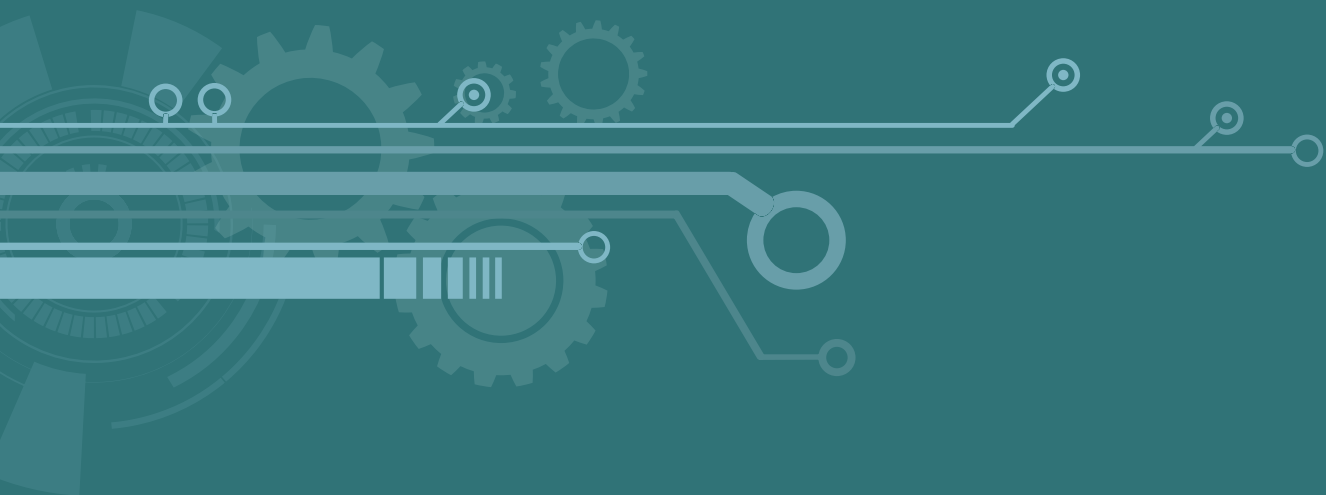


Materials: overview



Introduction

Materials are the different types of matter used in the making and production of the objects we use every day.

In the world we live in, the use and manipulation of materials to satisfy certain needs and improve our quality of life is obvious. For this reason it is important to choose the right materials for each purpose. The science of materials studies the applications, properties, structure and processing of materials.

The same object may be made of different materials because often the use it will be given can influence the choice of material.

Sourcing

The steps taken to transform any natural material into a useful product tend to follow the same procedure:

1. Raw matter is extracted from nature by different procedures.
2. Materials are taken to industries, which use them to produce objects.
3. Materials are taken to industries, which use them to produce objects.
4. After a given period of time, objects lose their functionality and generate waste.

Sourcing of raw materials

All materials are made from natural sources. There are materials of animal, vegetable, or mineral origin.

- **Animal origin:** leather, wool, silk, bone, etc.
- **Mineral origin:** iron, granite, clay, aluminum, etc.
- **Vegetable origin:** cotton, cork, linen, paper, etc.

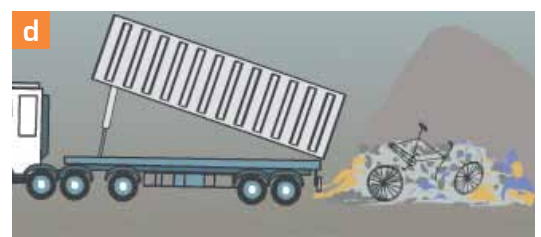
Processing

Not all materials we use are found in nature as we know them; some need to be transformed. Depending on the transformation, we can distinguish between natural materials and manufactured materials.

Natural materials

Natural materials are those that are used without having necessarily undergone a transformation process. Examples: solid wood, slate, marble, granite, gold, silver, etc.

Obtención y transformación



- a. Raw materials are extracted from nature.
- b. Raw materials are transformed into materials that can be worked with.
- c. The materials reach the industry, which will use them to produce objects.
- d. When objects are no longer functional, they generate waste.

Manufactured materials

The materials that have been transformed after being extracted from nature are referred to as manufactured materials. Examples: paper, plastics, glass, ceramics, concrete, Teflon, etc.

Production of objects

In industry, both natural and manufactured materials are used in the making of useful products (objects of all kinds, such as: furniture, buildings, vehicles, machinery and tools, etc.).



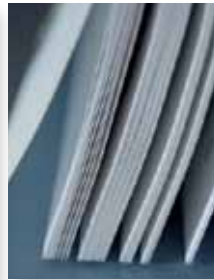
Wood



Granite



Gold



Paper



Plastic



Concrete

Generation of waste

When we throw an object away, either because it is no longer useful, or because it is broken and we want to replace it, we are generating waste.

Many of these objects can be reused in industry or sent to a special plant where the materials they are made of will be recycled. That's why we should always bear in mind the '3Rs': reduce, reuse, and recycle. This is an important step to protect the environment.

When the production rate of a material is lower than the consumption rate, it means we are using it up more quickly than it is produced, meaning that, sooner or later, the material will run out. This is just another reason to reduce, reuse, and recycle as much as possible.

Properties

Physical properties

Sound conductivity

Sound conductivity is a material's capacity to conduct sound.

The greater the sound conductivity of a material, the more easily sound waves travel through it.

Electrical conductivity

Electrical conductivity is a material's capacity to conduct an electrical current. The greater the electrical conductivity of a material, the more easily electricity is conducted through it.

Thermal conductivity

Thermal conductivity is a material's capacity to conduct heat.



Sound conductivity



Electrical conductivity

The greater the thermal conductivity of a material, the more easily heat is conducted through it.

Density

Density is the mass of a material per unit of volume.

Expansion

Expansion is the variation in the size of a material when subject to changes in temperature.



Thermal conductivity

Melting point

Melting point is the temperature at which a solid material becomes liquid.

Fusibility

Fusibility is a property of materials that refers to amount of heat they require so they can melt.



Density

To increase the temperature of a unit of mass by one Kelvin (one degree centigrade), a given amount of heat is required, which differs for each material. This amount is referred to as specific heat.

Fusibility is related to specific heat, melting point, as well as some other properties of materials.

Hygroscopicity

Hygroscopicity is the ability of a substance to attract water molecules from the surrounding environment. Hygroscopicity affects wood; its density and putrefaction. Damp wood can easily rot, which is why it needs to be previously treated.



Melting point

Porosity

Porosity is a measure of the volume of void spaces in a material with respect to its total volume.

Mechanical properties

Types of stress

When any given force acts on an object, we can say that it undergoes **stress**. The response of a piece of 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 the type of stress.

We can distinguish the following main types of stress:



Fusibility



Traction

Compression

Bending

Shearing

Torsion

Traction

Traction is the type of stress to which a material is subject by two opposing forces that stretch it. This type of stress always causes the piece to lengthen in the direction of the forces. If the stress is intense enough, it reduces the piece's cross section, eventually breaking it.

Compression

Compression is the type of stress to which a material is subject by two opposing forces that squeeze it, reducing its length. This type of stress causes the piece to shorten in the direction of both forces. If the stress is intense enough, it reduces the piece's cross section, eventually breaking it.

Bending

Bending is the type of stress to which a material is subject when certain forces act on it, causing it to bend. This type of stress always causes the piece to bend and 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 but very close spots, in such a way the piece tends to break. This type of stress always causes the piece to deform, and if the stress is intense enough, the piece will eventually break.

Torsion

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

Response to stress

Depending on their intensity of the stress, each type of material responds in a specific way. In spite of the differences, we can draw some general conclusions. As the intensity of the stress increases, materials show their elastic properties first, their plastic properties second, 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.

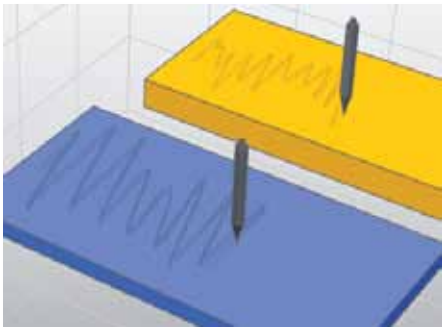
Resistance

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 undergoing 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

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

Toughness

Toughness is a material's resistance to breaking when hit.

The response of materials when stresses are suddenly applied is different from that when they 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.

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, to break a piece instantly with a sole application, a more intense stress is needed

Creep

Creep, or fluency, is the slow and progressive deformation of a material, caused by the action of its own weight or very small loads.



Toughness.

Machinability

Machinability is a property that refers to the ease with which it can be machined; that is worked. This property is variable, as it does not only depend on the physical properties and certain mechanical properties, but also on more practical aspects.

Weldability

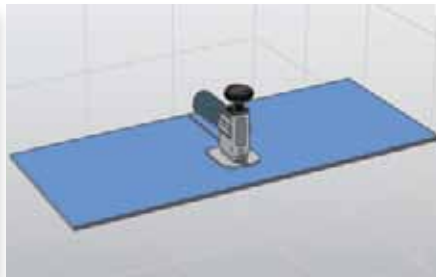
Weldability is the capacity of some materials to join together due to the effect of heat, and if necessary, the presence of other additional materials.



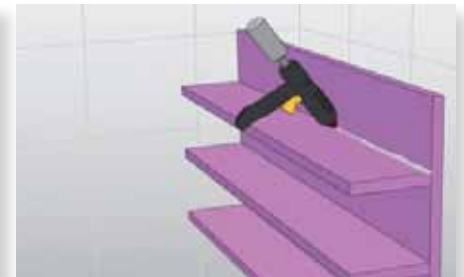
Fatigue.



Creep



Machinability



Weldability

Chemical properties

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

Permeability

Permeability is a material's capacity to absorb water or other fluids.

Solubility

Solubility is a material's capacity to mix with another substance, which acts as a solvent.

Combustibility

Combustibility is a material's capacity to burn, giving off thermal energy.

Biological properties

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

Recyclability

Recyclability is our ability to transform a material that has already been used into another product, with a new useful life.

Generally speaking, the new product will not be the same type as the previous one. It is important to emphasize that the recyclability of a material depends essentially on our technical abilities: many materials that could not be recycled some years ago, are now recyclable.

Biodegradability

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

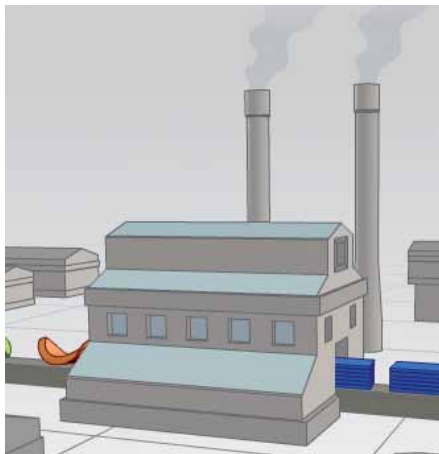
It usually takes a long time for plastics to degrade. As a consequence of this and the massive use we make of them, the storage of plastic waste has become a serious problem.

For this reason recycling plastic is so important. Many plastics have components to accelerate the process of decomposition.

Toxicity

Toxicity is the property of materials to cause negative effects on living organisms.

The greatest danger of the toxicity of plastics is when they are in contact with food and drinks, especially if these are heated up inside the same container. Some plastics of toys, glues, and paint are also toxic.



Recyclability



Biodegradability



Toxicity

Commonly-used materials

Wood

Wood is obtained from trees. They are felled, delimbed, chopped, and left to dry.



Wood.

Wood can be classified into two large groups:

- **Natural wood:** This is obtained directly from tree trunks. If it comes from trees that grow slowly, it is referred to as hard, and if it comes from conifers, it is referred to as soft.
- **Manufactured wood:** It is obtained from wood choppings, sawdust, bark, or branches.

Metals

Metals are usually obtained from the minerals that are inside rock. (Some, however, can be found in their pure state in nature.) The minerals are extracted from rocks and natural deposits, then the metallic part is separated and transported to a transforming plant, where the pure metal is separated from the other components.

They can be classified into two large groups:

- **Ferrous:** They contain iron that can be mixed with other metals.
- **Nonferrous:** They do not contain iron.



Metals.

Stones

Stones are obtained from rocks. (Some rocks can be used without hardly being transformed.) The rocks are extracted from quarries, they are ground, cut into slabs, polished, possible irregularities are eliminated, stored, and finally transported to a transforming plant. Toxicity is the property of materials to produce negative effects on living organisms.

They can be classified into two large groups:

- **Natural stones:** These are used without hardly being transformed after they have been extracted from quarries. They can be subclassified into igneous, sedimentary, or metamorphic.
- **Processed stones:** These are obtained from natural stones. Stone materials can be subclassified into ceramic, binding, and conglomerating.



Stone materials.

Plastics

Plastics are obtained from resources such as petroleum, natural gas, or coal. They are extracted from raw material, they undergo a chemical process of polymerization, they are enriched with additives, and then they are shaped.

They can be classified into three large groups:

- **Thermosetting plastics:** They don't soften or deform with the effects of heat.
- **Thermoplastics:** They soften and deform when heated, and they harden when they get cold.

- **Elastomers:** They deform under stress and they recover their original shape when the force is withdrawn.

Materials can be classified in many different ways and this is not the only one. We can classify them according to their origin (natural or manufactured; animals, vegetable, or mineral; etc.), according to their composition (elements or compounds, metals or non-metals, organic or inorganic, etc.), according to their properties (tough or brittle, conductive or insulating, recyclable or nonrecyclable, etc.). In this chapter we have dealt with materials you are most definitely familiar with!



Plastics.

