Product Knowledge Document

HEAT TREATMENT

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AGENDA : HEAT TEATMENT

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CHAPTER 1 : INTRODUCTION TO HEAT TEATMENT

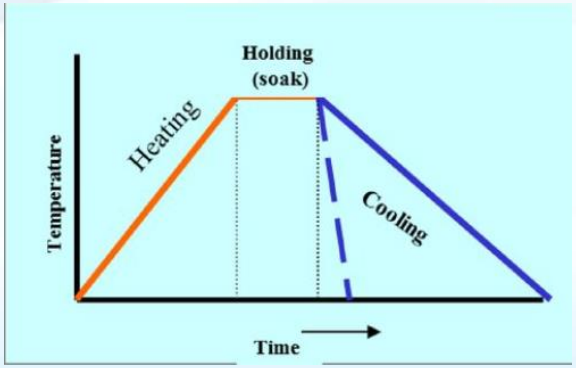
1 - INTRODUCTION TO HEAT TEATMENT

Heat treatment is heating and cooling of metal at controlled rate to get desired Outcomes in mechanical properties.

Heating is done without letting temperature of parts reach its melting point. Heating is done slowly so that parts maintain a uniform temperature. Uneven heating may lead to distortion.

Soaking or holding part at prescribed, elevated temperature is done so that desired internal structure takes shape.

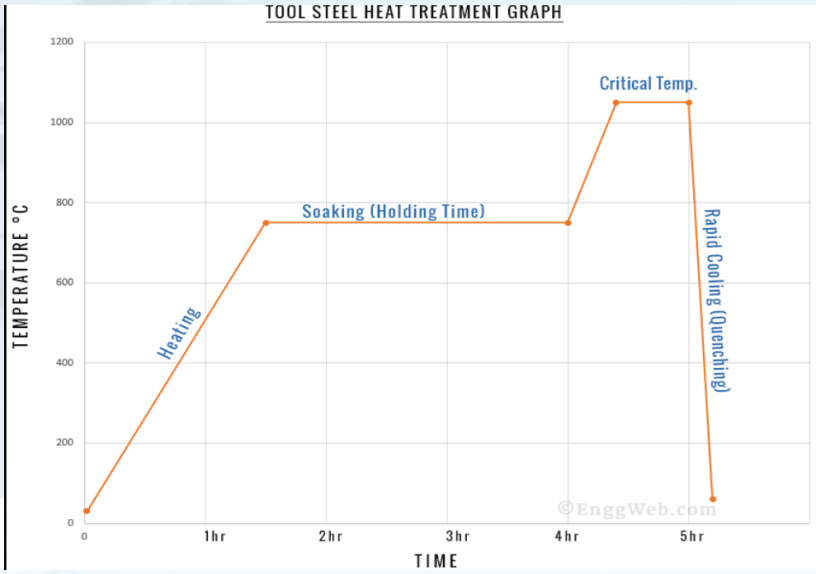
Cooling is done as per target properties and microstructure. It is done at different rates and in different medium.

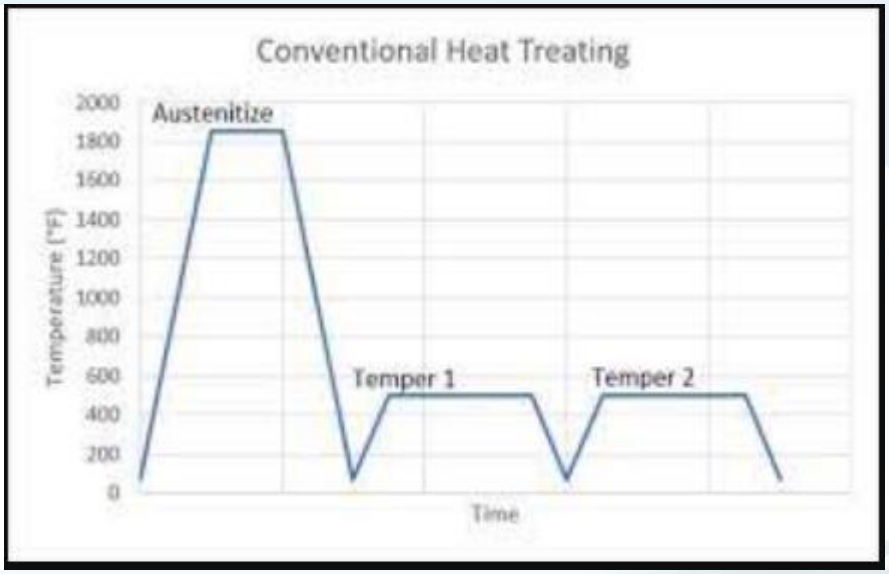


1 – BASIC STEPS IN HEAT TEATMENT

Requires three basic steps:

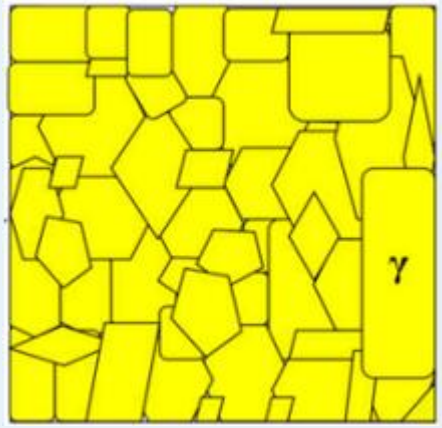
1. **Heating to a specific temperature**
2. **Holding (soaking) at that temperature for the appropriate time**
3. **Cooling according to a prescribed method**



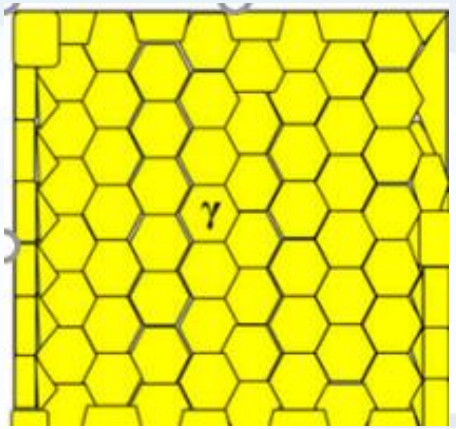


1 - PURPOSE OF HEAT TREATMENT

- To relieve internal stress.
- To refine grain size
- To soften the metal
- To improve the Hardness
- To improve mechanical properties.
- To increase resistance to wear.
- To improve ductility and toughness



Before Heat Treatment

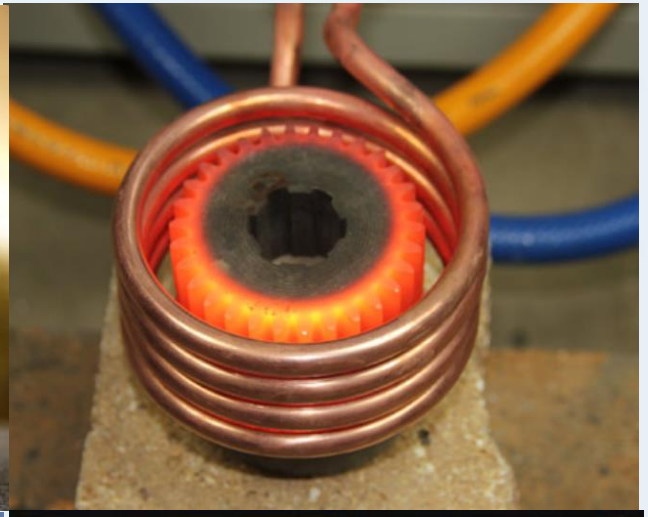


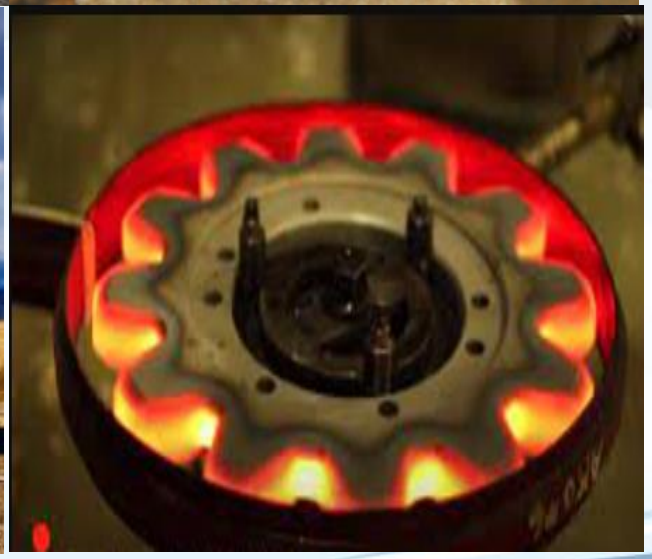
After Heat Treatment

1 – APPLICATION OF HEAT TEATMENT IN AUTOMOBILE INDUSTRY

Components undergo heat treatment.

1) Nuts
2) Casting parts
3) Gears
4) Shafts
5) Crank Shafts
6) Cam Shafts
7) Piston rod

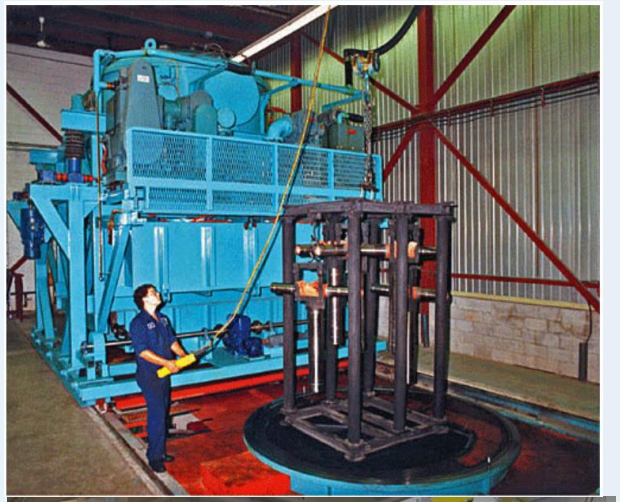




1 – APPLICATION OF HEAT TEATMENT IN AVIATION INDUSTRY

Components undergo heat treatment.

1) Landing Gear
2) Turbine Shafts
3) Planetary Gear
4) Bearings
5) Engine Blades
6) Gearwheels
7) Cranks Shafts



CHAPTER 2 : VARIOUS HEAT TEATMENT PROCESSES

DEFINATIONS PER CQI-9

- Carbon Restoration- A heat treat atmosphere process with proper carbon potential that will restore the surface of steel to the proper carbon content. It is usually performed on the raw material that has decarburization at the surface. This is not to be used as a re-processing process.

- Dew Pointers- A meter especially suited for measuring the dew point of carbon bearing atmospheres. Due point is used to indirectly determine the carbon potential of the atmosphere.

- Nitride layer- Total depth of nitride penetration measured from the surface of the steel into the core material. Typical processes are Nitriding, Ferritic nitrocarburizing, Plasma Nitriding etc.

- Pyrometry- In its simplest of terms, Pyrometry is the measurement of temperature.

DEFINATIONS PER CQI-9

- Quench Delay- A time delay between the end of the heat treat cycle and the start of quench operation. For furnace heat treating it is the time elapsed from the start of furnace doors opening until the parts are at the bottom of the quench tank. For induction hardening systems, this is the time from the end of the heat cycle to the start of the quench flow(or when the parts enter a quench system).

- Sinter Hardening- Heating a mass of fine particles for a prolonged time below the melting point, usually to cause agglomeration, Coupled with quenching and tempering steps to produced increased strength.

- Sintering- Heating a mass of fine particles for a prolonged time below the melting point, usually to cause agglomeration. CQI-9 does not apply to sintering where hardening is not performed, unless required by customer specific requirements.

- Soak Time- Total time elapsed during a single, uninterrupted, Continuous soak period, that concludes at the completion of the process cycle.

DEFINATIONS PER CQI-9

- **Temper Delay- Time delay from when the parts exit the quench the quench tank to the time when the parts are placed in the tempering furnace.**

- **Trap points- Areas in containers (Baskets, Fixtures, shipping boxes etc) or any equipment's that may inadvertently trap parts, allowing the potential for parts to be mixed between batches.**

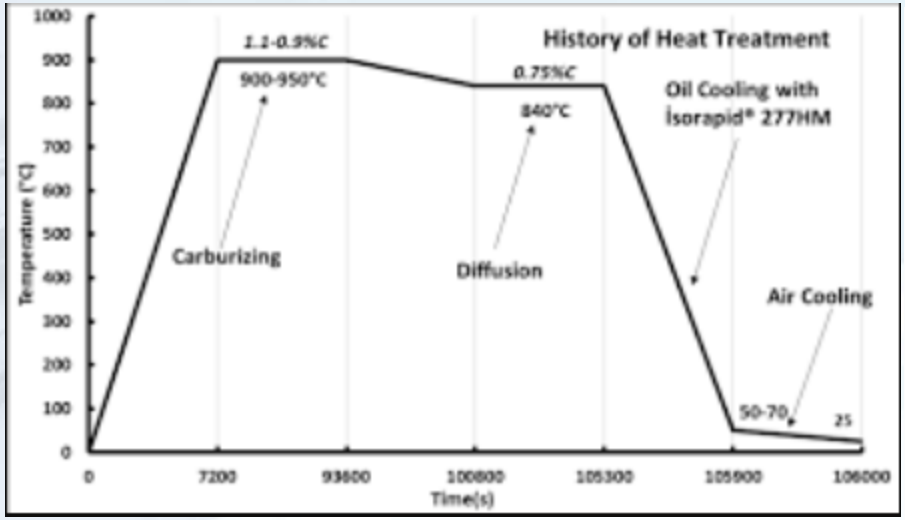
2 – VARIOUS HEAT TEATMENT PROCESSES

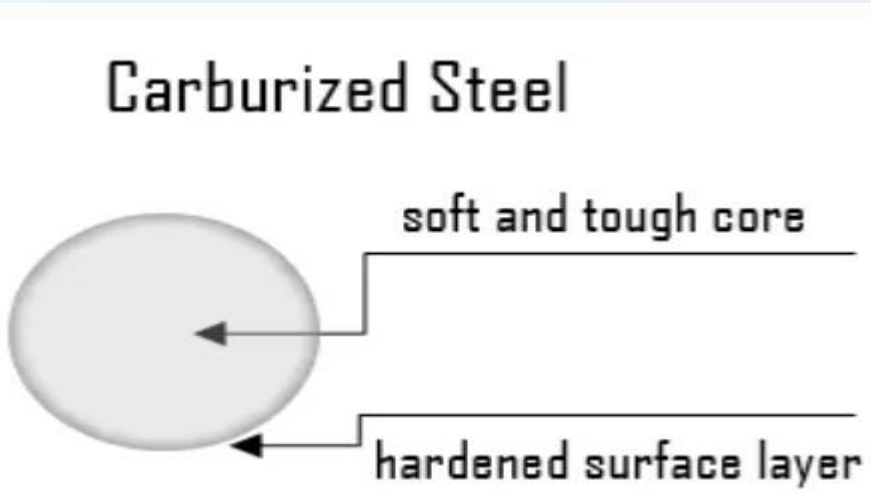
CARBURIZING	CARBONITRDING	CARBON RESTORATION	NEUTRAL HARDENINIG
AUSTEMPERING	MARTEMPERING	TEMPERING	PRECEIPITATION HARDENING
GAS NITRIDING	FERRITIC NITRO CARBURIZING	ALUMINUM HEAT TREATMENT	INDUCTION HARDENING
ANNEALING	NORMALIZING	STRESS RELEIVING	SINTER HARDENING
ION NITRIDING	HOT STAMPING	LPC CARBURIZING	LPC HARDENING

2 – CARBURIZING

Carburizing is surface hardening phenomena which provides wear resistant case by enriching carbon on surface. Low alloy steels are used for the process.

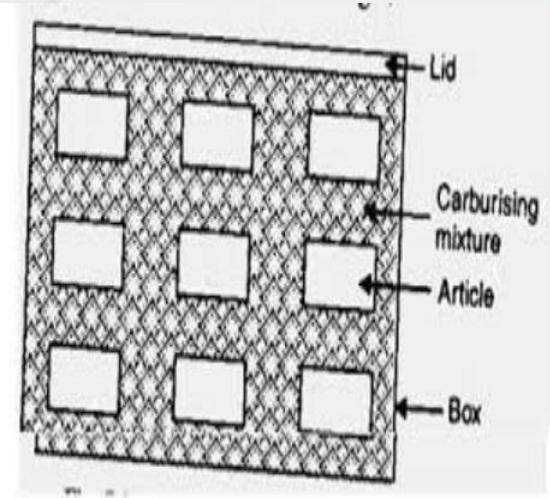
In many application such as crankshaft ,camshafts, gears etc., hard and wear resistance is required with tough core(at center) to withstand impact loads .





2 CARBURIZING- TYPES OF CARBURIZING

Solid/Pack



Liquid

Gas

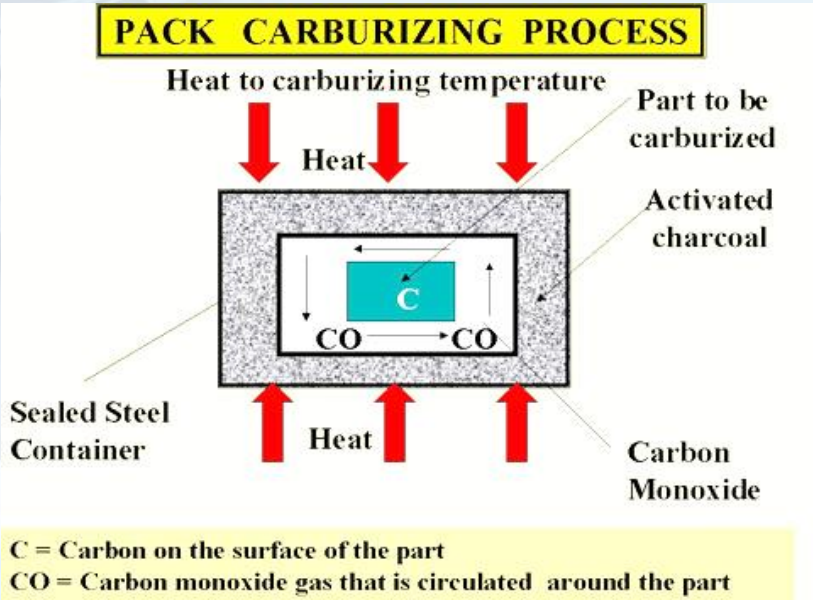
2 CARBURIZING – SOLID/PACK CARBURIZING

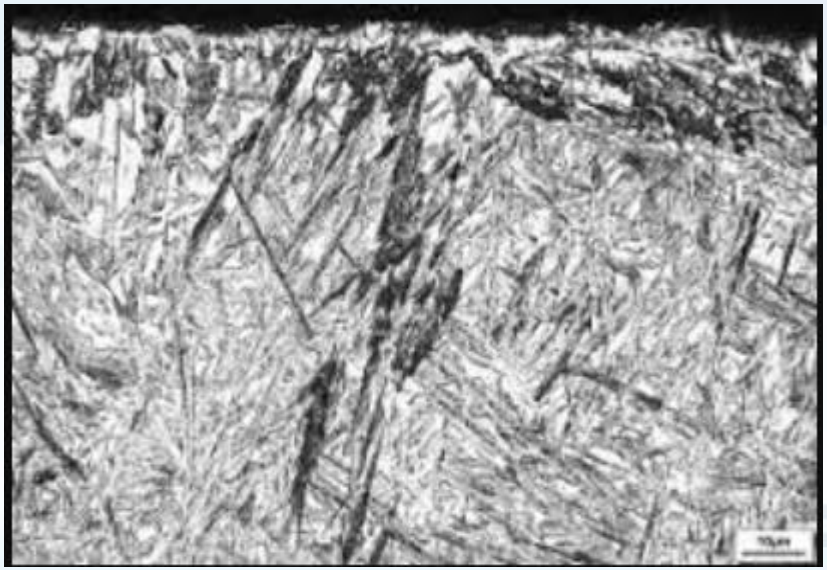
The component to be carburized are packed with a carbonaceous material in the steel or cast iron boxes clay.

If the boxes are not properly sealed, air comes in contact with the carbonaceous medium and medium simply burns without any carburizing .

The usual carbonaceous medium consist of hard wood charcoal ,coke and an energizer or accelerator such as Barium carbonate or other sodium or calcium carbonate.

These boxes are heated to some temp. In austenitic region and kept at this temp until the desired degree of penetration is obtained.

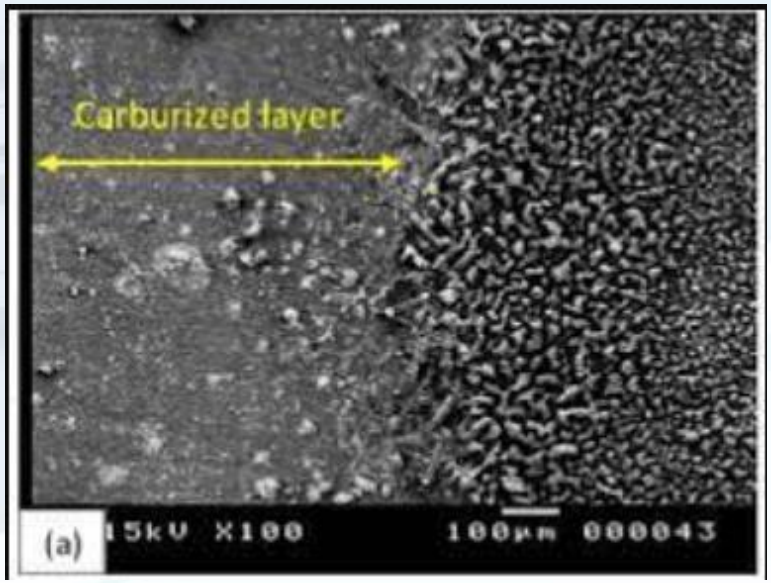


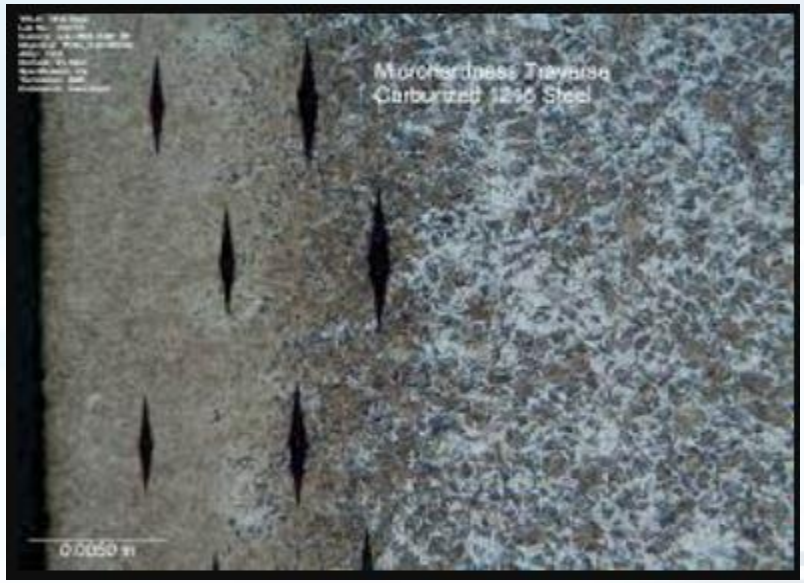


2 CARBURIZING – GAS CARBURIZING

Here the components are heated in the austenitic region in the presence of a carbonaceous gas such as methane, ethane propane or butane diluted with a carrier gas such as flue gas.

These gases decomposes and the carbon diffuses in to steel. To maintain a constant and uniform rate of carbon diffusion ,gas composition must be properly controlled along with proper circulation of gas in the furnace chamber.

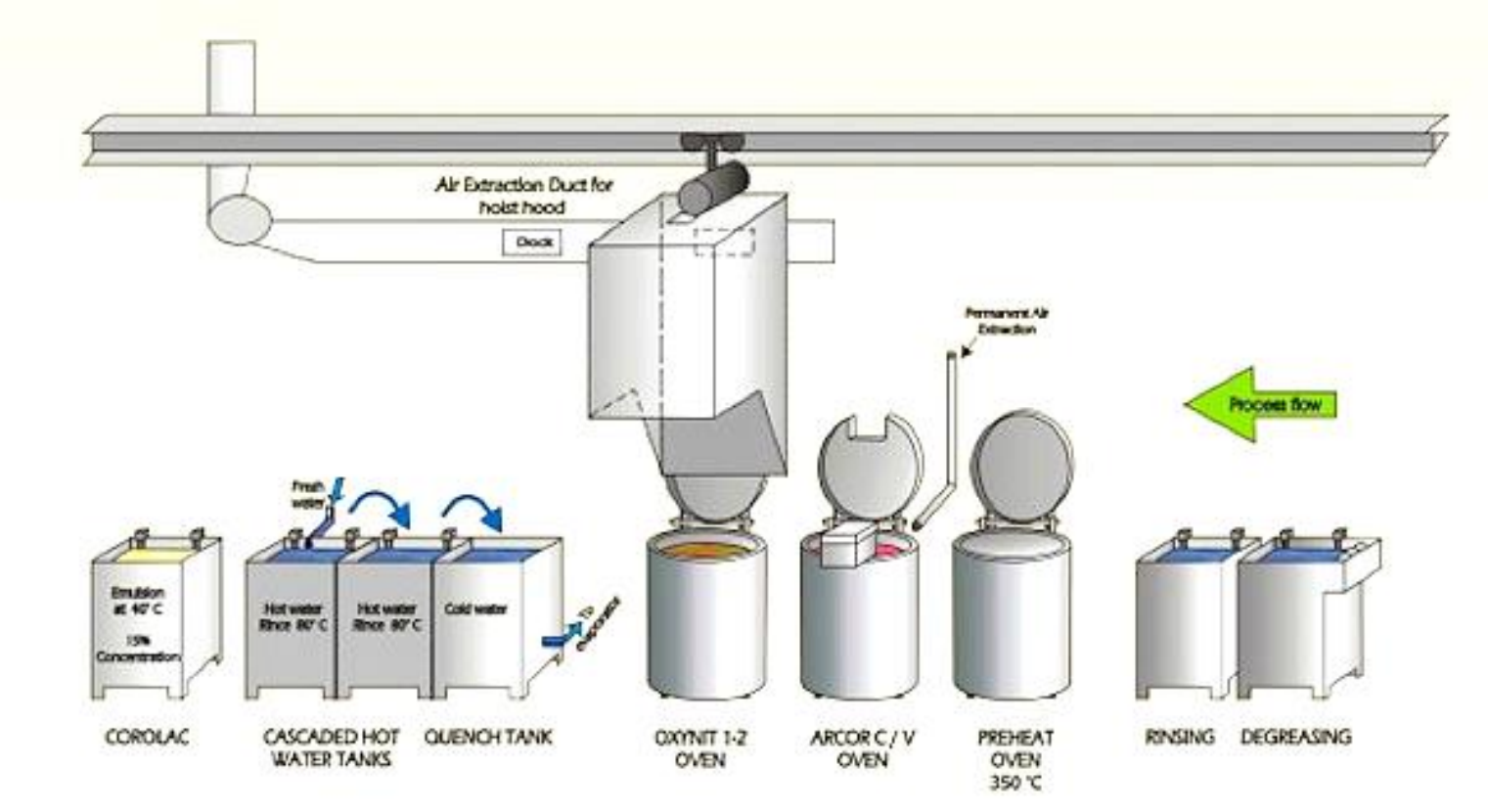




2 – CARBURIZING – LIQUID CARBURIZING

In this method carburizing is done by immersing the steel component in a carbonaceous fused salt bath medium at a temp in the austenitic region .

This bath is composed of sodium cyanide ,sodium carbonate and sodium chloride .

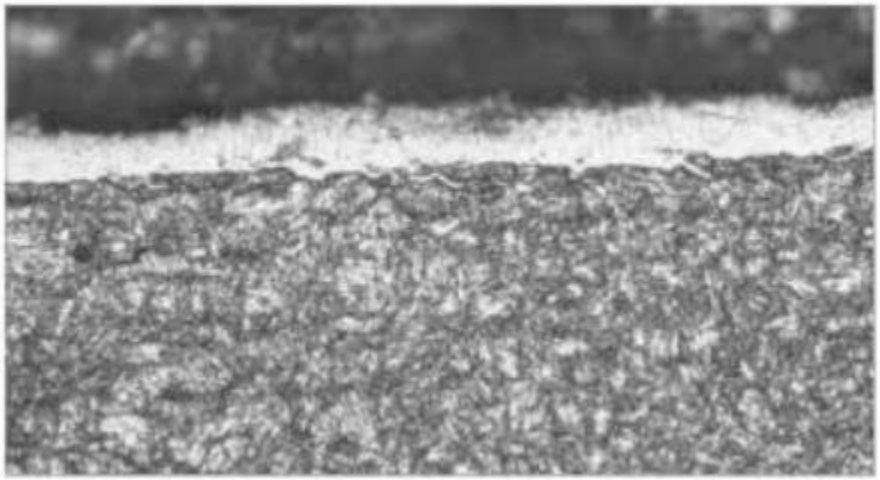


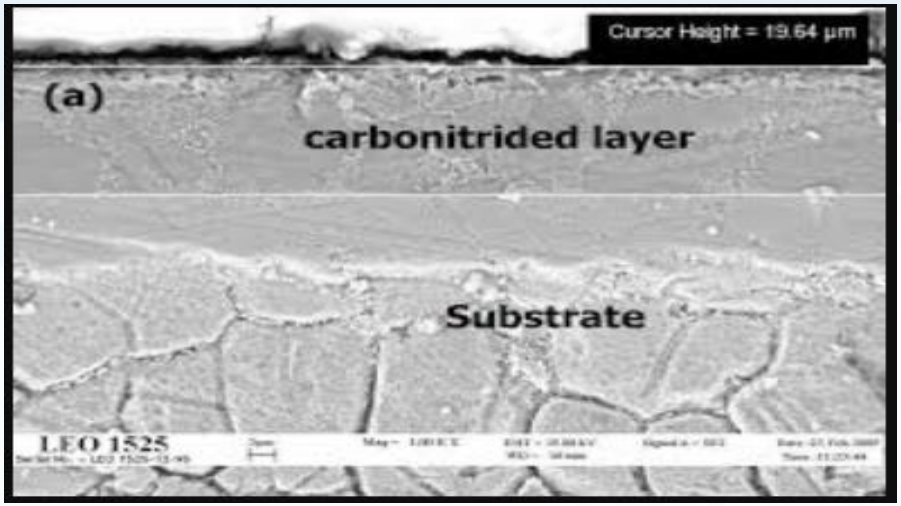
2 – CARBONITRIDING

Carbonitriding is surface hardening phenomena which provides wear resistant case via enriching surface with Carbon and Nitrogen.

A carbonitrided layer has better hardenability than carburized layer due to addition of Nitrogen.

Process involves Heating job up-to austenitizing temperature (around 850 deg cel) in carbon and nitrogen atmosphere followed by quenching.



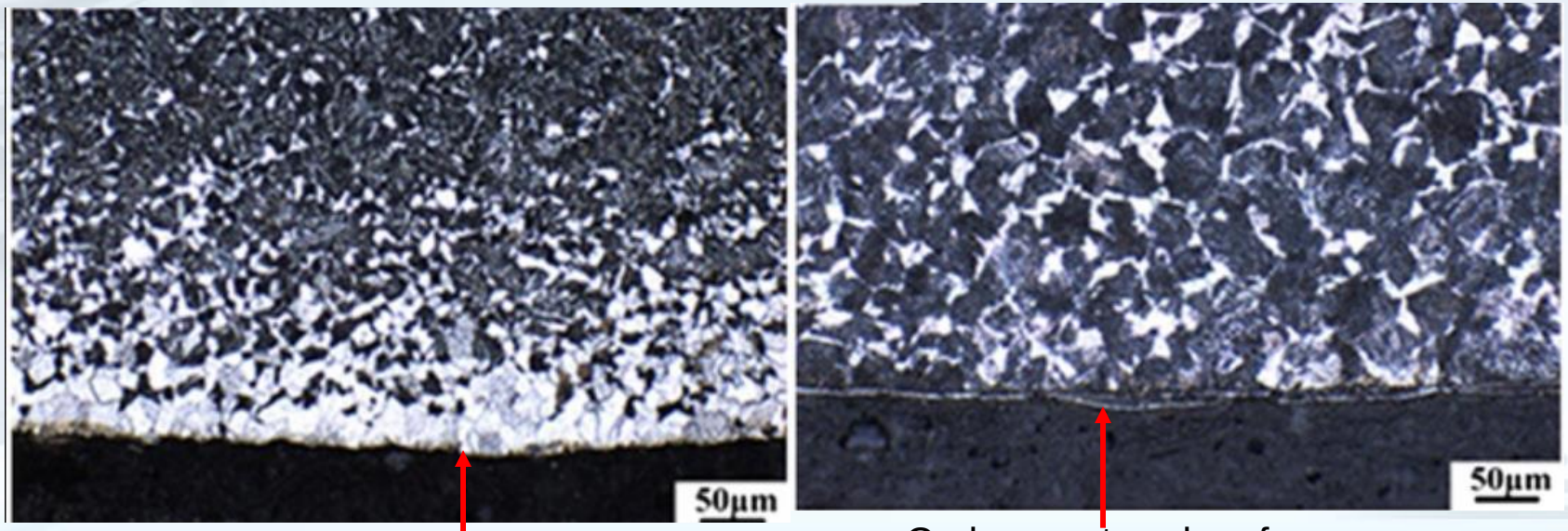


2 – CARBON RESTORATION

Carbon restoration is a type of carburizing process which enriches the carbon of surface of casting or forging back to its original carbon content and to restore the hardness of the surface.

This process is typically done to correct the surface oxidation or decarburization occurs at high temperatures.

It is typically done in spring steel to restore the carbon on surface.



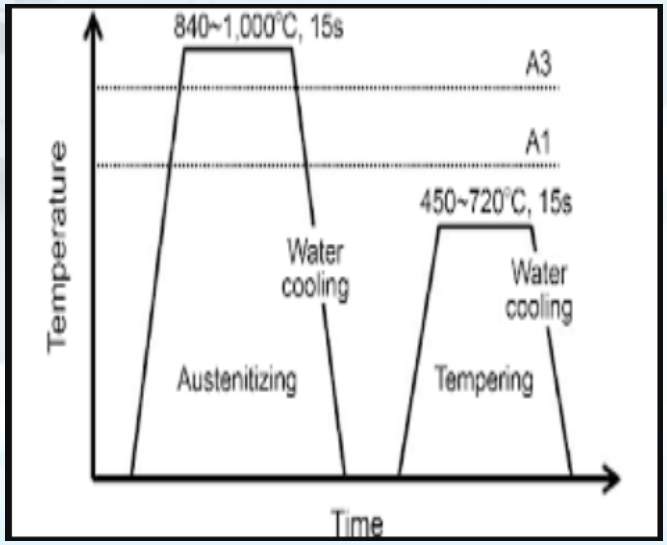
2 – NEUTRAL HARDENING (QUENCHING AND TEMPERING)

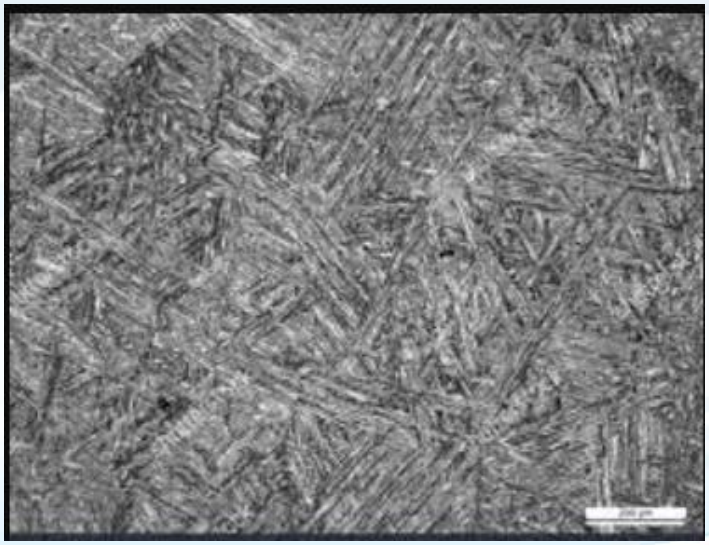
Neutral hardening is done in medium carbon steel to improve mechanical properties and get martensitic microstructure.

It is a diffusion-less process.

It is always followed by tempering to gain some toughness as material becomes brittle after quenching.

In this process material is heated up-to austenitizing temperature and cooled rapidly in water, polymer or oil to obtain martensitic microstructure.

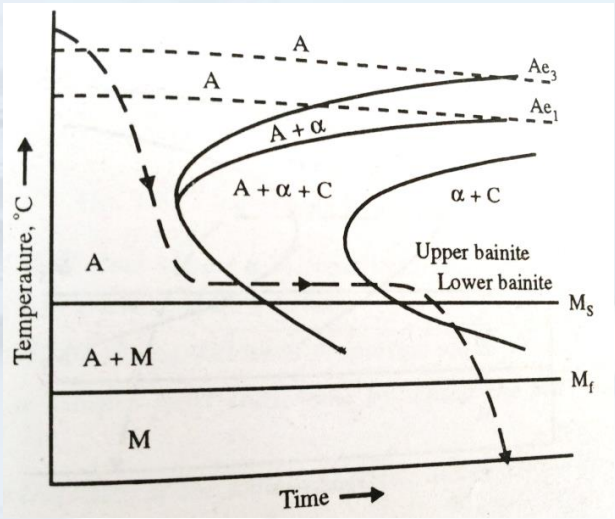


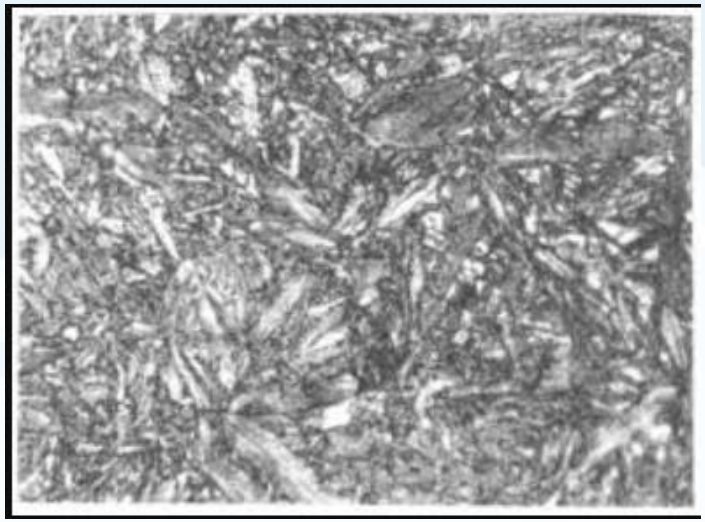


2 – AUSTEMPERING

In this process Austenitized steel is cooled with rate exceeding the critical cooling rate and held at constant temp. Between the nose Of TTT diagram and Ms temp i.e. In Bainite region, holding at this temp. For a sufficient period for the Complete transformation of Bainite transformation and cooling To room temp.

Typically used in springs.

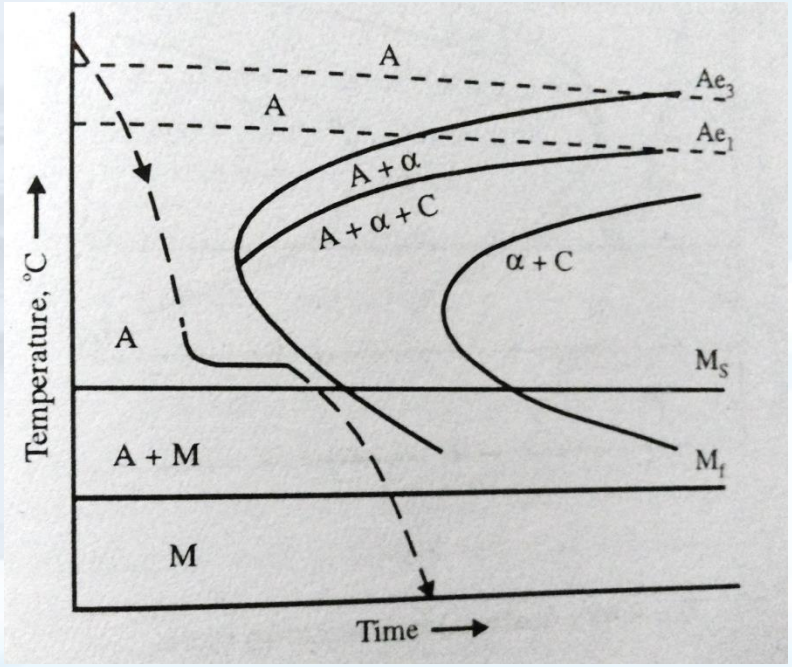




2 – MARTEMPERING

In this process austenitized steel is cooled rapidly avoiding the nose of the TTT diagram to temp between nose and held at this temp. till austenite is transformed to martensite and then cooled to room temp.in air or oil.

It is used to avoid warping, distortion, quenching cracks.
Mostly used in bearings, tools, dies where tolerance are concern.

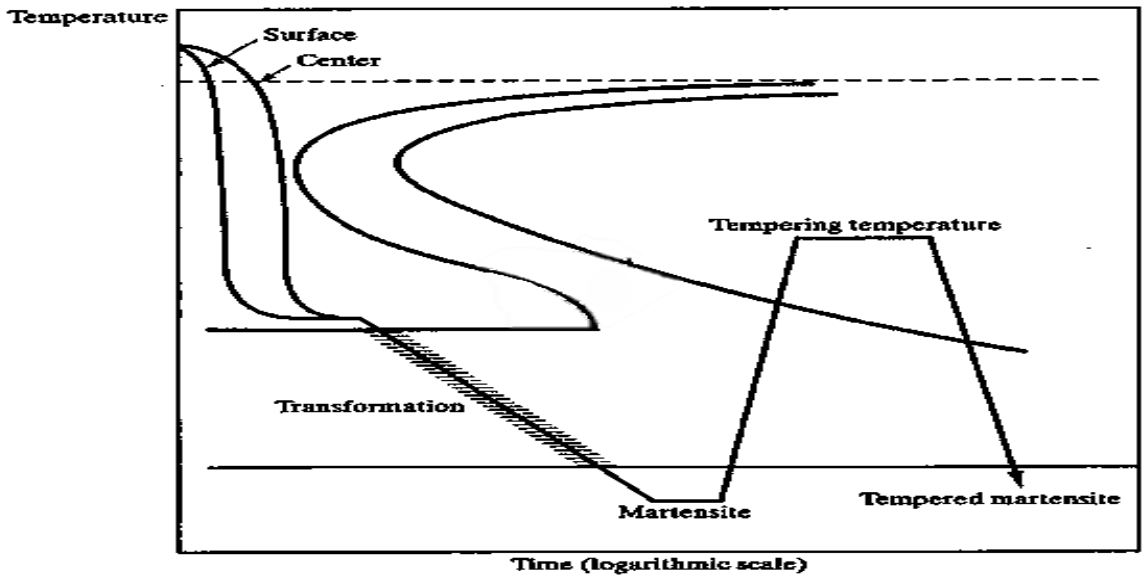


2 – TEMPERING

Tempering process is a process of heat treating, which improves the toughness characteristics of parts.

It is basically heating the parts and holding it at elevated temperature followed by cooling in air.

It is typically done after quenching.

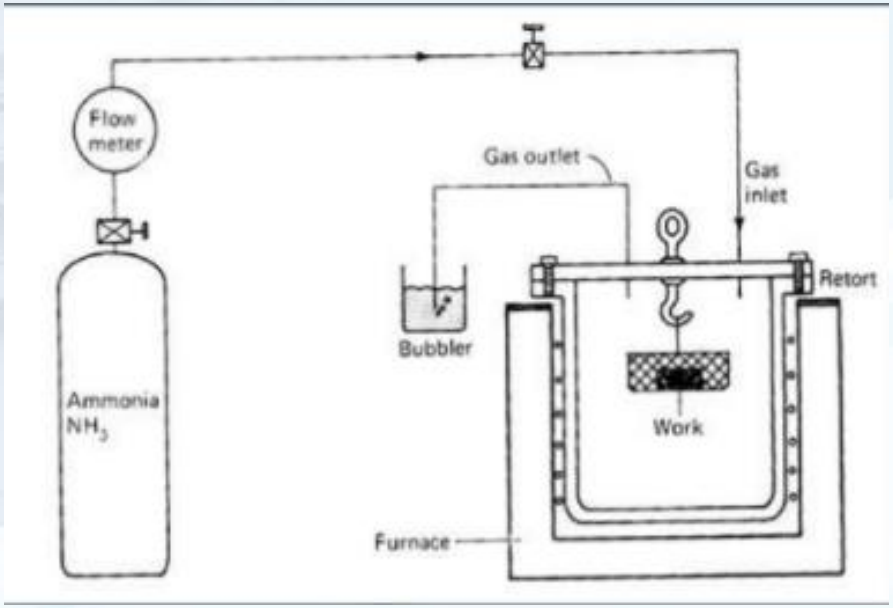


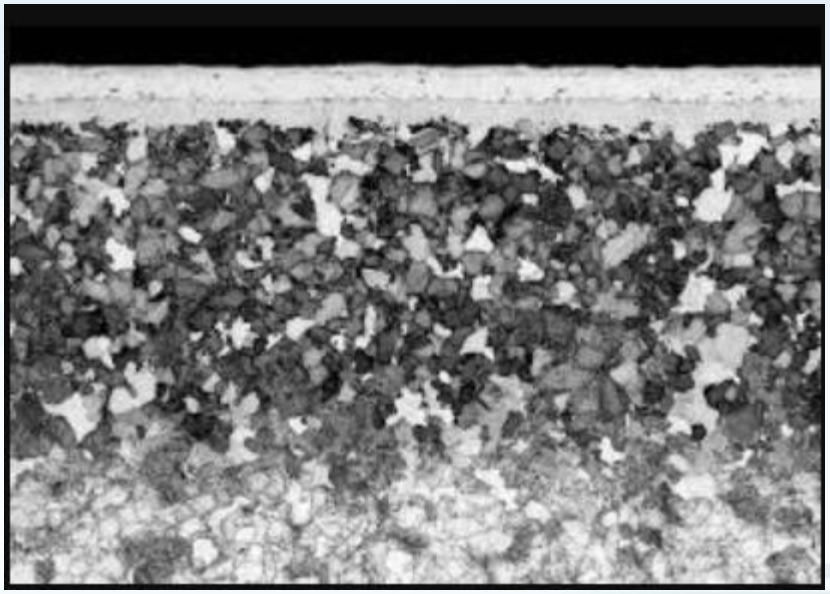
2- ALUMINUM HEAT TREATMENT

- Aluminum heat treat is a process by which strength and hardness of a specific subset of Aluminum alloys are increased.
- Typical temperature ranges from 150- 600 deg centigrade.
- Typical heat treatable series are 2XXX, 6XXX, 7XXX which are strengthened by Aluminum heat treatment.
- Typically Aluminum heat treatment are annealing, Homogenizing, etc.
- Annealing is done on work hardened alloys to reset the crystalline grain structure.
- Homogenizing is done to redistribute the precipitating elements more evenly throughout the aluminum part.

2- GAS NITRIDING

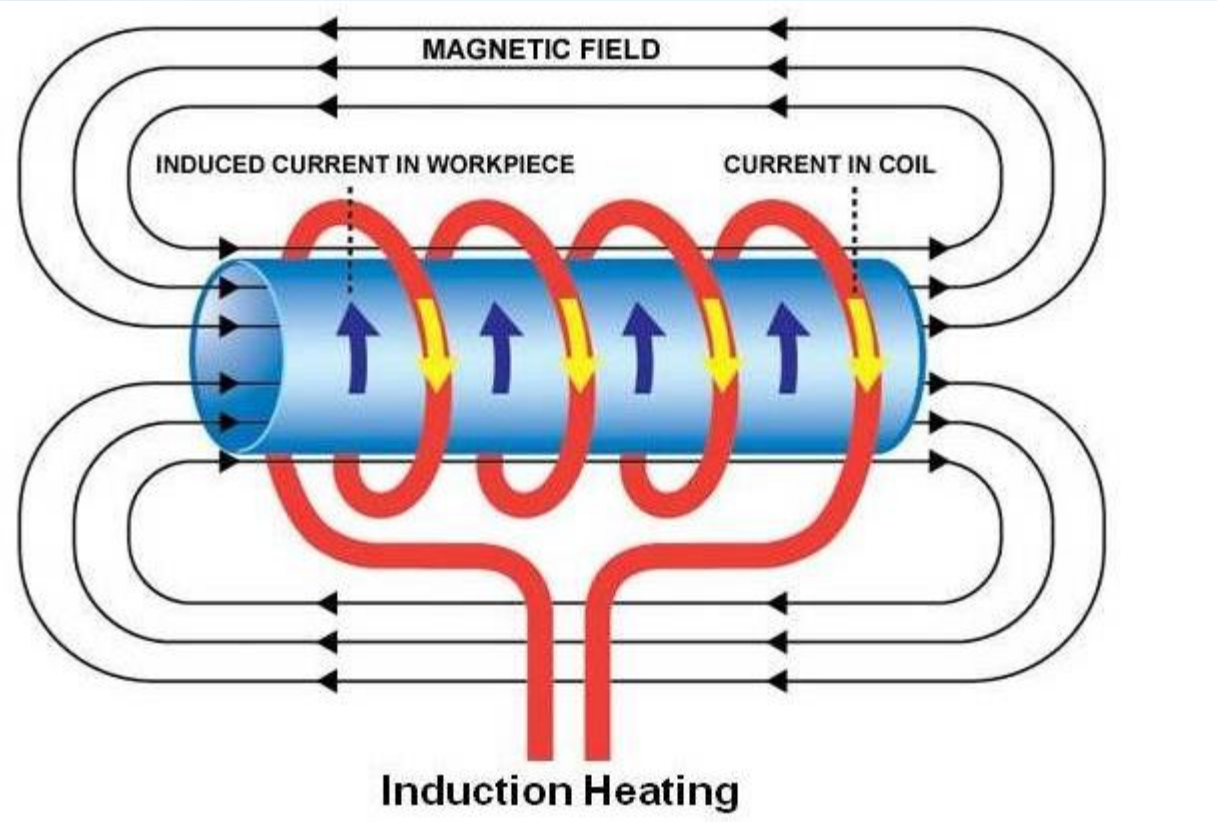
- In this process steel is heated in 500-600 C in presence of Ammonia
- This forms the nitride product on surface of metal
- Nitride are hard in nature which increase the hardness of surface
- Quenching is not required in this process so distortion is not an issue.





2 – INDUCTION HARDENING

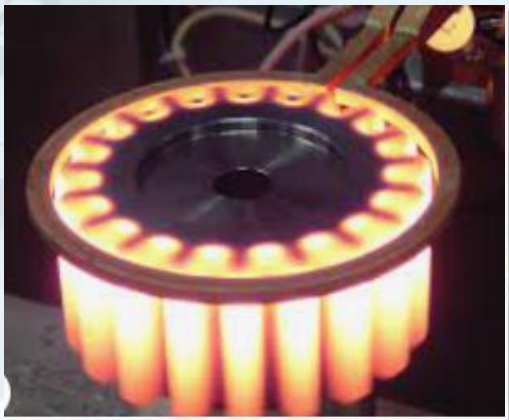
- Induction hardening is a process used for the surface hardening of steel and other alloy components. The parts to be heat treated are placed inside a copper coil and then heated above their transformation temperature by applying an alternating current to the coil.

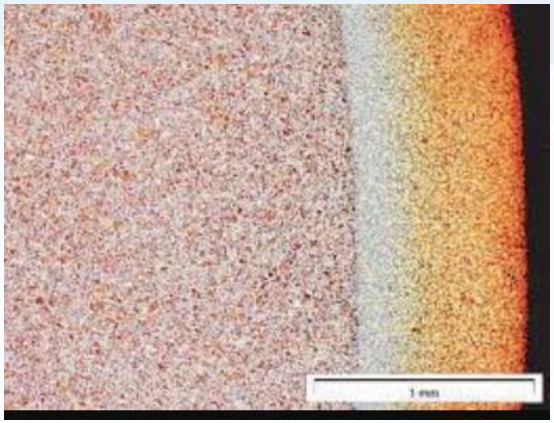


2 – INDUCTION HARDENING

- Induction hardening is process used for the surface hardening of steel and other alloy components. The parts to be heat treated are placed inside a copper coil and then heated above their transformation temperature by applying an alternating current to the coil and followed by water or polymer quenching.

- It can quickly and selectively harden the job.





2 – ANNEALING

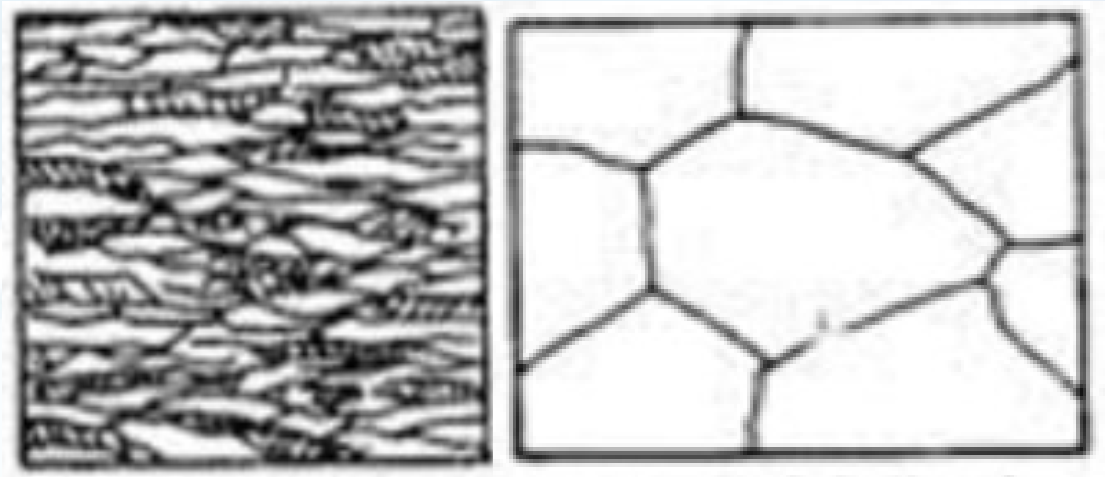
It refers to a heat treatment in which the material is exposed to an elevated temperature for an extended time period and then slowly cooled.

When an annealed part is allowed to cool in the furnace, it is called a "full anneal" heat treatment.

This process provides high ductility and toughness.

Types of annealing

- **Full Annealing**
- **Process Annealing**
- **Stress Relief Annealing**
- **Sub-critical Annealing**



2 – ANNEALING

PURPOSE

- To relive internal stresses that are developed from welding and cold rolling.
- To reduce hardness
- To refine the grain size
- To make material homogeneous.

2 – NORMALIZING

Material is heated 40 to 50c above its critical temp then it is hold at that temp and then allowed to cool slowly in air

Normalizing is done on cold work parts to remove internal stresses and restructure the material grain

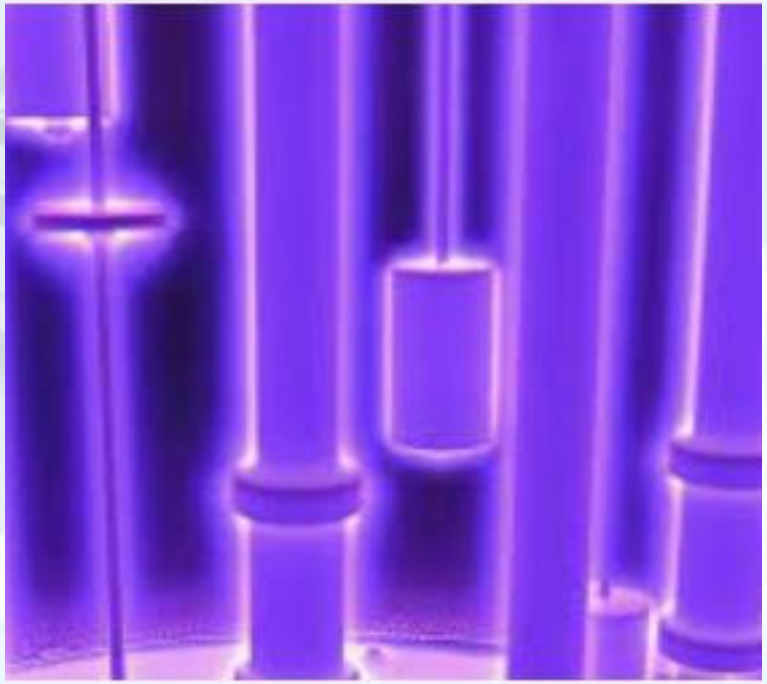
Normalizing is done at higher temperature and takes relatively less time than Annealing.

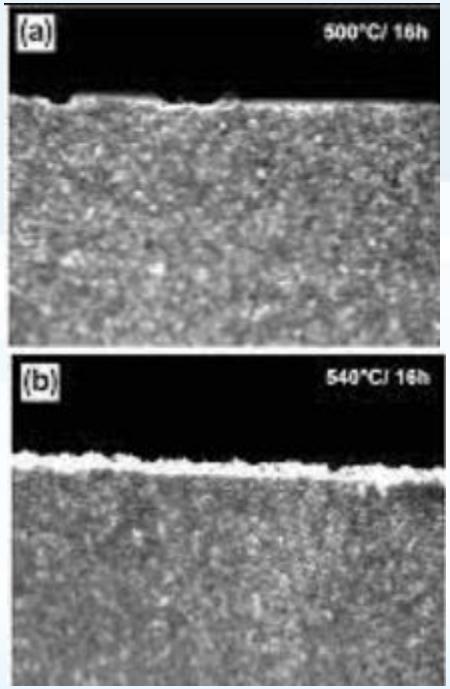
Main Objectives:

To refine grain structure.
To remove strains
To remove internal stress
To improve mechanical properties.

2- ION NITRIDING

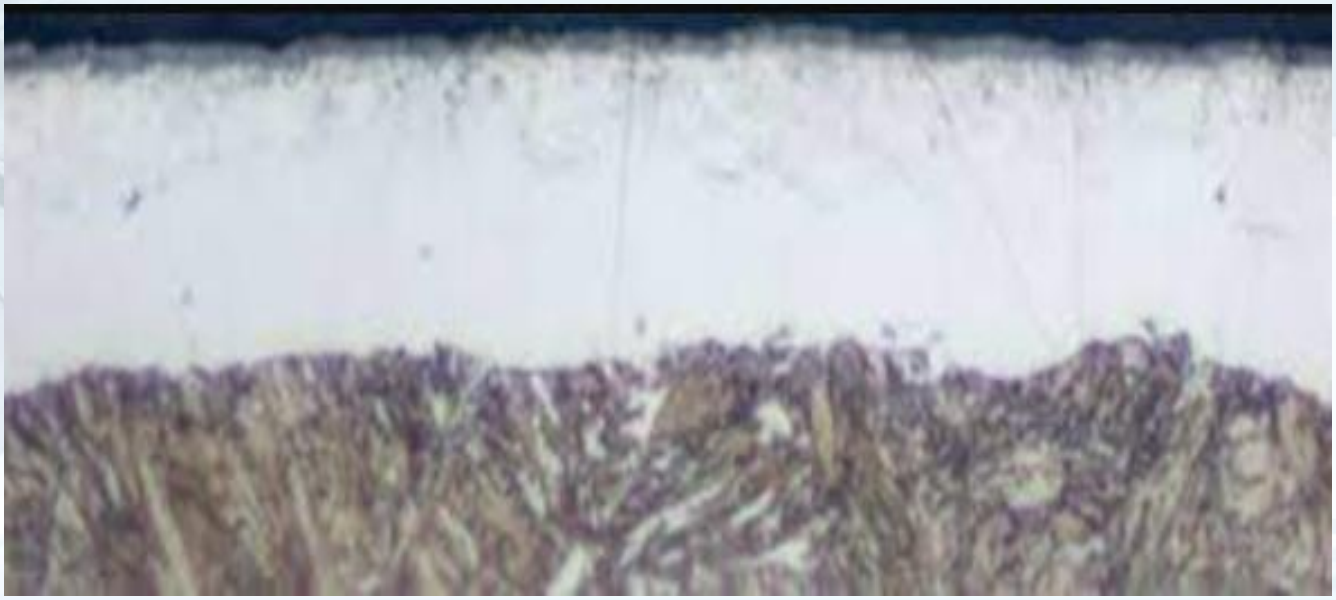
- It is plasma supported thermo chemical case hardening process use to increase wear resistance.
- It is carried out in vaccum vessel where a high voltage electrical charge forms plasma causing nitrogen ions to accelerate and impinge on the metal.





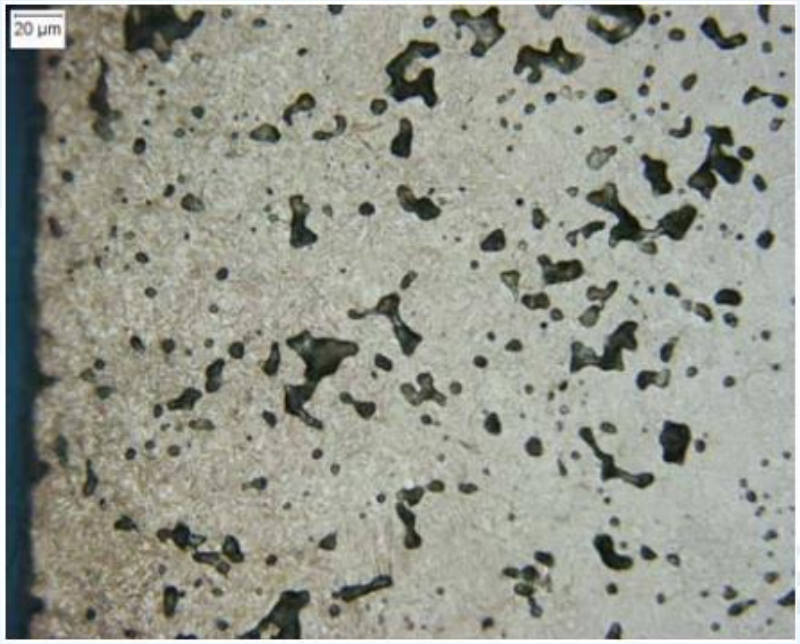
2- FERRITIC NITRO CARBURIZING

- It is a thermo chemical heat treatment involves enrichment of nitrogen and carbon into surface.
- It is of two types austenitic and ferritic.
- As compared to carbonitriding, more nitrogen is required in this process.



2- SINTER HARDENING

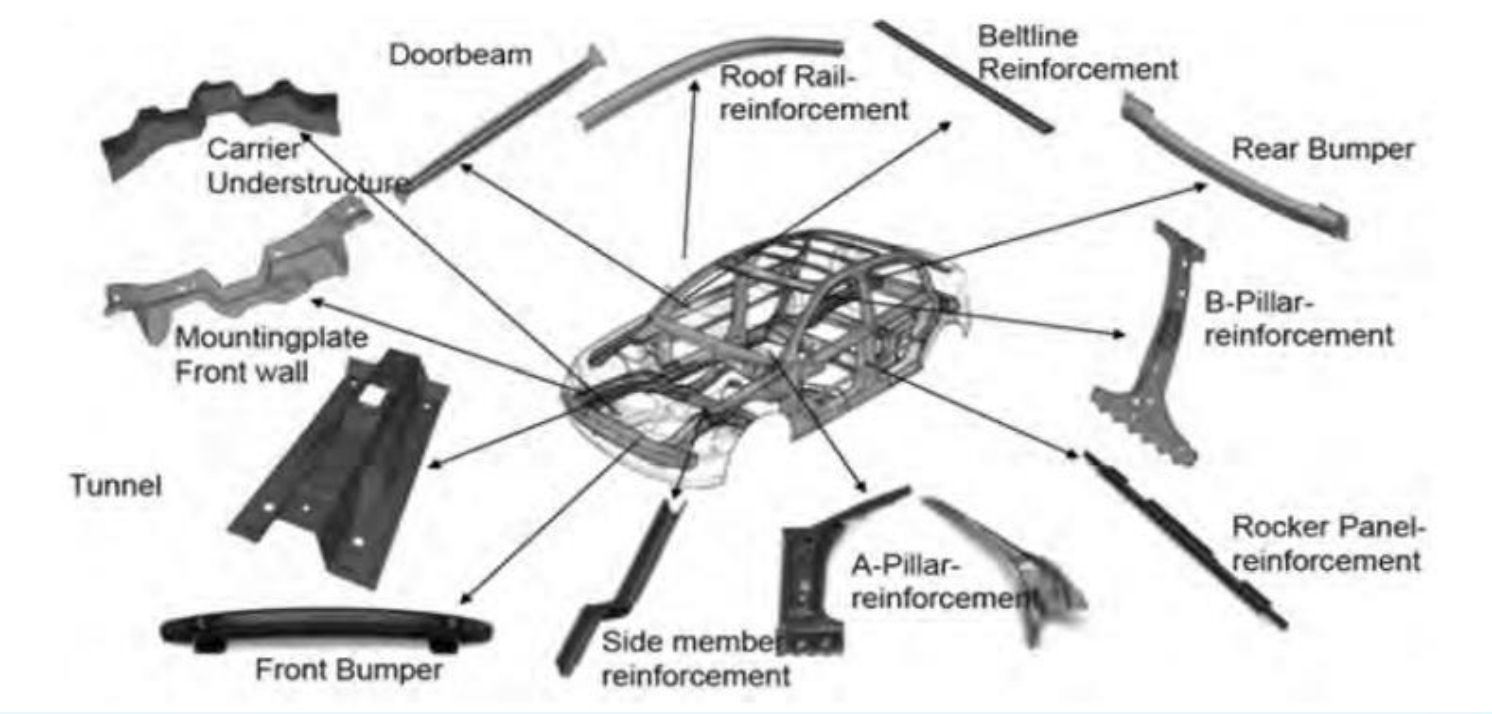
- In this process cooling is fast enough to transform significant portion of powder metal steel matrix into martensite.
- It has better dimensional control due to less severity of quench.
- It is followed by tempering for relieving of high internal stress.



2- HOT STAMPING

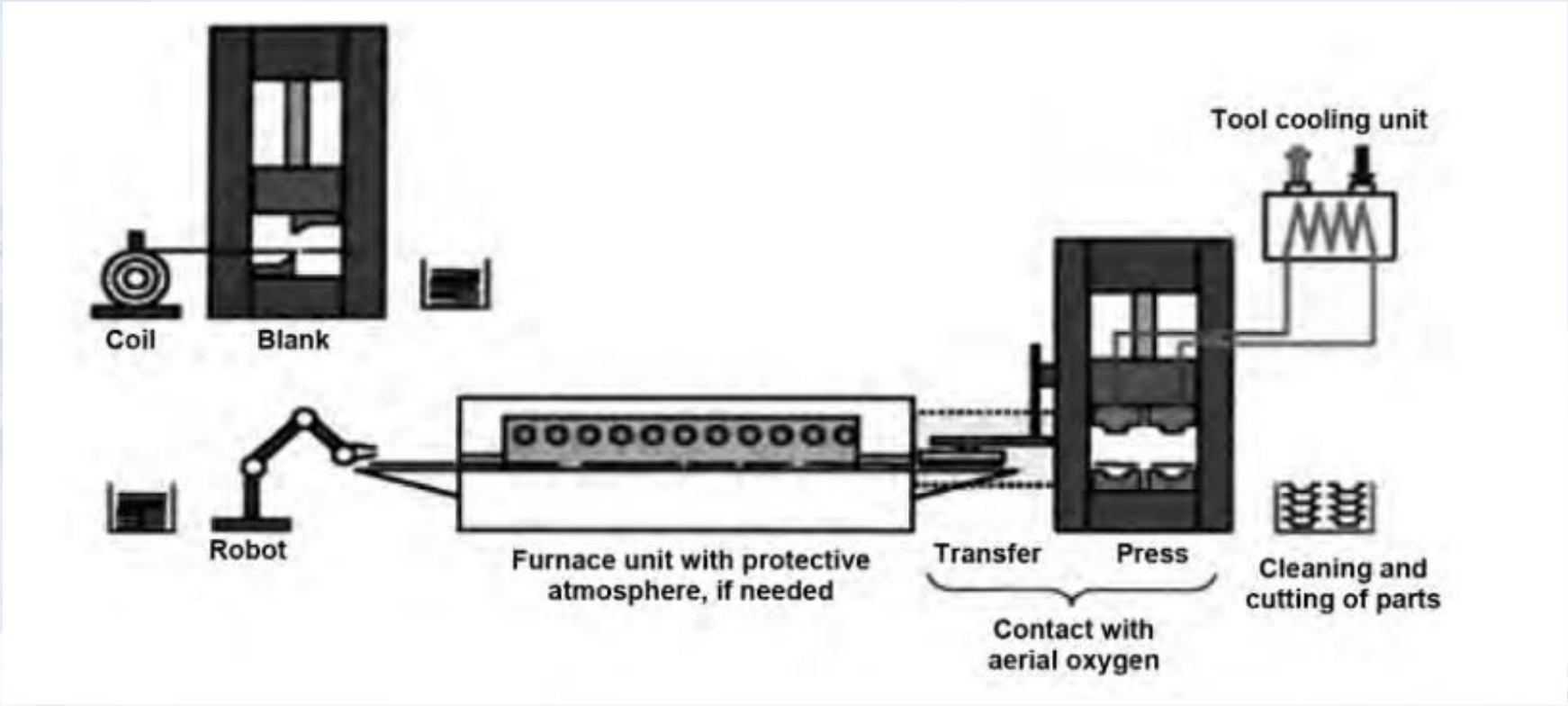
- It's a no iso thermal forming process for sheet metal where forming and quenching takes place at forming step.

- This process takes advantage of low flow stress and allowing manufacturing of ultra high strength parts with minimum spring back and reduced thickness.



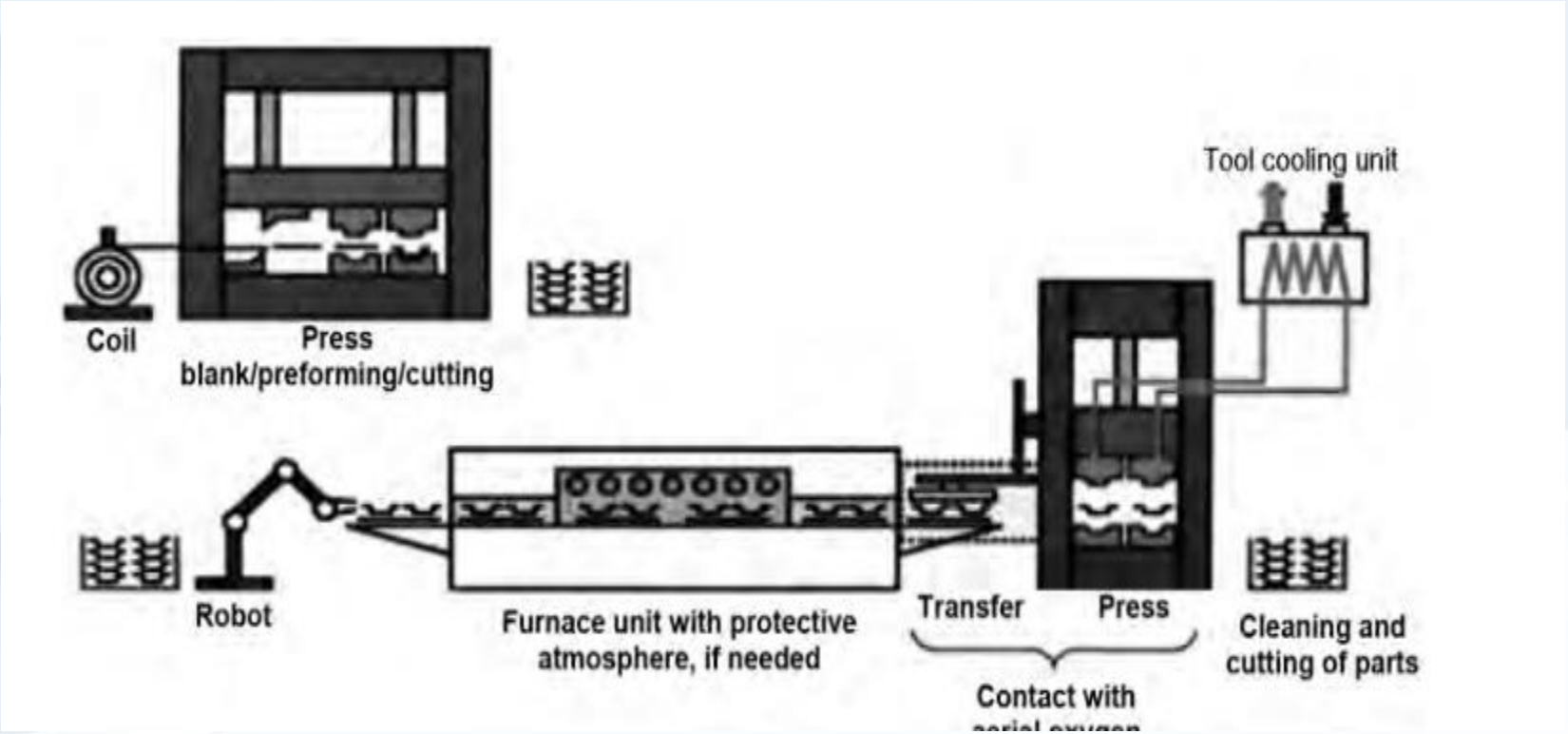
2- HOT STAMPING

- There are two methods of Hot stamping.
- Direct and indirect method.
- Below is the schematic of direct hot stamping process.



2- HOT STAMPING

- **Below is the schematic of In direct hot stamping process.**



2- COMMON IMPORTANT PARAMTERS

- Below are the few common parameters among other important parameters always to be taken care of when heat treating components.
- Temperature
- Tolerance of temperature
- Time(Soaking, Cooling and heating)
- Power.
- Flow.
- Dwell time.

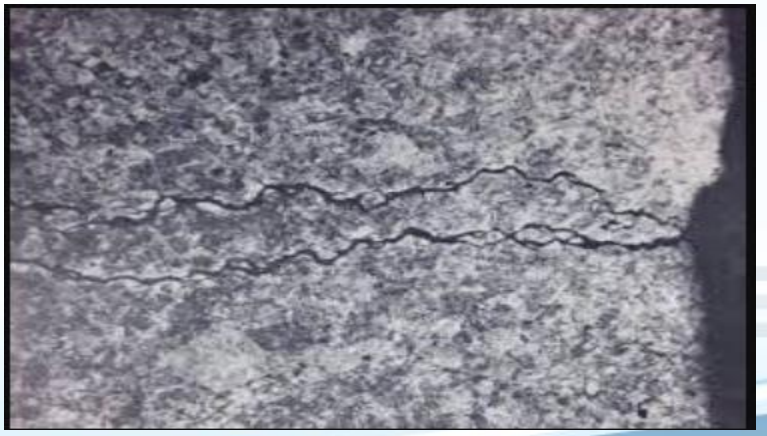
CHAPTER 3 : DEFECTS

3-DEFECTS

- Quench Cracks

- Possible causes- Rapid cooling, Low polymer concentration, quenchant with high quench severity(wrong quenchant)

- Possible remedies- Correct polymer concentration, uniform cooling.

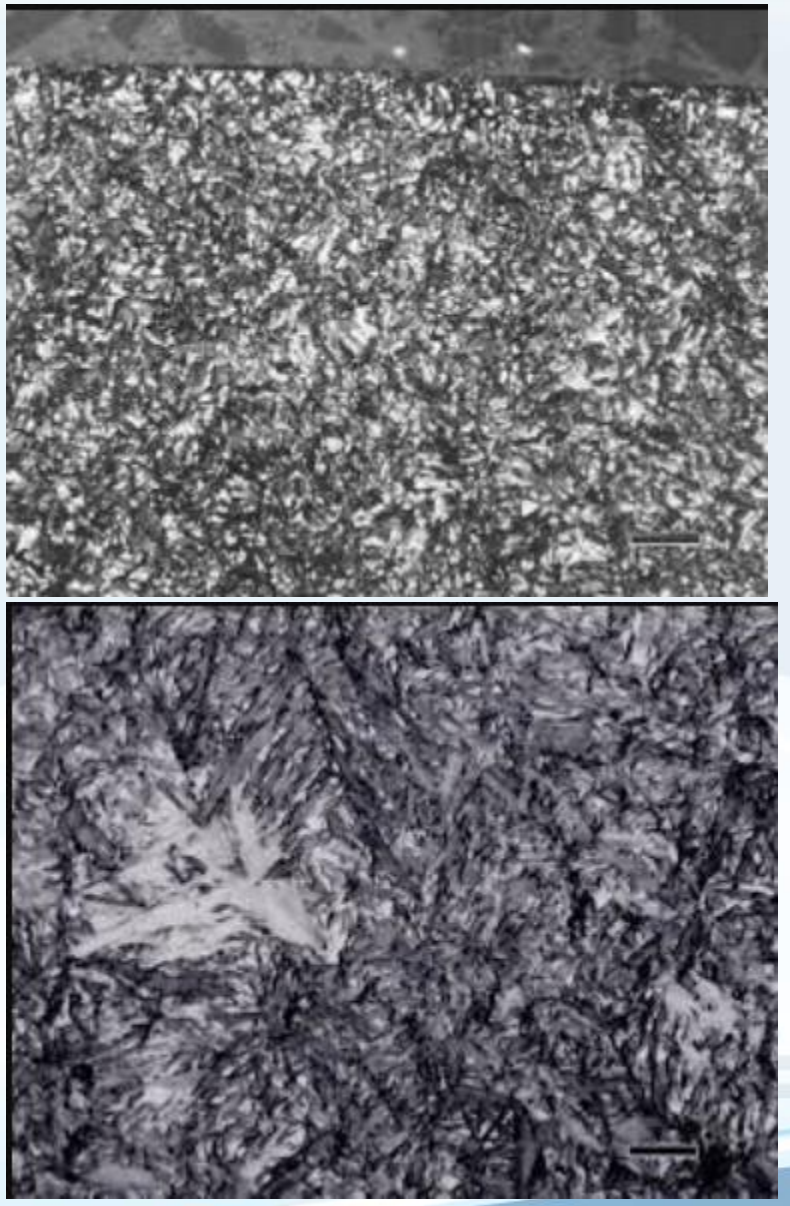


3 – DEFECTS

- Low Surface hardness

- Possible causes- Presence of large amount of retained austenite or decarburization.

- Possible remedies- By increasing the hardening temperature. More alloys will get dissolved in austenite lowering the Ms temperature.

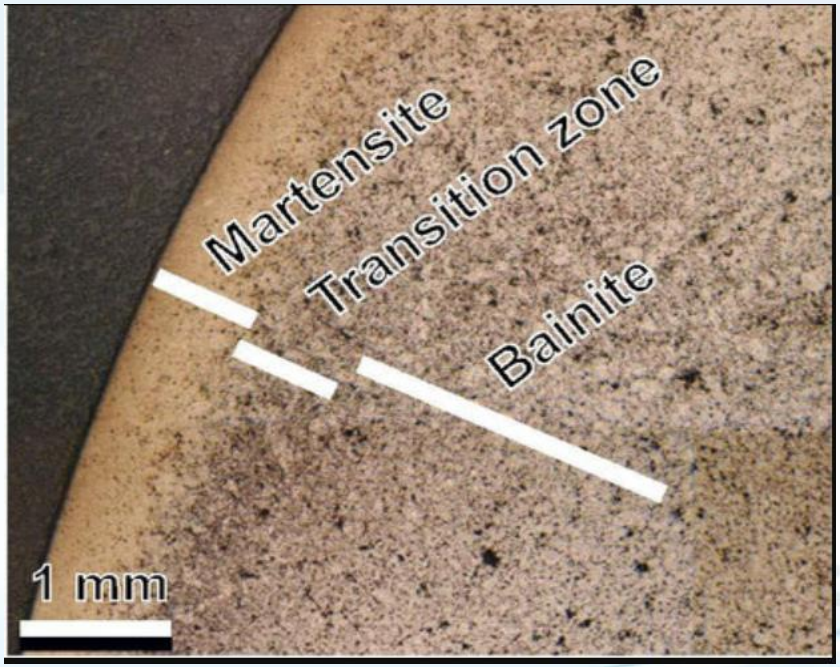


3 – DEFECTS

- Low Case depth

- Possible causes-
  low temperature.
  lean solid carburizer is used .
  The amount of enriching hydrocarbon was less.

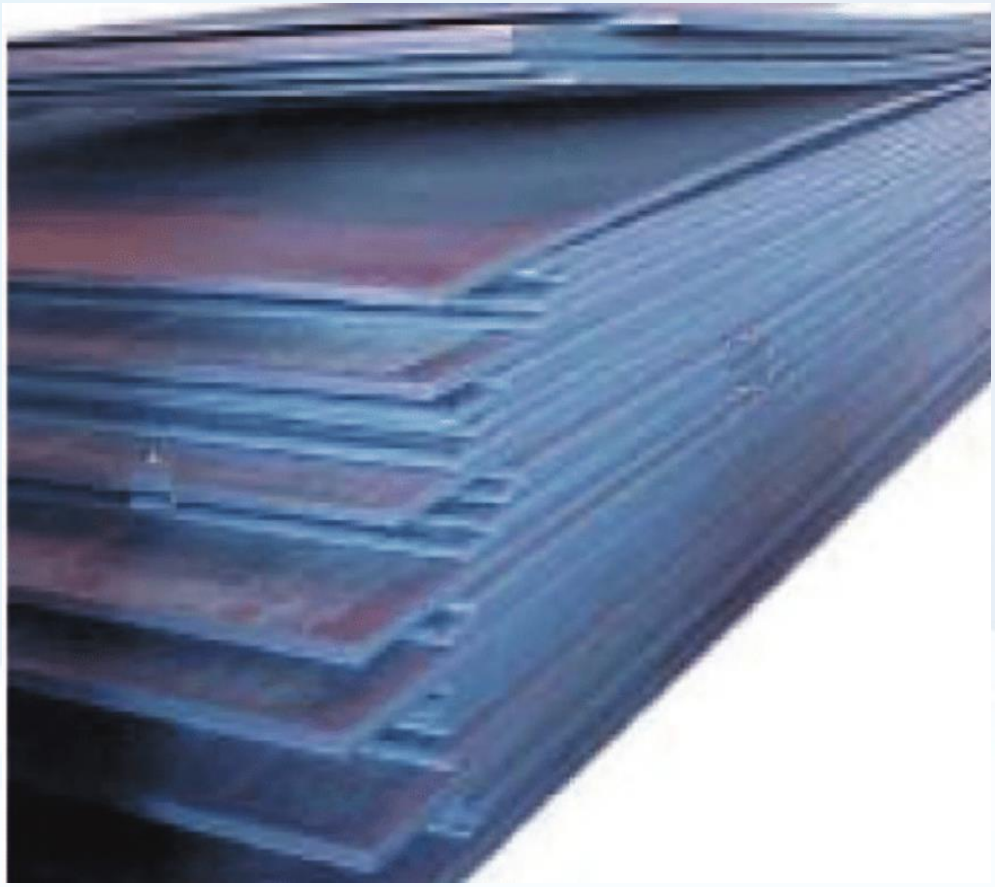
- Possible remedies-
  By optimizing parameters.



3 – DEFECTS

- Distortion- Change in shape and size can arise in case hardened components due to temperature, rapid cool, high soaking. Some attributable to design shortcomings.

- Possible remedies- normalizing job before surface hardening process could lead to reduction in internal stresses due to prior work hardening.

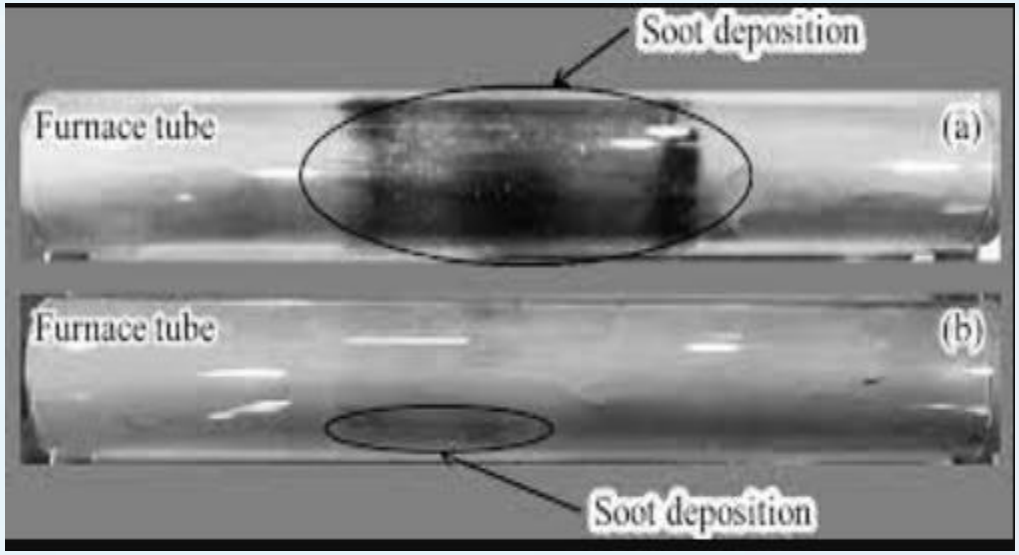


3 -DEFECTS

- Sooting

- Possible causes-
  large amount of hydrocarbon gas or masking of surface due to foreign material.

- Possible remedies-
  By optimizing gas flow.

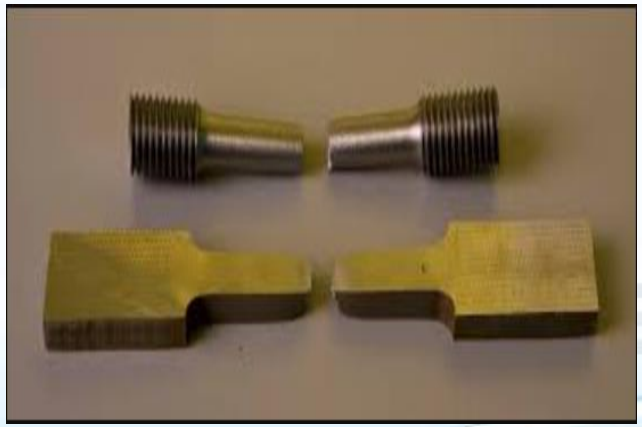


3- DEFECTS

- Low Tensile strength or low hardness

- Possible causes- Oversoaking.

- Possible remedies- Soaking and temperature to be controlled.



3 – DEFECTS

- LOW HARDNESS

- Possible causes- Low dwell time, low temperature, low power, high scan speed.

- Possible remedies- Optimizing the process parameter.

CHAPTER 4 : TESTINGS

3 – Testing involved in heat treatment

- Tensile strength per ASTM E 8 or ASTM 370.
- Hardness Per ASTM E 10, ASTM E 18.
- Microhardness testing Per ASTM E 384.
- Impact testing Per ASTM E 8 or ASTM E 370.
- Microstructural studies including grain size measurement per ASTM E 112.

THANK YOU

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Are there any Questions?