Compiled by
Dr. Arbind Prasad
Assistant Professor(Mech. Engg.)
Katihar Engineering College,Katihar
Bihar, India-854109

HEAT TREATMENT

(2 MARKS)

Q.1.What is heat treatment?

Ans: It is an operation or combination of operations involving heating and cooling of a metal/alloy in solid state to obtain desirable properties and conditions.

Q.2. What is hardening?

Ans: Hardening is defined as the heat treating process in which the material is heated to a temperature within or above its critical temperature and held at this temperature for a considerable time to ensure proper penetration of the temperature inside the component and allowed to cool by quenching in water, oil or brine solution.

Q.3. What is tempering?

Ans:- It is the process of reheating a quench hardened steel to reduce its inter stress and to increase its toughness.

- Re-heating is done to a temperature varying from 250°c to 650°c. Depending upon the reheating temperature the process is called low temperature tempering medium temperature tempering or high temperature tempering.

Q.4. Name the different type of quenching media for hardening of steel?

Ans: Different type of quenching media for hardening of steel are air, oil, solution of special component (sodium hydroxide and sulphuric acid and water) water, brine.

Q.5. Define Martempering?

Ans:-Martempering is define as heating the steel to austenite temperature and is quenched in a liquid bath having high temperature and again it is transferred to a bath having low temperature.

- Improve ductility
- Improves mechanical properties
- Improves strength and toughness

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Katihar Engineering College,Katihar
Bihar, India-854109

Q.6. What is normalizing?

Ans: It is defined as the process of heating the steel 40° to 50°above the upper transformation range, holding there for a specific period and then allowing it to cool in still air at room temperature

Q.7. What is heat treatment?

Ans: it is an operation or combination of operations involving heating and cooling of a metal/alloy in solid state to obtain desirable properties and conditions.

5 MARKS

Q.1 Define annealing?

Ans: Annealing is defined as a softening process consisting of heating the steel to a temperature at or near the critical point, holding there for a proper time and then allowing it to cool slowly in the furnace itself. The temperature required for annealing varies with different steels. low carbon steels are heated to a temperature slightly above the upper critical temperature high carbon steels having more than 0.9% carbon are heated to a temperature within the critical range. High carbon steels are heated to a temperature below their critical point. Hypereutectoid steel is heated to 20°c above the upper critical temperature, while hypereutectoid steel is heated to 20°c above the lower critical temperature.

Q.2 Define hardening?

Ans: Hardening is define as sheeting the steel to a temperature within or above its critical temperature and held at this temperature for a considerable timeto ensure proper penetration of the temperature inside the component and then allowed to cool by quenching in water, oil or brine solution.

Q.3.What is hardening? What are the purposes of hardening?

Hardening is define as heating the steel to a temperature within or above its critical temperature and hold at this temperature for a considerable time to ensure proper penetration of the temperature inside the component and then allowed to cool by quenching in water, oil or brine solution.

The purposes of hardening are to

- Improve strength and toughness.

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Katihar Engineering College,Katihar
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- Improve ductility.
- To develop hardness and wear resistance properties.
- To develop mechanical properties.

7 MARKS

Q.1. Explain the purpose of heat treatment?

Ans:-

- To improve strain hardening of cold worked metal piece and improve its ductility.
- To improve gases from casting.
- To soften a metal to improve its machinability.
- To improve resistance against wear, heat and corrosion.
- To improve the cutting ability i.e. to improve hardness of a tool steel.
- To restore electrical conductivity of cold worked metal
- To improve magnetization properties, especially of steels, for producing permanent magnets.
- To refine grain structure after hot working a metal
- To produce a hard, wear resistance case on a tough core of a steel.
- To soften and toughness a higher a high carbon steel piece
- To harden non-ferrous alloy and metals, especially aluminum alloys.
- To toughen a hardened steel piece at a low cost of its hardness
- To remove effects of previously performed heat treatment operations.
- To relive inter stresses set up by un equal contraction in castings.

Q.2 List the effect of heat treatment of properties of steel?

- Steel are used for varied purpose engineering industry and thus they required different properties according tom the field of application.
- The properties of plain carbon steel can be by heating and cooling them under definite condition making them suitable for specific application.
- The properties of plain carbon steels have relation with the type of heat treatment the subjected to various heat treatment processes annealing, hardening, and tempering etc. properties of plain carbon steels as described below

Compiled by
Dr. Arbind Prasad
Assistant Professor(Mech. Engg.)
Katihar Engineering College,Katihar
Bihar, India-854109

Annealing:

- Homogenizes the structure
- Reduce hardness
- Improves machinability
- Hardening followed by tempering:
- Hardens steel to resist wear
- Enables steel to cut other metals
- Improves strength, toughness

Normalizing:

- Produces a uniform structure
- Refine grain size
- Reduces internal stresses
- Case hardening processes:
- Increase the surface hardness of low carbon steel
- Provide a wear resistant case and a relatively soft, tough, and shock resistant core.

Q.3 Describe the method of annealing?

Ans:-

- Annealing: - It is define as a softening process consisting of heating the steel to a temperature at or near the critical point, holding there for a proper time and allowing it to cool slowly annealing varies with different steels.
- Low carbon steels are heated to a temperature slightly above the upper critical temperature high carbon steels having more than 0.9% carbon are heated to a temperature within the critical range. High carbon steel is heated to a temperature below their critical point. Hypo-eutectoid steel is heated to 20°c above the upper critical temperature, while hyper eutectoid
- Purposes of hardening. If consists of heating steel to a temperature a little below the critical range(A1) and then cooling it slowly. It is applied to remove the effect of cold wok, to soften and permit further cold work as in sheet and wire industries.
- Ferrous alloys are heated to a temperature closed to but below, the lower limit of the transformation range (550-650°c) are held at that temperature and then cooled usually in air in order to soften the alloy for further cold working as in wire drawing.

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Assistant Professor(Mech. Engg.)
Katihar Engineering College,Katihar
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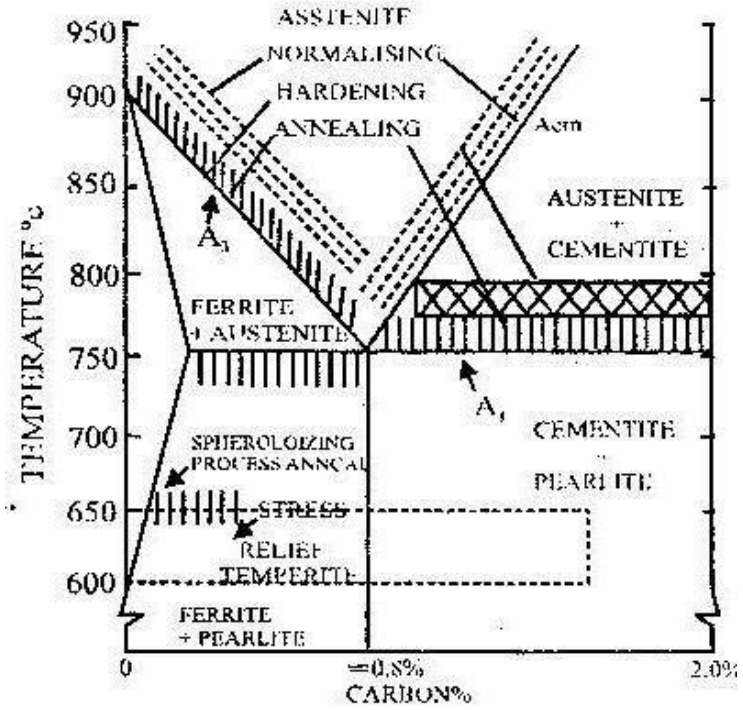
- Process annealing associates with it only partial recrystallization of the distorted ferrite and since mild steel contains only a small volume ofstraine4d pearlite, a high degree of soften is induced.



Treating temperature for Carbon Ste

- Process annealing does not involve any phase change and the constituent ferrite and cementite remain present in the structure thought out the process.

Full annealing:

- The definition of annealing describes the full annealing that it consists heating the steel to a temperature at or near the critical point, holding there for a proper time and then allowing it to cool slowly in the furnace itself.
- The austenitizing temperature for hypo eutectoid steel is usually between 723°c (133°F) and 910°c(1670°F) and for hyper eutectoid steels, austenitizing temperature is between 723°c (1333°c) and 1130°c(2066°F)

Refine grains

- Removes strains (from forging and castings)
- Improves machinability
- Improves formality
- Improves electrical and magnetic properties.

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Assistant Professor(Mech. Engg.)
Katihar Engineering College,Katihar
Bihar, India-854109

Q.4.Describes various heat treatment processes and elaborate the annealing and tempering?

Ans:

Heat treatment is defining as an operation of heating of solid metal to specified temperatures holding them at that temperature and then cooling them at suitable rates in order to enable the metal to acquire the desired properties

The following heat treatment processes are:

- 1.annealing
- 2.normailising
- 3.tempering
- 4.spheroidising
- 5.hardening
- 6.case hardening
- 7.age hardening
- 8.induction hardening
- 9.flame hardening
- 10.cryniding
- 11.nitriding

1. <u>Annealing:</u>

- Annealing is defined as a soften process consisting of heat in the steel to a temperature at or near the critical point, holding there for a proper time and then allowing it to cool slowly in the furnace itself.
- The temperature required for annealing varies with different steels. Low carbon steels are heated to a temperature slightly above the upper critical temperature high carbon steels having more than 0.9% carbon are heated to a temperature within the critical range.
- High carbon steels are heated to a temperature below their point. Hypo-eutectoid steel is heated to 20°c above the upper critical temperature, while hypo-eutectoid steel is heated to 20°c above the lower critical temperature.

<u>Objects of annealing:</u>

- To soften the metal
- To improve machinability

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Assistant Professor(Mech. Engg.)
Katihar Engineering College,Katihar
Bihar, India-854109

- To improve mechanical properties like ductility
- To refine grainsize.
- To relive internal stresses.
- To remove gases to produce a definite micro structure
- To minimize segregation of essential constituent of the steel
- To modify electrical and magnetic properties.
- To prepare steel for subsequent heat treatment

Types of annealing treatment: It consists of heating the steel to a temperature a little below the critical range (A1) and then cooling it slowly. It is applied to remove the effects of cold work to soften and permit further cold work as in sheet and wire industries.

- Ferrous alloys are heated to a temperature close to but below, the lower limit of the transformation range (550-650°c) are held at that temperature and then cooled usually in air in order to soften the alloy for further cold working as in wire drawing.
- Process annealing associates with it only partial recrystallization of the distorted ferrite and since mild steel contains only a small volume of strained pearlite, a high degree of softening is induced. Process annealing does not involve any phase change and the constituents ferrite and cementite remain present in the structure throughout the process.
- Full annealing: The definition of annealing describes the full annealing that is it consist of heating the steel to a temperature at or near the critical point, holding there for a proper time and then allowing it to cool slowly in the furnace itself.

The austenitizing temperature for hypo-eutectoid steel is usually between 723°c(133°F) and 910°c (1670 F) and for hyper eutectoid –tool steels, austenitizing temperature is between

- (i)Refine grains
- (ii)Removes strains (from forgings and casting)
- (iii)Improves machinability
- (iv)Improves formability
- (v)Improves electrical and magnetic properties.

Normalizing: -

Normalizing or air quenching consist in heat in steel to about 40-50°c above its upper critical temperature (i.e. Aз and Am line) and if necessary, holding it at that temperature

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Dr. Arbind Prasad
Assistant Professor(Mech. Engg.)
Katihar Engineering College,Katihar
Bihar, India-854109

for a short time and then cooling in steel air at room temperature normalizing differs from full annealing in that the rate of cooling is more repaid and there is no extended soaking period.

- The type of structure obtained by normalizing will depend largely on the thickness of cross section as this will affect the rate of cooling. Thin section will give a much finer grain than thick sections.
- Normalizing produced microstructures consisting of ferrite (white network) and pearlite (dark areas) for hypo eutectoid (i.e. up to about 0.8% c) steels.
- Normalizing (purpose)
- Produces a uniform structure
- Refine the grain size of steel, which may have been unduly coarsened at the forging or rolling temperature.
- May achieve the required strength and ductility in a steel that is too soft and ductile for machining.
- Reduces internal in welds.
- Improves structures in welds.
- Produce a harder and stronger steel than full annealing.
- Eliminates the carbide network at the grain boundaries of hypereutectoid steels.
- In general, improves engineering properties of steel

Hardening:

Hardening is define as heating the steel to a temperature within or above its critical temperature and hold at this temperature for a considerable time to ensure proper penetration of the temperature inside the component and then allowed to cool by quenching in water, oil or brine solution.

- If the carbon content of steel is known, the proper temperature to which the steel should be heated may obtained by the iron-carbon equilibrium diagram.

Purpose:

- Improves strength and toughness
- Improve ductility
- To develop harness and wear resistance properties.
- To develop mechanical properties.

Process: The steel is heated to a temperature of 790-850°c.the steel is held at this temperature 2.5 minutes 25 mm thickness and then is rapidly cooled in water or brine.

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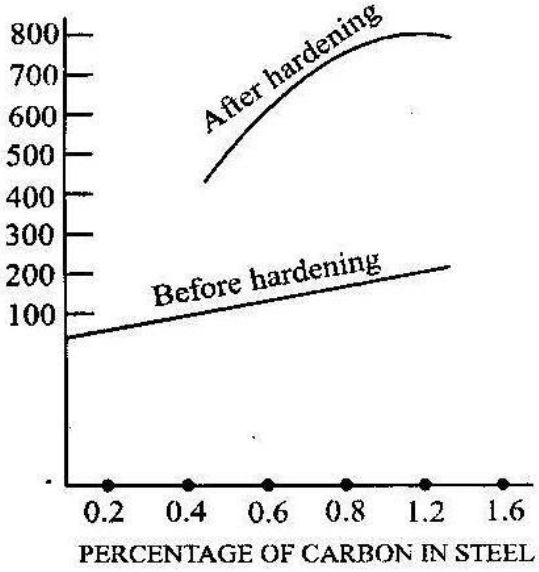
Assistant Professor(Mech. Engg.)
Katihar Engineering College,Katihar
Bihar, India-854109

A graph of maximum hardness versus carbon content



Tempering:

The steel obtaining after hardening is brittle and unsuitable for most uses. So another operation known as tempering is required to be applied in order to reduce hardness brittleness.

- Tempering is define as reheating the previously hardened steel to a temperature below the critical temperature (A1) and cooling takes place at room temperature.

Such reheating permits the trapped marten site to transform and relieve the internal stresses. The tempering temperature is determined by the specification of steel and final hardness and toughness desired.

Purpose:

- To reduce hardness, brittleness and tensile strength.
- To increase ductility and toughness.
- To relive quenching stresses.
- To equalize the hardness in a piece, as far as possible

According to usefulness of steel the tempering is divided in to three classes

- Low temperature tempering
- Medium tempering
- High temperature tempering

Martempering : -

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Assistant Professor(Mech. Engg.)
Katihar Engineering College,Katihar
Bihar, India-854109

- Mar tempering is define as heating the steel to austenite temperature and is quenched in a liquid bath having high temperature and again it is transferred to bath having low temperature.

Purpose:

- Improve ductility
- Improve mechanical properties
- Improve strength and toughness

Surface hardening:

- Surface hardening is defining as a process for hardening a ferrous material in such a way that the surface layer known as case, is substantially harden than remaining material known as core. surface hardening involves without changing the chemical composition at the surface of steel.

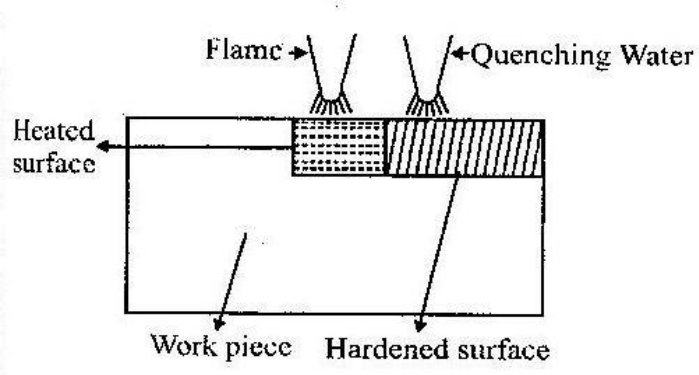
Depending upon the method of heat in surface hardening is of two types

- Flame hardening
- Induction hardening

(a) Flame hardening:

It is the heat treatment process in which surface of steel is heated rapidly above the transformation temperature by a high temperature flame and quenched to produces marten site.

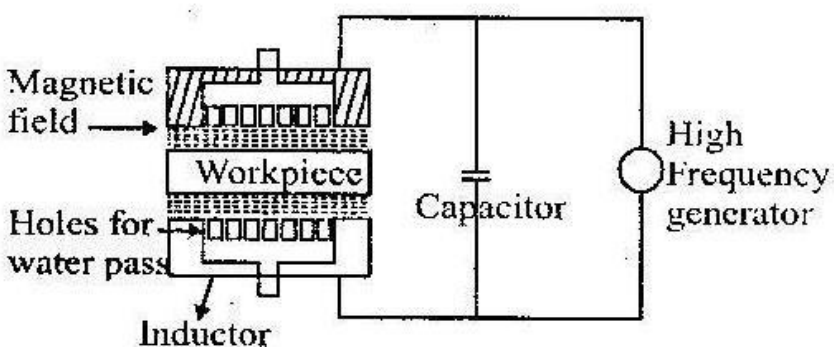
- In flame hardening oxyacetylene flame is used which can generate temperature up to 3000°c.



(b) Induction hardening:

Compiled by
Dr. Arbind Prasad
Assistant Professor(Mech. Engg.)
Katihar Engineering College,Katihar
Bihar, India-854109

it is define as heating the medium carbon steel by means of alternating field to a temperature above transformation range (750°-800°c) followed immediately by quenching. the work piece can be heated by electromagnetic induction by passing an alternative current through an inductor, piston rod, pump shaft spur gear, crankshaft is hardened by this method.



Age hardening:

When aluminum alloy containing about 4% copper is heated to a temperature and quenched in water, its hardness increase with time on keeping the alloy at room temperature. This phenomenon is called age hardening.

Process:

The two phase alloy at room temperature is heated to a temperature at which homogeneous single phase solid solution is obtained. The alloy is held at this temperature for homogenization. The holding time may vary from 30 minute to several hours.

After obtaining the homogeneous solid solution the alloy is cooled rapidly by water.

After quenching, the alloy is aged at particular temperature for some time.

- Process: The steel is heated to austenizing temperature, it is quenched in a medium. the particle is held in the both until it reaches the temperature of medium and then it is cooled further to a temperature in air. Sometimes cooling takes place in oil. Austenite is transferred in to room temperature.

Q.5. Notes on Normalizing and Martempering.

Ans: Normalizing: -

- Normalizing or air quenching consist in heat in steel to about 40-50°c above its upper critical temperature (i.e. Aз and Am line) and necessary, holding it at that temperature for a short time and then cooling in steel air at room temperature normalizing differs from full annealing in that the rate of cooling is more rapid and there is no extended soaking period.

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- The type of structure obtained by normalizing will depend large on the thickness of cross section as this will affect the rate of cooling. thin section will give a much finer grain than thick section.
- Normalizing produces micro structure consisting of ferrite (white network) and pearlite (dark areas) for hypo eutectoid (i.e. up to about 0.8% c) steel.

Purposes of normalizing:

- Produce a uniform structure,
- Refine the grain size of steel which may have been un duly coarsened at the forging or rolling temperature.
- May achieve the required strength and ductility in a steel that is too soft and ductile for machining.

Reduce internal in welds.

- Improves structures in welds.
- Produces a harder and stronger steel than full annealing.
- Eliminates the carbide network at the grain boundaries of hypereutectoid steel.
- In general, improves engineering properties of steels.

Martempering:

- It is also known as stepped punching and employee producing marten site.

In is also known as stepped punching process and employee for producing marten site.

In this type of tempering process, the steel is heated above the transformation range and then suddenly quenched in a molten salt bath at a temperature 180 to 300°c. It is held at this temperature until the cone and outside temperature are eqalised.it is then removed from the bath and allowed to cool at moderate rate.

- The holding time in the quenching bath-should be sufficient to enable a uniform temperature to be reached throughout the cross-section last not long enough to cause austenitic decomposition. Austenite is transformed in to marten site during the subsequent period of cooling to room temperature. The main purpose of mar tempering is to minimize distortion, cracking and internal stresses that result from normal quenching in oil or water.

Advantage of martempering:

- Less distortion or warping

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Dr. Arbind Prasad
Assistant Professor(Mech. Engg.)
Katihar Engineering College,Katihar
Bihar, India-854109

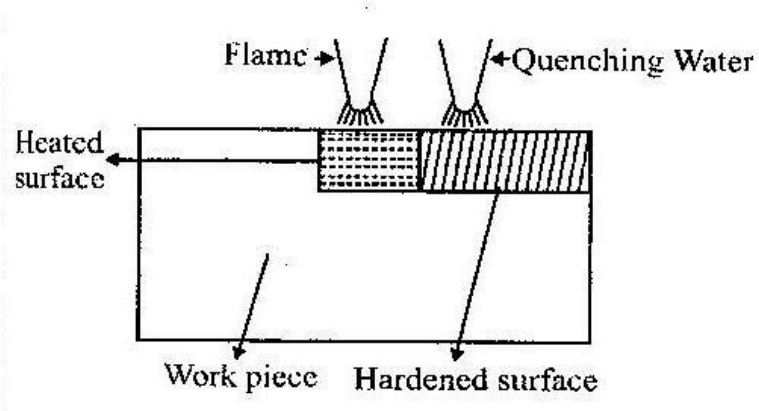
- Less change in volume
- Less change at quenching cracks and internal stresses.

Q.6. Explain different types of surface hardening method?

Ans:- Surface hardening:

- It is defining as a process for hardening a ferrous material in such a way that the surface layer known as case, is substantially harder than remaining material known as core. Surface hardening involve the hardening of the surface without changing the chemical composition at the surface of steel.
- Depending upon the method of heating surface hardening is of two types
  - Flame hardening
  - Induction hardening.

Flame hardening: It is the heating treatment process in which surface of steel is heated rapidly above the transformation temperature by a high temperature flame and quenching to produce marten site. In flame hardening oxyacetylene flame is used which can generate temperature up to 3000°c.



Induction hardening:

It is define as heating the medium carbon steel by means of alternation magnetic field to a temperature above transformation range (750°-800°c) followed immediately by quenching.

The work piece can be heated by electromagnetic induction by passing an alternative current through an inductor, piston rod, pump soft spur gear, crankshaft and hardened by method.

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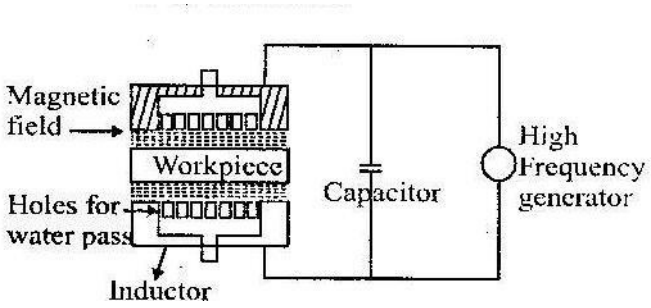

Q.7 Write the composition properties and uses of Y-alloy?

Ans: Composition

Copper=3.5-4.5%

Manganese=1.2-1.7%

Nickel=1.8-2.3%

Silicon, magnesium, iron=0.6% each and the remaining is aluminum.

Properties:

- It is good at high temperature
- It is non-magnetic.
- It is good conductor of heat.
- It is very ductile.

Use:

- Transportation industry –structure flame- work, engine parts, trim and decorative features, hardware, doors, window frames, tanks, furnishing and fittings.
- Train, truck, buses, automobile cars and aero planes use many component part made up aluminum alloys.
- Overhead conductors and heat exchanger parts.
- In food industry, aluminum alloys find application as food preparation equipment (pianistic), refrigeration, storage containers, bakery equipment, shipping containers, etc.
- Mangles and waffle molds.

Q.8 List effect of heating treatment on properties of steel?

Compiled by
Dr. Arbind Prasad
Assistant Professor(Mech. Engg.)
Katihar Engineering College,Katihar
Bihar, India-854109

Ans: Steels are used for varied purpose in engineering industry and thus they required different properties according to the field of application.

- The properties of plain carbon steels can be altered by heating and cooling them under definite conditions to make suitable for specific applications.
- The properties of plain carbon steels have definite relation with the type of heat-treatment they are subjected to various heat treatment processes such as annealing, hardening and tempering etc. affect the properties of plain carbon steels as described below.

Annealing:

- Homogenizes the structure.
- Reduces hardness.
- Improves machinability.
- Hardening followed by tempering.
- Hardens steel to resist wear.
- Enable steel to cut other metals.
- Improves strength, toughness and ductility.

Normalizing

- Produces a uniform structure
- Refine grain size.
- Reduces internal stresses.
- Case hardening processes.
  - (i)Increase the surface hardness of low carbon steels.
  - (ii)Provide a wear resistant case (outer surface) and a relatively soft, tough and shock resistant core (inside of the component).