Materials

THE PROCESS of manufacturing can involve the use of various materials. Those materials are chosen for the properties they possess and based on their cost. How these materials are shaped and formed into the objects they become depends on the properties the materials possess and the functions they perform. All of these factors contribute to the manufacturing process.

Objective:

Identify various uses and qualities of common materials in the manufacturing process.

Key Terms:

alloy
aluminum
bronze
casting
conductivity
copper
ferrous metals
friction
hardwoods
insulator
iron
lead
malleable
metals
nanotechnology
non-ferrous metals
nylon
pewter
plastics
plywood
polystyrene
PVC
rubber
softwoods
stainless steel
steel
synthetics
tin
wood

Common Materials Used in the Manufacturing Process

The manufacturing process involves various materials used for specific purposes based on their useful qualities and characteristics. Various materials are used in manufacturing. Three major categories are metals, plastics, and woods.

METALS

Metals are a set of unique elements that contain many similar properties. Most metals are good conductors of heat and electricity. In addition, they generally appear to have a shiny coating. Metals have the ability to be formed into different shapes. Also, they can be divided into two major categories: ferrous and non-ferrous.

Ferrous Metals

Ferrous metals are metals that contain iron within their composition. In general, ferrous metals are magnetic. However, some rare exceptions of ferrous metals are non-magnetic. Also, in the presence of air and moisture, they will form a layer of rust and will eventually lose their solid structure.

Iron

Iron is a ferrous metal with many uses in the manufacturing process and is characterized by its ability to be casted. **Casting** is a process by which a metal is taken in a liquid state, poured into a mold, and allowed to harden into the shape needed. Iron has a low weight-to-strength ratio. Therefore, iron is very strong, but it is also heavy in relation to the strength supplied.

Steel

Steel is a type of metal known as an alloy. An **alloy** is a metal that is a combination (mixture) of two or more elements. Steel is mostly iron, with carbon mixed in at varying amounts. It is formed into objects in the same way as iron—casted. Depending on the process and the amounts of carbon added, steel can be made with many unique attributes. Stainless steel is popular. **Stainless steel** is a type of steel that is very resistant to rust and is non-magnetic (even though it is ferrous). Steel generally has a higher strength-to-weight ratio than iron. There is greater strength in steel while using less weight. For this reason, it is a widely used construction material.

Non–Ferrous Metals

Non-ferrous metals are those metals that do not contain iron within their makeup. In general, non-ferrous metals are non-magnetic. Additionally, non-ferrous metals are rust-resis-

tant and have very high strength-to-weight properties. (They are strong while generally weighing less than their ferrous counterparts.)

Aluminum

Aluminum is a non-ferrous metal characterized by its high resistance to rust, extreme pliability (flexible), and high melting point. Aluminum is also non-magnetic. It can be rolled into very thin and flexible sheets and can be easily recycled. Also, it can be shaped into almost any form without having to be casted (melted down). Because of its flexibility, aluminum is one of the most widely used metals in manufacturing. It is a good conductor of electricity, too.

Copper

Copper also has many uses in the manufacturing industry. **Copper** is a non-ferrous metal that is golden brown, has good pliability (in lower thicknesses), is very resistant to corrosion, and has excellent electrical conductivity. **Conductivity** is a measure of the ability for electricity to pass through a material.

Tin

Tin is a non-ferrous metal used and combined with other metals to form different alloys. Some examples of tin alloys are **bronze** (an alloy of tin and copper) and pewter. **Pewter** is an alloy formed of tin and lead. Tin is resistant to rusting. For this reason, tin is often used to coat iron and steel as a way to stop rusting and protect the strength of the coated metal. Also, tin is an important part of glass making. In the "Pilkington process," molten glass is poured on top of a pool of molten tin. The glass will float on top of the tin and produce very flat and uniform sections of glass as it cools. For this reason, almost all window glass is produced this way.

Lead

Lead is a non-ferrous metal that has characteristics of being heavy in weight when compared to its relative size. It is generally soft (non-rigid) when compared to its ferrous counterparts. Lead has a low melting point and is sometimes used in electrical components (lead-acid batteries). Its dense nature makes it a useful material for protection from radiation. Lead has many uses in the medical industry (as protection from radiation in x-rays, CT scanners, and more). Additionally, lead is used for balance in products that

FIGURE 1. Metals are being put through the casting process. Notice the high temperatures required.

BROADENING AWARENESS...

AMAZING ASPECTS: Facts About Steel

According to the American Iron and Steel Institute, the following facts concerning steel are a testament to its usefulness in the manufacturing process. More than half of all the types of steel used in today's automobiles did not exist 10 years ago. Almost 69 percent of all steel in North America is recycled each year. Steel-framed homes will not warp, crack, twist, rot, split, or settle. In addition, they are impervious to termites. Steel is continually being recycled and refined to make new and better products.

require added weight. Yet lead is poisonous to the human body and can cause many problems and diseases (and death in high quantities). For this reason, lead has been banned from use in many products (e.g., paint) that once contained it.

TABLE 1. Types of Metals with Properties and Uses

Metal	Alloy	Properties	Common Uses
Iron	No	Magnetic, will rust, high melting point, very strong but with great weight	Construction and support beams
Steel	Yes	Malleable, high melting point, generally magnetic (except stainless steel), resistant to rust, great strength but with lower weight	Construction and manufacturing automobiles, roofing, steel beams, and ship building
Tin	No	Malleable, will not rust, medium melting point when compared to iron and steel	Used in manufacturing of glass (especially windows), used to coat ferrous metals to prevent rusting, and used as a solder of electrical connections
Lead	No	Very dense, excellent for protection from radiation, very malleable, low melting point, non-magnetic	Shielding for medical devices, counterweights, and ballistics
Copper	No	Excellent conductor, non-magnetic, malleable, will not rust	Wiring, water lines, and decorative adornment
Aluminum	No	Non-magnetic, lightweight, very malleable, high melting point, will not rust, great strength with low weight, good conductor	Manufacturing, cans, automobiles, and computers

PLASTICS

Plastics are a group of synthetic materials. **Synthetics** are items formed from other elements and materials. Most plastics are made from crude oil separated into its basic parts. However, some groups of plastics are made from organic materials (e.g., corn and soybeans). Plastics are a widely used material group. They are valued for their low production costs, ease in their ability to be formed, and their high strength-to-weight ratio. As a result, plastics are one of the most widely used materials.

FIGURE 2. Plastics blanks are being prepared to be used to manufacture bottles at a plant.

PVC

PVC (Poly Vinyl Chloride) is a widely used plastic with unique properties that make it resistant to heat and water. Also, it is very strong (in terms of stiffness). PVC can be softened with chemicals. For this reason, it is widely used in plumbing (as it can be joined like metal pipes and is resistant to water). Additionally, it is widely used as coverings for electronics because of its heat resistance. Lastly, the water resistance of PVC makes it useful in the process of shrink-wrapping and in the making of waterproof and water-resistant clothing.

Nylon

Nylon is a type of flexible plastic used in many aspects of manufacturing. Because of its extreme flexibility, it is used to make everything from toothbrush bristles to stockings. Nylon is unique in its ability to absorb and hold oil. Once it absorbs oil, it becomes wear resistant. So it is used in manufacturing gears, bearings, and other components found in machines with moving parts. Nylon has heat-resistance properties, and its uses can be found in cars and other machines that produce heat with moving parts.

Rubber

Rubber is a plastic that comes in two types: natural and synthetic. Both types have similar characteristics that make it a useful material in manufacturing. One of its primary qualities is its resistance to electricity. For this reason, rubber is used as an insulator. An **insulator** is a material that prevents electricity from passing through something. Additionally, rubber is flexible and has excellent friction properties. **Friction** is the ability (or tendency) of a material to

stick or grab onto another material. Rubber is used as the primary material in making tires, insulating electrical wiring, and providing waterproofing for materials exposed to water.

Polystyrene

Polystyrene is a type of plastic commonly used to make many inexpensive and lightweight products. It generally comes in two forms. In its porous form, many people refer to it as Styrofoam. In its non-porous form, it is called "plastic." Because of its ability to be produced in these two forms, it has a wide range of uses, such as packing materials (porous variety) and model cars (solid form).

TABLE 2. Types of Plastics with Definitions, Properties, and Uses

Plastic	Definition	Properties	Common Uses
PVC	Poly vinyl chloride is a plastic commonly used in construction and manufacturing.	It is waterproof, can be rigid and flexible, and is a good insulator (for heat and electricity).	It is used for plumbing supplies, clothing, electrical cable coverings, and inflatable products.
Nylon	Nylon is an extremely flexible plastic used in many aspects of manufacturing.	It is very flexible and stretchable, can absorb oil, is wear resistant (when oil is absorbed), is heat and water resistant, and melts instead of burning.	It is used for clothing, moving parts (gears and cogs), and tires.
Rubber	Rubber is a type of plastic that can be manufactured from natural and synthetic sources.	It is malleable, has a high coefficient of friction, and has good insulation properties (electricity).	It is used for car tires, wire insulation, clothing (rain gear), and hoses.
Polystyrene	Polystyrene is a type of plastic commonly used to make many inexpensive and lightweight products.	It can be rigid and flexible; it melts easily; it can be colored or transparent; and it has good insulation properties (electricity).	It is used for plastic models, packaging (e.g., bottles, cases, and wraps), and window panes.

WOOD

Wood is a hard, fibrous substance that forms the greatest part of the stems and branches of trees and shrubs. It is a renewable material. In addition, wood has many aesthetic qualities (e.g., the closeness of its grain, its hue and color, and its fragrance) that make it a desirable material for manufacturing. Many woods have additional properties, such as resistance to water, insects, and rot. In working with wood, a person must consider it is a natural product that can be affected by insects, the weather, and disease. Knowing a distinct wood's characteris-

tics allow for it to be manipulated in ways that make it useful in manufacturing. The ability to stain, cut, shape, and combine wood with other materials make it a good manufacturing material.

Hardwoods and Softwoods

Trees from which wood is obtained are classified as hardwoods or softwoods. **Hardwoods** are woods from trees with broad leaves. **Softwoods** (conifers) are woods from trees with needle-like leaves or scale leaves. No degree of hardness divides the hardwoods from the softwoods. Some hardwoods are soft, and some softwoods are hard.

Hardwood trees include oak, maple, beech, ash, cherry, and mahogany. Many hardwoods have natural resistance to water (e.g., Osage orange). Wood is used in the construction of products for every facet of life. For instance, wood can be cut into various sizes and worked into many shapes, as well as stained or painted to match just about any color. Hardwoods, such as oak, have nice grain patterns that many people find aesthetically pleasing. Therefore, hardwoods often are used for manufacturing.

Softwood trees include pine, firs, and spruce. Like hardwoods, softwoods are used in various aspects of production and construction. They can be used in decorative carvings as well as supporting timbers for large-scale construction. Some softwoods (e.g., cedar) are excellent in their ability to resist water and to repel insects. For these reasons, cedar is a sought-after wood for making fences and for ship building. In addition, its fragrant aroma often makes it a popular choice for clothing chests and for lining closets.

Plywood

Aside from the solid pieces of wood, the scraps leftover from the cutting and shaping process are reused to make other wood-based materials. One of these materials is plywood. **Plywood** is wood material formed into flat sheets that come in varying thicknesses and a variety of forms. These forms indicate how the plywood was produced. Examples are medium-density fiber board (MDF), hard board, and particleboard. In general, plywood is made from parts of other pieces of wood bonded together with pressure and glue. These processes provide for minimal material waste when wood is being cut and processed at factories. As an example, as wood is being cut into boards for construction, the sawdust from the cut pieces will be gathered and combined with glue, pressed, and formed into fiber and particleboard sheets. Many types

FIGURE 3. This wood is being shaped for use in furniture manufacturing.

of plywood have special chemicals and glues added to them that make them resistant to rot, decay, insects, and water.

TABLE 3. Types of Wood, Properties, and Uses

Wood	Properties	Common Uses
Pine	It is easily cut and nailed, relatively lightweight, and plentiful.	It is used as construction timbers and for furniture framing.
Cedar	It is aromatic (smells nice), has nice grain patterns, and is water and insect resistant.	It is used as closet liners, for storage chests, and in housing shingles.
Spruce	It is lightweight and can be warped easily (made flexible).	It is used for musical instruments, airplanes, and construction.
Oak	It is very dense, comes in varieties (white and red), has excellent grain patterns, and can be stained a variety of colors.	It is used for fine furniture, flooring, cabinets, and decorative applications.

VARIOUS USES OF METAL

Common materials used in the manufacturing process serve different purposes because of the qualities of the materials. Because of many properties (e.g., conductivity, strength, and pliability), metal is a material used in the manufacture of almost everything.

Strength

One of the greatest assets that metal provides to manufactured items is strength. Metal is typically very dense in its makeup. For this reason, it can provide great strength to objects that need to support great weight or resist considerable forces. Metal is used in the construction and support of massive bridges, skyscrapers, and cargo ships, as well as the production of small gears and cams that can be classified as nanotechnology. **Nanotechnology** is the science and technology of devices and materials constructed on extremely small scales—too small to be seen by the naked eye. Nanomachines and parts are part of the current and future wave of

ON THE JOB...

CAREER CONNECTION: Materials Engineer

According to the Bureau of Labor Statistics, a materials engineer earns a median income of $83,110 a year. A materials engineer helps develop, process, and test a wide range of materials used to create products. He or she may select and develop appropriate materials used in the manufacturing of products. A bachelor's degree is required. A graduate degree may increase an applicant's chances of being hired and/or promoted.

manufacturing. Depending upon the metal, great strength can be garnered with small amounts of material. However, for extremely heavy support, the use of iron and steel will dominate the manufactured materials because it provides the greatest durability and strength for the cost.

Conductors of Electricity

Most metals are very good conductors of electricity. For this reason, they are the primary material used in the production of items driven by electricity or that require electricity to pass through them. Some metals are better than others at providing this quality. So the choice of which metal to use in the manufacture of items that use electricity is something an engineer will carefully consider. As an example, in an automobile, the activation of the safety airbag has to be as close to failsafe as possible. Electricity is used to activate the airbag, so the use of metal to wire the airbag is essential. However, to make it safer, a metal that does not rust and that can be formed into very fine strands is used, such as gold. Gold is chosen because it will not rust, and it is very malleable. A substance that is **malleable** is capable of being shaped via pressure. Malleability reduces the amount needed, and there is almost no chance that the wiring will fail because of metal corrosion.

Pliability

Pliability (and malleability) is the ability of metal to be shaped into various forms and sizes. The quality of metal in these two areas gives it an advantage over most other materials. It is possible to add to metal. If a mistake is made in cutting or shaping something metal, more material can be added to the existing piece to make it meet the required specifications. Additionally, metal can be formed into its needed shapes using a variety of methods. Metal can be casted and poured into molds to form every shape imaginable. Metal can be plied by applying pressure to it. In this way, metal can be formed without the application of heat. Again, different metals have a variety of qualities and are applicable to various manufacturing situations.

Aluminum

Aluminum is very strong and very pliable. For this reason, it is sometimes rolled out in thin sheets, and the sheets are formed into many objects used to contain items. On the other hand, iron is not very pliable, but it can be heated and poured into many shapes. It can have more material welded to it. This allows it to be used in large construction projects where the support of very heavy weights is required.

VARIOUS USES OF PLASTICS

Plastics are a synthetic material that can be developed for a variety of uses. Since plastics are created through a development process, new and better plastics are constantly being created. Plastics have many positive traits, but they have their limitations. Depending upon the process used to develop the plastic, a variety of traits may apply to their usage.

Poor Conductors of Electricity

Most plastics have a very low ability to let electricity pass through them. For that reason, they are used in the manufacturing process to encase and surround electrical parts. Whether it is to wrap and surround electrical wires or to provide a covering for exposed electrical components, plastic protects people and animals from electrical shock with its ability to inhibit the passage of electricity. Many plastics (e.g., PVC) have a high-resistance to the buildup of heat. For this reason, they are used to enclose devices that generate heat. This is a safety facet for humans who may touch the devices, and it allows for an engineer to design an efficient and inexpensive way to channel the heat out of the device. Lastly, plastics may have extreme resistance to water. So they may be used to shield electrical devices and to provide inexpensive conduits for plumbing fixtures.

Flexibility

Plastics have the ability to be formed into an infinite number of shapes. As a result, plastics are the most common material used in the manufacturing process. Although plastics can be molded into an infinite number of shapes, they have a weakness in that the ability to repair them is almost non-existent once they crack or break. Plastics are used in everything from gears to automobile bodies to large-scale construction projects.

VARIOUS USES OF WOOD

Wood is a natural material with many uses. Because of its many qualities, it can be applied to use in numerous situations. It is easy to work with and can be cut, shaped, and decorated easily. So it is one of the most prevalent materials. Wood has been used in the manufacture of everything from automobiles to large-scale construction projects.

Limited Conductivity

Wood does not conduct electricity (unless wet), so it can be combined with many other materials regardless of whether or not they carry electricity. This allows wood to be found in many manufacturing applications. Wood may be found being used as a material to house electrical components or as a framing component used to support electrical conduit and wiring. It is susceptible to heat, so it is not used in areas that generate high temperatures.

Easily Shaped

Wood can be shaped rather easily (using the correct tools). However, material cannot be added back on once it is cut off. As a result, precise planning is required when working with wood. Wood is diverse in its application. It can be cut so it is used for support in construction projects (as framing timbers), or it can be shaped using a lathe so it functions as a decorative piece. Furthermore, it can be stained and finished so it functions as purely an aesthetic adornment. Wood is used to floor buildings, manufacture chairs, and adorn car interiors. In addition,

it is used as equipment in sporting activities. The music industry relies heavily upon wood to make its products. Guitars and violins are excellent examples of the exceptional qualities that wood offers. The use of wood is only limited by the imagination. However, attaining the necessary skill to craft intricate objects generally takes many years of practice and understanding of the material.

Summary:

Materials used in the manufacturing process come from many sources. Some are made from natural materials, and others are manufactured. The materials chosen for a manufactured product are chosen because of the properties they possess and their cost. Many products contain a combination of a variety of materials. How these materials work together is essential to why they are chosen.

Some of the major categories that provide materials used in the manufacturing process are metals, woods, and plastics. In these categories, materials have various properties. Properties such as malleability, conductivity, and magnetism are considered when a particular material is chosen to be used in a manufactured product.

Checking Your Knowledge:

1. Metals are divided into two categories. What are those two categories?
2. What are some of the properties that metals possess that make them useful in manufacturing?
3. What are two sources from which plastics can be made?
4. What are some of the properties of plastic that make it widely used in the manufacturing process?
5. What are three properties of wood that make it a useful material for certain types of manufacturing?

Expanding Your Knowledge:

Visit a local home improvement store or lumberyard. Speak with an associate who works in the lumber area about which woods should be used for specific projects. Be sure to ask about which woods are good to be used in moist areas, outside, inside, around animals, and for decorative purposes as opposed to construction projects. Lastly, ask why there are large differences in prices for the different types of woods.

Web Links:

Wood Properties and Uses

http://www.woodbin.com/ref/wood/

Properties of Metals

http://www.tpub.com/air/1-18.htm

Properties and Uses of Metals

http://www.globalsecurity.org/military/library/policy/navy/nrtc/14250_ch1.pdf

Plastic

http://en.wikipedia.org/wiki/Plastic#Representative_polymers