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Introduction

Construction material science is the engineering object that involved with the use of construction materials in constructing buildings in a way that achieve the strength, economy, safety and durability. This science also search a new suitable materials to be used in building construction.

Building materials have an important role to play in this modern age of technology. Although their most important use is in construction activities, no field of engineering is conceivable without their use. Also, the building materials industry is an important contributor in our national economy as its output governs both the rate and the quality of construction work.

There are certain general factors which affect the choice of materials for a particular scheme. Perhaps the most important of these is the climatic background. Obviously, different materials and forms of construction have developed in different parts of the world as a result of climatic differences. Another factor is the economic aspect of the choice of materials. The rapid advance of constructional methods, the increasing introduction of mechanical tools and plants, and changes in the organization of the building industry may appreciably influence the choice of materials.

Reference books

1- Building Materials (Third Revised Edition), S. K. Duggal.
2- A Text Book of Building Materials, C.J. Kulkarrni.
3- Building Materials, P. C. Varghese, PHI, Pvt. Ltd.
4- Building Construction, P. C. Varghese, PHI, Pvt. Ltd.

Engineering materials

Structure of engineering materials

As engineers we are primarily concerned with the properties of materials at the macrostructural level, but in order to understand these properties and to modify them to our advantage, we need an understanding of the structure of materials at the atomic level through bonding forces, molecules and molecular arrangement.

Atoms, the building block of elements, consist of a nucleus surrounded by a cloud of orbiting electrons. The nucleus consists of positively charged protons and neutral neutrons, and so has a net positive charge that holds the negatively charged electrons, which revolve around it, in position by an electrostatic attraction. The charges on the proton and electron are equal and opposite (1.602×10^{-19} coulombs) and the number of electrons and protons are equal and so the atom overall is electrically neutral.

Protons and neutrons have approximately the same mass, 1.67×10^{-27} kg, whereas an electron has a mass of 9.11×10^{-31} kg, nearly 2000 times less. These relative densities mean that the size of the nucleus is very small compared to the size of the atom. Although the nature of the electron cloud makes it difficult to define the size of atoms precisely, helium has the smallest atom, with a radius of about 0.03 nanometers, while caesium has one of the largest, with a radius of about 0.3 nanometers.

Types of bonding

A significant feature of the structure of atom is the number of electrons in the outermost shell. These are called valence electrons. They are important in determine the ability of an atom to bond with other atoms.

1. Covalent Bonding:

Some times, an atom will share valence electrons with a neighboring atom in order to satisfy such a stable configuration. This sharing of electrons produces very strong attractive forces between the atoms and is termed Covalent bonding as shown in Fig.1.

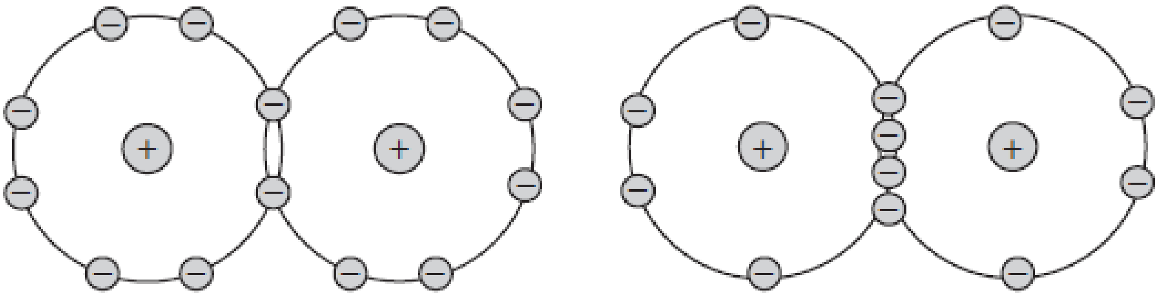

Figure (1) Covalent bonding.

2. Ionic Bonding:

This type of atomic bonding results from mutual attraction of positive (+) and negative (-) charges. It depends on the ability of the atoms to gain or lose electrons. If an electron is removed from the outer shell, the atom becomes positively charge (electropositive). When an electron is added to outer shell, the atom becomes negatively charge (electronegative).

An atom which has lost or gained an electron is called ion and the atoms are said to ionized. Electropositive and electronegative ions attract each other and ionic bond is established between them.

The negative charged ion is now attracted to a positive ion, thus, forming the basic for ionic bonding. Both types of ions have achieved a more stable electron configuration by the transfer of valence electrons, and in so doing, they have been mutually attracted. Compound that format ionic bonds include NaCl , $CaCl_2$, Al_2O_3 and MgO. The ionic bond for typical compound is show in Fig.2 below:

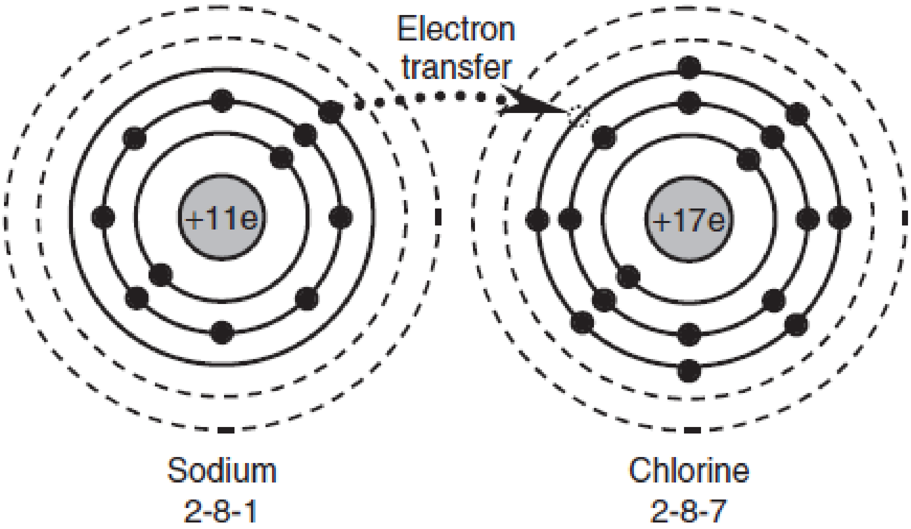

Figure (2) Ionic bonding.

3. Metallic bond:

The covalent or ionic bonds are almost exclusively found in non metallic materials. Unlike the covalent or ionic bonds, the metallic bond can not exist simply between a few atoms, it is found only where there are a large number of atoms in close approximately. In a piece of metal, the valence electrons of all. The atoms are shared mutually in complex system. The metallic bond in crystals is shown in Fig.3 below:

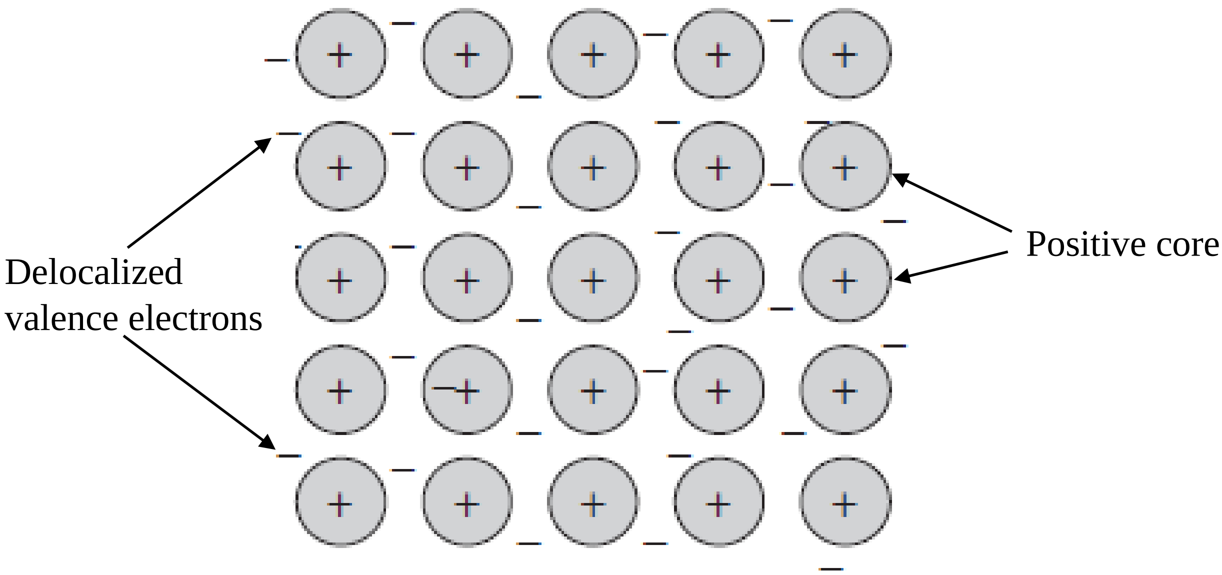

Figure (3) The free electron system in the metallic bond in a monovalent metal.

The combination of positively charged cores and the surrounding electron cloud or gas produces the attractive forces of the metallic bond. The detached valence electrons or electron cloud are responsible for such metallic characteristics as:

1. High thermal conductivity
2. High electrical conductivity
3. Opaqueness to light

4. Van der Waal's Forces:

Van der Waal's inter atomic attraction is relatively week, and therefore is not considered extremely important with respect to engineering materials. However, sometimes, Van der Waal's forces are the only that operate between atoms.

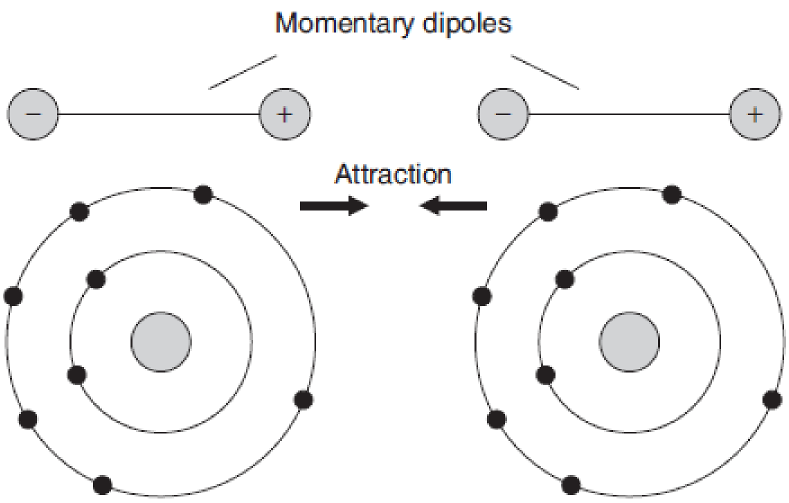

Figure (4) Weak Van der Waals linkage between atoms due to fluctuating electrons fields.

Classification of engineering materials

Almost every substance known to man has found its way into the engineering workshop at some time or other. The most convenient way to study the properties and uses of engineering materials is to classify them into 'families' as shown in figure below:

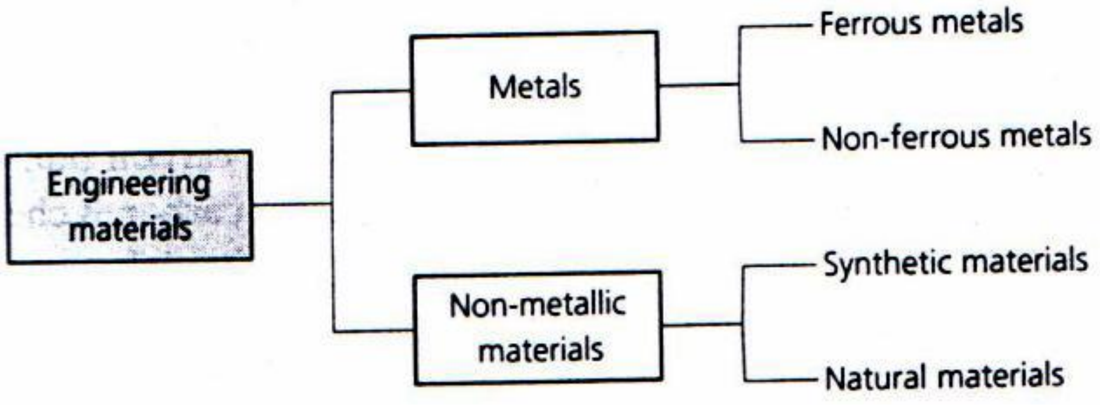

Figure (5) Classification of engineering materials.

Metals

1.1 Ferrous metals

1. These are metals and alloys containing a high proportion of the element iron.
2. They are the strongest materials available and are used for applications where high strength is required at relatively low cost and where weight is not of primary importance.
3. As an example of ferrous metals such as : bridge building, the structure of large buildings, railway lines, locomotives and highly stressed engine parts of road vehicles.

The ferrous metals themselves can also be classified into "families', and these are shown in figure 6.

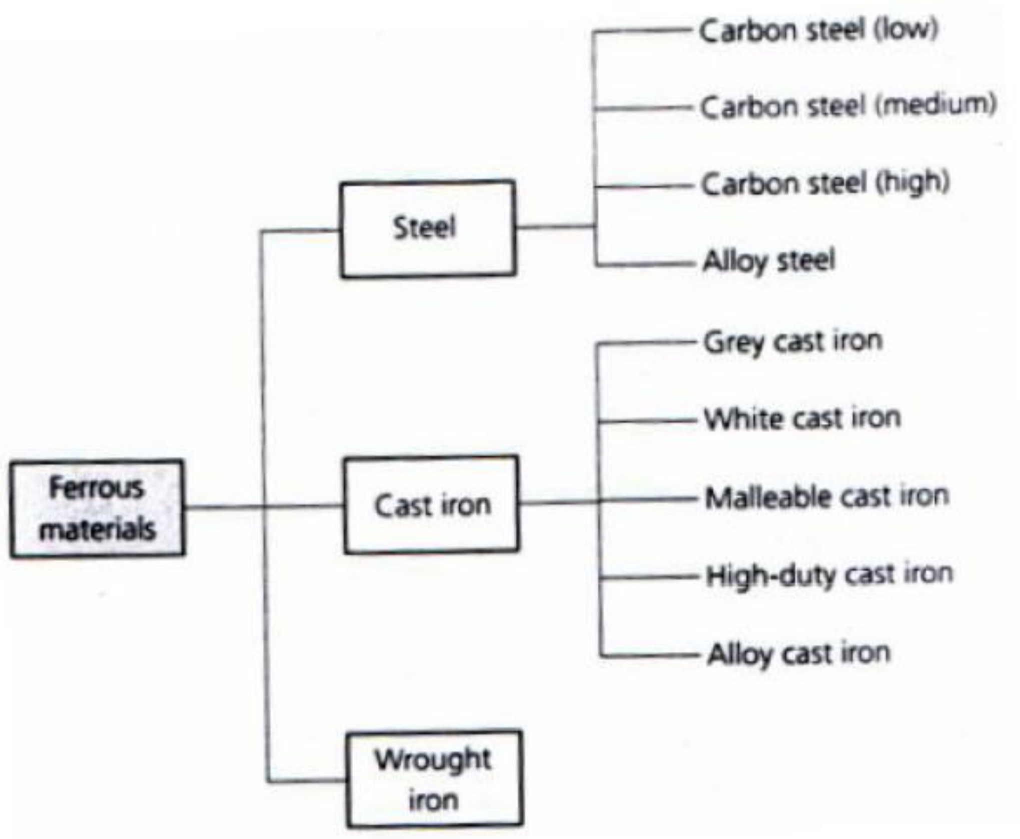

Figure (6) Classification of ferrous metals

1.2 Non – ferrous metals

1. These materials refer to the remaining metals known to mankind.
2. The pure metals are rarely used as structural materials as they lack mechanical strength.
3. They are used where their special properties such as corrosion resistance, electrical conductivity and thermal conductivity are required. Copper and aluminum are used as electrical conductors and, together with sheet zinc and sheet lead, are use as roofing materials.
4. They are mainly used with other metals to improve their strength.

Some widely used non-ferrous metals and alloys are classified as shown in figure 7.

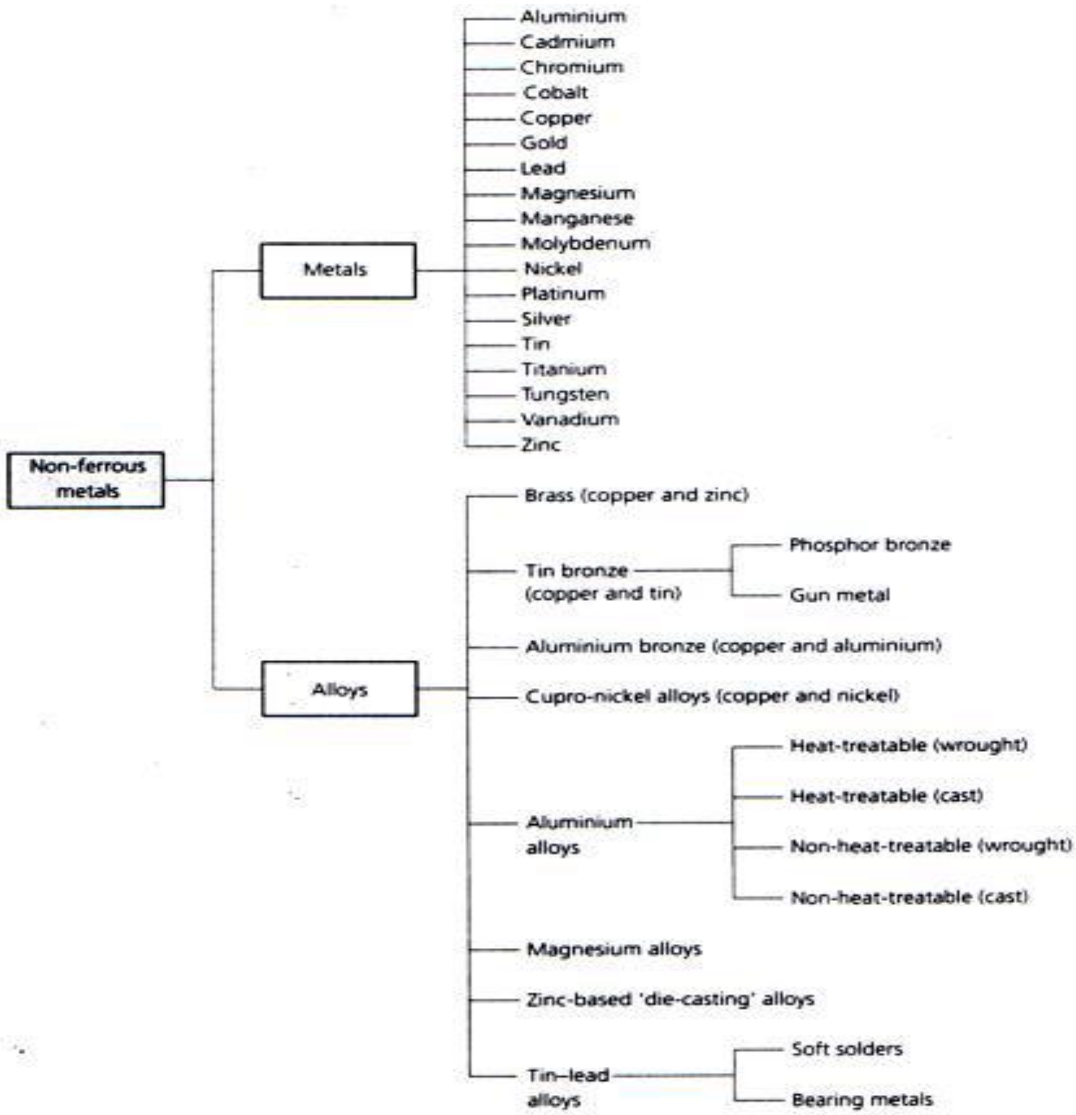

Figure (7) Classification of non-ferrous metals

2. Non – metallic materials

2.1 Non – metallic (synthetic materials)

These are non – metallic materials that do not exist in nature, although they are manufactured from natural substances such as oil, coal and clay. Some typical examples are classified as shown in figure 8.

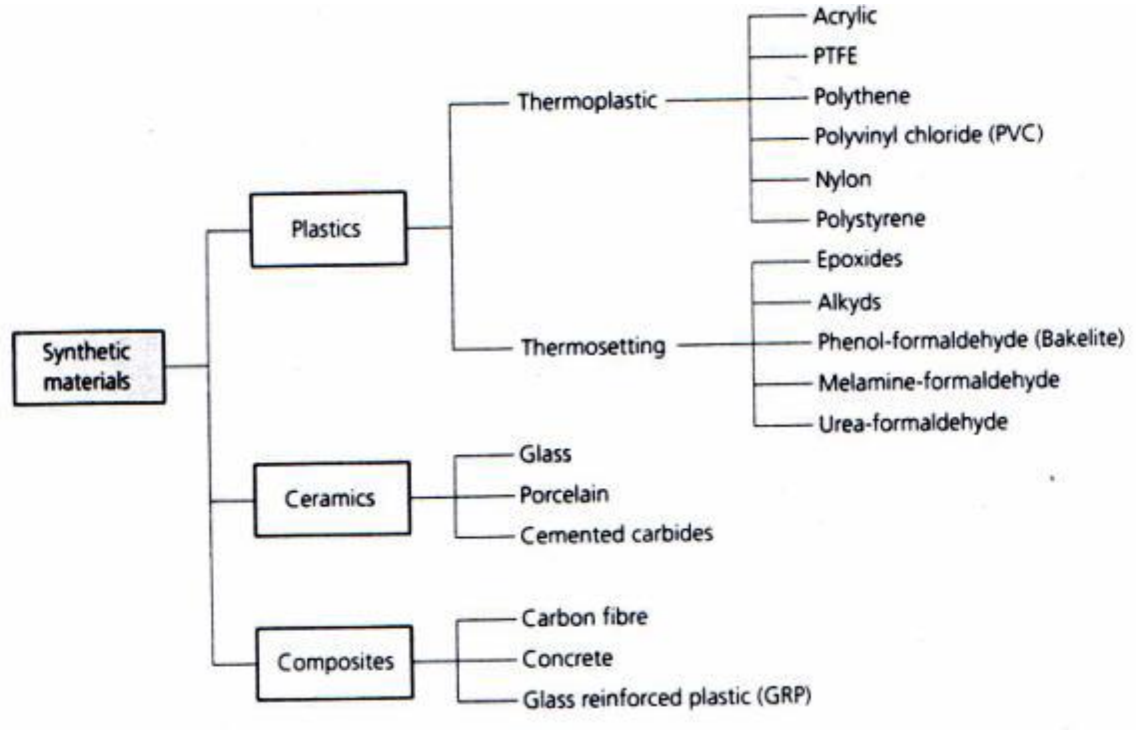

Figure (8) Classification of synthetic materials

They combine good corrosion resistance with ease of manufacture by moulding to shape and relatively low cost. These synthetic materials such as:

1. **Glass** : This is a hardwearing, abrasion-resistant material with excellent weathering properties. It is used for electrical insulators, laboratory equipment, in the form of fibers, is used to reinforce plastics. It is made by melting together the naturally occurring materials : silica (sand), limestone (calcium carbonate) and soda (sodium carbonate).
2. **Ceramic**: These are produced by baking naturally occurring clays at high temperatures after moulding to shape. They are used for high – voltage insulators and high – temperature – resistant cutting tool tips.

Non – metallic (Natural materials)

Such materials are so diverse that only a few can be listed here to give a basic introduction to some typical applications.

1. **Wood**: This is naturally occurring fibrous composite material used for the manufacture of casting patterns.
2. **Rubber** :This is used for hydraulic and compressed air hoses and oil seals. Naturally occurring latex is too soft for most engineering uses but it is used widely for vehicle tyres when it is compounded with carbon black.
3. **Diamonds**: These can be used for cutting tools for operation at high speeds for metal finishing where surface finish is greater importance. For example, internal combustion engine pistons and bearings. They are also used for dressing grinding wheels.
4. **Oils** : Used as bearing lubricants, cutting fluids and fuels.
5. **Silicon** : This is used as an alloying element and also for the manufacture of semiconductor devices.

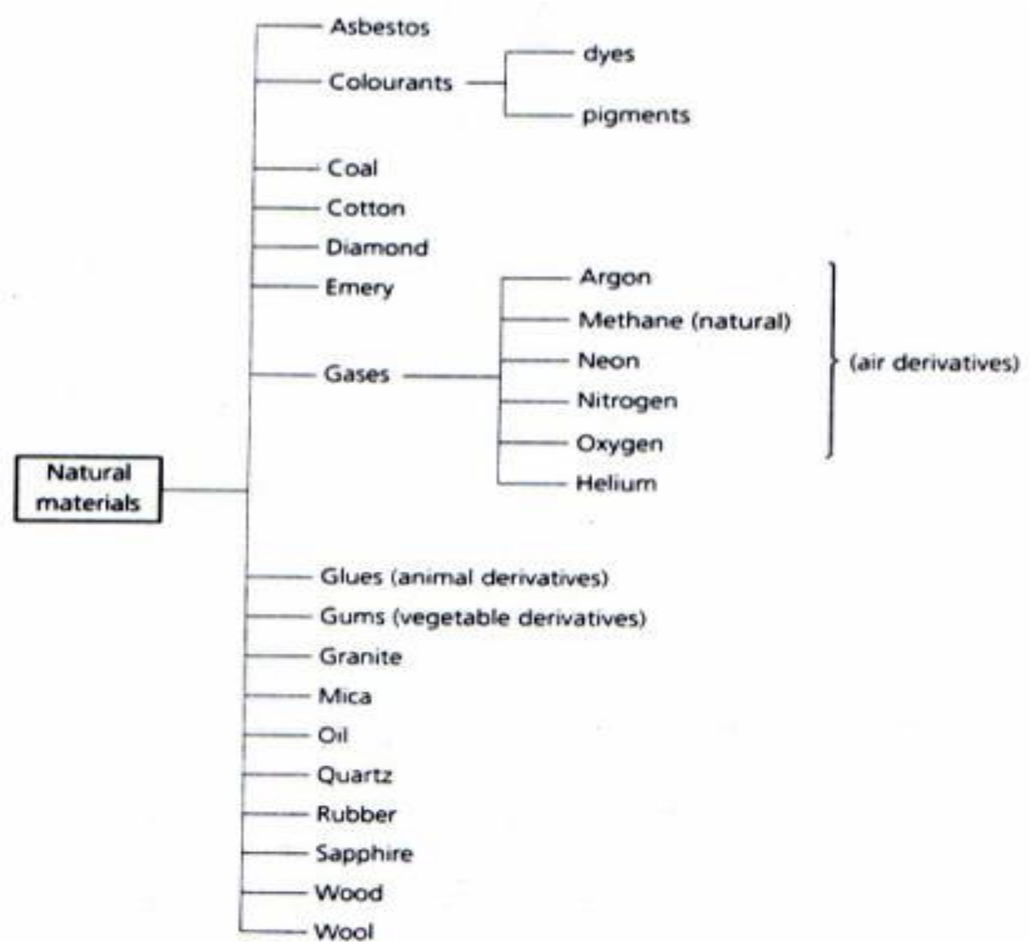

Figure (9) Classification of natural materials

Factors affecting materials properties:

The following are the more important factors which can be influence the properties and performance of engineering materials.

1. Heat treatment

This is the controlled heating and cooling of metals to change their properties to improve their performance or to facilitate processing.
An example of heat treatment is the hardening of a piece of high carbon steel rod. If it is heated to dull red heat and plunged into cold water to cool it rapidly (quenching), it will become hard and brittle. If it is again heated to dull red heat but allowed to cold ***very slowly*** it will become softer and less brittle (more tough). In this condition it is said to be ***annealed*.**

After the heat treatment happened on the material it will be in its best condition for flow forming, during flow forming (working) the grains will be distorted and this will result in most metals becoming ***work hardened*** if flow formed at room temperature. To remove any locked in stresses resulting from the forming operations and to prepare the material for machining, the material has to be ***normalized*.**

2. Processing

Hot –and cold working process will be referred to understand what is meant by terms hot and cold working as applied to metals. Figure 10 shows examples of hot and cold working.

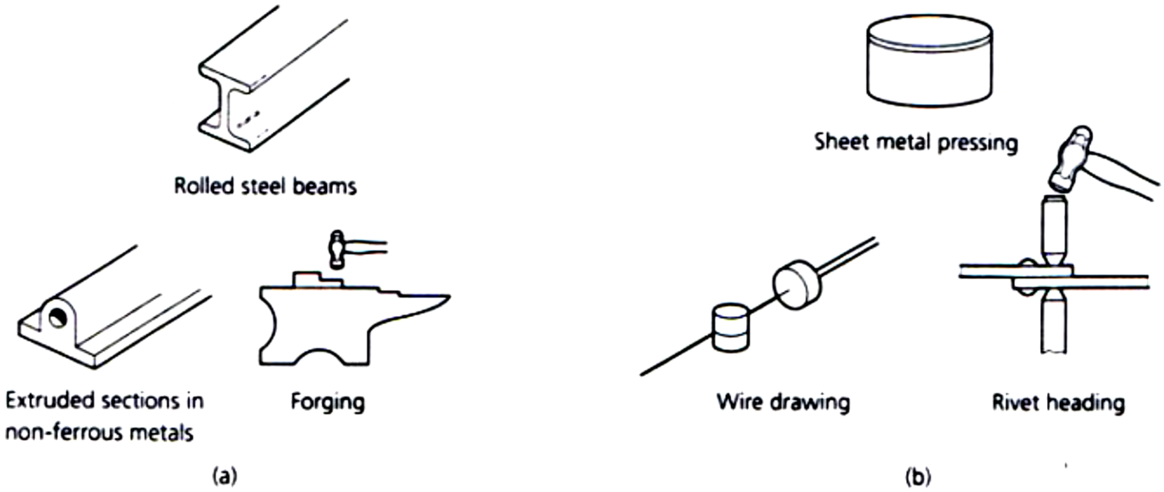

Figure (10) Examples of (a) hot-working and (b) cold-working process.

3. Environmental reactions

The properties of materials can also be effected by reaction with environment in which they are used. For example:

Resting of steel

Unless steel structures are regularly maintained by rest neutralization and painting process, resting will occur. The rest will eat into the steel, reduce its thickness and, therefore, its strength.

Dezincification of brass

Brass is an alloy of copper and zinc and when brass is exposed to a **marine** environment for long time, the salt in the sea water pray react with the zinc content of the brass so as remove it and leave it behind on spongy, porous mass of copper. This obviously weakness the material which fails under normal working conditions.

Degradation of plastic

Many plastic degrade and become weak and brittle when exposed to the ultraviolet content of sunlight.