Heat Treatment

Objectives : At the end of this lesson you shall be able to

- **state the importance of heat treatment**
- **list the stages of heat treatment**
- **state the type of Heat treatment process**
- **explain the process of Annealing, Normalising, Hardening and Tempering**
- **state the importance of case hardening**
- **explain the process of carbursing, Nitriding, Induction hardening and flame hardening.**
- **state the types of heat treatment and surface hardening used for production of automotive components.**

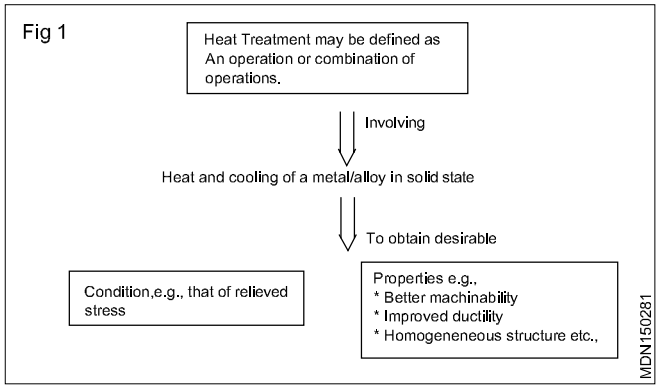
Introduction

The automobile is a typical industrial product that involves a variety of materials and technologies. Beginning with raw metal products leading all the way to final component assembly, various types of heat treatment and surface engineering processes are applied in the manufacture of automotive components.

Heat treatment impart the required strength or hardness properties as dictated by the given component application. Other processes involved in metal processing may include forming, machining as well as quench and tempering, carburizing and hardening and nitriding during production. Surface modification, when properly applied, yields optimum surface properties enhancing corrosion and wear resistance while improving frictional properties.

Definition of Heat Treatment (Fig 1)

Fig 1



Some of the common industrial heat treatment operations are as follows:

a) Annealing

b) Normalising

c) Hardening and Tempering

- Ferrous metals (metals with iron) are annealing, normalizing, hardening, and tempering.
- Nonferrous metals can be annealed, but never tempered, normalized, or case-hardened.

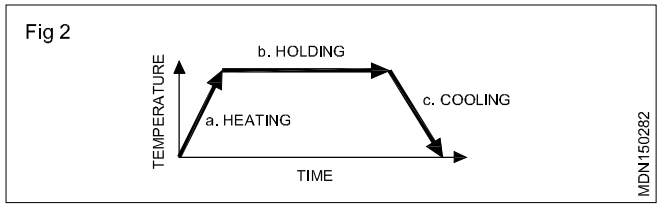
Stages of Heat Treatment (Fig 2)

Stage a : Heating the metal slowly to ensure a uniform temperature.

Stage b : Soaking (Holding) the metal at a given temperature for a given and cooling the metal to room temperature.

State c : Cooling the metal to room temperature.

Fig 2



Annealing

Annealing consists of heating a metal to a specific temperature-based on the carbon content, holding it at that temperature for a set length of time, and then cool it very slowly in the furnace

Full annealing is used to obtain the following properties:

- To relieve the internal stresses and strains developed by various fabrication methods like forgings, castings etc.
- To improving properties of elasticity and ductility
- To reduce hardness

Normalising

Normalising is a type of heat treatment applicable to ferrous metals only. It differs from annealing in that the metal is heated to a higher temperature and then remove from the furnace for air cooling.

Normalising may be employed to

- to remove the internal stresses induced by heat treating, welding, casting, forging, forming, or machining
- Refine the grain and provide homogeneous micro-structure, to improve response to hardening treatment.
- Improve machining characteristics

Hardening

Hardening is a heat treatment process in which steel is heated to an appropriate temperature based on the carbon content of the steel and held at this temperature for sufficient time to allow the steel to obtain a uniform

temperature throughout the section. Then the steel is rapidly cooled through a cooling medium. Water, oil, molten salt or air may be used as a cooling medium depending upon the composition of the steel and the hardness required.

Carbon steels are usually quenched in brine or water, and alloy steels are generally quenched in oil.

Purpose of Hardening

- To increases the hardness and strength of the steel,but makes it less ductile

Tempering :

Tempering consists of heating the steel to a specific temperature generally below its hardening temperature, holding it at that temperature for the required length of time, and **then cooling it, usually instill air.**

Purpose Of Tempering

Steels in its hardened condition, it is often harder than necessary, generally too brittle and too severally strained in the quenching operation. The aim of tempering is:

- To relieve the steel from internal stresses and strains.
- To regulate the hardness and toughness
- To decrease the brittleness and to restore some ductility to induce shock resistance.

Tempering immediately after quenching prevents development of such destructive cracks

Case Hardening

Case hardening produces a hard, wear-resistant surface or case over a strong, tough core. The principal forms of casehardening are carburizing, cyaniding, and nit riding. Only ferrous metals are case-hardened.

Importance of Case Hardening

Case hardening is ideal for parts that require a wear-resistant surface and must be tough enough internally to withstand heavy loading. The steels best suited for case hardening are the low-carbon and low-alloy series.. In case hardening, change the surface of the metal chemically by introducing a high carbide or nitride content. The core remains chemically unaffected. When heat-treated, the high-carbon surface responds to hardening, and the core toughens.

While surface hardening by induction hardening and flame hardening does not change the chemical composition of the material techniques like carburizing. Nitriding and carbonitriding change the surface composition.

Carburising

Carburizing is a case-hardening process by which carbon is added to the surface of low-carbon steel. This results in a carburized steel that has a high-carbon surface and a low-carbon interior.

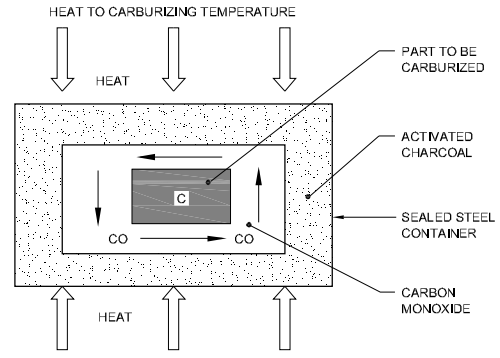
When the carburized steel is heat-treated, the case becomes hardened and the core remains soft and tough.

a) Pack Carburising

Components are placed in a container along with solid carburizing material like charcoal, wood charcoal energized by sodium, potassium and barium carbonate. A lid is fitted to the container made of heat resisting cast iron. The box with the contents is sealed with fire clay and is placed in muffle furnace at 900° - 920° C as shown in (Fig 3) and held for a period of time depending upon the case and held for a period of time depending upon the case depth required (Fig 4).

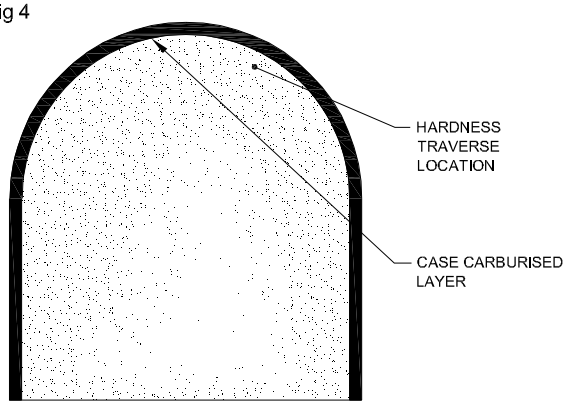
After carburizing the component is hardened by re-heating at 760 - 780° C followed by quenching in water or oil. Thus the case hardening improves surface hardness and the core toughness.

Fig 3



PACK CARBURISING PROCESS

Fig 4



Advantages : It requires no prepared atmosphere and is economical process.

b) Gas Carburising

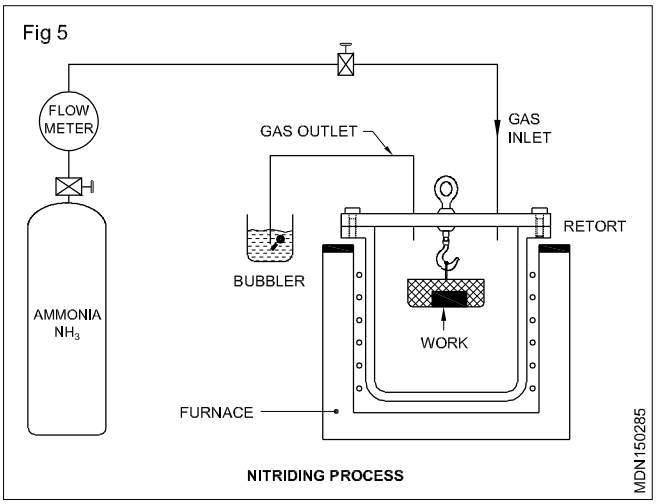
If a suitable carbonaceous furnace atmosphere namely hydro carbon atmosphere or carbon monoxide atmosphere can be provided, the components can be directly loaded in the furnace so as to achieve gas carburizing. The time and temperature can be compared to that of pack carburizing. Hydrocarbon atmosphere decomposes readily at the carburizing temperature at 95°C.

Advantage : It is used to carburise large number of components simultaneously thus saving the heat energy, labour and carburizing compound. Thus it supercedes pack carburizing. It enables quicker handling by direct quenching.

Nitriding (Fig. 5)

Nitriding case-hardening method produces the hardest surface of any of the hardening processes it introduces nitrogen into the surface of steel. Medium carbon steels are generally nitride. It differs from the other methods in that the individual parts have been heat-treated furnace that has an ammonia gas atmosphere as shown in (Fig 5) No quenching is required so there is no worry about warping or other types of distortion. Time of nit riding is long and will be about 70 hours. The case depth is less than 0.5 mm.

Fig 5



NITRIDING PROCESS

This process is used to case harden items, such as gears, cylinder sleeves, camshafts and other engine parts, that need to be wear resistant and operate in high-heat area

Induction Hardening

When high frequency alternating current is passed through the heating coil an electromagnetic field is created around it. It gives rise to eddy currents in the surface of the metal bar centered in the coil.

Thus, the surface of the metal bar gets heated above the critical temperature and subsequently gets hardened during quenching.

This method is employed for very long parts and normally requires a cross sectional area that is uniform along the entire length of the hardened surface.

Flame Hardening

Flame hardening is another procedure that is used to harden the surface of metal parts. When you use an oxy-acetylene flame, a thin layer at the surface of the part is rapidly heated to its critical temperature and then immediately quenched by a combination of a water spray and the cold base metal. This process produces a thin, hardened surface, and at the same time, the internal parts retain their original properties.

Types of Heat Treatment And Surface Hardening Used For Production Of Automotive Components

Types of heat treatment	Typical components
Annealing	Forged blanks for gearing and misc. parts
Normalizing	Reduce hardness for machining
Quench and temper	Fasteners, Rods and Arms
Case hardening : Carburizing	For fatigue and wear resistance Gears and shafts
Induction hardening	Cam shafts, Drive shafts, steering knuckles
Nitriding :	Cam shafts, oil pump gears, valves, Brake pad liner plates, A/T gears