STEEL

Steel is the most suitable building material among metallic materials. This is due to a wide range and combination of physical and mechanical properties that steels can have. By suitably controlling the carbon content, alloying elements and heat treatment, a desired combination of hardness, ductility, and strength can be obtained in steel. On thebasis of carbon content steel may be classified as under:

Type of steel	Carbon content (%)
Dead mild steel	< 0.15
Mild steel	0.15–0.3
Medium carbon steel	0.3–0.8
High carbon steel or hard steel	0.8–1.5 (> 1 is also called cast steel or tool steel)

Manufacturing Methods

The prominent steel-making processes are:

1. Bessemer process
2. Cementation process
3. Crucible process
4. Open Hearth process
5. Electric Smelting process
6. Duplex process
7. Lintz and Donawitz (L.D.) process

The most prominent present-day steel-making process is the Bessemer process was introduced in 1856. The pig iron is first melted in Cupola furnace and sent to Bessemer converter (Fig.) Blast of hot air is given to oxidize the carbon. Depending upon the requirement, some carbon and manganese is added to the converter and hot air is blasted once again. Then the molten material is poured into moulds to form ingots. L.D. process is

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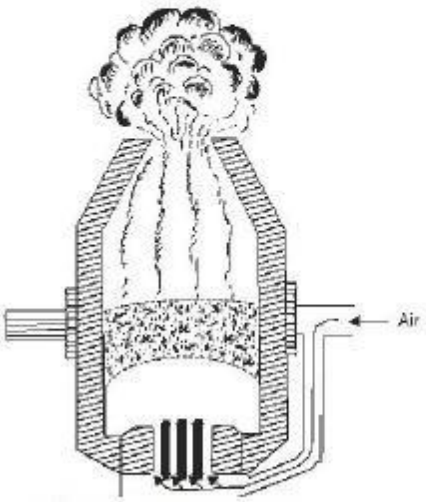

Fig. Bessemer Converter for the Manufacture of Steel modification of the Bessemer process in which there in no control over temperature. By this method steel can be made in hardly 25 minutes. In Open-hearth process also known as Siemen's-Martin process, the steel produced is more homogeneous than by Bessemer's. The electric process is costly but no ash or smoke is produced. The Crucible process involves melting of blister steel or bars of wrought iron in fire clay crucibles. Cast steel so obtained is very hard and is used for making surgical equipments. The Duplex process is a combination of Acid Bessemer process and Basic Open Hearth process

Properties and Uses

Mild Steel Also known as low carbon or soft steel. It is ductile, malleable; tougher and more elastic than wrought iron. Mild steel can be forged and welded, difficult to temper and harden. It rusts quickly and can be permanently magnetized.

The properties are: Sp. gr. = 7.30, ultimate compressive and tensile strengths 800–1200N/mm2 and 600– 800N/mm2.

Mild steel is used in the form of rolled sections, reinforcing bars, roof coverings and sheet piles and in railway tracks.

High Carbon Steel: The carbon content in high carbon steel varies from 0.55 to 1.50%. It is alsoknown as hard steel. It is tougher and more elastic Than mild steel. It can be forged and welded with difficulty. Its ultimate compressive and tensile strengths are 1350 N/mm2 and 1400–2000 N/mm2, respectively

High carbon steel is used for reinforcing cement concrete and prestressed concrete members. It can take shocks and vibrations and is used for making tools and machine parts.

High Tensile steel: The carbon content in high tensile steel is 0.6–0.8%, manganese 0.6%, silicon 0.2%, sulphur 0.05% and phosphorus 0.05%. It is also known as high strength steel and is essentially a medium carbon steel. The ultimate tensile strength is of the order of 2000 N/mm2 and a minimum elongation of 10 per cent.High Tensile steel is used in prestressed concrete construction.

Properties of Steel

The factors influencing the properties of steel are chemical composition, heat treatment, and mechanical work.

Chemical Composition

The presence of carbon in steel gives high degree of hardness and strength. The addition of carbon to iron decreases the malleability and ductility of the metal, and reduces its permeabilityto magnetic forces.

The tensile strength of hot rolled steel bars is maximum between 1.0 and 1.2 per cent carbon. The elastic limit and the ultimate strength of steel increase with carbon content but at a lower rate. The compressive strength of steel increases directly with carbon content up to 1.0 per cent. The shear strength of steel also increases with the carbon content. The ratio of shear strength to the tensile strength is 0.80 for medium and low carbon steels and 0.60 for high carbon steels. The modulus of elasticity is nearly same for tension and compression and is practically independent of the carbon content. The ductility of steel decreases markedly as the carbon content increases. The resistance of steel to heavy shocks or blows decreases with increase of carbon content.

Heat Treatment

The object of heat treatment is to develop desired properties in steel. The properties of steel can be controlled and changed as well by various heat treatments. A steel of given composition may be made soft, ductile and tough by one heat treatment, and the same steel may be made relatively hard and strong by another. Heat treatment affects the nature, amount, and character of the metallographic properties. Heat treatment influences the solubility relations of the constituents, changes the crystallization either with respect to form or degree of aggregation and introduces or relieves internal stresses in the metal. The heat treatment process consists in subjecting, a metal to definite temperature–time course.

Some of the principle purposes of heat treatment are as follows.

1. To enhance properties such as strength, ductility, hardness and toughness.
2. To relieve internal stresses and strains.
3. To refine the grain.
4. To remove gases.
5. To normalize steel after heat treatment.

Hardening

This heat treatment consists of heating the steel above the upper critical temperatureholding at that temperature until phase equilibrium has been established, and then quenching rapidly to produce a martensite structure. Martensite is the chief constituent of hardened steel and is fibrous or needle like structure. Hardened steel is very brittle and cannot be used for practical purposes. The quenching medium is usually brine, water or oil, depending on the desired cooling rate.

Tempering

A plain carbon steel that has been hardened is in metastable condition or equilibrium. If this hardened steel is reheated to some temperature below the critical range, a more stable condition will be obtained. Since hardened steels do not usually have the combination of properties desired for specific uses, modification is affected by tempering.

When a thick piece of steel is cooled rapidly it develops additional strains as the surface cools quicker than the interior. To relieve this strain, steel is subjected to the process tempering which consists in slowly heating the steel to a predetermined subcritical temperature and then cooling it slowly. This temperature varies from 100°C to 700°C. The higher the temperature of tempering the softer is the product. The properties like toughness and ductility are automatically introduced with release of strain.

Annealing

It is a general term used for heating and slow cooling of metal, glass or any other material, which has developed strain due to rapid cooling. The process consists of heating the steel to a temperature below the critical range, but high enough to obtain strain re-crystallization and then cooled in any manner. The exact heating temperature depends on the composition of steel and the amount of work that it has received, but is frequently between 500°C to 600°C. Annealing of steel in addition to removing strain introduces one or more of the following properties.

1. Introduces softness, ductility, and malleability.
2. Alters electrical, magnetic, and other physical properties.
3. Produces a definite microstructure and grain refinement.
4. Removes gases.

Full annealing consists of heating iron alloy 20°C to 50°C above critical temperature range, holding at that temperature for the required period of time to convert it to austenite followed by slow cooling. Full annealing usually decreases hardness, strength, and resistance to abrasion, and increases ductility and merchantability.

Normalizing

It consists in heating steel above critical range and cooling rapidly in air, but at rate slower than the critical cooling rate. The purpose of this heat treatment is to refine the grain structure resulting from rolling, forging or other manufacturing processes.

Mechanical Works

Steel products are made by casting molten refined steel of suitable composition into the desired form or by mechanically working steel form the ignot through many intermediate forms to the desired product. Mechanical work may be hot or cold. Mechanical working involves many stages of hot working and may or may not include eventual cold working.

The most important methods of hot working steel are hot rolling, hammer forging, hydraulic and mechanical press forging, and hot extrusion. Miscellaneous hot working methods include hot spinning, hot deep drawing, hot flanging and hot bending, Heat treatment after hot working is seldom used with low-carbon steels, whereas high-carbon steels are always hardened and tempered.

The principle methods of cold working steel are cold rolling, cold drawing and cold extrusion. The cold working methods are used to provide increased strength, accurate dimensions, and bright and scale free surfaces. Thin sheets and small diameter wires are produced by cold-working methods. Cold working results in increased density, hardness,

and brittleness, and produces an internally strained condition in the steel.

Mechanical work alters the form of the crystalline aggregate and introduces internal stresses. Cold rolling increases the tensile elastic limit from 15 to 97 per cent and tensile strength from 20 to 45 per cent. In elastic resilience the cold-rolled metal is superior to the hot-rolled, whereas in energy of rupture it is inferior to the hot-rolled metal. The modulus of elasticity is slightly increased by cold rolling. Practically, metals are rolled, forged, drawn, stamped and pressed.

Most of steel building components—beams, rails, steels, bars, reinforcement, pipes— are manufactured by rolling. Rivets and bolts are made by forging operations. Thinwalled items (tubes) and round, square, hexagonal rods of small cross-sectional areas (up to 10 mm2) are manufactured by drawing. Stamping and pressing increases the buckling strength of plates to be used for making them suitable for steel tanks and containers. Steel trusses, towers, tanks, bridges and frames of multistorey buildings are some of the examples of structures made of steel.

The most common and important application of steel in buildings is the rolled steel sections and reinforcing bars and are described in the following sections