2.2 Steel – Mechanical treatment – Aluminum – Uses – Market forms

Steel is an alloy of iron and carbon containing less than 2% carbon and 1% manganese and small amounts of silicon, phosphorus, sulphur and oxygen. Steel is the world's most important engineering and construction material. It is used in every aspect of our lives; in cars and construction products, refrigerators and washing machines, cargo ships and surgical scalpels. It can be recycled over and over again without loss of property.

Properties of steel

Steel has a number of properties, including: hardness, toughness, tensile strength, yield strength, elongation, fatigue strength, corrosion, plasticity, malleability and creep.

Hardness is the material's ability to withstand friction and abrasion. It is worth noting that, while it may mean the same as strength and toughness in colloquial language, this is very different from strength and toughness in the context of metal properties.

Toughness is difficult to define but generally is the ability to absorb energy without fracturing or rupturing. It is also defined as a material's resistance to fracture when stressed. It is usually measured in Joules per sq. centimetre. It is important to distinguish this from hardness as a material that severely deforms without breaking, could be considered extremely tough, but not hard.

Yeild Strength is a measurement of the force required to start the deformation of the material (i.e. bending or warping). TENSILE strength is a measurement of the force required to break the material.

Elongation (or Ductility) is the "Degree" to which the material can be stretched or compressed before it breaks. It is expressed as a percent of the length being tested and is between the tensile strength and yield strength (i.e. what percent does the material bend before breaking).

Fatigue strength is the highest stress that a material can withstand for a given number of cycles without breaking.

Corrosion is the irreversible deterioration and destruction of the steel material and its vital properties due to the electrochemical or chemical reaction of its surface to environmental factors such as acids, moisture and oxygen.

Plasticity is the deformation of a material undergoing non-reversible changes of shape in response to applied forces.

Malleability describes the property of a metal's ability to be distorted below compression. It is a physical property of metals by which they can be hammered, shaped and rolled into a very thin sheet without rupturing.

Creep is a type of metal deformation that occurs at stresses below the yield strength of a metal, generally at elevated temperatures.

Following are those operations involved in the mechanical treatment of steel:

- Drawing
- Forging
- Pressing
- Rolling.

Each operation will now be briefly described.

Drawing:

- This operation is performed to reduce the cross-section and increase the length. In this operation, the metal is pulled through dice or specially shaped tools. The drawing is continued until the required diameter wire or cross-section is obtained. This process is used for making-wires and spokes.

Forging:

- The foraging operation is carried out by repeated blows under a power hammer or press. The metal is heated over a critical temperature range. It is then placed on the figure and subjected to a hammer blow.
- This process increases the density and improves the grain size of the metal. Rewriting belongs to counterfeiting operations. This process is used for the manufacture of bolts, clamps, etc.
- In the case of the former, steel is free to spread in all directions as it is hammered. In the latter case, steel flows under the blows of a hammer to fill the inside of a die, and the excess material is forced out through a special groove, and then it is cut off. Die-forged parts have very accurate dimensions.

Pressing:

- This is a slow process and is carried out on devices called presses. The main advantage of this process is that it does not involve any trauma. The press mainly consists of die and punch.
- Die and punch arc in the appropriate shape to get the article of the desired shape. The metal is placed on the die and then the punch is dropped under heavy pressure. The metal is thus pressed between the die and the punch and an article of the desired shape is obtained.
- For preparing articles with wide changes of shape1 pressing is to be carried out in different stages. This process is helpful when a large number of similar engineering articles are to be produced.

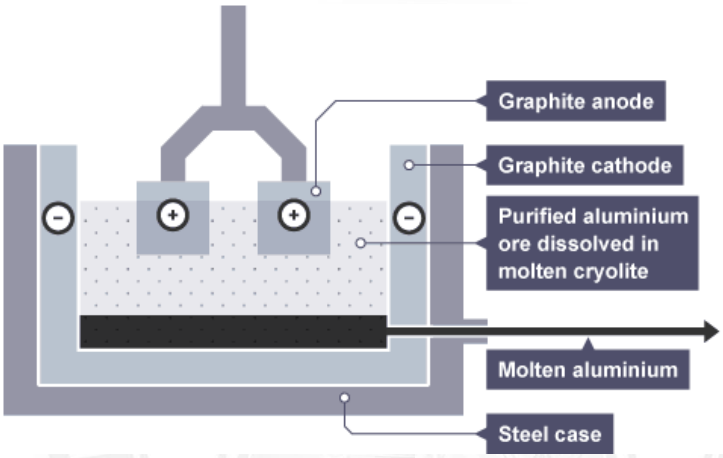
Rolling:

- This operation is carried out in specially made rolling mills. Ingots, when the still red is hot, are shipped sequentially through various rollers until the articles of desired shapes are obtained.
- A variety of shapes such as angles, channels, flats, joists, rails, etc. are obtained by the rolling process. It is also possible to make jointless tubing with the help of this process. Bored with rollers in stages until a solid rod gets the required diameter and thickness of the pipe.

Aluminum – Uses – Market forms

Aluminium is a silvery-white metal, the 13 element in the periodic table. It's the most widespread metal on Earth, making up more than 8% of the Earth's core mass. It's also the third most common chemical element on our planet after oxygen and silicon.

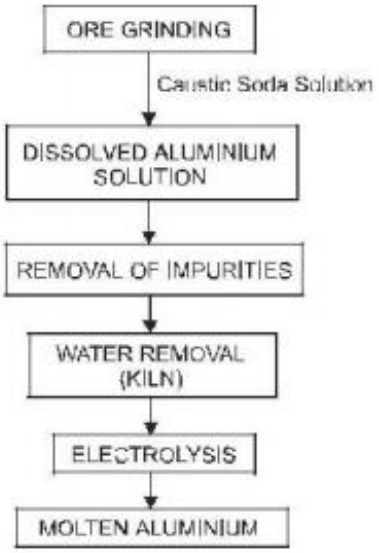
The most common form of aluminium found in nature is aluminium sulphates. These are minerals that combine two sulphuric acids: one based on an alkaline metal (lithium, sodium, potassium rubidium or caesium) and one based on a metal from the third group of the periodic table, primarily aluminium.



Aluminium is too high in the electrochemical series (reactivity series) to extract it from its ore using carbon reduction. The temperatures needed are too high to be economic. Instead, it is extracted by electrolysis. The ore is first converted into pure aluminium oxide by the Bayer Process, and this is then electrolysed in solution in molten cryolite - another aluminium compound. The aluminium oxide has too high a melting point to electrolyse on its own.

The principal constituents of bauxite ($Al_2O_32H_2O$) which yield aluminum on a commercial scale are hydrated oxides of aluminum and iron with some silica. Some of the other aluminum ores are corundum, kaolin or china clay, and kryolite. The ore is purified by Bayer's process and is reduced to aluminum by Hall Hiroult's process in two stages. In the first stage bauxite is converted into alumina by roasting, grinding, heating (with sodium hydrate) and filtering. Then it is agitated for several hours to precipitate the hydrate, which is separated, washed, and calcined at 1000° C. In the next stage aluminum is extracted by electrolysis of alumina in a molten bath of crystolite (a fluoride of alumina and sodium). A flow diagram for extraction of aluminium is shown in Fig. Aluminum is silver white in color with a brittle metallic lustre on freshly broken surface. It is malleable, less ductile than copper but excels zinc, tin, and lead. Aluminium is harder than tin. Aluminium is very light, soft, strong and durable, has low thermal conductivity but is a good conductor of electricity. Aluminium can be riveted and welded, but cannot be soldered. It can be tempered at 350° C. The melting point is 657° C, tensile

strength is 117.2 N/mm2 in the cast form and 241.3 N/mm2 when drawn into wires. Aluminium is found to be resistant to the attack of nitric acid, dissolves slowly in concentrated



Flow Diagram for Extraction of Aluminum

Uses of aluminum

- Aluminum is widely used in the packaging industry for the production of coils, cans, foils, and other wrapping materials.
- It is also a component of many commonly used items such as utensils and watches.
- In construction industries, aluminum is employed in the manufacture of doors, windows, wires, and roofing.
- It is used in the transport industry for the production of cycles, spacecraft, car bodies, aircraft and marine parts.
- Many coins are made up of alloys that contain aluminum.
- Aluminum also finds applications in the production of paints, reflective surfaces, and wires.

Market forms

Alloy Aluminum is commonly alloyed with copper silicon, magnesium, or zinc to improve its mechanical properties. Some aluminum alloys also contain one or more of the metals manganese, lead, nickel, chromium, titanium, and beryllium. A large part of the aluminum production is utilized in making light, stiff, corrosion-resistant alloys with these metals. Aluminum alloys may be classed as the cast alloys, which are shaped by casting and wrought alloys, which are worked into different shapes by mechanical operations. Cast alloys are generally binary alloys containing copper or silicon, and sometimes magnesium. Wrought alloys contain copper, magnesium, silicon, and manganese that form precipitation hardening alloys with aluminum. Following are some of the aluminum alloys.

Duralumin contains 3–5% copper, 0.51–1% magnesium and 0–0.07% manganese. 0.3–0.6% iron and 0.3%–0.6% silica are present as impurities. The relative density is 2.80, which is quite low as compared to that of mild steel. However, when rolled and heat treated tensile strength equals that of mild steel. Its yield point is 206.85 N/mm2. It is highly resistant to corrosion. Wire and sheets are drawn from duralumin. Duralumin may be fabricated into different structural shapes to be used for construction

Magnesium is an alloy of aluminum and magnesium (6 per cent). It has got very good mechanical properties and is a little lighter than pure aluminum. It is easy to work, exceptionally strong, and ductile and is widely used as deoxidizers in copper smelting operations.

Aluminium Bronze contains less than 11 per cent of aluminium and is rather inappropriately named. It is highly ductile when aluminium is less than 7.3 per cent.

Y-alloy invented during World War II contains 4 per cent copper, 20 per cent nickel and 1.5 per cent magnesium. Toughness and hardness are achieved by heating it to 500° C for six hours and then cooling it down in boiled water. Its relative density is 2.80 and resists corrosion better than duralumin. Y-alloy has good thermal conductivity and can sustain high temperature. It is used for making pistons of I.C. engines, cylinder head, connecting rod and propeller blades