

There are many ways to obtain these templates; in countries like Spain, one technique widely used is the so-called “half hull model” made of wood, which is a scale wood-carved model of half the hull. The shipwright begins by carving the wood from the longitudinal plane or amidships following a completely artisan process. The most frequently used scales are 1:10, 1:20 or 1:25.

This wood model will help defining the surface of the hull and provide the dimensions for drawing the cross sections and profile lines of the stem and the stern post on a natural scale. This natural-scale model is made on a wooden board. The lines drawn from it will determine the data to draw up and cut the templates of the frames and other parts of the ship.

Pine wood is frequently used, avoiding knots and choosing a soft piece. Mahogany or cedar are the main options when dark woods are also used. On this piece of wood, the contours of bow and stern, the midship frame, the construction frame and the deck must be marked.

The dimensions of these contours are then transposed on a natural scale to a board; all the geometry of the parts that will form the hull structure is deduced from this drawing.

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# Unit 2. Getting to know the behaviour of wood inside water

Wood must always be considered a renewable resource. The sustainable management of our forests must be a key matter for society as a whole, since every act of reforestation carried out will have a positive impact on nature.

The cutting down of trees is one of the oldest activities carried out by man in order to provide wood for the most diverse purposes.

The good quality of wood depends both on the very constitution of the tree and on the season when it is cut down. The cutting down must be carried out when the tree has acquired its full development. A young tree produces a wood that is too soft, while if it is too old its interior may be dry due to a lack of moisture. Besides, the wood of a dead tree has no commercial value if it is cut down afterwards. This wood has neither consistency nor elasticity, and may become very brittle.

Late winter is the best period for the cutting down of trees, before the beginning of spring. During this period, there is no sap's activity, the bark is easily separated from the sapwood, an attack of xylophagous insects is unlikely, and the tissues present no modifications since there is little sap in the cells.
The physical structure of wood can be described as a fibrous and woody substance composed of approximately 60% cellulose, 30% lignin and 10% other elements such as water, minerals and resins.

Wood production demands minimal energy consumption since it does not require large transformation processes; the ability of trees to absorb atmospheric $CO_2$; the easy recycling process of wood elements, and the use of all by-products originated in the processes of sawing (1$^{st}$ transformation) and of machining wood (2$^{nd}$ transformation) give it an environmental performance of great value.

Regarding timber trees and according to the taxonomic classification, there are two groups: **coniferous** (pines, fir trees, cypresses, junipers) and **non-coniferous** species (eucalyptus, poplars, beech, walnut trees, oaks, chestnut).

All trees are classified into two botanical categories: **gymnosperms** and **angiosperms**

## 2.1. Types of Wood

### 2.1.1. Coniferous or resinous woods. Gymnosperms.

**Gymnosperms** have no fruit and their reproductive seeds are pineapples or cones. They are soft and light woods, easy to work with, and mostly from the northern hemisphere. They usually have a marked resin odour. Some of its properties are characterised by the cold weather and a few hours of light. **Conifers** are known as evergreen trees (except larch trees) **, which retain their scale-like leaves throughout**

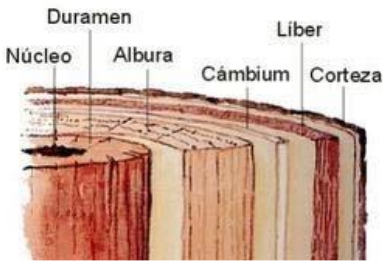
**the year**. They grow in cold and temperate regions of the north, providing most of the worldwide traded wood. These are light and soft woods

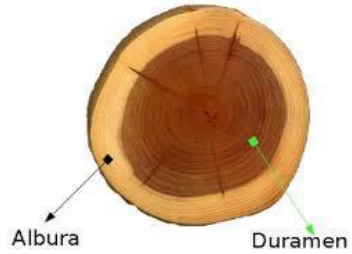
### 2.1.2. Non-coniferous woods. Angiosperms.

Commonly called flowering plants, among which we find the broad-leaf trees that give fruits and flowers. They are seed plants whose flowers receive pollen on their stigmatic surface rather than receiving it directly into the ovum like gymnosperms; when the fruit matures, they are found with their enclosed seeds, i.e. the mature seed is enclosed in the fruit; they are fruit trees of wide leaves. **Deciduous** trees lose their leaves in cold winters; these woods are made up of thick-walled cells with small hollow spaces, which makes them heavier than coniferous species. Their woody tissue is more compact and as a result, they offer higher resistance to that of coniferous woods.

## 2.2. Wood structure.

From the pith to the bark, examining a cross section, we distinguish six different parts:





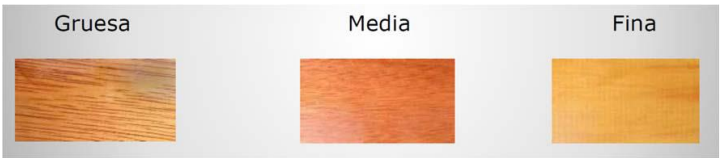
- The pith or core: the wood formed in its first year of life. It forms the heart of the tree. The central nucleus of the cells. In many cases, it will be weak and susceptible to fungal attack
- Heartwood or duramen: it is the wood itself. It is constituted by the tissues that have reached their maximum development and resistance, that is, the mature wood that constitutes the column of the tree.
- Sapwood or alburnum: it is the outermost part of the wood. Young wood whose cells carry or store nutrients. Water storage and transport by the tree takes place in the sapwood.

- Vascular cambium: is unnoticeable in sight. A very thin cylindrical layer formed by breeding cells around the wood.
- Phloem: it is a very fine tissue that wraps around the sapwood and leads the sap down.
- Bark: it is the waterproof tissue that wraps and protects the phloem and the rest of the plant. It is a protective outer layer formed by dead cells.

## 2.3. Characteristics of wood.

There are several properties of wood to be considered:

- **Grain**: referred to the visual appearance of wood. Classifying values range from low, minor, medium, high or very high depending on whether it is flat or very marked.
- **Defects**: referred to the defects characteristic of each species of wood. Genetic of each species is the major cause of most defects, which are also a product of the growth or attacks of insects and xylophagous fungi.
- **Volumetric shrinkage coefficient:** it is the percentage of volume variation for each degree of moisture lost or gained by wood.
- **Grain**: referred to the visual and tactile feeling of the wood, that is, the size and arrangement of its fibres. It is rated as thick, medium, fine or very fine. It defines to a great extent the texture of the wood.




- **Fibre tilt:** in general, the direction of the fibre is indicated; it can be straight, it can present undulations, it can be inclined or interlinked. Straight fibres will result in woods with less marked aesthetic properties than thick fibres.
- **Resistance to static bending**: it indicates the average resistance to breakage measured in $kg/cm^2$, in the face of a short-lived load that makes the wood to flex in the direction of parallel fibres.
- **Resistance to parallel compression of fibres:** it indicates the average resistance to breakage in $kg/cm^2$ against a load of a short duration that pressures the wood to compression parallel to the fibres.
- **Resistance to light**: referred to the resistance of the colour of the wood to its exposure to light.

## 2.4. Wood classes.

The terms: softwood and hardwood are used as synonyms for coniferous wood and non-coniferous woods.

### 2.4.1. Hardwoods

The task of identifying these woods is and has always been problematic, especially those from tropical areas which are known to be much more numerous. Their identification is very challenging, since very similar varieties of a single species are found in the same region, even on a single hectare, and they can only be verified once cut and converted to logs. Due to this fact, end-use has been given more importance in these species than their plant composition. The woods are valued according to factors such as density, hardness, durability, colour, permeability or stability, which will be taken into account for their final use.

**Hardwoods** include: oak, ash, European box, elm, alder, beech, birch, walnut, cherry, rosewood, *palo santo* (lignum vitae), maple, larch, eucalyptus, *ebano*, American linden, mahogany and balsa tree.

### 2.4.2. Softwoods

Coniferous woods are usually called softwoods, although some are even harder than hardwoods. Softwoods are the most used wood by the wood industry, partly due to their geographical location , but also to the growth of these woods. Trees generally grow straight, with a more pronounced central trunk than hardwoods; moreover, the small number of species that exist in forests makes cutting and harvesting easier. Conifers grow very rapidly and are much more profitable than hardwoods in plantations.

**Softwoods** include: Scots or European red pine, fir, spruce, cypress, yews, cedar, Oregon pine, sequoia or redwood, ceiba and Kauri.

## 2.5. Physical properties of wood

- **Homogeneity:** referred to the structure and composition of the fibres being uniform throughout all parts of the trunk.
- **Hygroscopicity:** the ability to absorb moisture from the atmosphere and retain it in the form of liquid water or water vapour.
- **Density** or specific weight: is the relationship between weight and volume in a substance, i.e., a higher or lower weigh in the same volume unit.
- **Hardness**: is the value of the hardness perpendicular to the fibre according to the Monnin (Chalais-Meudon) test, standard UNE 56540. This hardness is not referred to the classification or typology of softwoods and hardwoods, but to a characteristic of woods that cannot

be easily hit, dented, brushed or split, i.e. a property indicating the ease of penetration of foreign bodies into the surface or of abrasion.

- **Flexibility** or elasticity and plasticity**:** a property of some woods which show great resistance against longitudinal bending, being difficult to split and withstanding well pressures, i.e. a property to bend or curve, in the longitudinal direction without breaking.
- **Easy polishing:** the working material shows a close relation to polishing. When facing a wood surface of fine fabric, the polishing can throw very good results, as the surfaces will be smoothed, highlighting the grain and the colour of the wood itself. The most suitable woods for polishing are hardwoods, such as walnut, cherry or beech. Conversely, softwoods do not behave well with this type of finish**,** since the fibres are separated or lifted due to the own polishing.
- **Dent:** a property that describes how easily the wood splits in the fibre direction, i.e. its resistance to the opening of its structure by introducing a wedge in the direction of its fibres.
- **Duration:** the life of the wood depends on many factors, such as the climate, the species or the drying process. In fact, dry and humidity cycles , together with weather, are their main causes of death.
- **Conductibility:** wood is a poor heat conductor, since the pores of dried wood are filled with air which is a poor heat conductor itself.

## 2.6. Mechanical properties of wood

- **Compression:** resistance against the action of a force that tends to crush wood. The crushing is greater in the perpendicular direction to its fibres and smaller in the axial direction.
- **Traction:** resistance caused by the action of two forces of opposite sign, which tend to break the piece of wood, prolonging its length and reducing its cross-section.
- **Bending:** force applied to a piece of wood resting on two supports that withstands the weight in its length.
- **Shearing or cutting strength**: referred to the stress performed by wood molecules against the action of parallel forces that tend to cut the cross-section of the wood.
- **Torsional strength:** resistance offered by a piece of wood, fixed at one end, that turns normal angled to its axis, due to a force applied by a lever arm at its free end.

- **Wear:** the wood pieces that undergo rubbing or erosion suffer a material loss**.** Wear resistance will be large in the extreme areas, lower in the tangential areas and very small in the radial zones.
- **Longitudinal sliding of the fibres**: when a stretched part is held at one end, there is an effort that results in the sliding of some fibres over others in a longitudinal direction.
- **Impact resistance**: resistance opposed by wood to the impact of a hard body. The resistance will be greater in the axial direction of its fibres and lower in the cross direction.

## 2.7. Behaviour in water

For the construction of ships, especially the structural elements that bare the greatest responsibility, the use of oak is a tradition, because it is a hardwood with good mechanical resistance, good behaviour against humidity and the action of sea water; besides, it exhibits a good resistance to fungi, insects and molluscs attacks. The tannin enclosed in its fibres accelerates the oxidation of bolts and nails made of iron alloys, which is a problem that has been solved historically with the periodic renewal of these elements and more recently by applying a galvanised finish in the manufacturing process.

For the lining of the hull and the deck, the use of pine wood has been maintained over time, because of its regular hardness, very resinous properties, yellow white aspect with reddish grains that smells of turpentine.

Species such as chestnut, beech, ash, walnut, larch and others of marginal application have been used for the production of smaller pieces.

In recent years, American, African and Asian wood showing good characteristics and lower price than national wood (e.g. North Indian rosewood, iroko, European red pine, sapelli, teak, West Indian locust, makore wood, abebay, Lagos mahogany, tatajuba, etc.) has been incorporated into the catalogue of woods used by shipwrights.

The main problem of wood as a shipwright's material is its vulnerability to the attacks of plant and animal organisms. Plant organisms that act on wood belong to the chromogenic and rotting bacteria, moulds and fungi. The latter feed on cellulose or lignin depending on their type, spread easily in damp environments, in the case of wood with more than 20% humidity, and they are favoured by the vicious air and darkness as it is the case of the hold of and interior spaces of wooden ships. The most harmful animal organisms are xylophagous insects such as moth larvae, woodworm and termites, crustaceans and xylophagous molluscs such as the turu or naval shipworm (*Teredo navalis*) that bores and destroys the wood.

Historically, different procedures have been used to protect the hull wood against the turu:

- The bottom of the ship was lined with lead sheets, a practice already used in the 16th century.
- Use of a double wooden lining in the bottom of the ship, the outermost destined to suffer the attacks of the naval shipworm so it was replaced periodically. This solution was used when the boats made the trip to America where the attack of the naval shipworm was more acute.
- The bottom of the ship was lined with copper sheets, a practice that began to be used in Spain toward the last third of the 18th century.
- Coating of the bottom of the ship with large head nails.

As a way of protecting wood from the effects of sea and weather, different types of oils and tars have been used:

- Fish oils, such as that obtained from sardine or train oil used in Galicia and Portugal, and obtained from pollack liver.
- Flaxseed oil cooked to its boiling point, also used with highly diluted minium or other similar substances. The minium prepares the surface for a better grip of the finishing paint that is then applied to the wood.
- Vegetable tar. Used also adding linseed oil or diesel oil by 50 %. Diesel oil acts as a drying agent, although it entails the problem that the paint applied on it peels off.
- Mineral tar is used to protect the bottoms of small boats and *nasas* (other type of fishing boat). A product of coal distillation, it is also called *pichi*.

# Unit 3. Wood storage

When the supply chain is being designed, regarding the warehouse, aspects ranging from the most basic to the most complex must be considered. For example, for a standard function, there is a classification following a standard predefined order: product units, packaging, boxes, pallets, loading units, shelves, warehouses, machinery, personnel and facilities.

## 3.1. The load unit

A load unit is the basic storage and transport unit placed on a carrier or package (container, box, pallet, holder, etc.) in order to achieve effective maintenance. Load units are handled at work points such as a general warehouse, a reserve warehouse, a consolidation zone, a picking warehouse, an internal transport element (pallet truck, forklift), etc. Several recommendations must be considered:

- to minimise the frequency of movement to reduce its traceability;
- to have standard storage and maintenance equipment to standardise operations;
- to reduce maintenance, transport and storage costs;
- to minimise loading and unloading time;
- to prepare the cargo by grouping it in their respective packaging;
- to improve safety and conservation;
- to use warehouse facilities and transportation efficiently, having all units and products sorted in their locations.

There are two fundamental physical factors when stacking load units: resistance (static) and stability (dynamic). To design correct load units, products on the bottom must support the weight of the products on top of them.

This same rule applies to the machinery used for the transport of the wood, since the weight and size of the load unit will be conditioned by the capacity of the maintenance system used. Therefore, maximum balance must be found when designing the load unit. In the case of wood, the design must consider the maximum force that can be made by the forks of the forklift truck (the most used support) and its own counterweight. To provide greater stability to a load unit, strapping of various materials are used (elastic rubber, nylon, polypropylene, polyester and steel). The banding process can be manual or automatic by means of strapping machines.

## 3.2. Support Items

The most commonly used elements for the design of a load unit are:

- **Pallets**: are platforms designed to allow the forks of a forklift truck to pass through.

- **Pallet box**: is a pallet type with several folding modules to reach the required height.
- **Racks and containers**: are more rigid and robust. They are usually made of metal or plastic and can be opened on two sides to load rolls of material, or elongated materials (plates and wooden beams).
- **ISO containers**: metal containers, frequently standardised, used to transport goods.


## 3.3. The storage function

A warehouse is a facility that regulates the inflows and outflows through the available storage and product handling systems and specialised labour.

An adequate balance is achieved when a warehouse is in good condition and in full operation.

The key features of the wood storage function are:

- Reception: this is the first phase and it requires determining the needs of human, mechanical and computer resources beforehand. An analysis of the incoming products is made, considering the volume and weight of each item/loading unit, the type of packaging, the delivery time and the quantity of each unit received in each shipment.
- Quality control: is the verification of their content and nature. For this task, each load unit must include a delivery note that indicates the properties of the load and the number of units contained. Later, a sample is carried out and the load is randomly reviewed.
- Management and inventory of stored items: it consists in counting the available units and entering data into the system (WMS), if it exists. When the load inflow has been entered into the computer, each product must be placed in the warehouse.
- Optimal storage: requires the product transport machines needed for proper entry of load units. Efficient storage cannot be performed without the adequate physical, human and material resources. The weight, volume and size of each load unit must be taken into account for further storage.

- Issuing orders: preparation of the items for their leaving the warehouse and being sent in good condition and under the agreed conditions.
    - Order preparation or picking: location and stacking of required stored units.
    - Product consolidation: it is the grouping of all products together to form load units.
    - Cargo load: the action of entering each prepared load unit in the shipping area on its respective means of transport.

## 3.4. Warehouse types

Currently, for the storage of wood and wood products, different storage systems can be found; the following systems stand out:

### 3.4.1. Block storage

It consists of stacking load units into blocks separated by aisles, so that each one can be easily accessed. No special storage equipment is required. They use to be the most frequently used type of warehouse for the storage of wood as raw material.

Advantages: ideal for similar load unit (palletised goods), so that the whole goods overlap between them.

Disadvantages: difficulty of direct access to the load units, poor selectivity of similar references (the same goods -unit loads- must be put together), so that by overlapping them no problems of balance or geometric disequilibrium arise when forming the block. This type of storage can cause instability and the goods to crush. the stability and integration of the block formed by the different loads to be stored, the maximum weight that the lower loads can support and the maximum lift that can be carried out by the forklift truck, limit the stack height of the warehouse.

### 3.4.2. Conventional or traditional storage

In industrial environments, this is one of the most widely used types of storage. Its shelves are designed to accommodate different types of load units, which determine the organisational structure of the shelves to be used. The plant layout within a warehouse of this kind is made taking into account that the perimeter racks (located next to a wall) have a single access, while the central ones have double access. The gap between them (the width of the aisles) and their height is subject to

the characteristics of the forklift trucks used and the total height of the warehouse. Conventional warehouse racking provides direct access to each shelf location without moving other stored loads. The design and layout of these racks in warehouses, makes it easy to control stocks in each existing location through the various resulting corridors.

### 3.4.3. Storage in compact systems

It consists of a racking system that allows conventional forklift trucks to pass through them. Instead of conventional racks, this system consists of a pallet rack strut that supports palletised loads, thus allowing forklift trucks to enter (drive in system) or pass through (drive through system), thus leaving a single operational aisle.

Advantages: it delivers a greater use of the surface and volume than the previous systems; this type of storage requires minimum aisles, large enough to be able to store load units and to be easily driven through by the forklift trucks. This saves 94% compared to conventional systems; compact storage has an increase of approximately 40% in total warehouse capacity, and also offers a 40% savings in warehouse costs (construction, consumption and maintenance).

Disadvantages: its limitations in establishing classifications based on age or shelf life criteria. In other words, this type of storage is recommended for the storage of similar or identical products, unaffected by time (obsolescence is not an issue) and with a considerable number of load units per reference. This type of storage presents a low flexibility due to its low capacity to dispose different goods. It is recommended for LIFO (Last In First Out) flows. There is a great danger of damage to the loads, and even to the handling machinery used, when handling goods in or out inside the compact racks.

### 3.4.4. Dynamic racking storage

It is a product-to-operator system. It is intended to take advantage of the available space and force a First In First Out (FIFO) flow. Pallets or load units are stored over rollers in a compact metal structure, and slide by gravity as the units at the exit are removed, due to the slightly inclined based of the structure.

Advantages: increased available space, perfect product rotation, decreased handling time, high versatility (diverse storage), and ease of total stock control.

Disadvantage: there is a risk of crushing loads when they fall on top of each other, especially when heavy loads are involved.

There is another type of dynamic racking known as the dynamic double racking, which combines the product stock area with picking operations. There are two aisles, one for loading and one for unloading operations, preventing the replacement and shipment movements to hinder each other.

### 3.4.5. Storage in mobile racks

This storage system allows for full space use, as well as compact storage, but with the advantage of being a conventional storage system. The racks are slid on rails that allow the movement of each one, so that a space (aisle) is created to ease the entry and exit of the goods. It is an operator-to-product storage system. For the storage of small loads, a manual mobile racking system (levers) is used, while for palletised loads, self-propelled systems (automatic) are used.

Advantages: it can be opened by radiofrequency, it has a great use of space, similar to the compact storage systems, but with the comfort of traditional racking for entry and exit of products; it allows the integration of information systems, which facilitates operations and shortens replenishment and dispatch times.

Disadvantages: it requires a large economic investment, management is more complex than in the traditional system, since there is no direct contact with all stored goods, it is designed for low frequencies of loading and unloading of products. Automation for maintenance of the racking and storage inventory cannot be performed.

### 3.4.6. Storage in a self-supporting structure

This system is based on the complete integration of the storage structure with the building. This type of structure can exceed 35 meters in height. The greatest advantage such structure provides, in industrial warehouses with heights above 15 meters, is that it guarantees constructive savings over 25%. These warehouses, where the racks support the structure of the warehouse, require large, robust racks. In addition, the racks used must be structurally very precise, because their main use is to house an automatic warehouse which must support very tight tolerances. Its main drawback is that it can be affected by climatic factors, especially wind and extreme cold/heat.

### 3.4.7. Storage in cantilever racks

This type of cantilever racks are designed to store load units of large lengths or varying dimensions, such as wood panels or plates, beams, etc. These storage systems are highly adaptable to all types of loads, because, to increase the capacity of the available space, the racks can be placed on mobile bases. This system provides a good inventory control and offers good versatility, although it requires plants or warehouses of large lengths. Together with block storage, they are the most used systems to store wood of any kind (beams, mouldings, strips, boards, plates, etc.).

## 3.5. Means of transport and maintenance

Working with the right machines in the warehouse provides great safety for the goods and operators, as well as an effective reduction in time and costs. The different types of transport that can be found inside a warehouse are:

- **Hand pallet truck**: a type of pallet truck that constitutes basic equipment, due to its simplicity and efficiency, and which has a widespread use in the maintenance and transfer of loads. They can lift loads up to 2,500 kg.
- **Electric pallet truck**: motorised, both to facilitate its movement and to lift the pallet slightly off the ground. The worker accompanies the pallet truck on foot and operates it using controls. They can support weights between 1,400 and 2,000 kg.
- Electric pallet truck with **driver**: the operator is standing on a folding platform or resting on a seat. They can support weights between 2,000 and 2,400 kg.

*Transpaleta manual.*

*Eléctrica para operario a pie.*

*Eléctrica con conductor.*

- **Stacker truck**: formed combining a pallet truck and a lifting element. They can lift loads between 1,400 and 1,600 kg, and at heights up to 2 meters.
- **Order Pickers**: support up to 1,000 kg and up to 6.3 m in height.

- **Counterbalance** forklift truck: it incorporates a large counterweight providing stability for heavy loads. They have a load capacity of 2,000 to 2,500 kg and reach a height of up to 3 meters.

*Apilador eléctrico con conductor a pie.*

*Máquina preparadora de pedidos.*

*Carretilla elevadora contrapesada.*

- **Retractable** forklift truck: it moves, turns and lifts by retracting the mast, moving it toward the centre of gravity of the machine. They have a capacity ranging from approximately 1,400 to 2,000 kg and can reach a lift height between 4.40 and 11.5 meters.
- **Narrow aisle forklift and turret truck**: used to work in narrow aisles, between 1,500 and 1,800 mm, these trucks have a capacity to withstand loads between 1,000 and 2,000 kg, and in turn can reach load lift heights between 7 and 14 meters.

*Carretilla retráctil.*

*Carretilla bilateral*

*Carretilla trilateral combi.*

- **Stacker crane**: created mainly for the storage of products in automatic warehouses. They move along the warehouse aisles by performing the entry, location and exit functions of the various stored stock.

*Transelevador en almacén automático.*

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The choice of means of transport depends on the type of warehouse designed, the dimensions of the warehouse and the type of products stored. As mentioned above, there are many suppliers of this type of machinery. Therefore, it is advisable to analyse all the technical information available of each type to identify the ideal equipment for each situation. The manufacturers specification catalogue includes all dimensions of each truck.

### 3.6. Security

The correct storage of the various materials, as well as their proper handling and transport, will greatly prevent the risks of their detachment, drift, etc., with the serious consequences that can result from this. The poor location of the warehouses, in addition to causing significant time losses, can result in crashes, run-offs, knocks, fires, etc. Its good location must improve working conditions and productivity.

- To properly store objects vertically above ground level to avoid losing balance (strength).
- To avoid objects protruding from the spaces or ranks where they are located.
- Not to climb on the rack to reach upper shelves, to use a ladder or forklift truck instead.
- Not to support heavy elements on structural walls.
- Not to exceed the safety load of frames, step surfaces or floors.
- To wedge objects that can roll and to keep the heavier items as close as possible to ground level.
- To protect material from adverse weather conditions.
- To inspect containers and frames periodically. To avoid damage to the forks of forklift trucks and other vehicles. This could become a disaster, both for facilities and humans.

When carrying out safe handling and transport of goods, some factors must be considered:

- The content to be transported: solid, liquid or gaseous products.
- The route to transport the content: on a horizontal plane, on an inclined plane or on a vertical plane.
- The place where it will be stored: to supply the materials in their fair quality and quantity, at the right time and at the lowest possible costs.
- Who will transport it: not all operators can direct any means of transport for handling loads.

- What means are to be used: forklift trucks, electric pallet trucks, bridge-crane, hand pallet trucks, etc.

# Unit 4. Wood sawing (techniques and machines)

Wood industries are divided into first transformation and second transformation of wood.

The first transformation or primary processing refers to those industries that receive the wood logs to process them and transform them into commercial value woods, which require further handling before final use.

The second transformation or secondary processing refers to those industries that use the previous commercial value woods as raw material and generate a final product ready for consumption.

Wood sawing and timber board industries are among the outstanding first transformation industries.

## 4.1. The wood sawing industry

The output of this industry is sawn wood from roundwood. A series of by-products are obtained, such as hardwood slabs, sawdust, solid waste and bark. Roundwood refers to those logs of a felled tree that have their limbs trimmed, the treetop removed, and are then cut to standard dimensions.

Each piece is named sawlog, if it is destined for sawn wood or veneer sheet; and log if it will be crushed.

### 4.1.1. Obtaining wood

**Extraction, stocking and transportation process.** The extraction process entails first a study of the forestry concession and the construction of access roads causing the least environmental impact with the aim of felling the trees in a process of extreme care and risk. Once the logs of the respective concession have been felled, they are transported to collection centres with specialised machinery. Then the next step is to transport them to the sawmills, where they will be processed.

Sometimes, the sawing industry itself performs the drying wood operations and the subsequent preparation of the sawn wood by grinding or planing. This industries may also manufacture second-processing products, such as pallets for construction.


### 4.1.2. Sawing operations

The sawing process of wood comprises the following operations:

**Bucking:** it consists of cutting the logs to reduce handling costs and to adjust the length of the logs to the length of the sawn wood.

**Debarking:** to remove the bark, as well as stones and sand that are embedded in the bark and that gradually blunt the saws.

**Canter:** it is optional. It consists of a system of sharp toothed grinding wheels or mills that eliminate the slab **turning** them into chips, which will later be used for the manufacture of particle/fibre boards or paper pulp.

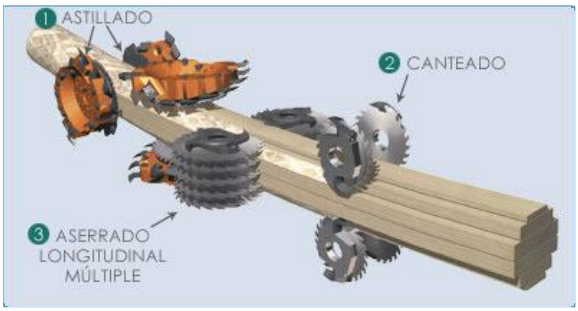
**Main sawing process:** the main saw is usually a belt or band saw in one or two sides, with multiple blade band saws in some occasions.

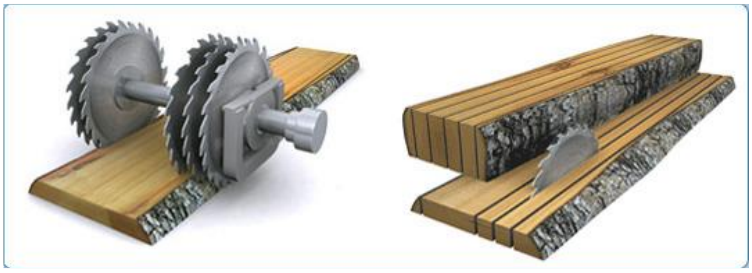
**Resawing:** the machine consists of two parallel circular saws that cut the pieces to the desired width. This may or not be used.

**Trimming the edges:** it consists of a circular saw that is responsible for trimming the edges of the pieces, eliminating any possible defects and leaving them at the desired length.

### 4.1.3. Classic sawing method

The sawing process begins with an automatic classification of the pieces according to their diameter, in order to ensure a higher yield in the processing lines of the wood. This division characterises as well the final destination of the wood, since the wood pieces obtained according to their dimensions will fit in their final use, such as wood beams (sections of 15x20, 25x35), planks (thickness between 4 and 10 cm) and tables (thickness up to 3 cm, where the width is greater, between 10 to 30 cm, than its thickness).

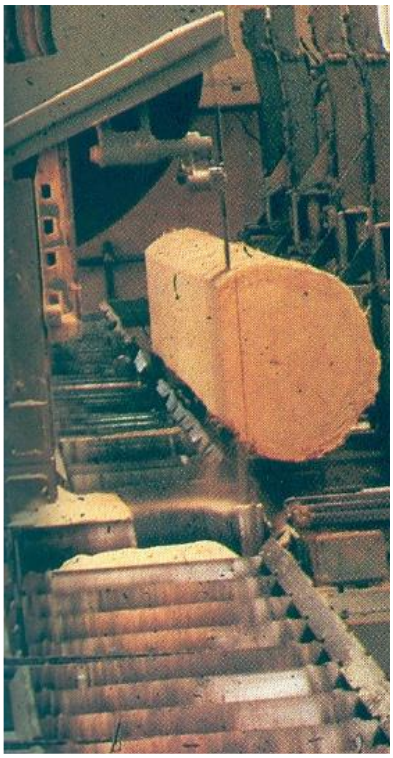


Its typical production line consists of:

- **Miter saw**: it adjusts the length of the logs for them to fit in the main saw. The purpose of this is to optimise the use of the wood.
- **Log sorting line**: this is a line of drive rollers that moves the logs forward for the operator of the dozer to inspect them and, using a pusher, to separate each sawlog in the appropriate drawer according to the intended quality and destination.
- **Debarker**: the main purpose of this machine is the removal of the bark of the wood trunk, which is covered with soil and sand. The aim of this process is to extend the service life of saws and knives used in the following processes.
- **Head saw or head rig saw**: this machine performs the main process to cut the sawlog and provide a reference plane that will be taken as the basis for the cuts of the following machines.
- **Resawing saw**: taking the cut of the head saw as reference, this machine cuts parallel to this reference and according to the desired and predetermined thickness of the table.

- **Canter**: it treats parts from other machines and cuts them in two axial cuts separated by the width of the table to be produced.
- **Band saws**: it can be simple or multiple. It cuts perpendicular to the reference cut, in the cross-cutting direction. The purpose of this machine is to adjust the length of the table and to remove main singularities of the wood pieces.



### 4.1.4. Sawmill and manufacturing

There are two essential factors to take into account during the processes of sawing and bucking of the trunk: the thickness and the type of cut.

#### 4.1.4.1. Standard thickness manufactured

This is the different sizes of the thickness of the boards manufactured. This is an essential factor for the optimisation of the wood yields in the second transformation processes, where the size of the required design will be adjusted to the standard market measures.

- American standard in inches:

| | | |
|---|---|---|
| 3/4” | 3/4” | 19,0 mm |
| 4/4” | 1” | 25,4 mm |
| 5/4” | 1 ¼” | 31,8 mm |
| 6/4” | 1 ½ “ | 38,1 mm |
| 8/4” | 2” | 50,8 mm |
| 10/4” | 2 ¼ “ | 63,5 mm |
| 12/4” | 3” | 76,2 mm |
| 16/4” | 4” | 101,6 mm |

- European standard in mm: thickness dimensions will vary depending on boards or planks, and depending on the type of wood (in relation to its use). The general standard thicknesses are: 18, 20, 22, 25, 27, 30, 38, 50, 60, 70, 80, 90, 100, 120 mm or more.

The following tables are examples of structural wood classification:

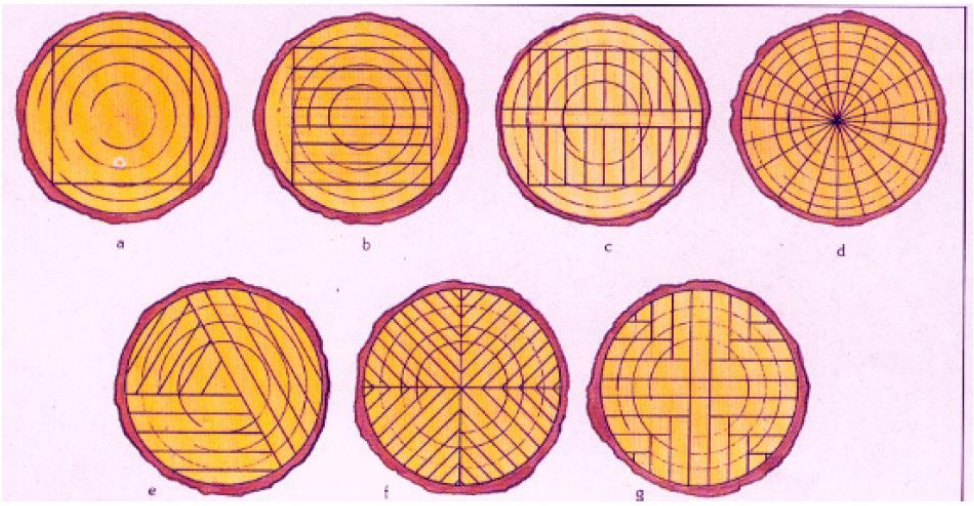
**MADERA DE HAYA**

| **Denominación** | **Tablas** | **Tablones** | |
|---|---|---|---|
| Espesores mm. | 27 38 | 50-60-70-80 | 90-100-120 o más |
| Anchuras | 115 como mínimo | 115 como mínimo | 185 como mínimo |
| Longitudes cm. | 100 y superiores a 100, variando por múltiplos de 10 | 100 y superiores a 100, variando por múltiplos de 10 | |

**MADERA DE PINO Y ABETO**

| **Denominación** | **Tablas** | | | | | Tablones | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Espesores mm | 20-25-30 | 18 | 25 | 22 | 38 | 52 | 65 | 76 | 105 | 120 o más |
| Anchuras mm | 100-200 de 20 en 20 | 105 | 125 | 150 | 180 | 150 | 180 | 205 | 230 | 250 |
| Longitudes mm | 100 y superiores a 100, variando por múltiplos de 10 | | | | | | | | | |

## 4.1.4.2. Conversion (sawing methods) of the logs




A sawlog can be cut fundamentally in two general types of sawing: tangential sawing and radial sawing. Radial sawing provides pieces of greater stability in the drying process; tangential sawing provides more aesthetically appealing pieces depending of the species. The machinery generally used is the head saw.

When the aim of the sawmill is to produce pieces with a better physical performance and better aesthetic qualities, or with a maximum use of the wood, the following particular sawing methods are usually carried out:

a) BAULKING SAWING: the log is debarked with the saw, producing boards perpendicular to each other. The slabs are used for smaller parts, such as boards, cripples, etc.

b) B) THROUGH AND THROUGH SAWING: also called tangential sawing, is a method used in low quality wood. The boards produced are of equal width and no trace of bark.

c) INTERLOCKED SAWING: the boards produced are of equal width to the trunk, but the central part is easily slit. In addition, the remaining tables tend to bend toward the bark area where sap and humidity increase.

d) RADIAL SAWING: in theory, this is the best method to eliminate cracks and warps. The cut is radial following the core, but it is the least optimal method to produce rectangular section parts. The manufactured pieces retain the veins in all their surface.

e) CANTIBAY SAWING METHOD: this is the most appropriate method to eliminate the heart when it is warped or blight. Wide tables are obtained with a minimum of waste. This system is used in exotic woods.

f) QUARTER SAWING: this method is widely used in high quality woods, since the result is a pattern and mesh on the whole surface. It represents a considerable loss of wood, but better quality tables are obtained.

g) RIFT SAWING: alternative cuts are made in each quadrant, parallel to the axes of the trunk, minimising the possibility of board deformations.

The different cuts will result in formats that are later found on the world timber market, with a multitude of measures depending on their origin (Anglo-Saxon, European, etc.). We must essentially distinguish three formats:

| | | |
|---|---|---|
|  |  |  |
| Stacked lumber, products of a through and through sawing, presented as a complete trunk, some including even the bark of the tree. | Unedged lumber boards, provided with bark and classified according to the qualities of each board. | Edged lumber, each piece has been cut in its axial direction and classified according to its quality in a sawmill. |

### 4.1.5. Machinery for sawing and cutting wood

Traditionally, when working with wood was a manual job, carrying out any task involved hours of dedication. The main objective of workshop machinery is to save time and money.

Currently, wood processing is quite automated thanks to the technology of chain production. Machinery has become critical to the industry.

#### 4.1.5.1. Conventional machinery. General.

The main purpose of a machine is to carry out a series of tasks, managing the wood piece to obtain a partial or final result. This is a list of common operations performed by classical machinery working with wood (carpentry or the industry): sawing, planing, thicknessing, moulding, sanding, etc. The continuous evolution of machinery has led to a single instrument that gathers more and more functions.

The basic machinery for wood working shares a series of fundamental elements and parts:

- Base: the support that attaches the machine to the ground. It has stops to hold it in place and prevent its movement. Some models can be screwed down to the ground through special holes. The base can be a plate or a cast.
- Table: the woods are supported on this platform to work them. A table is flat and straight. Only a few models are tilted to make miter cuts .
- Shaft: it carries the current of the motor for the machine to operate. A series of pulleys, belts, gears and chains that connect the engine to the cutting blade are the transmission mechanism for the current. The shaft is attached to the rear of the table by bearings.
- Transmission: shaft and transmission form a whole. Actually, the set of pulleys, belts, gears and chains is what is called transmission. The transmission moves the shaft and the shaft moves the motor.
- Motor: currently, the motor of these machines is electric; its main feature is power, being able to develop a lot of work (blade movement, for example) in a very short time. Machines can work at two types of voltage: 220 and 380 V.

#### 4.1.5.2. Sawing and resawing of wood in conventional machines

Once the next wood work has been mapped out and the complete sawing of the object has been carried out on paper, the first processing operation that will be performed is the sawing of the piece of wood and its sectioning in the previously designed size pieces of wood.

In this first sawing process and when another sawing is required, the operator must bear in mind the total measurements of the parts to saw the piece to the appropriate measure, since the parts will later go through a process of planing and thicknessing to achieve a smooth and squared surface, with the final predefined measures.

**A) Band saw**

Band saws, or belt saws, are one of the most used and popular machines in any workshop or factory dedicated to the manufacture and processing of wood. The saw consists of a steel blade that slides through several band- or flywheels (depending on the model two or three flywheels).

The advantages of using a band saw are:

- The saw always moves down and toward the machine table; therefore, possible hits are avoided and the person using it is safer.

- There is no need to previously mark the wood, although, it is advisable in certain accurate tasks (tenons, contouring, etc.).
- It can cut curved and wider parts than circular saws. Very fine thickness blades result in a very little amount of wood wasted.
- It is cheaper than a circular saw and takes up little room in the workshop.

The disadvantages of using a band saw are:

- The performed cuts are less efficient than those of a disc saw.
- The quality of the cut is rougher than that of a disc saw.

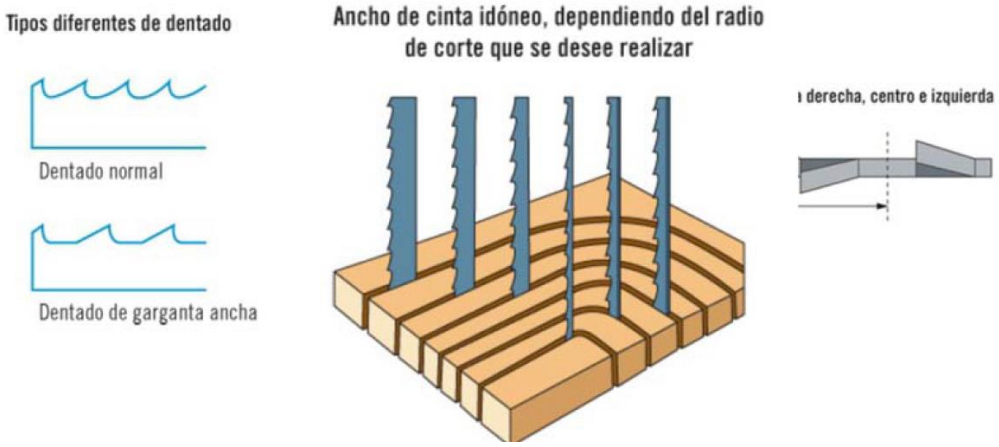

**Blade characteristics:**

Material: flexible, strong, hard sharp edge and fragile to perform the cuts, with teeth that can be sharpened and set; the blades are durable and have a wide range of uses, not just for wood. These characteristics are provided to the blade by the steel of which is made.

Blade width: depending on the model, 3 to 2 mm thick. For straight cutting, the blade should be wide and, for parallel cuts to the fibres, the blade should be narrow. For curved cutting, always choose the narrowest blade that can fit the cut required to saw the minimum radius. As a rule of thumb, a medium-width saw is used to avoid switching blades from one job to another.

**Teeth size:** they are sorted by the number of teeth that fit in an inch (2.54 cm). Cuts with higher precision are generally achieved with smaller teeth, i.e. more teeth per inch, with the saw at slow pace and working rate. Depending on the material, the appropriate number of teeth varies.

**Teeth arrangement:** it is lateral and set (alternating left and right), allowing for greater cut opening , thus avoiding the greatest friction in the straight cuts and allowing the workpiece to be rotated in the curves.

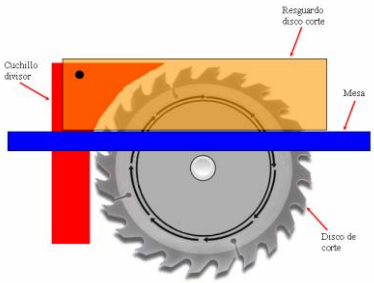


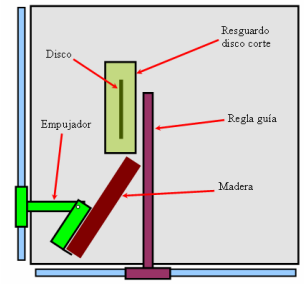

## B) Miter saw

The main function of this process is to saw through, that is, to cut the wood in the direction of its length. These machines allow for straight and sometimes angled cuts.

The miter saw is a machine made up of a horizontal table, usually of a metal type, in which a toothed disc protrudes through an opening, being its height adjustable. The disc works thanks to an electric motor located under the table. A button panel located in a position close to the operator starts and stops the disc. The operator is positioned in front of the table, in the same cutting direction and opposite to the rotation of the disc

The bucking process poses risks if the operator's training or experience are not sufficient. The main risks are: risk of cutting with the disc, risk of backward movement and projection of the wood, risk of rupture and projection of the cutting disc, risk of electric shock, risk of entrapment by transmission organs.




## C) Edging and trim sawing

The processes of trim sawing (operation of cutting wooden parts to standard lengths) and edging are key as well to prepare the wood piece for the following machining processes.

Trim saw machines are often equipped with different moving heads (between 2 and 5), designed to cut independently of each other. One is usually fixed and the rest can slide. This machine allows fast, accurate cutting of boards and planks. Up to 3-meter-long logs can be sawn in it, which is one of its main advantages. With the trim saw machine, maximum yield of the raw material can be achieved, since it allows the cutting of all types of woods, regardless of their size, state or characteristics.

Edgebanders are used to reduce the edge of the wood piece and give it the desired shape. It is suitable for uniform and smooth finishes, especially when looking to reduce the edge of the wood, remove impurities or join different parts. They usually have different saws, allowing for joint or individual displacement. They often are equipped with roller entry carts and electronic measuring systems, as well as laser light projectors.

There are different types of edgebanders. Depending on the type of work to be performed.

- Preglued edgebander: these machines are the most useful for the furniture industry. They work with pre-glued strips. Its use is not complex.
- Edgebanders with adhesive: offer more possibilities. Its materials are easier to acquire and better quality finishes are achieved.

In addition, there are several models for each type of wood edgebander. There are manual and fixed preglued edgebanders. And several edgebanders with adhesive, from small-sized profilers to automatic systems, much more sophisticated and thought of, above all, for a higher volume of work.



# Unit 5. Panel sectioning (techniques and machines)

The sectioning of manufactured panels (agglomerates, plywood, etc.) is a work that is increasingly carried out in any workshop or factory specialised in the manufacture of any type of wood pieces. The arrival of boards to the market solidified a finished product, which was simpler, faster to be obtained and with less inconveniences in its production; after that moment, the processing industry of manufactured boards has been growing and evolving constantly. It demands the manufacture of machinery that is increasingly specialised, much more practical and accurate and with higher quality in the cut.

The most widely used conventional machines in the industry are circular saws. There are three main versions on the market:

- Panel cutting saw (for large panels)
- Horizontal circular saw or sliding table saw
- Vertical circular saw or wall saw

## 5.1. Panel cutting saw

Horizontal panel cutting saws or beamsaws perform accurate cuts, without tearing the wood panel materials. They are used to divide large panels (up to 6500 mm) into smaller pieces (later processed by smaller saws). High accuracy cutting is a characteristic of this type of machine, resulting in high performance. The machine works with individual parts as well as with multiple stacked panels that are sectioned at the same time. The cut length depends on the panel formats and usually varies from 3200 mm to 5800 mm. The machine is equipped to provide an initial guided positioning; then, the piece moves forward into the work area with the help of programmable stops that secure and position the pieces with maximum accuracy.

These machines often include advanced suction systems with suction valves controlled with respect to the cutting plane; they open or close depending on the cut length. The suction power adapts and varies in the saw blade and ensures that the machine table is always clean.

The larger ones feature 115 mm saw blade teeth, powerful modules and control functions, as well as operator-friendly interfaces. The most advanced machines provide high quality prismatic guides. They can reach speeds of 130 m/min for high accuracy and short cycles. The automatic cutting length mechanisms controlled by the optimisation software lead to minimising processing time for all cutting planes.

Its main features are:

- Laser-assisted positioning systems
- 2-level suction management

- Smart clamps
- Double angle press
- Professional software
- Sawing modules up to 21kW
- 115 mm saw blade protrusions
- Cutting widths up to 6,500 mm
- Cutting lengths up to 4,300 mm

## 5.2. Horizontal circular saw or sliding table saw

It is a saw blade that is located in the centre of the bench or table and protrudes above it. It has fences and stops and is mainly used for table cutting, although it can be used for wood cutting.

The circular saw is among the essential machines of a processing workshop, especially when the workshop lacks a band saw. The same piece can be processed several times in this machine until it is completely finished, performing with great efficiency actions such as squaring, grooving, shaping, bucking, etc.

Circular saw blades diameters range from 140 to 300 mm. The depth of the cut depends on the height of the part of the saw protruding from the table, which is usually one third of the diameter of the blade. The visible height of the blade ranges between 4.7 and 10 cm.

For those tasks that require deep cuts, it is advisable to use a 250 mm blade rather than a 300 mm blade. The blade can be raised and lowered with a handle and, for a clean cut, the blade must be raised so that the teeth are 6 to 9 mm above the workpiece, which also extends the blade life.

Co-funded by the
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### 5.2.1. Saw discs

Special discs are used whether cut is straight or perpendicular to the direction of the wood. If the machine is going to perform this function for a long time, it is advisable to use a specialised disk for each case; in general practice in a workshop where several very different tasks are carried out, the most convenient thing to do is to use a universal disc and avoid having to change discs numerous times in a day.

The sectioning of particle boards such as conglomerates, which are made of abrasive adhesives and various materials, requires the use of cutting discs with reinforced teeth of a hard-material. In addition, discs with a small gullets (there is a large quantity) and large hook angles must be chosen. Universal tungsten carbide tipped saw blades have a higher costs, but can cut not only wood straight or perpendicular, but also materials such as chipboard and plywood, leaving a flawless finish and generating very few chips.


**TIPOS MÁS EMPLEADOS DE DISCOS DE CORTE**

| Tipo de disco | Breve descripción | Imagen |
|---|---|---|
| **Discos de corte al hilo** | Tienen un dentado triscado y con canales profundos para que salga el material sobrante. |  |
| **Hojas de corte a través** | El dentado de estas hojas es mucho más pequeño. Las hojas son de grosor descendente (su grosor desciende hacia el centro de la hoja). El acabado es de gran calidad. También se les conoce como hojas cepilladoras. |  |
| **Hojas universales** | Las hojas universales cortan tanto al hilo como a través. Sus dientes son mixtos, es decir, tiene un grupo de dientes a través separados por un diente al hilo y un surco profundo. El rendimiento es menor que el de las hojas especiales. |  |
| **Hojas con punta de carburo tungsteno o widia** | Sus dientes no poseen triscado. Tienen la punta de carburo fijada a cada uno de los dientes. Las hojas de carburo están ranuradas para evitar que se dilaten y, para que no hagan ruido, en parte de las ranuras tienen un metal más blando. Estas sierras se emplean en tableros recubiertos de chapa de metal o de material melamínico. La forma y capacidad de corte de los dientes es seleccionada según el material a trabajar, por ejemplo, para los tableros de aglomerado o DM, es del tipo trapezoidal plano con 80 dientes de tungsteno en total. |   |

## 5.3. Vertical circular saw or wall saw

Also known as wall saw, this machine is specially designed and adapted for cutting manufactured panels and for sectioning them in the shortest possible time and with the highest quality. They are widely used machines in warehouses and workshops dedicated to DIY.

In modern workshops and factories, the use of space is one of the important aspects that is taken into account. This is why entrepreneurs prefer machines such as wall saws, because, while providing high production speed, good quality and excellent job accuracy, they allow maximum use of space in the processing centre or workshop.

The main difference with a table saw is that in this machine, the moving element is the saw itself. It has sliding mechanisms for the operator to effortless perform cuts. However, the thrust force of the worker is the force that puts the process in motion.



The main advantages are:

- Space: the shape of the machine and the vertical system against the wall generate significant savings in workshop space.
- Quality, speed and accuracy in the cut: providing a guarantee of quadrature (perfect angles) in a single movement, allowing for a multitude of very accurate and splinter-free cuts in a row. Comfort: reducing operator fatigue as the saw moves without their help to start cutting, minimising the movement of the panel itself.
- Safety: work accidents are minimised, as hands are kept away from the cutting disc and parts are held very firmly in the supports, preventing them from moving backwards toward the operator.
- Cost-effectiveness: this type of machines are listed as being under high performance in production, since they can be running 24 hours a day for almost a whole year, requiring minimum maintenance (change of saw discs, cleaning, greasing, etc.).

The drawbacks are:

- The wall saw is a machine fully specialised in square cutting of panels. Therefore, these machines do not offer the possibility of performing other types of jobs and cuts (thicknessing, assembling, etc.), so their acquisition depends mainly on the volume of work of each company, which will have to evaluate their profitability.
- Slats and small parts cannot be cut, as the machine supports and stops are only adapted and prepared for large pieces and can cause these products to tip over and cause an accident to the operator holding them.

## 5.4. Multirip saw

This saw cuts wood and produces strips/slats of wood of equal or different widths.

Its basic running consists of 4, 5 or more circular saws placed at an adjustable distance to divide the board/plank into wood slats (adjusting the number and width). It is a highly productive, robust and rigid machine.

It allows to work with short pieces of only 25 cm length. It is very compact and easy to operate. It is fast and the saws can be set lightly.

Optional elements such as the laser reference line for cutting are available, as well as a six-position programmable fence, with pneumatic pedal operation, and additional saws.

# Unit 6. Planning and Thicknessing (techniques and machines)

Once the wood has been properly sectioned in the saws and cutting discs, the following procedure is the planning and thicknessing, since the sawing machine generates surfaces in the wood pieces that are very uneven, out-of-square and rough; without this processes, it is practically impossible to obtain a perfectly squared and even piece.

The process of planning and thicknessing is a basic work performed daily in any workshop oriented to the transformation of wood. The planing produces already prepared face and edge sides of the pieces of wood, then they are thicknessed and the rest of the piece is squared.

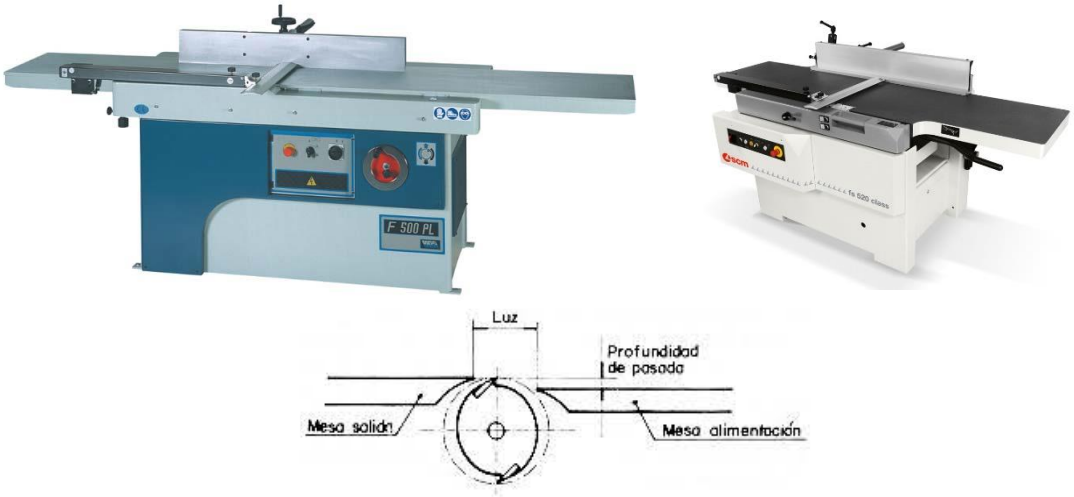
The proper working sequence to successfully transform a piece of wood is:

1. Cutting the wood with a saw to the approximate measurements, leaving 3 to 8 mm more than the width and thickness of the final size, depending on the quality of the wood and whether it is warped or presents curved defects.
2. With the planer, first planing the face and then the edge of the wood.
3. Using the thicknesser, raising or lowering the table to the required size, to finish the workpiece and leave it at the desired square.

## 6.1. Surface planer

The aim of this machine is to plan the wood, leaving it with the best possible finish, levelling it in the two axial directions (face and edge) with its blade shaft, where the machine plans by means of a circular cutting movement.

The piece of wood slides forward in the direction of the cutterhead knives, this describes the movement of the piece.



Its aim is to plan and square the first side of raw or other types of wood (multilayer panels, plastic, etc.), using a horizontal rotating tool, located between two tables, used to position and hold the workpiece.

The base is made of cast iron and welded steel. The tables can be adjusted by means of a pedal or steering wheel to choose the required amount of wood to be removed.

The machine can comprise a combined group for drilling through a drill spindle at the end of the same axis of the blade shaft and a workbench with manual movements to the drill chuck.

Its main features are:

- Standard planing width: 510 mm
- Planing table length: 2250 mm
- Maximum chip collection: 8 mm
- Hollow convex seal: quick adjustment

## 6.2. Thickness planer

This machine is used to smooth surfaces (parallel to the bottom face), when one or two sides of the piece have been prepared on the surface planer. Its function is to deliver the wood with its final width and thickness, having previously planed its face and edge. With this machine, the section is reduced, making all faces parallel to each other and equal.

In the shape of a prism, this machine is complementary to the surface planer, as the simple machine is not able to perfectly square all the faces of a piece of wood.

The operating system is very similar to that of the surface planer and it is common to find both machines combined in a single one.

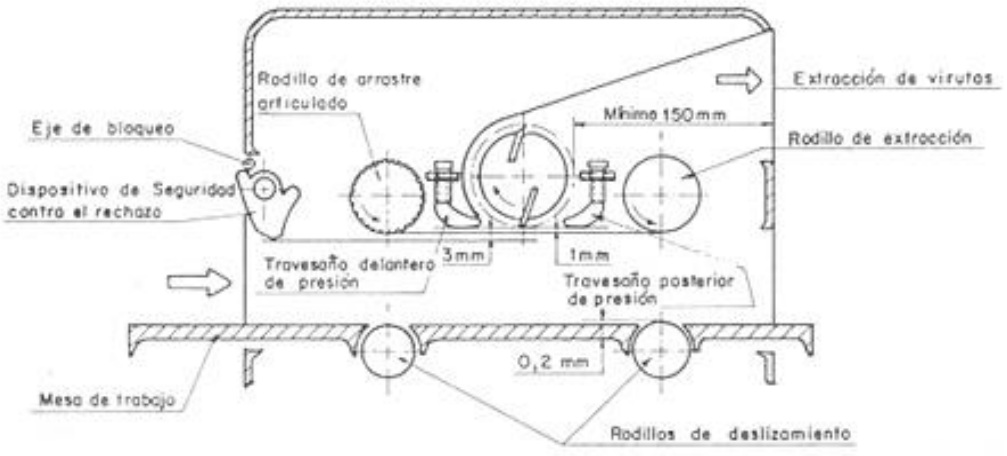
This is a very safe machine, as the blades remain inside a metal housing, where they are also housed in the trailing rollers that are used to move forward the piece. It calibrates the finish to achieve an even piece.

The machine base is made of cast iron and welded steel.

The work table on which the workpiece slides is either manually or electrically raised to choose the size of the workpiece. The width ranges from 400 to 500 mm. The workpiece slides forward over motorised rollers.

The greatest risk is the piece moving backwards to the operator, but the machine has a system to prevent this danger.

The preparation time is reduced and the accuracy is very high.


Its main features are:

- Planing shaft: self-adjusting blades;

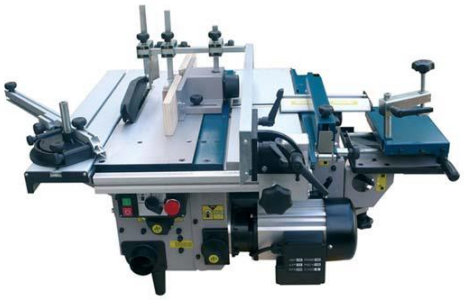
- Planing shaft with spiral blade
- Overall table length: standard 1050 mm (up to 1650 mm)
- Maximum chip collection: 10 mm
- Thickness planing height: 3–300 mm
- Forward speed: adjustable in motion 5–20 m/min.

## 6.3. Universal combined machine

This machine is present in much of the carpentry workshops, since it manages to gather different work teams in a single machine; a set example can be the following: 6 multi-function tabletop operations combined. It includes: planing - thicknessing - drilling - circular sawing - sliding carriage - vertical milling.

It is, therefore, a small and compact machine, whose use is ideal for a bench or workbench. It is well suited for small woodwork and craft work.

Sharing this perspective, there are other models that incorporate their own base and are the most common machines that can be found in any factory in the industry.



# Unit 7. Sharpening wood (technology and machines)

## 7.1. Spindle moulder

The spindle moulder is perhaps one of the most versatile machines used in woodworking. The axis of the machine allows the exchange of milling tools (milling cutters), and it is possible to carry out many different operations (moulding, groove cutting, etc.).

The forward movement is always generated by the piece of wood, which is processed by the turning movement of the cutter inserted in the shaft of the machine.

Benchtop milling machines perform several operations and include a lot of accessories, such as saws, cutters, etc., that can be exchanged with each other.

This machine is a core machine in wood manufacturing workshops. Its structure is a vertical shaft in a tree shape, which allows the attachment of different interchangeable cutters, knives and cutting tools. A single motor powers the machine, which is considered a dangerous machine that requires previous experience. An essential accessory for greater safety in handling and for better finishing and productivity is the automatic feeder that can be attached to move parts on the work table.


## 7.2. Moulder

In recent years, moulders have taken the main role, not only for large wood industries, but also for the SMEs involved in the transformation of raw wood (doors, windows, natural wood furniture, etc.).

Some of the main characteristics of these machines are:

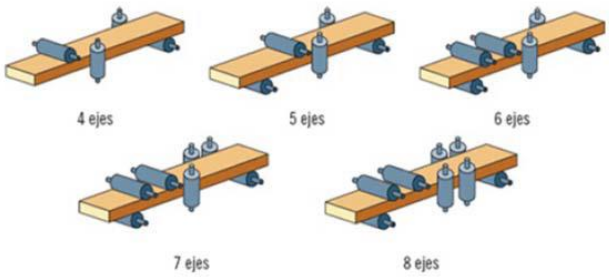
- Maximum accuracy in the processing
- High performance and efficiency in wood processing

- Very high safety in handling

These machines allow to combine some of the fundamental cycles of wood processing (planing, thicknessing, moulding, etc.), directly producing considerable time savings, since they prevent the operator from moving through the different processing phases and save space in the workshop. Therefore, there is no need for an operator to go switching on each one of them.

Moulders are compact and relatively small compared to the volume and space they would occupy in the workshop by separating their functions into separate machines.

Carpentry workshops must value their acquisition when they exceed a craft level (custom furniture, decorations, etc.), being forced to perform series jobs that require a substantial increase in labour. In these cases, it is appropriate to bet on a moulder, as it provides speed, accuracy and performance in the processes of wood transformation. The correct choice of type or model will depend mainly on the production levels and characteristics of each particular company.


The moulder can do almost anything thanks to the variation of the axes, for example:

- ✓ Planing pieces on all their faces.
- ✓ Rebating pieces.
- ✓ Moulding pieces.

- ✓ Finishing doors and windows before assembly.
- ✓ Making inclined and curved planes in pieces.

## 7.3. Edgebanding. Edgebander

Solid wood has been replaced in many areas by the use of boards or industrial wood. These types of materials entail many advantages, standing out a relatively lower cost, a huge variety of designs or very good dimensional stability.

However, when the aim is to achieve a perfect result working with a board, this must be edgebanded, that is to say, bands or strips are glued on the edges of the board. These elements hide the unsightly interior of the board. These strips or bands can be found in very different colours and textures. From natural wood veneer to PVC or other synthetic materials which share the aesthetic feature of the board. Most board manufacturers are concerned about offering these different band designs to their customers or at least making sure that a specialised manufacturer executes their designs. The process for edgebanding wood panels is not complex, and can even be carried out without specialised machinery. However, to achieve a really good, and mainly lasting, result, it will be necessary to use machinery or industrial processes.

From an industrial point of view, there are different methods and adhesives to edgeband boards:

- EVA adhesives: this is the most basic form within industrial methods. It simply consists of applying the melted glue at high temperatures. The result is higher than any other method. However, in terms of humidity resistance and high temperatures resistance it is not superior to the following industrial alternatives.
- PUR glue: its name refers to reactive polyurethane and offers a much better result than EVA glues, not only in temperature and humidity, also in durability. The application of PUR glue in the board edgebanding requires specific machinery, and a relatively large investment, since it dries in contact with the air and not when cooled as it is the case of most glues. Vacuum preservation, diffusion and dosing, similar to that of an ink pump, are different.
- Laser edgebanding. This is a new technology that eliminates the need for glue or adhesive. It also offers a higher quality result. The downside is that it requires a great investment and not all edges are available in that technology.



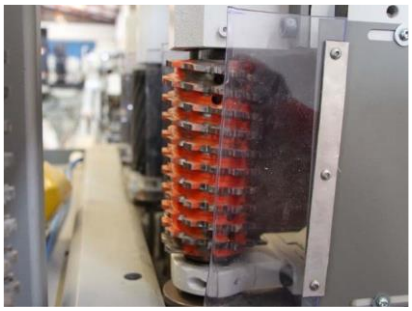
## 7.4. Linear edge milling machine

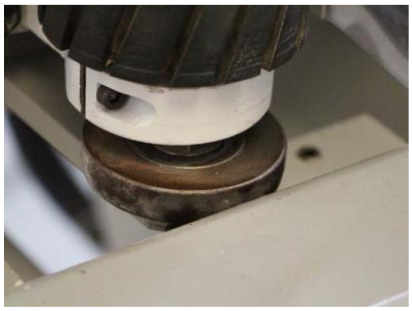
To obtain a curved piece of wood, the wood must be sawn in the belt saw, previously marked with the shape of the curve; or the belt saw is operated with an automatic cutting system.

From any of the above options, manual or automatic cutting will result in a “raw” cut surface product of the saw teeth.

To shape the parts with a suitable finish and in the exact final dimensions (in the same way as we plan and thickness longitudinal pieces), a machine is required that, by moving on a template, will mill based on the shape of the template.

This machine, called a linear edge milling machine, will mill according to the movement of the cutting elements on a template with the final shape of the workpiece. Generally, this is a twofold operation, processing two faces at the same time.





## 7.5. CNC machining centres

Numerical Control (NC) or Computer Numerical Control is an automated system for machine tools that are operated by programmed commands on a storage medium, compared to manual control which works with wheels or levers.

The market change on processors being now more affordable and smaller has generalised digital electronics in all tool types, resulting in the so called computer numerical control or numerical control (CNC), to differentiate it from machines without a computer. The term numerical control is currently used to refer to such systems, with or without a computer.

This system has shaken up the industry due to the lower cost of microprocessors and the simplification of programming of CNC machines.

**Operating principle**.

A Cartesian coordinate system that will specify the movement of the cutting tool is used to process pieces.

The system is based on controlling the movements of the work tool in reference to the coordinate axes of the machine, using a program run by a computer.

In the case of a lathe, the movements of the tool must be controlled on two coordinate axes: the X-axis for longitudinal carriage movements and the Z-axis for transverse movements. In the case of spindle moulders, vertical movements are also controlled, the Y-axis

For this purpose, servo motors are integrated in the carriage and turret movement mechanisms, in the case of lathes and in the table of the spindle moulder; depending on the capacity of the machine, the limit may be greater than the three axes.

Applications

- CNC is used in the manufacture of many wood products. The use of CNC systems on machine tools has greatly increased production, while making it possible to perform forming operations that were difficult to carry out with conventional machines; for example, the processing of spherical surfaces while maintaining a high degree of dimensional accuracy. Finally, the use of CNC has a positive impact on production costs by leading to lower manufacturing costs for many machines, maintaining or improving their quality. There are many configurations depending on the application we need, they will mainly have drill, milling and grooving groups or disc cutting elements. Another important element is the support and clamping systems of the workpiece; they are selected based on the morphology of the workpiece and the work carried out.


## 7.6. Tools used

The use of cutting tools for wood processing is potentially dangerous due to the high number of revolutions and high knife edge angle.

Accident prevention and reduction when working with cutting tools is a constant goal among both machine and tool manufacturers and has been achieved by the use of:

- Protective devices on machines.
- Optimal working techniques.
- Strict safety regulations.

Focusing on this last paragraph, CEN (European Committee for Standardization) has established the standard set EN 847, “Tools for woodworking - Safety requirements - Part 1 to 3” which refers to the tools design, materials, identification, etc.

- The minimum requirements that a tool must meet according to the current technology to be considered safe are defined in this standard.

Referred to construction shapes, cutting tools for wood can be classified into two types:

- Tools for manual feed.
- Tools for mechanical feed.

Especially in manual feed tools, rules were developed for a construction that would reduce the backward movements. Limiting the size of the gullets and the teeth prevents the severity of injuries, which is reflected in a reduction in the number of accidents.

### 7.6.1. Tools for hand feed

Manual feed is defined as feeding generated manually, even if mechanical clamping devices are used.

When working with manual feed, on spindle moulders and similar machines, the backward movement of the pieces is a particularly dangerous moment. By measuring the backward speed, after a large number of tests, it has been determined that all tools that meet Vr/Vs<0.25 are suitable for manual feed, being Vr the backward speed of the wood and Vs the cutting speed of the tool.

There are two types of tools that meet these conditions:

1) Tools for manual feed with limiter or counter blade.

   - Maximum chip thickness limitation of 1.1 mm.
   - Round shape.
   - Reduced Smax chip slitting.

   In these tools, typically Vr/Vs < 0.20.

2) 2) Tools for manual feed without counter blade (round shape).

   - Maximum chip thickness of 3 mm.
   - Round shape.
   - Limited Smax chip slitting.

   These tools meet Vr/Vs < 0.25.

All tools suitable for manual feed, according to EN 847, will be marked with the MAN sign.

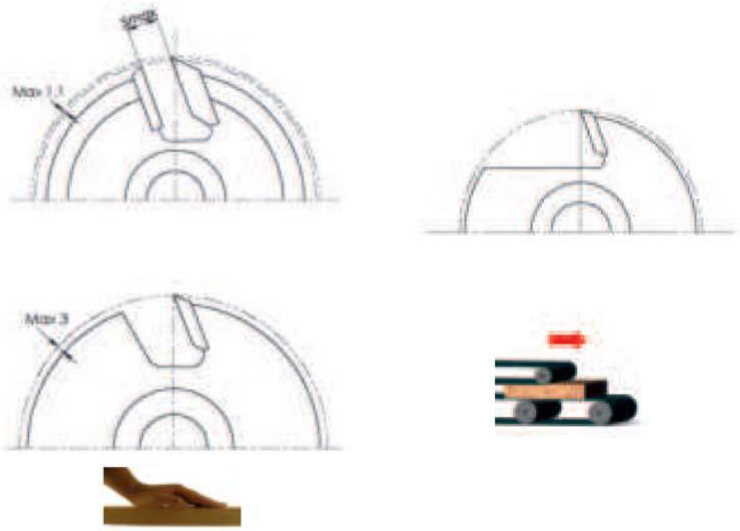
### 7.6.2. Tools for mechanical feed

Mechanical feed is defined as feeding and moving the pieces by a completely mechanical way, without the intervention of any operator.

The manufacturing features of these tools are:

- Open shape without cutting limitation.
- Large spaces for chip relief.

According to EN 847, these tools will be marked with the MEC sign.



### 7.6.3. Circular saws

For circular saws equipped with hard metal inserts and with a cutting width of less than 4 mm, these distinctions on the feed system do not apply, as the behaviour of a circular saw is different from that of a cutter. Circular saws can therefore be used for both manual and mechanical feed.

## 7.7. Cutting materials

The ideal cutting material should be both very hard and tough. Being these characteristics on opposite sides, the cutting material must be selected based on the working material, among a different range of qualities, from the soft and tough ones (alloyed steels) up to the fragile and hard ones, such as diamond.

These are the characteristics of the main qualities of cutting materials:

HL-SR: high alloy tools (more than 5% alloy). Used in blades and monoblock tools.

HS-HSS: high speed steel with cobalt, chromium, molybdenum, tungsten and vanadium alloy. This material is advised for soft and semi hard woodworking, and provides excellent surface finishes. It is not suitable to be used with abrasive wood or chipboard panels.

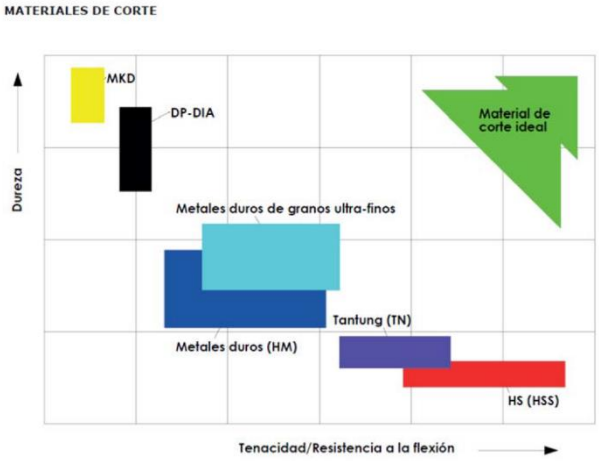
HM-HW: hard metal or tungsten carbide. This is a high hardness sintered material used to process all types of materials because of the different hardness of the several HM qualities. The main component and the one originating its hardness are tungsten carbide grains mixed with cobalt binder.

TN Tantung: a material with a high cobalt content (45-50%). Its characteristics are intermediate between HSS and HM, it has the toughness of HSS and its hardness is close to that of HM. Material suitable for hard and semi-hard woodworking.

DIA-DP: polycrystalline diamond (DP): It consists of diamond grains mixed together by adherence and a metal binder matrix. This layer (black) with a thickness ranging from 0.5 to 0.7 mm is fixed sintered to a hard metal substrate. It is mainly

used to work with abrasive materials (wood derivates, plastics and aluminium), although excellent results are also achieved for knots free solid woods.

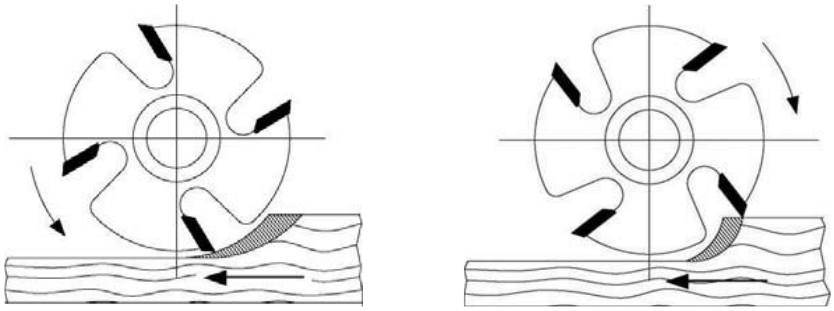
Efficiency from 40 to 200 times higher than that obtained with hard metal inserts, according to the type of work and the material to be machined, is obtained.




## 7.8. Rotation sense with respect to the feed

Counter-feed rotation: this is the main used system, where the tool rotates against the feed, obtaining a long, thickness increasing chip. This is the only way to work with manual feed. It has the advantage that the cutting edges of the tool last longer, but the disadvantage that splintering is generated working against the grain.

Feed-wise rotation: used when no splintering super-finishing is required. This is only used with mechanical feed. It has the disadvantage that the there is a lot of wear on the cutting edge, due to the longer contact time with the material.



# Unit 8. Drilling (techniques and machines)

Drilling is one of the most important machining works carried out in wood machining, mainly due to the need of machining fittings, assembly systems and components.

In its beginnings, drilling was carried out with conventional machines (vertical, horizontal drilling, etc.), but it posed a great disadvantage: it was a slow process and, above all, the machining accuracy was poor. For this reason, the production lines including the drilling system have become an essential tool.

## 8.1. Slot boring machine

Built in steel, these machines are aimed at drilling both solid wood and board. They present some limitations, but the range of boards produced extents to many areas. The maximum drilling depth can vary from 150 mm to 220 mm. The weight varies from 130 kg to 250 kg.

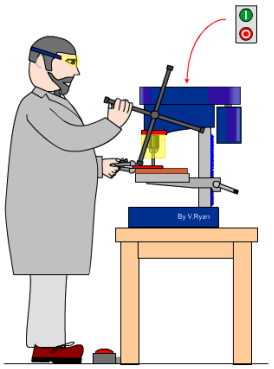

## 8.2. Multiboring machine

Following the same principle as above, it is used to perform multiple holes in the horizontal or vertical position. Drill bits 21, 27 and 35 are used on a regular basis.

## 8.3. Pillar drilling machine

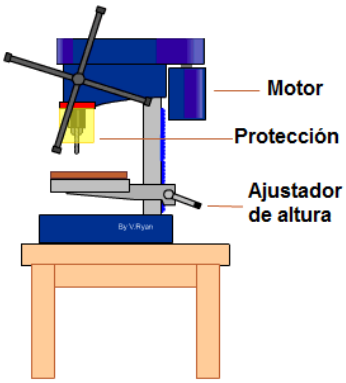
Also known as bench drill, this is a very manual machine that has been used for years for drilling through materials that include a wide range of woods, plastics and

metals. The workpiece is usually bolted to the bench to avoid its movement and achieve a drilling with greater safety and accuracy. The larger version is known as a pillar drilling machine.



The table height is adjusted by turning the height adjustment handle. When drilling, the table must be positioned very close to the drill bit so that the distance from the drill bit to the material is short.

The guard must always be used. If the material being drilled breaks or shifts, this would be the first line of defence. Wearing glasses is the second line of defence.




## 8.4. Semi-automatic drilling machine

This machine is special for all types of work: assembly, fittings, etc. Frequently, it has between 1 and 3 heads with automatic cycles.

They are mono block systems with a table, very resistant to the heads movement during machining.

The central position of the spindle motor allows to work with less power and ensures a better distribution of the same to each spindle. Automatic cycle drilling.

## 8.5. Automatic multi drilling machines

They are advanced systems with high production. In the case of boards, they can process more than 25 boards per minute.

They have high flexibility of use, reducing downtime to a great extent.

## 8.6. Drill bits

Among the most common drill bits for drilling wood are:

- Spur wood drill bit: it is the most used to drill wood and is usually made of chrome vanadium steel. They present different edges, but there are no big differences in their performance. There are three bits on the head, the central one, to perfectly centre the drill, and those on the sides that cut the material leaving a perfect hole. They are used in all types of woods: hard, soft, plywood, agglomerates, etc.

- Flat wood or spade drill bit: they are used when the diameter of the hole we want to create in the wood is large; since the shank does not vary in size, they can be inserted into the drill chuck. They are a little more difficult to use, because they must be kept perpendicular to the hole, so it is highly recommended to use a vertical support.

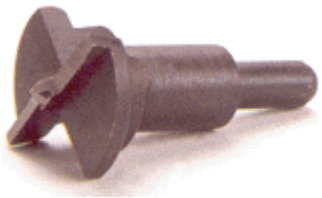
- Auger drill bit: special drills with hardened edges used to make very deep wood drills, in a shape that allows perfect chip evacuation.

- Adjustable wood drill bit: this is a type of drill bit that allows the adjustment of the drill diameter to be made within a defined limit. Its use is now rather scarce.

- Jobber wood assembly drill bit: these are special drills that, while making the blind hole where the assembly screw will be screwed, countersink the surface so that the screw head is perfectly even with the surface.

- Countersink drill bit: used for countersunk screws in wood. They are used after the hole has been made for the regular drill screw. There may be manual to work with wood (with handle). If used with an electric drill, it is highly recommended to use a vertical support.

- Hinge cutter bit: it is used to make the blind hole inside doors where the bowl hinge will fit. It is essential to use a vertical support or a column drill.



# Unit 9. Wood joints

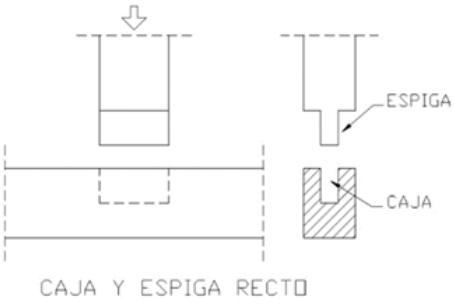
Carrying out assemblies and couplings in wood is an everyday work in any workshop or factory focused on the handling and processing of wood. This needs originates mainly in the dimensional limitations of wood planks, and as a result of sawing the trunk.

The characteristics of the wood and its products make it necessary, in most cases, that they fit together in a perpendicular or oblique manner. These connections are made by means of assemblies (mortise and tenon or coupling) or tabs.

This is one of the reason of the unstoppable progress and development of the wood machinery industry, which tries to adapt machines by means of complementary accessories or even by creating other more advanced machines, specific to the production of assemblies. The remaining idea is to make the job easier, to optimise times and to show accuracy.

Assemblies can be carried out manually or with the use of suitable machines. A loose fitting of the assembly provides the piece a very weak joint; conversely, a too tight joint can easily break the bond, which would result in a gradual loss of resistance to the assembly over time.

The assembly's own composition, which consists of two very distinct parts, namely the tenon and the mortise, characterises the machinery and assembly systems in a very different way.

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The advantages of using specialised machinery and equipment for assembly purposes not simply are reduced to optimise time and production, but also offer higher end quality by providing assemblies with smoother, more perfect surfaces. As a result, much more stable, safe and durable parts are also produced over time.

## 9.1. Machinery for the machining of tenons

The deep specialisation of processes has revealed the importance of tenoning, for which specific and highly productive machinery has been created.

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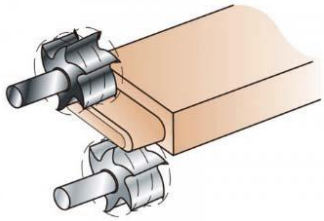
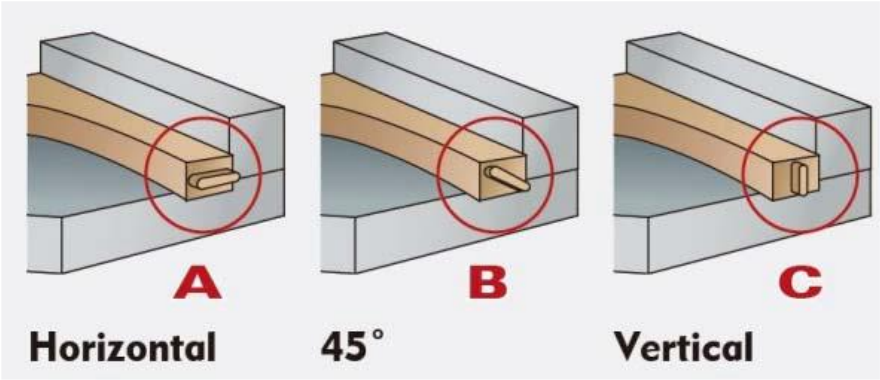



This type of machine allows high quality machining in a short time; thus, specialised factories value them highly.

One of the main advantages of the tenoning machine is its great versatility, as it is capable of making a wide variety of complex tenons, even for joints at compound angles, making it easy to work with a wide degrees of tenons.




The operating system of this machine is really simple, but at the same time very efficient. A very robust body contains the entire motor and accessories, which contain a special milling unit and a guide system that enable the oscillation movement of the group and the work tables on which the pieces are placed for machining.

Tenoning machines are designed for all their elements to have a perfectly synchronised movement by means of mechanical guides. These movements, and the valves of the clamping presses for the wood piece, are controlled by electro-pneumatic systems.

The cutting system consists of a milling unit responsible for shaping the wood to create the tenon. This cutting system works with a rotational movement and, meanwhile, allows adjustment to change the width or thickness of the tenon.

## 9.2. Machinery for the machining of mortises or chisel mortiser

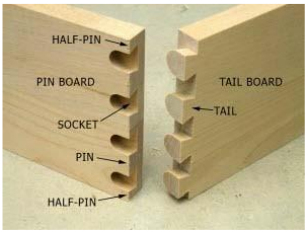
In any wooden assembly, it is essential to mortise the piece which receives the tenon. This machine is essential to perform mortise-tenon assemblies. The automatic chisel mortiser machine has both a rotating and oscillating bit movement, which will create a box on the part with the size of the oscillating movement of the machine.

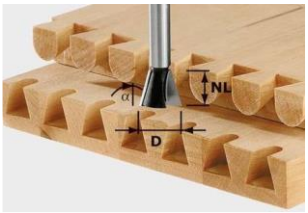
The machine can be replaced by vertical drills or combined surface planers, which are attached with this tool. Its mission is to make holes, boxes and mortise for all kinds of joints.

*Escopleado realizado en máquina*

## 9.3. Machinery for dovetail joints. Dovetailing machine

This type of machine allows for large-scale dovetail assemblies, with a high level of production and with a quality finish.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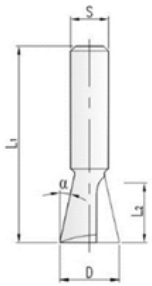
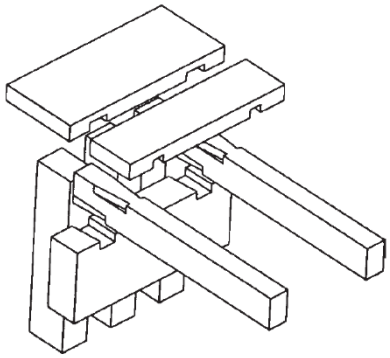


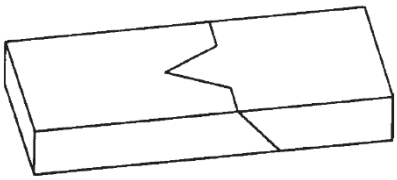

Dovetail joints prevent movement in one plane of one part with reference to the other. Also called a swallowtail joint when the top edge of the mortise part is lower than the corresponding edge of the tenon part.



## 9.4. Structural connections

The usual joints in the union of the pieces that form a hull are butt joints, scarf joints with undersquinted ends, lap joints, mortise and tenon joints and trait de Jupiter.

Scarf joints with undersquinted end, butt joints and simple halved-scarf joints are used to join two pieces of the same dimensions and maintain continuity.



Tongue and groove joints are used when the desired result is a continuous surface. The bevelled joints consists of joining two parts in the same way using perpendicular or oblique bolts or knobs to increase their section. Scarfs prevent the relative movement of parts in one direction. They are divided in half-joint or full-joint.

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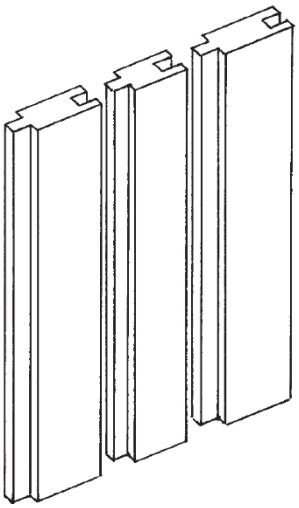
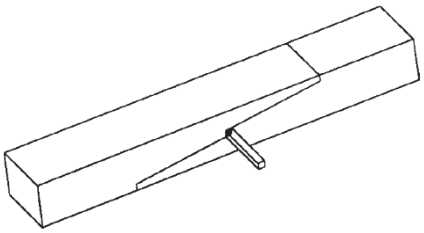
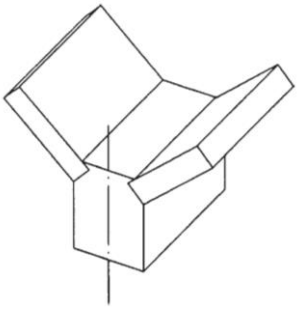


The full joint is also called trait de Jupiter. In order to achieve good contact between the cutting surfaces, a wedge is inserted in the middle of the scarf which, after final tightening, is cut even with the wood.



The dents or joint prevent the relative displacement of parts in one direction. When this shape is made in parts of equal thickness equally distributed, it is called half wood.

The garboard joint is a triangular dented joint from one piece to another. In the bottom of the hull the first line of wood has a chamfer to fit.



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# Unit 10. Sanding

The first step to obtain a good result in a process of wood painting or varnishing is the sanding process. It directly affects the end result of the furniture or wooden object.

If proper sanding is not performed, the end result will not be as expected and will result well below the expected quality.

The purpose of sanding is to eliminate damage to the wood levelling and smoothing the surface, providing an ideal condition for the application of chemicals such as sealer and lacquer.

The used grain sizes must be progressive and never exceed two particle sizes in relation to the previous sandpaper.

Example of grain size sequence: P100 - P150 - P220 - P280 - P360. This procedure is fundamental, since it removes the risks caused by more abrasive sandpapers, which damage the final appearance with defects that become more noticeable later when the sealer or varnish are applied.

The working direction must always follow the wood grain to avoid causing grooves on the surface. There are several ways to sand wood, including manual and automated sanding processes. With either system, the curved faces must be well taken care of to avoid deforming the piece.

The working direction must always follow the wood grain to avoid causing grooves on the surface. There are several ways to sand wood, including:

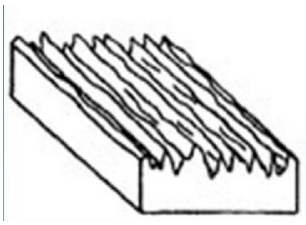
Manually with a narrow belt sander

Long belt machine sanders

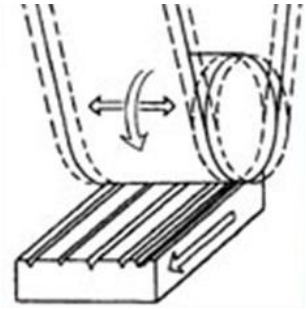
With either system, the curved faces must be well taken care of to avoid deforming the piece.

After the application of a sealer or varnish, a sanding process must be carried out to obtain a homogeneous layer on the whole surface of the wood. This should only be done when these products are completely dry. It is key to respect the drying time indicated by the manufacturer of the product. Otherwise, the sealer or varnish will be impregnated into the abrasive layer of the sandpaper, which will cause a premature fill of the sandpaper.

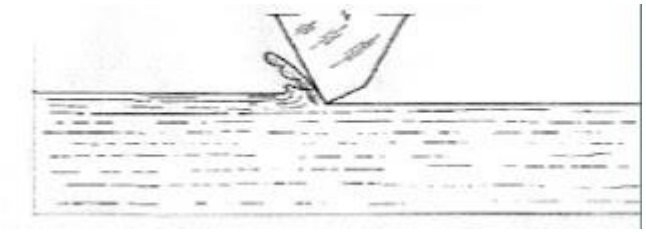
The sanding process must always use fine grain size sandpaper. For example, if the wood is sanded with a P220 grain after the sealer or varnish has dried, continue sanding with P400 or P600.



Unpolished wood surface



Polished wood surface



Cutting effect of the abrasive on the wood

The cutting action of an abrasive particle of the sandpaper produces a piece of wood similar to a chip.

To efficiently sand a wood piece that comes from the machining process (plan, thickness, saw, etc.) it is necessary to start with a grain of 80 to 100, and then gradually increase it, without leaving out any number in the sandpaper, until reaching the finest grains (80-100-120-150-180-220). During each step, the thickest defects are removed, those that were generated in the previous step; the grooves become finer and smaller until reaching 180 or 220, where they are practically unnoticeable.

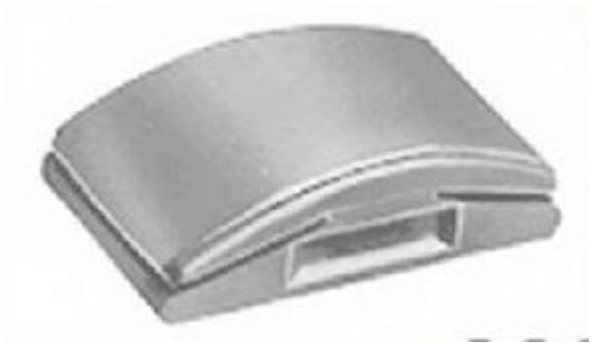
The wood must always be sanded in the fibre direction (except for some very exceptional cases). Skipping a grain step in the sequencing to save time and sandpaper is one of the most common temptations, but it is a bad idea when working with hardwoods. Scratches left by a 120 sandpaper can be erased with a 180 sandpaper, but it will take more time and work than if a 150 sandpaper is used first, (more sandpaper will also be used so no material will be saved).

- Sanding maple or teak is a typical example, since if two grains are skipped between 80 and 180, this causes twice the time and total sanding work.
- However, this is not the case with softwood lumber such as pine, as this type of wood does not require so much work to produce a smooth surface with the sandpaper; if a grain step is skipped, the work will increase slightly, but some materials can be saved.
- It is not always advisable to sand up to a very fine grain, some wood such as maple white sanding with a 400 grain does not retain pigmented dyes, because they stay inside the corners and grooves of the surface; without them, there is no place to adhere to.

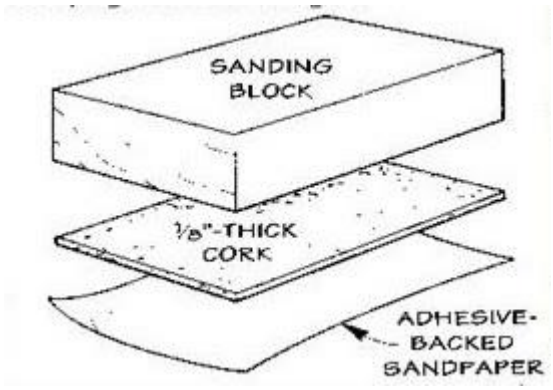
The myth of the already used sandpaper: in the process of sanding wood surfaces, one of the most widespread errors is to use a thicker sandpaper (e.g. 220), as if it were of a finer grain (280 to 320), based in the fact that this sandpaper has been previously used and is worn. After using a sandpaper, the abrasive element loses its cutting shape (edge) and becomes blunt. Thus, the only result of using this technique is an uneven and poor cut.

## 10.1. Manual sanding

When sanding manually without a sanding block, pressure should be applied to the sanding paper with the entire palm of the hand, taking advantage of the entire abrasive area of the sandpaper; if sanding only with two or three fingers, the sandpaper becomes blunt more quickly at these points and its cutting function is not conducted on the rest of the paper.








## 10.2. Automatic sanders and calibrating sanders

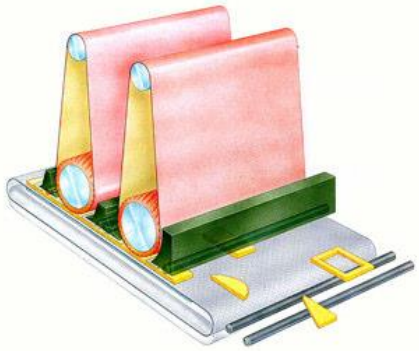
Also known as wide belt sanders, they are large, square-section, solid machines with approximate dimensions of 1,900 x 1,950 x 2,080 mm. Its operating system is very similar to that of a thicknesser, but the shaft of the cutterhead knives is replaced by a roller system that gives the rotation to the sanding belts.

One of the main advantages of these machines is that they are able, under total control of the operator and by means of the pre-regulation of the table, to sand with all guarantees a thickness of wood of few tenths of a millimetre; they are ideal to sand surfaces as delicate as manufactured panels with natural sheet coatings.

The calibrating sanders must be equipped with a suitable dust extraction system.

These sanders also stand out for their ability to sand very wide parts, as the table dimensions range from 950 to 1,300 mm, which makes them very practical.


It consists mainly of a table equipped with a belt that transports the wood piece through the rollers of the machine, which are arranged on top, and through which a continuous sanding belt runs. There is a round cylinder brush that removes excess dust produced by sanding just behind the sanding belt. To prevent an excess in the sanding unit, in addition to the turning movement, they oscillate, which also improves the sanding quality.



Some manufacturers of this type of machine have put on the market a model of sanders-calibrating sanders with a triple roller system. This system allows the machine to perform a rougher sanding first and then, in the same process and using sanding belts of much finer grain placed in the following sanding sections, to perform the final refining of the part, leaving it completely ready to receive the finishing material (varnish, lacquer, etc.). These machines can be used for boards and solid raw wood and later, by changing the sandpaper to the appropriate grain, the bottom varnish layer can be sanded.

## 10.3. Belt sanding machines

Also referred to in Spanish as “swan neck sanding machine”, it is based on the operation of the calibrating sander; however an operator will manually sand the surface until the whole piece is finished.

## 10.4. Edge sanders

The sanding machines described above are aimed at finishing the workpiece faces, but the edges of these pieces require sanding too; thus, edge sanders can be used for this purpose. It is very simple to operate: a belt sandpaper on a vertical plane will easily sander the edge surfaces.

These machines can be fitted with a similar feeder to the one used in spindle moulders.


# Unit 11. Sharpening of manual tools

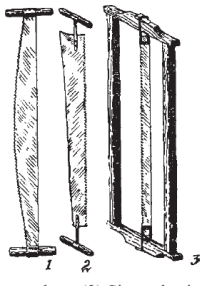
The traditional tools to carry out woodwork have been maintained for many years, since they have proved their usefulness in the work for which they had been conceived, developed and improved, with daily practice.

These tools are generally made up of a wooden frame, adapted to a hand to handle it, for which it takes the form of a grip, handle or support. They also include another element, the one that interacts with the wood, which is usually made of iron or steel and it is fixed to the first element.

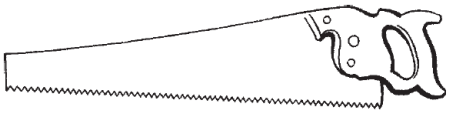
## 11.1. Best-known tools

### 11.1.1. Cutting tools

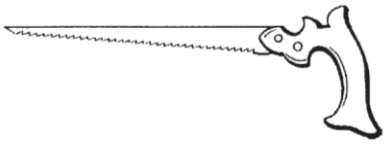
- Saw: to cut logs.
- Framed or sash saw: for the first cut of the lumber directly from the logs.



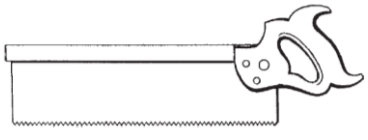

- Hand saw: toothed blade on one of the edges.



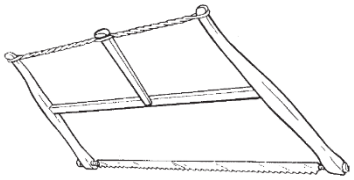
- Compass saw: narrower blade, to open cuts.



- Backsaw: rectangular blade, for cuts where greater accuracy is required.

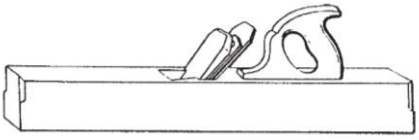


- Bow saw: allows tensioning by means of a piece of wood that rotates around a twisted rope.

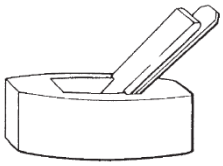


### 11.1.2. Planing tools

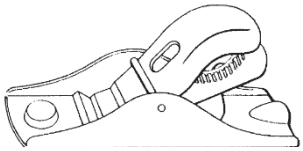
- Plane: (also *garlopin* if smaller).



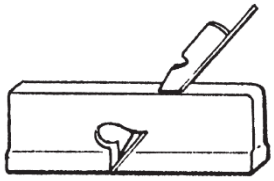
- Toothing plane: smaller and without handle.



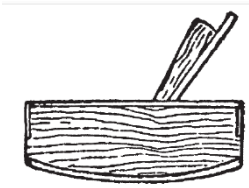
- Metal hand plane: with a cast iron frame.

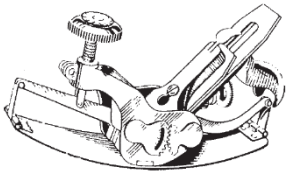


- Rebate or rabbet plane: it can carry blades of different width.

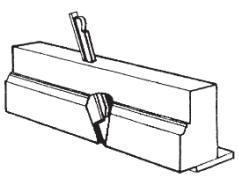


- Compass plane: it adjusts the curvature of the surface where the blade is located.

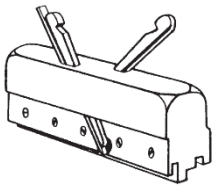




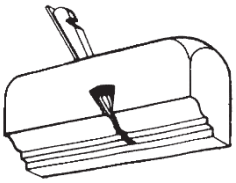
- Jointing plane: its position can be regulated to modify the width of the cut.



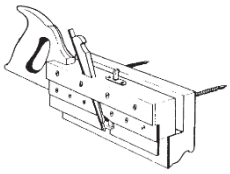
- Tongue and groove plane: two blades in opposite directions to make respectively tongue and groove for tongue-and-groove joints.



- Moulding plane: with a stepped lateral, it can have different shapes, but the most common ones are concave or bead, and convex or torus.

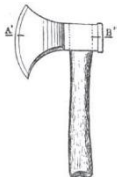


- Adjustable grooving plane: to make grooves and channels.

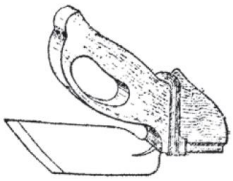


### 11.1.3. Carving tools

- Ax: sharp steel sheet with wooden handle.

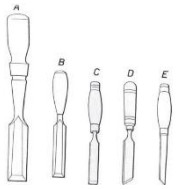


- Hand adze: curved, sharp steel sheet with wooden handle.

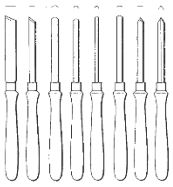


- Two-handed adze: Longer.

- Firmer chisel: it consists of a steel sheet with straight and bevelled edges and a wooden handle. *Trencha* is referred to those chisels of small size.




- Gouge: similar to the firmer chisel, but with the bent tip.

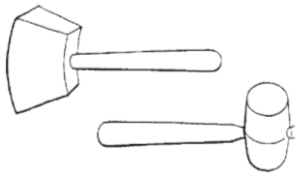


### 11.1.4. Surface finishing tools

- File: there are sections of different shapes, half-cane, round, triangular, flat and squared, among others.
- Rasp: these are larger files, with thick, triangular and more separated teeth.

### 11.1.5. Hand hitting tools

- Mallet: used to adjust the wood joints, hit the chisels, gouges, etc.



- Regular hammer: consists of a piece of steel, as a head with wooden handle. The head has one flat end and another with a cleft for nail removal. The ball hammer has one rounded head and the other flat.

### 11.1.6. Extraction tools

- Tweezers: used to remove and cut nails.

- Drift: cone-shaped metal part used for drawing nails.

## 11.2. Sharpening hand tools

Sharpening tools is a knowledge that a good carpenter should possess. Learning how to sharpen the manual tools is not difficult and is essential to achieve successful results.

There are several types of tools to sharpen woodworking tools. Two of the most common systems are the sharpening guides and stones and the bench grinder.

Due to its complex geometry, sharpening the disc teeth of a stationary table saw or circular hand saw is difficult and is best left to experts. In addition, the teeth of such discs are usually made of hard metals such as wolfram carbide, so they remain sharp for a long time. Instead, the steel of hand tools is quickly challenged. Fortunately, unlike discs for electric machines, sharpening hand-tools for carpentry are not overly complex.

### 11.2.1. Sharp

Edge is defined as the 'sharp, cutting edge of an object', while sharpening means ‘make or become sharp an object or grinding its edge'. Therefore, there are two types of sharpening:

- Integral sharpening: when the tool is badly worn and the angles (chamfers) have been lost, the edge is completely recreated, starting from scratch.
- Refine the tool: this sharpening is much faster than the previous one. It consists of slightly grinding the cutting edge to recover the tool edge.

Sharpening consists in progressively removing excess steel from the tool using abrasives. The more polished the knife steel and the less imperfections the blade has, the better the tool will cut: chisel, plane, scraper blade, etc. This degree of perfection is achieved gradually, first with thicker abrasives, second with medium-grain abrasives, and finally with the finest grain, to achieve mirror polishing.

Why is there a need of using several abrasive grains to sharpen a tool properly? Why can't we use the finest grain directly? We can do it, but it would be ineffective and unprofitable.

Sharpening a metal blade adds no material to it, it only removes it, but the idea is the same. Progressive sharpening with increasingly fine grains removes scratches and defects left by previous abrasives. Little by little, until getting a very smooth and

polished finish. At the edge of the blade this translates into an even edge, without peaks or scratches, i.e. in a very sharp and cutting edge.

### 11.2.2. Sharpening tools

To restore the edge, the tool is first sharpened with a bench grinder. Then, sharpening stones are used to achieve a final result.

A) Bench grinding machines

- A grinder or bench grinder is an electric tool equipped with one or two grinding wheels and a support to sustain the blade to be sharpened. These are powerful machines used to quickly sharpen the cutting tool. There are two types: dry and wet.
- Excessive heating of the steel will loosen the knife and reduce its hardness. A certain skill and knowledge is required not to overheat the cutting tool metal with the grinding wheel of a dry bench grinder. For this reason, the best abrasive grinders include a water tank that cools the grinding wheel and prevents metal overheating. They are known as wet bench grinders.
- The wide grinding wheels of the professional wet bench grinders for carpentry make it easy to sharpen the large blades of the manual bench planer. They also have well-designed supports that help maintain the correct tilt angle.

B) Stones and sharpening guides

- After passing through the grinder, to achieve the perfect edge, the cutting edge must be sharpened on a fine-grained stone. Check out the stone and sharpening guide article to learn more about it.

The sharpening of chisels, gouges, planers, etc., is part of the knowledge that the carpenter must have. Unlike complex cutting tools such as stationary machine discs or cross-cutting saws (whose tool cannot be sharpened in most cases), hand tools can be easily sharpened if the necessary equipment is available.

The two most commonly used tools for sharpening woodworking tools are the bench grinder and sharpening stones and guides. The electric bench grinder facilitates integral sharpening (complete edge restoration), being able to remove a large amount of steel without effort. For final refining, stones can be used in the water with the slide guides.

Recommended reading: “La carpintería de ribera en Galicia (1940-2000)”. José Mª de Juan-García Aguado.

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