

ANALYSIS OF MATERIALS

2. MATERIALS II

2.1. Metallic Materials

About three quarters of the elements available can be classified as metals, and about half of these are of at least some industrial or commercial importance. Although the word metal, by strict definition, is limited to the pure metal elements, common usage gives it wider scope to include metal alloys. Although pure metallic elements have a broad range of properties, they are quite limited in commercial use. Metal alloys, which are combinations of two or more elements, are far more versatile and for this reason are the form in which most metals are used by industry.

Metallic materials are crystalline solids. Individual crystals are composed of unit cells repeated in a regular pattern to form a three-dimensional crystal-lattice structure. A piece of metal is an aggregate of many thousands of interlocking crystals (grains) immersed in a cloud of negative-valence electrons detached from the atoms of the crystals. These loose electrons serve to hold the crystal structures together because of their electrostatic attraction to the positively charged metal atoms (ions). The bonding forces, which are large because of the close-packed nature of metallic crystal structures, account for the generally good mechanical properties of metals. Also, the electron cloud makes most metals good conductors of heat and electricity. Metals are often identified as to the method used to produce the forms in which they are used. When a metal has been formed or shaped in the solid, plastic state, it is referred to as a wrought metal. Metal shapes that have been produced by pouring liquid metal into a mold are referred to as cast metals.

There are two families of metallic materials ferrous and nonferrous. The basic ingredient of all ferrous metals is the element iron. These metals range from cast irons and carbon steels, with over 90% iron, to specialty iron alloys, containing a variety of other elements that add up to nearly half the total composition. Except for commercially pure iron, all ferrous materials, both irons and steels, are considered to be primarily iron-carbon alloy systems. Although the carbon content is small (less than 1% in steel and not more 4% in cast irons) and often less than other alloying elements, it nevertheless is the predominant factor in the

development and control of most mechanical properties. By definition, metallic materials that do not have iron as their major ingredient are considered to be nonferrous metals. There are roughly a dozen nonferrous metals in relatively wide industrial use. At the top of the list is aluminum, which next to steel is the most widely used structural metal today. It and magnesium, titanium, and beryllium are often characterized as light metals because their density is considerably below that of steel.

2.2. Plastic Materials

A plastic material is any of a wide range of synthetic or semi-synthetic organic solids that are moldable. Plastics are typically organic polymers of high molecular mass, but they often contain other substances. They are usually synthetic, most commonly derived from petrochemicals, but many are partially natural. Plastics are usually classified by their chemical structure of the polymer's backbone and side chains. Some important groups in these classifications are the acrylics, polyesters, silicones, polyurethanes, and halogenated plastics. Plastics can also be classified by the chemical process used in their synthesis, such as condensation, polyaddition, and cross-linking. There are two types of plastics: thermoplastics and thermosetting polymers. Thermoplastics are the plastics that do not undergo chemical change in their composition when heated and can be molded again and again. Examples include polyethylene, polypropylene, polystyrene and polyvinyl chloride. Common thermoplastics range from 20,000 to 500,000 amu, while thermosets are assumed to have infinite molecular weight. These chains are made up of many repeating molecular units, known as repeat units, derived from monomers; each polymer chain will have several thousand repeating units.

Thermosets can melt and take shape once; after they have solidified, they stay solid. In the thermosetting process, a chemical reaction occurs that is irreversible. The vulcanization of rubber is a thermosetting process. Before heating with sulfur, the polyisoprene is a tacky, slightly runny material, but after vulcanization the product is rigid and non-tacky.

2.3. Stone Materials

Rock structures have existed for as long as history can recall. It is the longest lasting building material available, and is usually readily available. There are many types of rock throughout the world, all with differing attributes that make them

better or worse for particular uses. Rock is a very dense material so it gives a lot of protection too; its main drawback as a material is its weight and awkwardness. Its energy density is also considered a big drawback, as stone is hard to keep warm without using large amounts of heating resources. Dry-stone walls have been built for as long as humans have put one stone on top of another. Eventually, different forms of mortar were used to hold the stones together, cement being the most commonplace now. The granite-strewn uplands of Dartmoor National Park, United Kingdom, for example, provided ample resources for early settlers. Circular huts were constructed from loose granite rocks throughout the Neolithic and early Bronze Age, and the remains of an estimated 5,000 can still be seen today. Granite continued to be used throughout the Medieval period and into modern times. Slate is another stone type, commonly used as roofing material in the United Kingdom and other parts of the world where it is found.

Stone buildings can be seen in most major cities; some civilizations built entirely with stone such as the Egyptian and Aztec pyramids and the structures of the Inca civilization. With examples dating back to the enormous prehistoric statues of Easter Island, many types of stone have been employed over the centuries in sculpture. Some of these stones yield more readily to the sculptor's chisel (such as limestone, marble, and soapstone), while others, such as granite, are more difficult to carve but have proved more durable over time. Although seldom used to form entire structures, stone is greatly valued for its aesthetic appeal, durability, and ease of maintenance. The most popular types include granite, limestone, sandstone, marble, slate, gneiss, and serpentine. All natural stone used for structural support, curtain walls, veneer, floor tile, roofing, or strictly ornamental purposes is called building stone, and building.

2.4. Polymeric Materials

A polymer is a large molecule, or macromolecule, composed of many repeated subunits. Because of their broad range of properties, both synthetic and natural polymers play an essential and ubiquitous role in everyday life. Polymers range from familiar synthetic plastics such as polystyrene to natural biopolymers such as DNA and proteins that are fundamental to biological structure and function. Polymers, both natural and synthetic, are created via polymerization of many small molecules, known as monomers. Their consequently large molecular mass relative to small molecule compounds produces unique physical properties, including toughness, viscoelasticity, and a tendency to form glasses and semi-crystalline structures rather than crystals.

The term "polymer" derives from the ancient Greek word πολύς (*polus*, meaning "many, much") and μέρος (*meros*, meaning "parts"), and refers to a molecule whose structure is composed of multiple repeating units, from which originates a characteristic of high relative molecular mass and attendant properties. The units composing polymers derive, actually or conceptually, from molecules of low relative molecular mass. The term was coined in 1833 by Jöns Jacob Berzelius, though with a definition distinct from the modern IUPAC definition. The modern concept of polymers as covalently bonded macromolecular structures was proposed in 1920 by Hermann Staudinger, who spent the next decade finding experimental evidence for this hypothesis.

Polymers are studied in the fields of biophysics and macromolecular science, and polymer science (which includes polymer chemistry and polymer physics). Historically, products arising from the linkage of repeating units by covalent chemical bonds have been the primary focus of polymer science; emerging important areas of the science now focus on non-covalent links. Polyisoprene of latex rubber and the polystyrene of styrofoam are examples of polymeric natural/biological and synthetic polymers, respectively. In biological contexts, essentially all biological macromolecules i.e., proteins (polyamides), nucleic acids (polynucleotides), and polysaccharides are purely polymeric, or are composed in large part of polymeric components e.g., isoprenylated/lipid-modified glycoproteins, where small lipidic molecule and oligosaccharide modifications occur on the polyamide backbone of the protein.

2.5. Wood

Wood is a hard, fibrous structural tissue found in the stems and roots of trees and other woody plants. It has been used for thousands of years for both fuel and as a construction material. It is an organic material, a natural composite of cellulose fibers (which are strong in tension) embedded in a matrix of lignin which resists compression. Wood is sometimes defined as only the secondary xylem in the stems of trees, or it is defined more broadly to include the same type of tissue elsewhere such as in the roots of trees or shrubs. In a living tree it performs a support function, enabling woody plants to grow large or to stand up by themselves. It also mediates the transfer of water and nutrients to the leaves and other growing tissues. Wood may also refer to other plant materials with comparable properties, and to material engineered from wood, or wood chips or fiber.

The Earth contains about one trillion tons of wood, which grows at a rate of 10 billion tons per year. As an abundant, carbon-neutral renewable resource, woody materials have been of intense interest as a source of renewable energy. In 1991, approximately 3.5 billion cubic meters of wood were harvested. Dominant uses were for furniture and building construction. A 2011 discovery in the Canadian province of New Brunswick uncovered the earliest known plants to have grown wood, approximately 395 to 400 million years ago. People have used wood for millennia for many purposes, primarily as a fuel or as a construction material for making houses, tools, weapons, furniture, packaging, artworks, and paper. Wood can be dated by carbon dating and in some species by dendrochronology to make inferences about when a wooden object was created. The year-to-year variation in tree-ring widths and isotopic abundances gives clues to the prevailing climate at that time.

2.6. Textile Fibers

A textile or cloth is a flexible woven material consisting of a network of natural or artificial fibers often referred to as thread or yarn. Yarn is produced by spinning raw fibers of wool, flax, cotton, or other material to produce long strands. Textiles are formed by weaving, knitting, crocheting, knotting, or pressing fibers together (felt). The words fabric and cloth are used in textile assembly trades (such as tailoring and dressmaking) as synonyms for textile. However, there are subtle differences in these terms in specialized usage. Textile refers to any material made of interlacing fibers. Fabric refers to any material made through weaving, knitting, spreading, crocheting, or bonding that may be used in production of further goods (garments, etc.). Cloth may be used synonymously with fabric but often refers to a finished piece of fabric used for a specific purpose (e.g., table cloth).

The discovery of dyed flax fibers in a cave in the Republic of Georgia dated to 34,000 BCE suggests textile-like materials were made even in prehistoric times. The production of textiles is a craft whose speed and scale of production has been altered almost beyond recognition by industrialization and the introduction of modern manufacturing techniques. However, for the main types of textiles, plain weave, twill, or satin weave, there is little difference between the ancient and modern methods. Textiles have an assortment of uses, the most common of which are for clothing and for containers such as bags and baskets. In the household they are used in carpeting, upholstered furnishings, window shades, towels, coverings for tables, beds, and other flat surfaces, and in art. In the workplace they are used in industrial and scientific processes such as filtering. Miscellaneous uses include

flags, backpacks, tents, nets, handkerchiefs, cleaning rags, transportation devices such as balloons, kites, sails, and parachutes; textiles are also used to provide strengthening in composite materials such as fiberglass and industrial geotextiles. Using textiles, children can learn to sew and quilt and to make collages and toys.

Textiles used for industrial purposes, and chosen for characteristics other than their appearance, are commonly referred to as technical textiles. Technical textiles include textile structures for automotive applications, medical textiles (e.g. implants), geotextiles (reinforcement of embankments), agrotextiles (textiles for crop protection), protective clothing (e.g. against heat and radiation for fire fighter clothing, against molten metals for welders, stab protection, and bullet proof vests). In all these applications stringent performance requirements must be met. Woven of threads coated with zinc oxide nanowires, laboratory fabric has been shown capable of "self-powering nanosystems" using vibrations created by everyday actions like wind or body movements.