Materials: metals

Introduction

When we look at an object it's quite easy to describe its shape or color; even its use. However, it is sometimes difficult to know what material an object is made of. If somebody asked us, "What material is this made of?", we would probably give a general answer, saying that it was made of either wood, plastic, or metal...
Such an answer would means that you can tell the difference between a metallic object and a nonmetallic one.
But what is a metal? What are its properties and characteristics?

Sourcing

The production process

Metals are usually obtained from the transformation of certain minerals.
These minerals are contained inside rocks, which are extracted directly from nature.
However, some metals, such as gold, silver, platinum, or copper can be found in a pure state in nature.
We call these types of metal native metals.
Human beings started to work with metals as soon as they were discovered. Due to the abundance of metals, and the need for materials to build things, many techniques for extracting and working metals have been developed ever since the Neolithic era to the present day.
Metals are usually concentrated in specific places, known as deposits.
In deposits, the rocks that contain exploitable minerals are found in seams, veins, strata, and pockets.
These deposits are exploited using mines, which can be underground or open pit.
Before exploiting a deposit, a study is carried out to determine the dimensions, the amount, and the quality of the metal. This is to decide whether or not the mining process will be profitable.
The process of extracting (removing) and refining a crude metal is called **metallurgy.**

In the deposits, there are rocks formed by minerals of different types. The mineral that contains the metal to be extracted is known as the ore, and the other minerals as **gangue minerals**.
First the rocks undergo a sieving process, which eliminates some of the gangue minerals and useless fragments.

They then undergo a **triturating** process that breaks everything down into very small pieces.
The remaining triturated mineral mixture is put into a water tank, called a flotation cell. Here the gangue minerals, which stay on the surface, are separated from the ore, which sinks to the bottom.
The metallic mineral is first stored, to be later transported to the transforming plant.
Here it is taken to the blast furnace, where the metal is separated from the rest of the components. This is how a pure metal is obtained. To obtain an alloy, we have to add other the other metals we want to mix with the molten metal.

Alloys are formed by mixing two or more metals together. This process gives rise to new metals that have characteristics and properties that are different to those of the metals that form them.

Commercial usage

Metals are usually sold commercially in the form of bars and with a specific profile. This profile is considerably small in comparison to the length of the bar. Nowadays, and depending on the type of industry, laminated profiles are made with different sections: "U-shaped", "T-shaped", "I-shaped", "L-shaped", round, hexagonal, square, rectangular, etc.

Properties

Physical properties

Electrical conductivity

Electrical conductivity is the capacity of a material to conduct an electrical current.
The greater the electrical conductivity of a material, the more easily electricity is conducted through it.
Metals, especially gold, silver, and copper are good conductors of electricity.
Most electrical wires are made of copper because it is a good conductor of electricity.
For safety reasons, some types of cables are coated with plastic or another insulating material.

Thermal conductivity

Thermal conductivity is the capacity of a material to conduct heat.
The greater the thermal conductivity of a material, the more easily heat is conducted through it.
Metals, especially copper, are good thermal conductors.

Density

Density is the mass of a material per unit of volume.
The density of metals is higher than that of other materials used in everyday life. However, not all metals have the same density.

Expansion

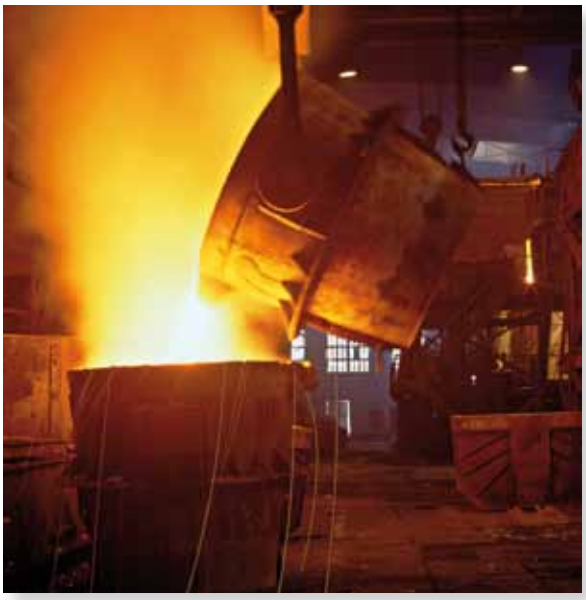
Expansion is the variation in the size of a material when subject to changes in temperature.
Expansion is usually measured by means of the linear thermal expansion coefficient, which corresponds to the increase of the length of a piece per meter for each degree the temperature increases. There are tables that contain this information for each metal.

Melting point

Melting point is the temperature at which a solid material becomes liquid.
Each metal has a specific point of fusion, a feature that has to be taken into account when making molded and welded pieces, shafts, and other related objects.

Fusibility

Fusibility is a property of materials that refers to the amount of heat they need before they can melt.
To increase the temperature of one unit of mass of a material by one kelvin (or Celsius degree), a certain amount of heat is needed, which is different for each material. This amount is known as specific heat.
Fusibility is related to specific heat, melting point, as well as other properties of materials.



Mechanical propertie

Types of stress

When there are forces of any kind acting on an object, we can say it undergoes stress.
The response of a piece a certain material undergoing stress depends on several factors: the intensity of the stress, the size of the piece, the material it is made of, and also the type of stress.
We can distinguish the following main types

• Traction

Traction is a stress caused by the action of two opposing forces that stretch a piece. This type of stress always causes the piece to lengthen in the direction of both forces. If the stress is intense enough, it reduces the cross section of the piece, eventually causing it to break.

• Compression

Compression is the type of stress to which a material is subject by two opposing forces that squeeze it.
Such a stress reduces the length of the piece in the direction of both forces. If the stress is intense enough, it increases the cross section of the piece, eventually causing it to break.

• Bending

Bending is the type of stress to which a material is subject when certain forces act on it, causing it to fold.
Such a stress causes the piece to bend. If the stress is intense enough, the piece will eventually break.

• Shearing

Shearing is the type of stress to which a material is subject when two opposing forces act on different spots, which are very close to each other.
This type of stress always causes a piece to deform, and if the stress is intense enough, the piece will break.

• Torsion

Torsion is the type of stress to which a material is subject when two forces twist it around an axis.
Such a stress always causes the piece to deform. If the stress is intense enough, the piece will eventually break.

Response to stress

Each type of material responds in a specific way to the different types of stress, depending on the intensity. Despite the differences, we can draw some general conclusions. As the intensity increases, materials first show their elastic properties, then their plastic properties, and finally, their resistance properties.

• Elasticity

Elasticity is a material's capacity to deform when a force is applied, and then return to its original shape when the force is withdrawn.

A material behaves elastically to a certain extent when it is subject to stress of a low intensity. This limit is known as the yield point and it is characteristic of each material. When this point is exceeded, the deformation becomes permanent and the material could break.

- **Plasticity**

Plasticity is a material's capacity to maintain the deformations that have been produced on it after the force is withdrawn.

A material behaves plastically when it is subject to a stress greater than its yield point.

Depending on the stress under which a material shows its plastic properties more clearly, we can distinguish:

- **Malleability**

This is a material's ability to deform permanently under the force of compression.

Malleable materials can be used to form thin sheets easily.

- **Ductility**

This is a material's capacity to deform permanently under the force of traction.

Ductile materials can be stretched into rods or wires.

- **Resistance**

Resistance is a material's capacity to undergo stress without breaking.

Whatever the material is and the stress applied, the material will eventually break. Regarding resistance, the only important thing is the intensity of the stress that causes the breakage.

It is said that materials that can undergo high-intensity stress without breaking are very resistant, and those that break with low-intensity stress are not very resistant.

Other mechanical properties

- **Hardness**

Hardness is a material's resistance to being scratched or dented.

Hardness varies considerably from one metal to another. Lead, for instance, is very soft compared to the different types of steel used to make tools.

• **Toughness**

Toughness is a material's resistance to breaking when it is banged.

The response of materials when stresses are suddenly applied is usually quite different than when the stresses are applied slowly. Therefore, this response is characterized by properties that are different from elasticity, plasticity, and resistance. One of these other properties is toughness.

When a material is not tough, meaning it breaks easily, it is referred to as brittle.

Most metals are tough. When an object hits against metal, the energy produced by the collision is absorbed by the object and transformed into a permanent deformation.

• **Fatigue**

Fatigue is the resistance to breaking that a material displays when it is subject to repeated stress.

We need to be aware that not all materials behave in the same way when stresses are repeatedly applied. Usually, a more intense stress is needed to break a piece with a sole application, than when it breaks after applying stress insistently.

For example, the suspension of vehicles, springs, and the wings of a plane are subject to this type of stress.

• **Machinability**

Machinability refers to the ease with which wood can be worked on with a machine.

This property is variable, since it not only depends on physical properties and on certain mechanical properties, but also on other more practical matters.

• **Weldability**

Weldability is the capacity of some materials to join together due to the effect of heat, and if necessary, the presence of other additional materials.

Welding plays a very important role in the manufacture of metal structures, in the car industry, aeronautics, electronics, etc.

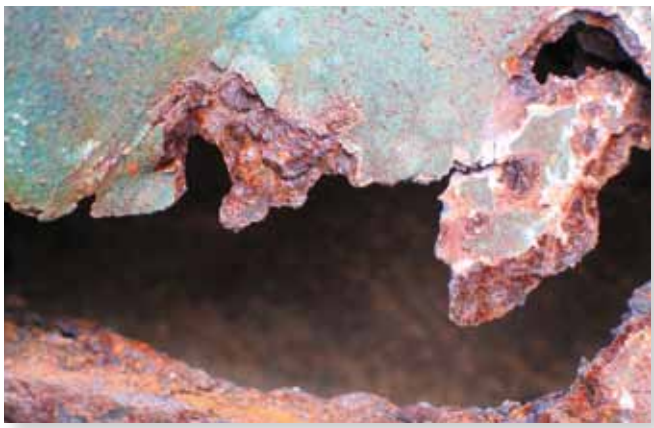
Important chemical reactions

Chemical properties describe the behavior of certain materials when they are in contact with other substances.

In the case of metals, their chemical properties decide whether the following reactions take place easily:

• **Oxidation**

Oxidation is the reaction of a material with the oxygen in the air.



Although the word oxidation was conceived to describe this idea (oxygen literally means "acid generator"), nowadays the word is used in a broader sense: it's a reaction in which an atom loses electrons. In this sense, oxidation is opposed to reduction.

Ferrous metals and some of their alloys oxidize easily. Oxidation covers their surfaces with a brownish layer.

Nonferrous metals react differently depending on the type of metal. Gold or silver hardly ever oxidize, whereas magnesium is prone to oxidation.

• Corrosion

Corrosion is the process of disintegration of materials as a consequence of the chemical reactions that are produced with the substances in the environment. Thus, for example, we speak of corrosion when oxidation has reached an advanced stage and has worked deeply into the material.

It can make an object completely useless, especially when they are thin sheets, wires, or thin rods.

Biological properties

Biological properties describe whether a material is damaging to the environment or living organisms.

• Recyclability

Recyclability refers to our ability to transform a material that has already been used so that it can be reused as a different product, with a new useful life.

Metals are recyclable. This means that the waste products of a manufacturing process can be used again.

• Biodegradability

Biodegradability is a material's capacity to deteriorate as a consequence of interacting with the environment.

Metals are biodegradable and over the course of time, they are naturally broken down. This process of degradation and decomposition is long and damaging for the environment.

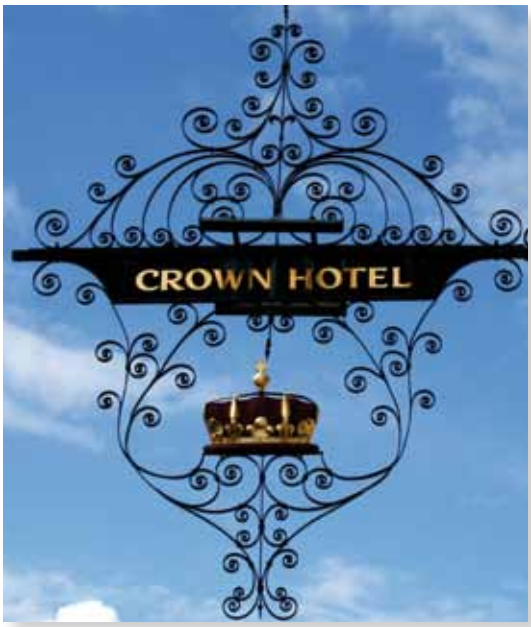
• Toxicity

Toxicity indicates whether small quantities of a material can produce negative effects on living organisms. Some metals, such as mercury and lead, are toxic.

Classifyng metals

Ferrous

These metals have iron as a base, although they can be mixed with other elements.



A sign made of iron.

- **Iron**

Characteristics

This is a gray, shiny metal, with a high-density and melting point, which oxidizes easily.

Uses

Pure iron is rarely used because it is fragile and soft in comparison with other ferrous metals.

- **Cast iron**

This a an alloy of iron and carbon, with a percentage of carbon of between 1.7% and 4%.

Characteristics

It is a very hard and fragile metal.

Use

It is used to produce machine work surfaces, engine blocks, street lamps, utility hole lids, garden furniture, fountains, etc.

- **Steel**

This is an alloy of iron and carbon composed basically of iron and carbon, with a percentage of carbon of less than 1.7%.

Characteristics

This is a metal with useful mechanical properties. It is tough, ductile, easy to machine and weld. It makes good alloys.

Use

It can be used in all types of industries.

Iron

Iron is very abundant in nature and it is the most commonly used metal in industry. For this reason, metals can be classified into two large groups, depending on whether they contain iron (ferrous) or not (nonferrous).
Iron is extracted from ores such as hematite, magnetite, siderite, and limonite.

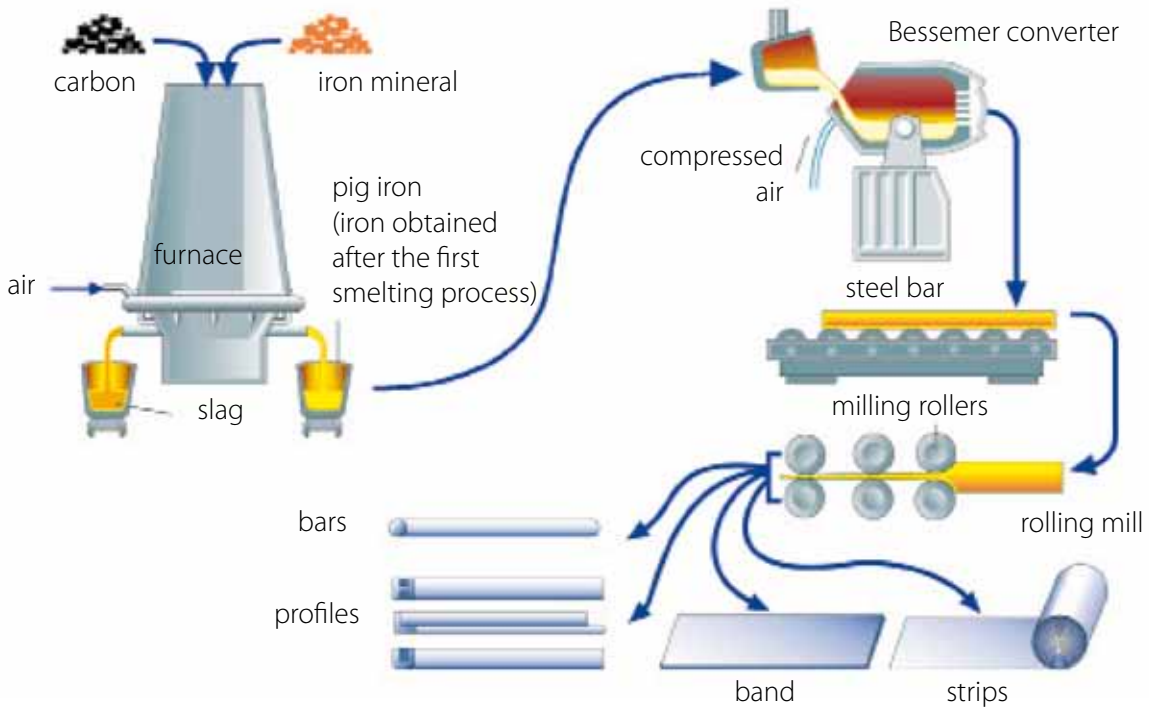
Cast iron

The way the iron mineral is processed in the furnace to obtain cast iron can be described in the following way:

- The mineral, a type of coal called coke, and the flux, which is a type of material that helps the smelting process, are put into the furnace through the mouth, located at the top of the furnace.
- The mineral, the coke, and the flux drop down to the shaft kiln, which is the widest part of the furnace.
- Hot hair is piped into this part, through holes called nozzles. This improves the burning of the mineral, the coke, and the fusion of the flux.

- The slag, formed by the gangue materials and the flux, floats and is removed through the slag notch.
- Since molten iron is heavier, it falls to the bottom.
- It deposits inside the crucible.
- It is withdrawn through the tap hole.
- The material obtained is called pig iron.
- Pig iron is used to make ingots.
- These ingots are then melted in other furnaces called cupolas, the result of this process is cast iron.
- Cast iron is suitable for making molded pieces, which is some cases are used as mechanical parts.

Production of steel in a furnace



Steel

Steel is obtained from smelting the pig iron that comes from special furnaces, called converters, by means of a combustion process.

The pig iron is put into the converter.

Impurities are eliminated by means of chemical reactions and the amount of carbon is reduced.

The other necessary metals are added in appropriate proportions.

This is how steel alloys are obtained. For example, nickel steel, nickel-chromium steel, molybdenum steel, chromium steel, chromium-vanadium steel, etc.

Nonferrous

These are metals that do not contain iron.

• **Copper (Cu)**

Characteristics

This metal is reddish and it has a high density. It is soft and very shiny, and a good conductor of electricity and heat. It is ductile, malleable and resistant to corrosion. It only oxidizes on the surface.

• Use

Electrical cables, telephone wires, pipes, sheets, containers, and certain alloys.

Copper wires.

• **Aluminum (Al)**

Characteristics

This metal is a silvery white color. It is a good conductor or electricity and heat. It is lightweight, ductile, and malleable. It oxidizes easily.

Use

It is used in the food industry (silver foil, tins and cans), the transport industry (vehicles, carriages, aeronautics), car wheel rims, motorbikes, bicycles, building (door frames, windows, banisters, ladders) and domestic utensils (pots, pans, trays, lids).

• **Zinc (Zn)**

Characteristics

This metal is a bluish white color. It is soft and shiny, and has a high density.
At room temperature it is brittle, but when it is heated (between 100 and 150° C) it becomes tough and malleable.

Use

It is used for the galvanization of iron, steel, and other metals, electrical batteries, rainwater downspouts, flumes, tanks, containers, domestic appliances, and different alloys, such as brass, etc.

• **Lead (Pb)**

Characteristics

This metal is soft and gray. It is shiny after the surface has been worked. When it is heated it is resistant to corrosion, but not to traction; it is malleable but not ductile.

Use

It is used for soundproofing, coatings, protection against radiation, batteries and accumulators, and it is used as an additive in the manufacture of glass.

• **Tin (Sn)**

Characteristics

This metal is a silvery white color, although when subject to temperatures under 13° C it transforms into a gray powder (gray tin). When heated, it is ductile, malleable and resistant to corrosion.

Use

It is used for industry, condensers, coating steel food and drink containers, soldering and bronze alloys.

Copper

Copper was the first metal used in technology. On occasions it can be found in a pure state, but its main source is mineral. Its ores are pyrite and chalcopyrite.
Bronze and brass are two of its alloys.

Bronze

This alloy is composed basically of copper and tin. It can sometimes contain zinc, lead, or aluminum. Then it is then known as special bronze.
It is resistant to wear and corrosion. It is used for making bells, statues, valves, etc.

Bronze statue.

Brass

This alloy is composed basically of copper and zinc. If it also contains lead or manganese, it is called special brass. It is resistant to corrosion and it is a good electrical conductor. It is ductile and malleable. It is used in faucets, gears, bars, lock parts, etc.

Aluminum

Although this metal is the most abundant on the surface of the Earth, it is not the most commonly used in industry; this is because it is expensive to extract.
Its ore is bauxite, which is chemically transformed into alumina. Aluminum is obtained from alumina by means of electrolysis, although this process requires an extremely large amount of energy. Recycling aluminum is now a common practice, as recycling is less expensive than the extraction process.

Aluminum chairs.

Zinc

Zinc is used a great deal all over the world. Its ore is sphalerite.

Lead

Man has known about this metal since pre-historic ages, after the discovery and use of copper. Its ore is galena. It is a very toxic metal. For this reason, since the end of the twentieth century, its use has been forbidden in pipes that carry drinking water, paint, and gasoline.

Tin

It is one of the most common metals. It started to be use at the same time as lead. Its ore is cassiterite.

Tools for metals

All the information in this section can be found on the online version in the chapter dedicated exclusively to tools.

Working with metals

Using tools and safety

When working with metals, the following standards must be respected:

- Always use good quality tools.
- Tools should only be used for the purposes for which they were designed.
- They should be kept clean and tidy.
- Measuring instruments should be kept apart from other tools.
- Cutting tools should be well-sharpened. They should be kept in a drawer or case, with the blade inside a protective cover.
- The pieces being worked on should be held securely in the vice on the workbench or the in clamps of the machine tool.
- To tighten or loosen screws, care must be taken to use the appropriate tool.
- The size of wrenches or Allen wrenches should properly fit the screw or bolt. Whenever possible, use wrenches instead of monkey wrenches.

Additionally, it is necessary to use protective equipment (goggles, gloves, face mask) for tasks that represent a risk to the safety of the worker.

- Goggles

These are usually made of resistant plastic. They protect the eyes and the area around them. They must always be used whenever there is a danger of pieces of metal flying around; for example, when drilling or sawing with a machine.

- Face mask

This provides general protection in dusty environments. Its use is recommended when filing, painting, or sweeping.

- Gloves

These are usually made of leather. They protect hands from cuts or splinters. Their use is obligatory when working with machine tools and there is danger of getting cut; for example, when sawing, drilling, or filing.

Joints

Normally, a piece of metal that has been worked on with the corresponding tools will form one of the parts of a larger, useful object. Think of the handle of a frying pan, the structure of a crane, the chassis and the bodywork of a car, etc.
All of these objects are formed by several pieces joined together. These joints can be temporary or permanent.

Permanent joint

A permanent joint is one which cannot be taken apart without it breaking.

Rivets

These are cylindrical objects made of ductile and malleable metals such as steel, copper, aluminum.
Rivets consist of two main parts, which are:

- Head

This can be flat, countersunk, protruding, semispherical, etc.

- Shank

This is the cylindrical part. It is inserted into the holes of the pieces to be joined together and forms the clinched head of rivets.
This type of rivet has been used since ancient times and it requires a special preparation and technique. This is why it has been replaced by blind rivet.
This type of riveting is carried out with a machine called a rivet gun.

Blind rivets consist of two basic parts: the body and the mandrel.

- Body

This is made of aluminum and it is formed by the:

- Mandrel

This can be flat or conical.

- Cylindrical part

This forms part of the clinched head and it is the reference that determines the size of the rivet.

- Mandrel

This is a steel rod that forms the head of the rivet. We can distinguish:

- Mandrel head

This is semispherical and it is at one end of the mandrel.

- Breaking point

This is where the mandrel breaks after forming the clinched head.

- Traction area

This part is inserted into the rivet gun.

- Filling area

This is the piece of broken mandrel that remains inside the rivet body.

Soldering and welding

These processes uses heat to join two or more pieces together.
When soldering and welding it is important to use all the corresponding protective equipment.

• Soldering

In soldering, pieces are joined by means of a filler metal (solder), which is melted with an electric soldering iron. It is a weak form of soldering and it is used to sold electrical circuits, printed circuit boards, plumbing, or for joining small pieces, wires or metal sheets.

When soldering, the use of gloves is obligatory.

The area of union has to be filed until it is free of grease, dirt, and oxide.

A kind of cream or paste (soldering flux) is applied to the metals, to allow the filler to spread and adhere better.

The pieces are fitted together.

An electric soldering iron consists of an insulated handle with an electric resistor that heats up, and a copper tip covered with iron, nickel, and chrome.

The area to be joined is heated by means of the soldering iron and then the filler metal is applied.

After cooling down, the filler metal solidifies.

The soldering process has finished.

• Electric arc welding

This process uses the spark (the electric arc) that is produced by jump-starting an electric circuit.

The ends of the conductors between which the electric arc is produced are called **electrodes**. An electrode is the piece being welded and it receives electric current from a clamp connected to the power source. The other electrode is the filler metal.

Temperatures of up to 3,000º C can be reached, which cause the two metals to melt and fuse together.

When carrying out this type of welding, it is obligatory to wear long-sleeved, leather gloves, protective sleeves, a leather apron, and a face plate or goggles with filters.

This system is used in metal carpentry, shipbuilding, repair work, metal pipes (oleo ducts, gas pipelines), metal structures, etc.

• Electric resistance welding

This system is based on the electrical resistance of the metals through which the electric current flows.

The pieces are pressed together by two electrodes that carry the electric current, causing the metals to fuse together. No filler metal is necessary. This system is used in the automotive industry, metal carpentry, and metal furniture (cupboards, doors, gates, and drawers). When carrying out this type of welding, it is obligatory to wear long-sleeved, leather gloves, protective sleeves, a leather apron, and a face plate or goggles with filters.

• Autogenous or oxyacetylene welding

Heat is provided by the flame from a gas welding torch, in which acetylene gas and oxygen are mixed together.

Welding

b) The flux is applied c) the joint area is filed d) the pieces are fitted together e) the joint area is heated and the filler metal is applied.

The acetylene and oxygen are kept in bottles which have safety valves and gauges to measure the pressure.
The gases flow into the welding torch through tubes.
The gases mix together inside the torch, and the flame is produced.
Temperatures of up to 1,500 ∞C can be reached, which cause the two metals to melt and fuse together.
This system is used for making pipes, bodywork, boiler work, repair work, structures for metal furniture, and for cutting sheets of metal and laminated profiles.
When carrying out this type of welding, it is obligatory to wear long-sleeved, leather gloves, protective sleeves, a leather apron, and a face plate or goggles with filters.

Detachable joints

A detachable joint is one made up by pieces that do not break when they are taken apart.
To join two pieces together with a screw or a nut and washer, we have to ensure both pieces have a hole with a diameter that is slightly larger than the screw (between 0.5 and 1 mm more).
To assemble metallic pieces with softer materials, such as wood, plastic, rubber, etc., a washer must be placed between both pieces.

Installing a steel roof.

Bolts

They usually made of steel. They consist of two main parts: the head and shank.

- Head

The head is usually round (with a groove or hexagonal socket), square, hexagonal, or countersunk (with a hexagonal socket). This type of screw is tightened or loosened with the aid of the appropriate tool.

- Shank

The shank is the cylindrical part which is screwed into the metal. It has a triangular thread along its whole length, or only a part of it, onto which the nut is screwed.

Classifying bolts

Bolts are classified according to the shape of their heads, the diameter of the threaded part, and their length.

The type of thread is described by means of an abbreviation: **M** (metric thread, expressed in millimeters), **W** (Whitworth thread, expressed in inches).

Nuts and washers

- **Nuts**

Nuts are usually made of steel and brass. They have a threaded hole in their center, through which the screw or bolt passes. There are several varieties: square, hexagonal, butterfly, blind,
and cap.

Classifying nuts

Like screws, they are classified depending on the outside shape and the type of thread. M5 hexagonal nuts or W 5/16" square nuts.

- Washers

These pieces are round with a hole in the center.

They are made of steel or other metals, and even of plastic, rubber, etc.

The diameter from the outside edges and their thickness depend on the diameter of the hole in the center, which is taken as a reference to know their size, and which is always slightly larger than the screws that will pass through them.

To stop the pieces from deforming and to be able to tighten the screws better, washers are placed under the head of screws and between the metal and the nut.

Pins

These are made of steel, brass, copper, or any other ductile and resistant material. They usually have a cylindrical or conical shape.

Their ends have a chamfered or rounded shape, so they can fit better into the hole.

There are different types, but the most common ones are usually cylindrical, conical, elastic or winged.

In some cases, pins act as safety elements. For example, if there is an overload the pin breaks, thus preventing the pieces it joins from deforming or breaking. These pieces are expensive and difficult to make.

Finishing techniques

Materials

Finishing a metallic surface consists in applying liquids (paints, lacquers, or varnishes) or other similar materials to protect metals from oxidation and improve their aspect or their feel.

- Varnishes or lacquers

Varnishes can be natural or synthetic, transparent, shiny or matt. Once applied and dry, they form a protective, waterproof layer that can withstand small knocks and bumps.

- Paints

Paint is basically made up of pigments and binders:

- Coloring or pigments

These are the elements that provide the color. They are produced with organic, chemical substances in powdered form.

These substances come from earth pigments, or certain metal oxides.

- **Agglutinant substances or binders**

Liquid products (water, oils, and resins) which, when dissolved in colorings, allow paint to be obtained. They make drying and adherence easier, and they form a protective layer.

• Priming

This is a protective, anti-corrosion process that requires special types of paint. It is applied before painting, in order to ensure the paint will adhere well.

• Galvanizing

Dying, varnishing, and painting need to be carried out with great care, following the necessary preparatory steps:

Finishing techniques

Finishing techniques: a) Priming b) Application of the product c) Maintenance and cleaning

Standards

Dying, varnishing, and painting need to be carried out with great care, following the necessary preparatory steps:

1. Preparing the surface

After applying the finish to the surface, it is necessary to remove all the dust that might be left on it.

2. Protection

During the finishing process it is necessary to use protective equipment, such as gloves and a face mask, because many of the products used are toxic if inhaled.

3. Priming

This process consists in applying a sealant to the surface (linseed oil or a similar product). This seals the pores and allows the products to adhere better. Priming reduces the amount of other products needed later.

4. Applying the product

Care must be taken to use the tools that are appropriate for each type of surface.

If a second coat of paint or varnish is necessary, the first coat must be completely dry.

5. Maintenance and cleaning

After the process has finished, all the implements must be properly cleaned with the appropriate products. Then they must be left to dry, the paint pots properly closed, and everything put away in its place.

Reduce, reuse, recycle

The 3Rs: metals and environment

Have you ever realized just how many metal objects surround you?

Metals are found in abundance on the Earth's surface, but you should never forget that they are cannot be renewed.

For this reason we have to be aware of the 3Rs: reduce, reuse, and recycle. Remember that most metals, especially ferrous metals, can be recycled as often as possible. This saves an enormous amount of energy, water, natural resources, and reduces pollution.

Reduce

To reduce the generation of unnecessary waste as much as possible, metals and metal objects must be used properly.

Whenever possible, we must try to:

- Avoid using nonrecyclable packaging.
- Avoid using silver foil to wrap food, sandwiches, fruit, etc.
- Avoid buying products containing toxic metals.
- Don't use machine tools whenever the operation (sawing, drilling, filing) can be carried out manually. This reduces the amount of energy we use.
- Control the heating up of the soldering iron.
- Avoid wasting solder when soldering.

Reuse

Before starting a task we should access what we need, what we have, and what we can use again.

Whenever possible, we must try to:

- Avoid buying unnecessary things.
- Share materials with our classmates.
- Calculate the exact amount of the material we need.
- Generate less waste.

Recycle

We have to ensure we:

- Buy or use recyclable products.
- Place recyclable products in the appropriate bins and containers.
- Put metal products that are difficult to recycle (batteries, cell phones, computers, small electrical appliances) or toxic products, in specially designed collection points.
- Food tins, drink cans, aluminum food containers (silver foil, drink cartons), electrical cables, copper pipes can and have to be recycled. Especially those objects that contain nonferrous metals, since their production is damaging to the environment.