Metals

Version 1.0

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1. Introduction to metals

1.1. What are metals?

The term metal is used to denominate the chemical elements that have these characteristics:
- They are good heat conductors.
- They are good electricity conductors.
- They have a high density, i.e. they are heavy materials.
- They are solid at room temperature (except mercury, which is liquid).
- They melt (become liquid) when heated at a high temperature.
- They shine in the light. Whether on a permanent basis, such as gold or chromium, or when they are polished.

The term metal is also used to refer to alloys. The alloys are mixtures of two or more elements, of which at least one must be a metal. Steel, bronze and brass are some of the most common alloys.

1.2. Other properties of metals

In addition to the above characteristics, other notable properties of metals are:
- They dilate when heated and contract when cooled.
- Generally suffer processes of rust and corrosion: air and water usually damages them.
- They're pretty tenacious: they are able to withstand shocks without breaking.
- Many metals are malleable: they can be converted into sheets or plates of little thickness.
- Many metals are ductile: wires or threads can be manufactured with them.
-They have considerable mechanical strength: able to withstand the tensile stresses, compression, torsion, bending and shearing without deforming or breaking.
- Some metals are magnetic: they are attracted to magnets.
- They have a mp (melting point - temperature at which they melt) that is very high.

1.3. Obtaining the metals

Very few metals are found in nature in its pure state; mainly gold, silver and sometimes copper. Most often they are combined with oxygen (oxides) or with sulfur (sulfides), as part of some mineral. The use of metals is a long and complex process that involves three steps:

1. Mining: consists of extracting minerals from the earth's crust. The excavations, shafts and galleries that are practiced in the ground to obtain minerals are called mines.
2. Metallurgy: is responsible for separating the metal from inside the mineral. A significant part of metallurgy is the iron and steel industry, which specializes in iron. The metallurgical industry consumes minerals which are rich in metals and generates semi finished products such as ingots, sheets, profiles, etc.
3. Manufacture of finished products: products made in the metallurgical industries (such as steel sheet) are finally taken and a useful product (a car, for example) is made. This operation is carried out in the processing industries.

1.4. Commercial forms of metallic materials

As we have seen, the metallurgical industry generates semi finished metal products, that then buy the processing industries. The most common commercial forms of these semi finished products are: bars and profiles from different sections, wires, sheets and ingots.

1.5. Classification of metals

Metals can be classified into two groups according to whether or not they contain iron: ferric metals and non ferric metals. Besides, ferric metals are classified according to the amount of carbon they contain, in: soft iron, steel and cast iron. Non ferric metals are classified according to their density.

1.6. Environmental impact

The use of metallic materials, as that of other materials, causes considerable environmental impact. We can highlight three aspects:
- Mineral extraction: in the mines, especially those that are in an open pit, move a large amount of land, generating a radical assault on the landscape.
- Metallurgical industry: the process of obtaining metals from minerals is very polluting. Greenhouse gases are emitted into the atmosphere, large amounts of electricity are consumed and harmful toxic sludge are generated for the flora and the fauna.
- Discarded products: in our consumer society, large amounts of metal waste are generated: containers, cars, machinery, boats, etc. These wastes accumulate in landfills if they are not recycled.

<u>Recycling</u>

Recycling is a good way to reduce the environmental impact because metals can be melted and shaped many times. For this we must:
- Collect: useless metallic products are removed and the usable metal they contain is recovered.
- Recycle: the recovered material is classified according to their composition (types of metals and alloys) and is prepared to be sent back to the metallurgical industry.

With this we manage to reduce the extraction of raw materials from nature.

2. Ferric metals

2.1. Introduction to ferric metals

The ferric metals are those containing iron, that is, the pure iron and its alloys (mixtures of iron with other elements). They are the most used metals, since iron is an easy element to find in nature (it constitutes 5% of the earth's crust), they are relatively inexpensive (compared to other metals) and have good technical characteristics.
Pure iron is rarely used because its low mechanical strength. The most used ferric metals are alloys of iron with carbon (steels and foundries).
In ancient times the production of iron weapons was of great importance, as it represented a great military advantage. At present, ferric metals are a significant part of the economy: bridges, building structures, boats, tools, etc.

2.2. Iron and steel products

The different products resulting from iron are called iron and steel products (remember that the iron and steel industry is iron metallurgy, that is, the transformation of iron ore into useful metals). As we have seen, pure iron has little mechanical strength, so it does not have many applications. To make it more resistant, and therefore more useful, it is necessary to alloy it with small amounts of carbon.
Iron and steel products are classified into three groups, depending on their carbon content. They are the soft iron, the steels and the foundries.
<u>Soft iron</u>: It has less than 0.1% carbon; it can be considered pure iron. Traditional blacksmiths called it "soft" because it can be forged (give shape by hitting it with a hammer) with ease. The metals that were difficult to forge were called "sour". In ancient times it was quite extensively used, today it has been replaced by steel.
Properties:
- Light gray color, almost silver.
- Ductile (it can be converted into threads) and malleable (it can be converted into sheets).
- It rusts easily.
- Difficult and expensive to obtain.

Applications:
It does not have many applications because of its low mechanical strength (it is easily broken). Its main use is the manufacture of electromagnet cores, as soft iron is not permanently magnetized upon being subjected to a magnetic field.

<u>Steel</u>: Iron and steel products that have a carbon percentage between 0.1 and 1.76% are called steel. It is the most widely used ferric material. Most of the iron objects you find in your daily life, are actually, made of steel.
The higher the carbon content in steel, the greater is its hardness and its tensile strength, but it increases its fragility (it will be less resistant to impact).
Steels that are formed exclusively by iron and carbon are called carbon steels or common steels. Below you can see some of the properties and applications of common steels.
Properties:
- Very resistant to mechanical stresses.
- Easy to weld.
- Little resistant to corrosion.
- Moderate price.

Applications:
They are very numerous: structures, vehicles, tools, nails and screws, etc.
The alloyed steels in addition to iron and carbon, have other elements that have been explicitly introduced in order to improve some of its properties. An example of alloyed steel is stainless steel. This is a steel containing chromium (at least 12%). Chromium makes the steel have a glossy finish and gives it resistance to rust and corrosion. It has many applications: cutlery, cookware, appliances, furniture, etc.

<u>Foundry</u>: Foundries have a set percentage of carbon between 1.76% and 6.67%. They are called cast, sometimes cast iron because they melt easily and have a lot of fluidity in its liquid state. They are used to manufacture parts pouring the liquid cast into a mold.
Properties:
- They are not ductile or malleable.
- They generally cannot be forged or welded.
- They are less resistant (stand less efforts) and are more brittle (they break if they are hit) than steel.
- They are cheaper than steel

Applications:
- Machine tool benches.
- Engine blocks.
- Urban furniture: fountains, lamps, etc.

2.3. Iron and steel industry

To obtain the different iron and steel products from iron ore requires a long process of transformation. We will study the most important steps to follow to obtain steel, the most important ferric metal.

Obtaining the iron mineral

Even though iron is very abundant in nature, it is not found in its pure form but together with other elements (basically oxygen, it is oxidized) forming part of various minerals. Some of the minerals that are used to obtain iron are hematite, magnetite, limonite and siderite. Iron ore is extracted in the mines, normally open pit mines, and it is loaded onto trucks that transport the ore to the iron and steel industry.

Separation of the ore and of the gangue

In the iron and steel industry, iron ore is transformed into metal. The first step to obtain the metal is to separate the part of the mineral that has iron, the ore, from the part formed by other elements and that has no use, the gangue. The most common method is to crush the mineral and submerge it in water. As the ore (the part of the mineral which is rich in iron) has a higher density than the gangue (the impurities), is deposited on the bottom. Thus, a material having an iron content of 70% is obtained. 30% impurities remains, still a very significant percentage that we must continue to eliminate. Most of these impurities will be eliminated in the next step: the blast furnace.

Blast furnace

To eliminate the remaining impurities in the iron ore, a blast furnace is used, that is so called due to its great height (it can measure up to 80 meters high). This is a furnace which is fed from the upper part and whose product is extracted from the bottom.

First step. Loading the furnace:

Introduce in the blast furnace:

a) The ore: the rich part of the mineral in iron (it has 70% iron, the rest are impurities).

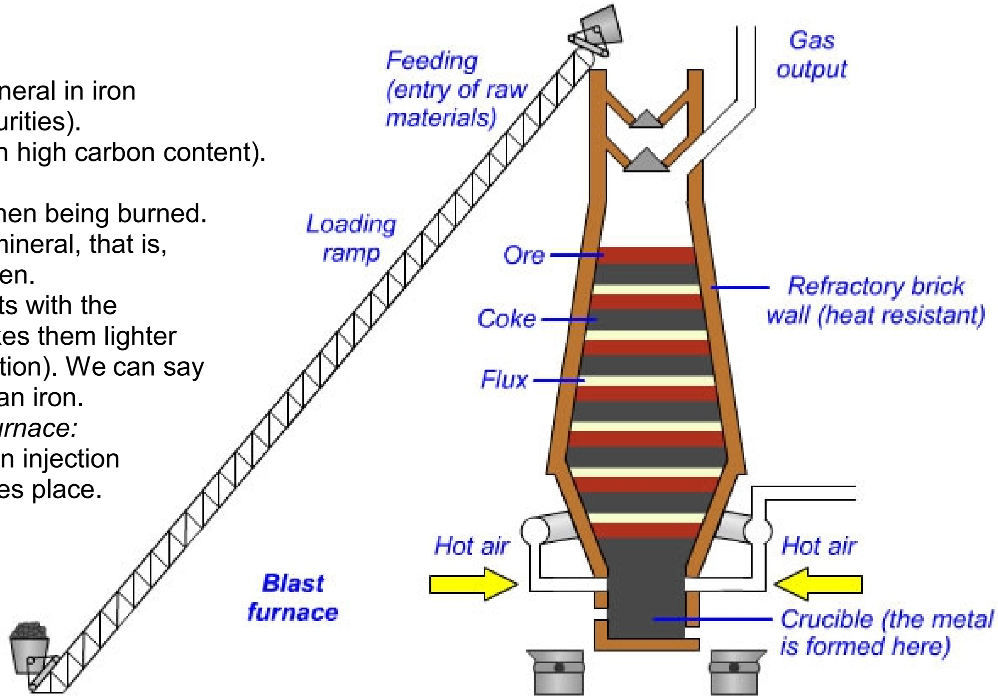
b) Coking coal (a type of coal with high carbon content). It is suitable for:

- Providing heat to the furnace when being burned.
- Reducing the iron oxide of the mineral, that is, separating the iron from the oxygen.

c) Flux: calcium carbonate. Reacts with the impurities of the mineral and makes them lighter (they will be removed by decantation). We can say it is the "detergent" we use to clean iron.

Second step. Lighting the blast furnace:

In the lower part of the furnace, an injection of hot air through the nozzles takes place. Coking coal starts burning and provides heat to the furnace. After some time, the temperature in the lower part of the furnace, the crucible, is 1800ºC.



At this temperature, a series of chemical reactions are produced which make the iron content in the mineral be released and starts to drip, accumulating in the crucible.

Third step. Extraction of the products:

The following come out from the lower part of the blast furnace:

a) Pig iron: is the liquid iron that has been released from the mineral. It is composed of 92% iron, 3 or 4 % carbon and silicium impurities, manganese, phosphorus and sulfur. Pig iron is very heavy; it accumulates in the lower part of the blast furnace. There is a hole where it can come out of.

b) Slag: is the residue formed by the reaction of the flux with the majority of the impurities in the ore of iron. As it weighs less than pig iron, it remains floating on top and can be easily separated.

Blast furnaces never stop. They are continuously loading raw materials and extracting products.

Obtaining steel

Most of the pig iron produced in blast furnaces, about 75%, is used for the manufacture of steel, which is the most widely used iron and steel product. This operation is called refining pig iron and it basically consists of eliminating part of the carbon it has. Pig iron has between 2% and 3% carbon; to convert it into steel it is necessary to reduce this percentage and leave it at most at 1.76%. The most common method to obtain steel is to use a oxygen converter. How it works?

1. The liquid pig iron that comes out of the blast furnace is poured into the converter
2. Scrap steel (recycled parts from cars, appliances, etc.) and flux (calcium carbonate used to eliminate impurities) are also introduced.
3. Next oxygen is injected by pressure through a spear. Oxygen reacts with the carbon of the pig iron and generates carbon dioxide that leaves in the form of gas.
4. Steel is obtained as a result of refining (remember that steel is an iron alloy that contains from 0.1 to 1.76% carbon). Most of the impurities that were in the pig iron react with the flux and form the slag, that remains floating on top of the steel and are eliminated by decantation.

3. Non ferric metals

3.1. Introduction

In the previous mini-unit we saw that the main component of ferric materials is iron. In this mini-unit we will study the non ferric metals, which are those that do not contain iron.
Non ferric metals are more expensive and difficult to obtain than ferric ones, however they have some properties that make them necessary in many applications:
- They resist rust and corrosion better.
- They conduct electricity and heat better.
- They melt at lower temperatures.
- In general they are easier to mechanize, that is, it is easier to shape by eliminating material to a piece of non ferric metal than to a ferric metal one.

They are classified into two large groups: pure non ferric metals and non ferric metal alloys.

Pure non ferric metals

When non-ferric metals are used without mixing them with other elements, we call them pure non ferric metals. They are classified, according to their density, into three groups: heavy, light and ultra light metals. In this table you can see the most significant, although there are other such as chromium, nickel, wolfram, cobalt or lithium that also have interesting technological applications.

Pure non ferric metals which are heavy (Density higher than 5 kg/dm^3)	Pure non ferric metals which are light (Density between 2 and 5 kg/dm^3)	Pure non ferric metals which are ultra light: (Density lower than 2 kg/dm^3)
Lead Copper Zinc Tin	Aluminum Titanium	Magnesium

Pure non ferric metals are, in general, soft and have a low mechanical strength. In most applications they are not used in their pure form, but mixed with other elements to form alloys.

Non ferric metal alloys

An alloy is a homogeneous solid mixture composed of two or more elements, one of which, at least, must be a metal. In the non ferric metal alloys, the metals used are always different to iron. The alloys are made in order to improve the properties of the main metal in order to obtain a more suitable material for a particular application.
The most classic examples of non ferric metal alloys are bronze and brass (later we will see their characteristics). Bronze is obtained by mixing copper and tin, and brass mixing copper and zinc. Bronze and brass are known since thousands of years, in Prehistoric times. The metallurgy of non ferric metals has evolved considerably since then, hundreds of different alloys with components, properties and varied applications are in use today.

3.2. Lead

Properties:
- Malleable (it can be deformed until it turns into thin sheets).
- Very soft (it scratches very easily).
- Very heavy (11,4 g/cm^3).
- Toxic (difficult to eliminate from the human body).
- Absorbs X-rays and nuclear radiations, which are harmful to living things.

Applications:
- In ancient times it was used in the water pipes of the houses, but because of its toxicity, it ceased to be used.
- Car batteries.
- Plates on which we lean on to get a radiography (to absorb the X-rays, and that these do not bounce) and vests for radiologists.
- Shielding of nuclear reactors. They prevent radiation from going outside.

3.3. Copper

Properties:
- Bright reddish color.
- Ductile (it can be deformed until it turns into a thread) and malleable (it can be deformed until it turns into thin sheets).
- It is a good electrical and thermal conductor.
- It is soft, easy to scratch.
- It resists rust and corrosion.

Applications:
- Electrical cables in houses.
- Electric motor coils.
- Heating pipes.
- Ornaments.

3.4. Zinc

Properties:
- Bluish white.
- Soft (easy to scratch).
- It is resistant to rust and corrosion.

Applications:
Coat steel parts to avoid their corrosion. It is used in streetlights, water gutters, roofing sheets, screws, etc. It is what is known as galvanized steel or zinc-coated steel. It can be done through two procedures: by introducing the steel parts into a bath of molten zinc or by electrolysis (applying electricity in a solution containing zinc salts).

3.5. Brass

Brass is a copper and zinc alloy. The percentage of copper is 60% to 95%, the rest is zinc.
Properties:
- Bright yellow (similar to gold).
- Good resistance to corrosion.
- Very ductile.
- Easily machined.

Applications:
- Hardware items (hinges, screws,…).
- Ornamentation and jewelry.
- Gas and water valves.
- Wind musical instruments.

3.6. Tin

Properties:
- Bright white appearance.
- It melts (becomes liquid) at a very low temperature: 232 ºC.
- Very malleable (can be converted into sheets).
- Good electrical and thermal conductor.
- Very soft (it scratches with a fingernail).
- Resists rust and corrosion.

Applications:
- Alloyed with lead, it is used for welding electronic components or pipes.
- Manufacture of tin plate. The tin plate, such as the one used in food cans, is a steel sheet coated with a thin layer of tin which protects the steel from rusting.

3.7. Bronze

Bronze is an alloy of copper and tin. The percentage of copper is from 80% to 97%, the rest is tin.
Properties:
- Its color ranges from dark yellow to brown.
- Much harder than copper (the more tin it contains, the harder it is).
- Resistant to corrosion.

Applications:
- Boat propellers.
- Bells.
- Mechanisms (e.g. Gears).
- Ornamental elements.

3.8. Aluminum

Properties:
- Light silver color.
- Light (2,7 g/cm^3).
- It is ductile and malleable.
- Easy to mechanize (shape the piece of aluminum by eliminating material).
- Good electrical and heat conductor.
- It is soft.
- Very resistant to rust and corrosion.

Applications:
It is almost always used alloyed with other elements.
- Soft drink cans, water canteens, kitchen utensils, wrappers and food containers.
- Metalwork (doors and windows).
- Cables of high tension towers.
- Forms light and yet very strong alloys, which are used to manufacture components for the automotive industry and the aerospace industry.

3.9. Titanium

Properties:
- Light (4,5 g/cm^3).
- Very good mechanical properties, similar or superior to those of steel.
- Very hard (very difficult to scratch).
- Resistant to rust and corrosion.
- Very expensive, reducing its industrial uses.
- It is biocompatible, it is not rejected by living tissues.
- Bright. The brightness is not lost over time.

Applications:
Almost always used alloyed with other elements, especially with aluminum.
- Dental implants and bone prostheses.
- Boat propellers.
- Blades of jet plane turbines.
- Structures of planes and space rockets.
- Covering some emblematic buildings such as the Guggenheim Museum of Bilbao.

3.10. Magnesium

Properties:
- Very light (1,7 g/cm^3).
- Highly flammable in a powder form.
- Very malleable and not very ductile.
- High price.

Applications:
- Athletes and climbers use it to dry hand perspiration and improve the grip of the objects.
- Pyrotechnics (fireworks and explosives).
- Its main application are the aluminum alloys which are used to make light weight components in the automotive industry and in the aerospace industry. Also in camera bodies and high priced computers.

4. Metals in the workshop

Metalworking techniques in the workshop
In the previous mini-units we studied the most important types of metals, but for the metals to be useful, it is necessary to shape them. In this mini-unit we will see some of the techniques that are used in the workshop for metal working. In the next we will study industrial techniques.

4.1. Cutting

The metal products we find in the market (profiles, plates, etc.) are presented with standardized dimensions, so normally they have to be cut. In this case the sheet metal shears or the hacksaw are useful.
The sheet metal shears have very strong blades and a long handle. The handle acts as a lever that allows a lot of force to be exercised in the cutting zone. They are used to cut thin metal plates.
The hacksaw has very fine teeth, designed to scrape small metal fragments in every to and fro movement. A vise is used to clamp the piece.
In addition to manual saws, the small workshops and the industries have mechanical hacksaws. There are many types; we can highlight circular saw, band saw and jigsaws.

4.2. Filing

Often the cut metal has to be reduced, so that it fits a shape, or polished, to give it a smooth finish (especially if it has sharp edges which can be dangerous). To achieve this we use files, tools that submit the material to an abrasion (wear). The files have a serrated surface enabling them to scrape small particles of material with every stroke, the filings. These are classified into fine or coarse, depending on the size of the grooving. The coarse files are used to reduce the metal, while the thin ones are used for polishing. Another feature of the files is the shape of its section, the most common being: flat, round, half-round and triangular.

4.3. Drilling

The drilling consists in making cylindrical perforations in a material using a tool called drill. The accessory that, when turning, makes the perforation called bit. There are different types of bits, depending on the hardness of the material being drilled. The most common are the bits for metal, wood and wall. Do not drill metal with bits for wood or wall.
It is said that the drill is a machine tool as it is powered by an electric motor that makes the bit spin. There are different types of drills. The portable drills can easily be transported to where they are needed; there are even models with batteries (less powerful) that do not require an electrical outlet. The tabletop drills or column ones are installed fixed on a workbench. They are more powerful than portable drills, and, by being still, allow a person to work more accurately.

4.4. Joint by threaded elements

There are several ways to join metal parts to form more complex objects. The non dismountable joints cannot be undone without breaking some piece; later, we will see two examples, riveting and welding. The dismountable joints make it easy to separate the parts when necessary. The most common dismountable joint is the one that uses nuts and bolts. A hole is made through the two pieces to be joined and a screw which is fixed with a nut is introduced. Both elements have a thread, the screw has an external thread (male thread) and the nut an inner thread (female thread), so that when tightened by turning with the proper tool, the joint is tight. For the two pieces to fit better together, washers are often used. On many occasions, particularly in complex machines, the nut is replaced by a threaded hole in one of the pieces.

There are different types of screws depending on the shape of the head. The most common is the screw with a hexagon head. Another very common one is Allen screw, whose head is usually circular but has a hexagonal hole where a key that has this form is inserted, the Allen key.

4.5. Joint by rivets

Riveting is a joining technique that enables to join two metallic plates, or two pieces of little thickness. It consists of interleaving a metal cylinder (a rivet) between the two plates and deform it, in cold or hot, so that it does not come off and it can keep the plates together. It is a non dismountable joint.

Before the invention of the electric welding, this technique was widely used in heavy industry, especially in the construction of ships and structures of buildings and bridges. Currently, riveting is used to work with thin plate, especially in the airplane construction (aeronautical industry) and in the manufacture of all kinds of metallic boxes or plate constructions.

<u>Tubular riveting</u>

The type of riveting that is currently used the most is the tubular riveting or pop riveting, which uses hollow rivets, usually of aluminum or alloys. It has the advantage that, in addition to being used in metallic plates, it can also be used in plastic plates and other less resistant materials. To put tubular rivets, a hand tool called riveter is used.

Necessary process to join two plates with a tubular rivet by using a manual riveting machine:

1. A hole is made in the two plates that are to be joined.
2. The rivet is inserted and then the riveting machine.
3. The riveting machine is activated until the stem is cut. The result is that the rivet is deformed and joins the two plates.

Pneumatic riveters are used in the industry. They are machine tools that increase work productivity. The necessary force to deform the rivet is exerted by pressurized air.

4.6. Joint by electric welding

Another example of non dismountable joints is electric welding, which allow joining steel parts by fusion of a metal rod (electrode) between the pieces to be joined. The heat needed to melt the electrode is produced by the electric current flowing between this and the parts to be welded. As they are slightly apart, the flow of electricity is produced in the form of voltaic arc, that is, as a very luminous electric shock. The light of this shock can be harmful to the eyes, so it is necessary to protect oneself with a mask. It is a kind of quick, inexpensive and very strong joint, so it has many applications: construction of metallic structures, channeling, boilers, garage doors, etc.

<u>Welding equipment:</u>

1. Transformer: Increases the intensity and lowers the tension in the current coming from the network.
2. Electrode: Metal rod with protective coating. During welding, the coating is evaporated and the gas displaces the air appearing around it, creating a protective atmosphere that facilitates binding.
3. Electrode holder: Holds the electrode and connects it to the current conducting cable.
4. Ground clamp: Holds the ground cable to the piece to be welded.
5. Welding cable: Connects the transformer to the ground clamp.
6. Electrode cable: Connects the transformer to the electrode holder.
7. Protection elements: mask, gloves and apron. Protect the health of the welder.

4.7. Turning

Turning is a machining* operation which is carried out with a machine tool called a lathe. The process consists of turning the piece that is to be machined and shaving away thin layers of it with a cutting tool until it reaches the desired shape.

* Machining is the set of operations involving the boot metal filings.

Turning is used with a variety of metals (brass, aluminum, steel, etc.), as well as non-metal materials such as wood and plastic. A variety of products are made with turning, such as axes, machine parts, decorative pieces, door knobs, etc. In general, any piece with a cylindrical shape.

<u>Basic operations</u>

Once the movement and appropriate type of tool have been selected, turning makes it possible to machine pieces with cylindrical, conical and spherical shapes. Other processes are also possible: threading (creation of threads), drilling (holes), boring (interior machining of a drill hole in order to achieve very precise measurements) and facing (machining of the end of the piece so that it is at a 90º angle with the symmetry axis).

There are manual lathes, which are activated by a person, and computer-controlled automated lathes, which are called CNC (computer numerical control) lathes.

5. Metals in the industry

Industrial manufacturing techniques with metals
In the previous mini-unit we studied the manual work techniques with metal in the workshop, in this mini-unit we will study some of the most used techniques employed in the industry, in the process to manufacture large arrays of metal objects.

5.1. Casting

Casting involves heating the metal up to the melting temperature, in the case of steel, for example, about 1375 ºC. Once in a liquid state, the metal is poured into a mold that has the shape of the object we want to obtain. When the metal cools, the mold is opened and the object is extracted. The objects obtained by casting usually have a rough finish, which is why it should subsequently undergo finishing operations: turning, cutting rough edges, polishing, etc. There are many types of molds; one of the most used is the sand mold. The sand molds are made by compacting sand around the object we want to get the mold of. When removing the object, its shape remains in the sand.
By casting, all types of industrial and decorative pieces are obtained.

5.2. Forging

When the steel is heated between 800ºC and 1000°C it becomes an easily deformable material, and, as clay, can be modeled by subjecting it to pressure or by hitting it. This forming technique (to give shape) is called forging. Traditionally, forging was a manual method. The blacksmith heated the steel until it was red hot and then kept hitting it with a hammer until the obtained the desired shape. Thus tools, grills, hinges, nails, horseshoes for horses, etc. were obtained. At present, manual forging is only used to produce handcrafted pieces, whereas the using forging machines is a widely used technique in the industry.
In the industry, forging is usually carried out by hydraulic presses, machines designed to exert great pressure on a material. By this procedure, large diameter shafts, crane hooks, engine cranks, tools (spanners, wrenches, pliers ...), train wheels, machine axles, etc. are made. When the metal piece is forged between two mold halves (instead of between two flat surfaces), it is also called hot stamping.

5.3. Laminating

Laminating consists of passing metal between two rollers. The pressure exerted by the cylinders reduces the section of the metal and increases its length. When several pairs of rollers are chained, a rolling mill is formed. By lamination, thinner sheets or very thin sheets from thick metal sheets can be obtained. In addition to flat shapes, by using different rollers, we can obtain products such as rails for trains, tubes and structural profiles.

5.4. Casting manufacturing

Die casting manufacturing is the process in which cast metal is pressed into a mold. The liquid metal is poured into a die casting machine, after which a piston forces it into the mold. By placing this pressure on the metal, it must fill the entire space of the mold. This is a very useful technique for creating pieces with complex shapes. Metals with a low melting point are used as the raw materials for this process, especially aluminum and its alloys.
Examples
With die casting, all types of industrial pieces can be manufactured: aluminum radiators, door knobs, drawer handles, lamps, machine cases, camera bodies, car wheels, iron fittings, frying pans, valves, pulleys, etc. In general, any type of piece that has a complicated shape can be made.

5.5. Metal extrusion manufacturing

Metal extrusion manufacturing is a process in which molten metal is forced through an exit nozzle called a die. Due to the pressure the ram places on the molten metal, this metal must go through the die, which gives it its shape. As the metal exits, it is cooled down by means of air or water. It is then cut to the desired length.
The machine used in this process (an extrusion press) is supplied with cylindrical ingots called "billets". These ingots are heated to a temperature that is similar to the temperature used to melt the metal. This is done so that the material can easily pass through the die when it is compressed.
This technique is primarily used with aluminum and its alloys, due to their low melting point, although it is also used with copper, lead and alloys of these metals.
Examples
One product created with metal extrusion is profiles, which are then used to make aluminum doors and windows, seamless tubes, handrails, lights, etc. In general, pieces that are long with a constant section, which can be manufactured from metals or alloys with a low melting point.

5.6. Die-cutting and punching

Die-cutting is used to cut pieces from a thin sheet of material, normally metal, plastic, cardboard or leather. This cut is made with a sudden movement: the material to be cut is pressed, with great force, between two tools, the punch and die, which are in the shape the material is to be cut. A machine called a die-cutter is used, which is simply a specialized press. The shape of the punch and die will determine the shape of the piece obtained in the end, which can range from simple to very complex.

5.7. Sheet metal bending

There are many metal objects around us that have been created through the bending of a flat metal sheet. Some examples are: metal cabinets, shelves, elevator doors and walls, rain gutters, tool boxes, computer cases, mailboxes, etc.

To make these types of objects, a machine called a bending machine or press is used. Small sheet metal shops have manual bending machines. Industries that manufacture large runs of the same product use computer-controlled bending machines. Often these bending machines are accompanied by a robot that inserts and removes the sheets to be bent, which is called a bending cell.

5.8. Sheet metal stamping

Stamping is a cold forming process which consists of shaping sheet metal by pressing it between two moulds, a lower mould and an upper mould. The moulds used in stamping are called dies. Sheets of steel and aluminum are frequently used in this process. The machines used to apply the pressure are hydraulic or mechanical presses; the first is more common.

With stamping, numerous small and large metal objects can be made. The most common use is the manufacturing of vehicle panels (doors, roofs, hoods, sides, etc.)

5.9. Sheet metal drawing

Drawing is one of the most commonly used techniques in the industry for manufacturing hollow or concave objects. It is a cold forming process that consists of applying pressure to sheet metal with a mould, which is called a drawing punch. The pressure forces the sheet to stretch and adapt until it takes the shape of the mould. This mould must be very well designed in order to prevent the sheet metal from cracking or creasing. This process is especially used with sheets of steel and aluminum. Hydraulic or mechanical presses are used to apply the pressure.

Examples

With drawing, all types of hollow or concave metal objects can be made, both for the industry as well as for domestic purposes. Some examples are: pots, pans, saucepans, ladles, metal cups and plates, container covers, stainless steel sinks, the oil sump of automobile engines (the container that holds the engine's oil), various tanks, lights, etc.

