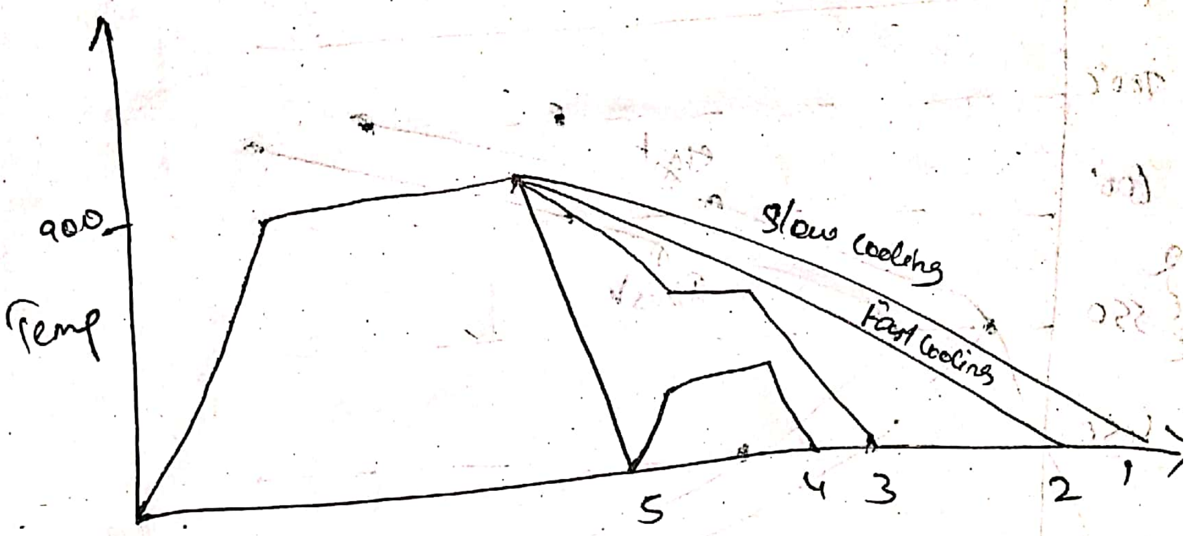
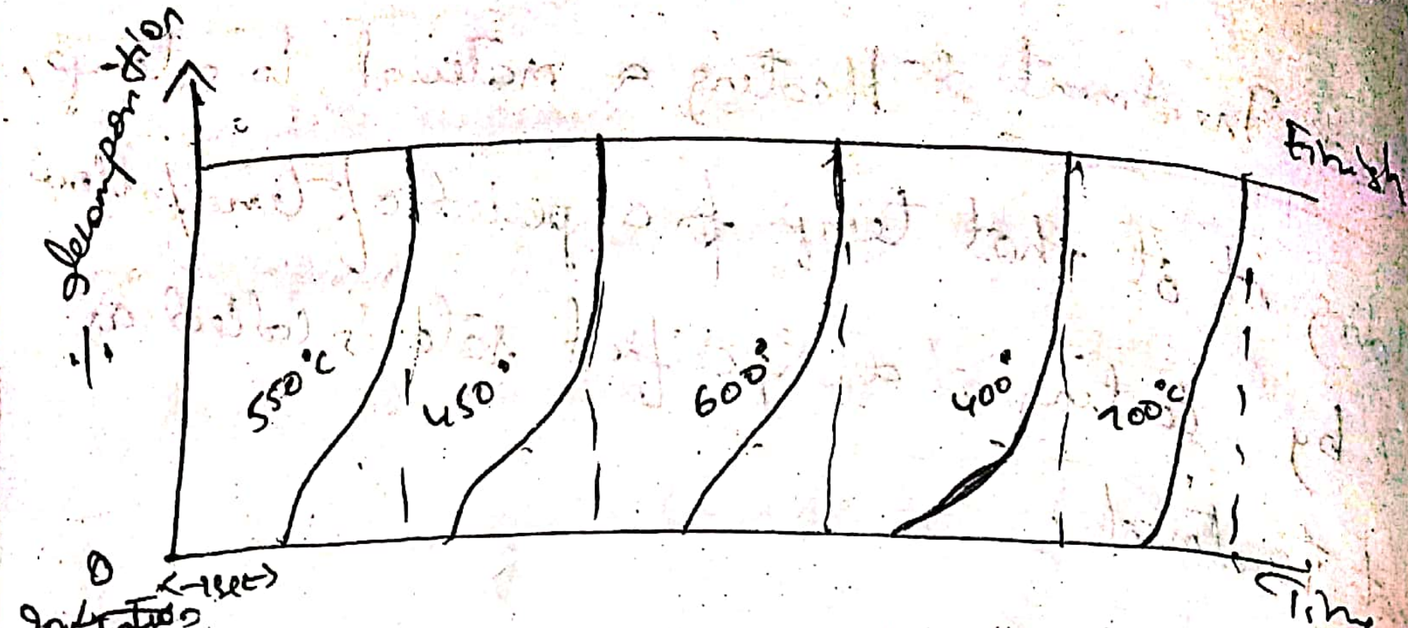
25/09/19 Unit :- 4 Heat Treatment

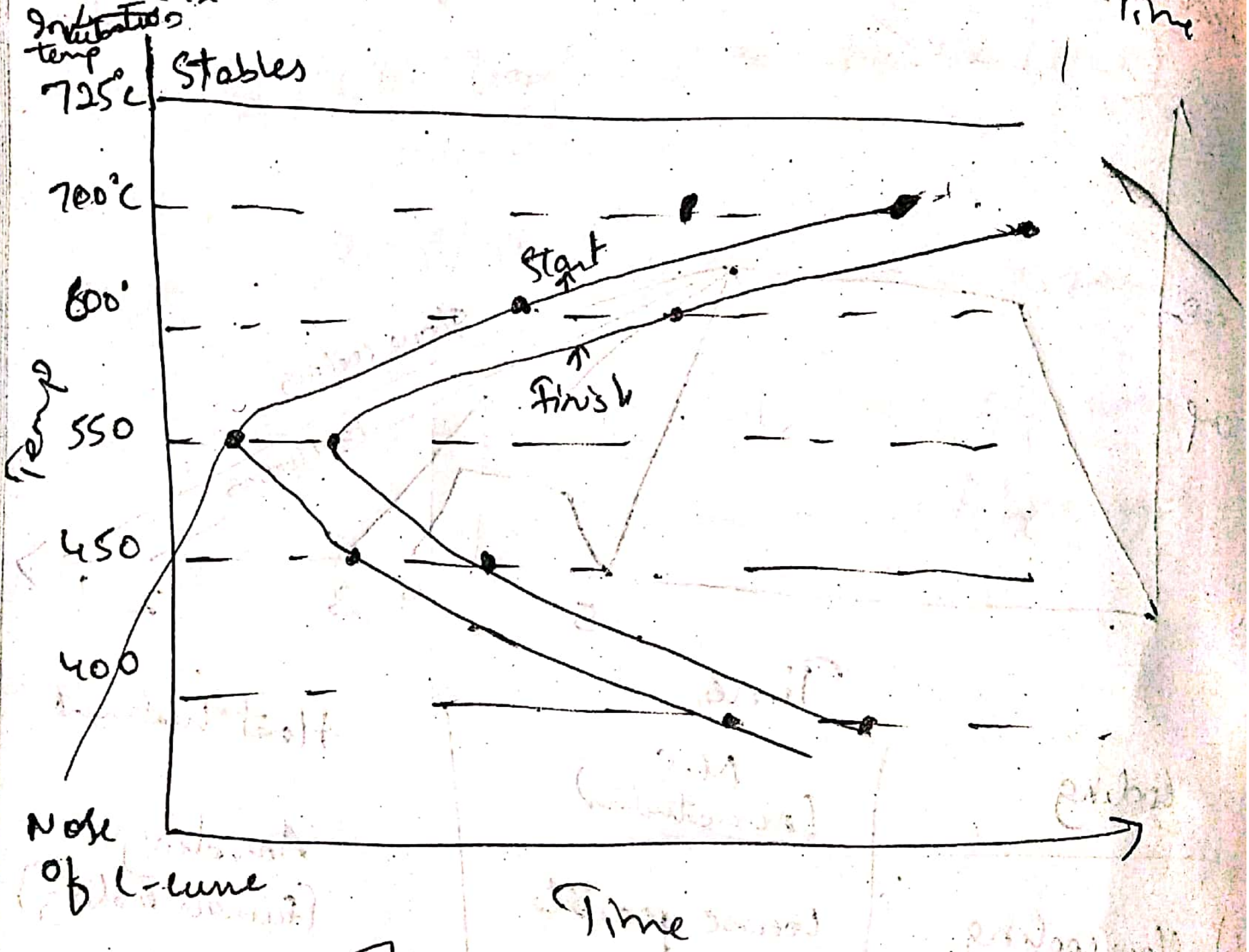
Heat Treatment :- Heating a material to a temp, holding it at that temp for a period of time followed by cooling at a specified rate is called as heat treatment.



Cooling	M.S (microstructure)	Heat treatment
1.) Slow cooling	Coarse pearlite	Annealing (furnace cooling)
2.) Fast cooling	Fine Pearlite	Normalizing (Air cooling)
3.) ~~Interp~~ Interupted quench	Bainite	Austempering
4.) Heating after quenching	Tempered Martensite	Tempering
5.) Fast cooling	Martensite	Quenching

TTT diagram (Time Temperature Transformation)

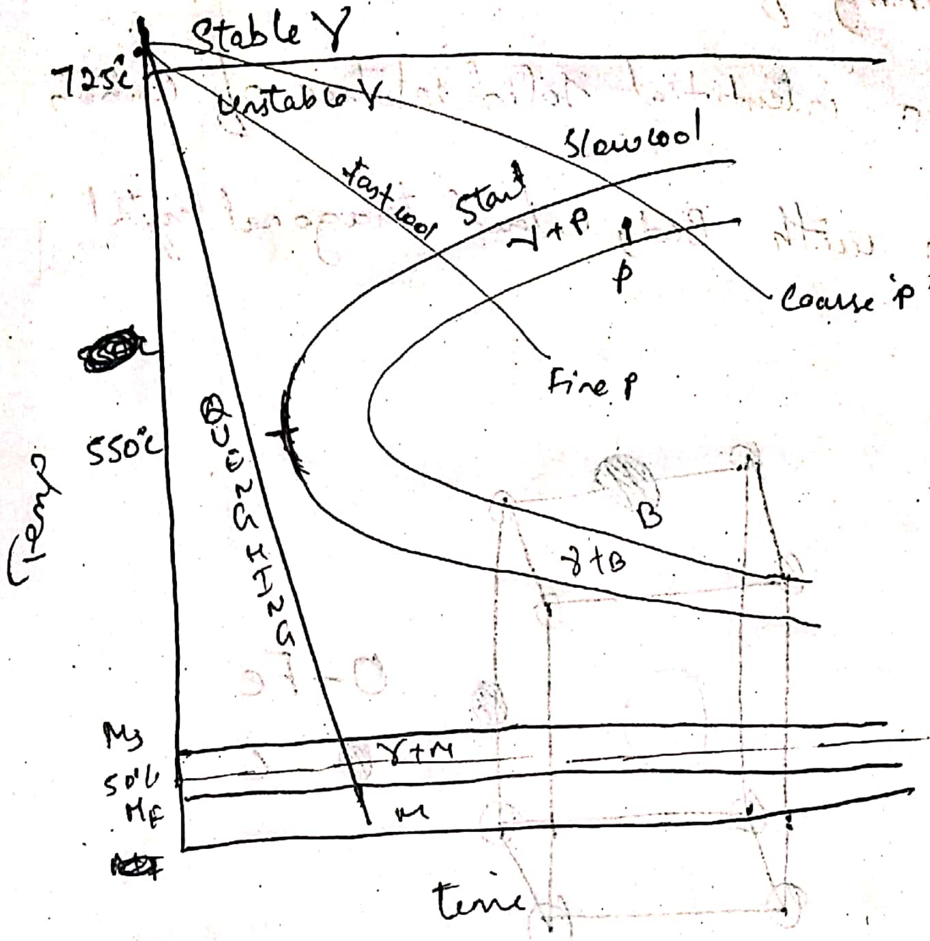




C-curve

Quenching & Martensite

$C_0 = 0.8$ wt % C
Eutectoid Steel.



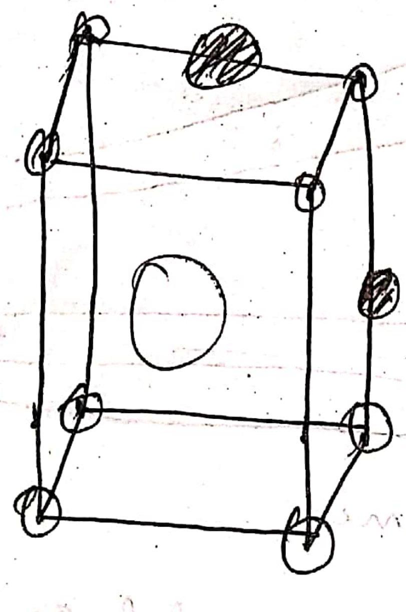
The Eutectoid Steel is cooled so fast that it just missed the nose of c-curve & so we don't get pearlite.

* A new transformation has begun i.e Martensitic transformation at Ms & ended at M_F.
* Role of time disappears in martensitic transformation since it is very fast.
* Amount of Martensitic transformation depends on temp

Martensite :-

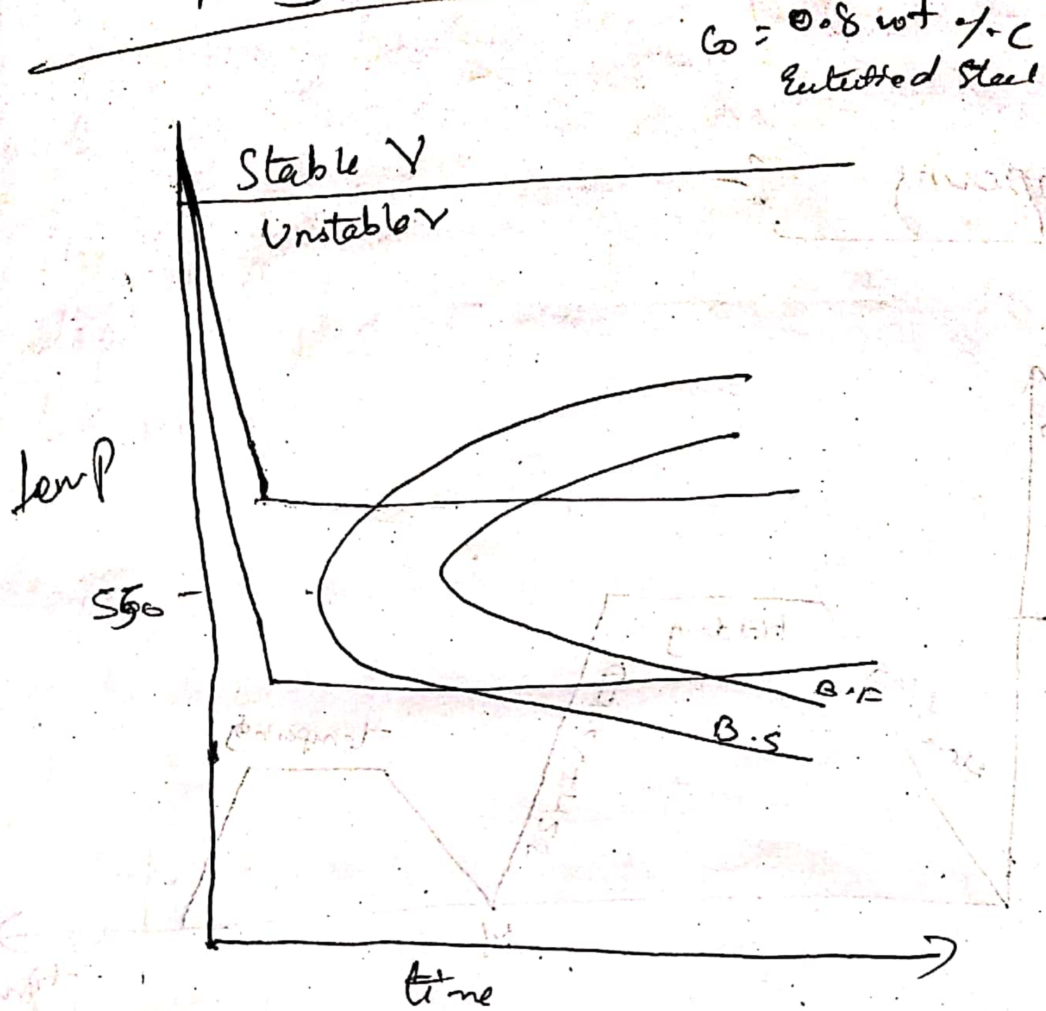
Its a non-Equlibrium phase. It forms on Quenching of Austenite.

* Its an interstitial solid solution of Carbon in Iron with Body centered tetragonal crystal Structure.



Martensite is very badly distorted that the slip propagation with in this Structure is very difficult. And so it Becomes Hard, Strong & Brittle.

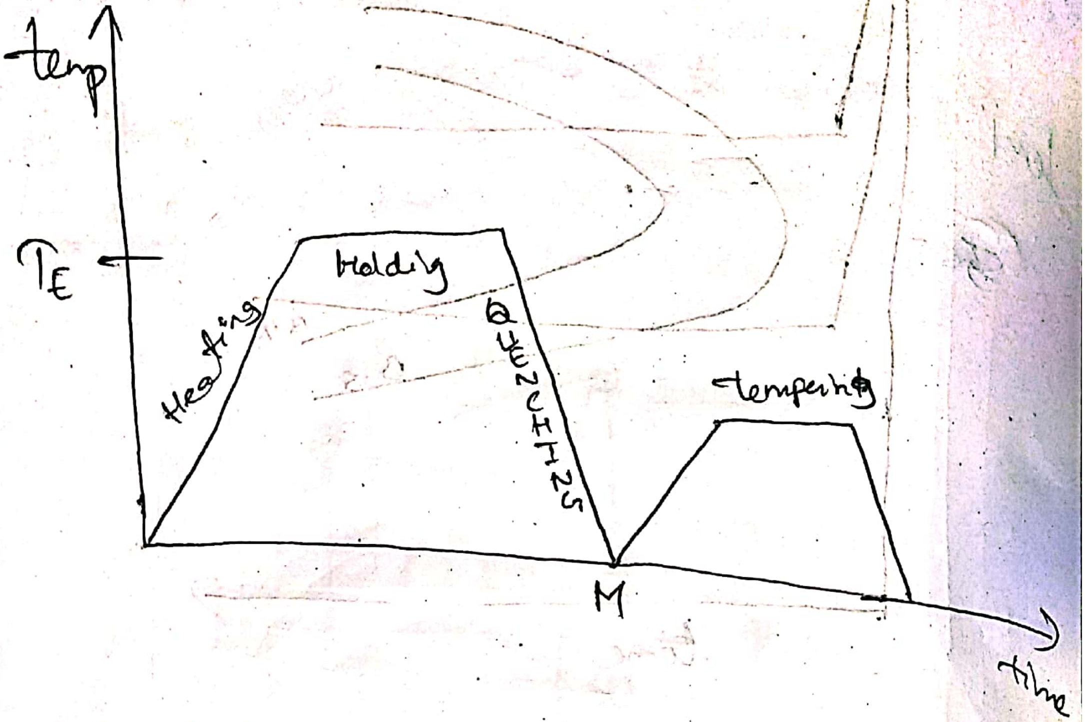
Austempering & Bainite :-



Eutectoid steel was Quenched so fast below the nose of C-curve & it was held there the transformed product did not resembles pearlite. The microstructure consisted of needles of Fe_3C in α - Matrix this was named as Bainite & this heat treatment is called as Austempering.

Pearlite & Bainite are mixture of α, Fe_3C but are different due to different shapes & distribution of these ~~of~~ phases ...

Tempering :-



Tempering is heating a Quenched Steel ~~[illegible]~~ below the eutectoid temp to transform ~~Martensite~~ to $\alpha + Fe_3C$

$\gamma \xrightarrow{\text{Quenching}} M \xrightarrow{\text{Tempering}} \alpha + Fe_3C$

$\alpha + Fe_3C$: here is not pearlite it is tempered Martensite. It consist of fine particle of Fe_3C in α-matrix

Tempering produces tempered Martensite with lower hardness than Martensite but with better toughness & Ductility.

The size & distribution of of Fe_3C particles depends upon temperature and time for tempering.

Tempering temperature & time controls the reduction in hardness & improvement in ductility. Higher the tempering temp & Higher the time lower is the Hardness & better is the ductility.

Various types of Annealing

1) Full Annealing :-

~~2) Isothermal Annealing~~

The purpose of full annealing is to ~~of~~ relief internal stresses induced due to cold working, to reduce hardness, to increase ductility, to refine grain size & to make material homogeneous in chemical composition.

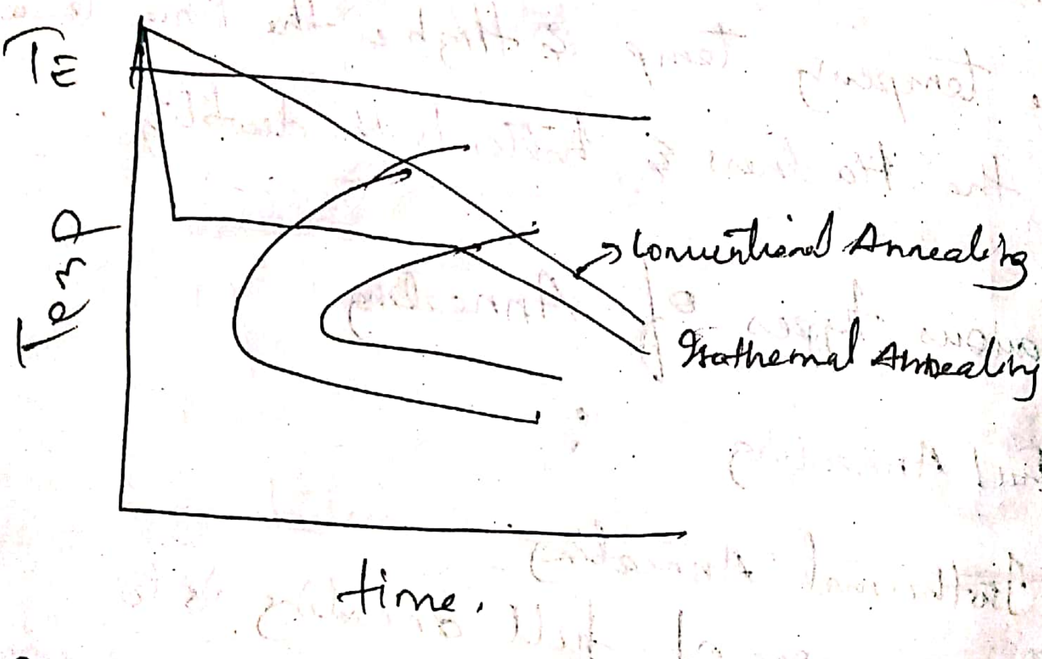
Process :-

This process consist of heating hypoeutectoid

Steels above A_3 temp by 30 to 50°C

& above A_1 temp for Hypereutectoid steels, holding at this temp for a definite period & cooling to room temp in the furnace.

2) Isothermal Annealing :-



In this process components are slightly fast cooled from Austenizing temp of conventional annealing to a constant temp just below A_1 (725°), holded that temp for sufficient period for the completion of transformation purpose :-

1.) To reduce annealing time
2.) Because of equalization temp transformation occurs at same time through out the crosssection leading to homogenity in structure

3.) Spherodize Annealing :-

This heat treatment is given to high carbon steel to soften them and to increase machineablity. The microstructure consists of ~~goto~~ globules of cementite in ferrite matrix,

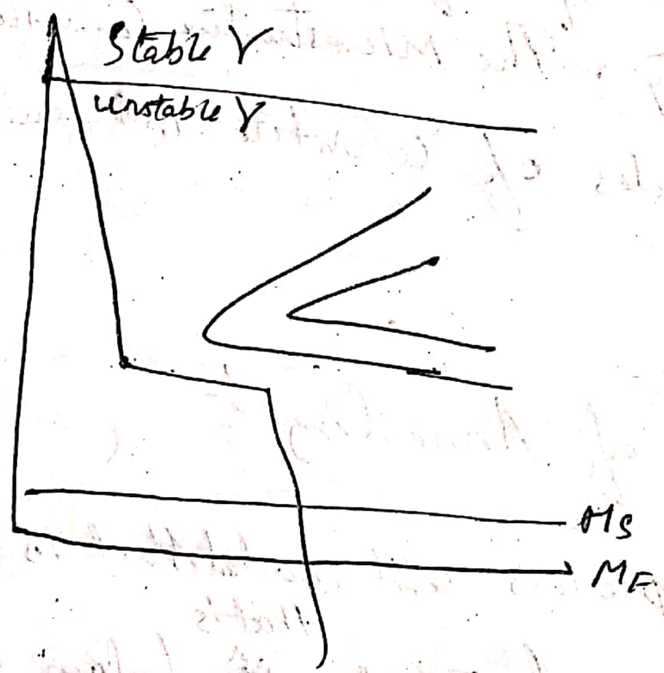
4.) Stress relief Annealing :-

In this process cold worked steel is heated to temp around 560°c that is below its recrystalization temp kept at this temp for 1 to 2 hours & cooled to room temp in air due to this internal stresses are relief without loss of strength, hardness.

5.) Process Annealing

In this method cold worked metal is heated above recrystallization temp leading to the formation of strainfree gains this is given to soften the metal so as to continue cool working process without cracking.

6) Martempering :-



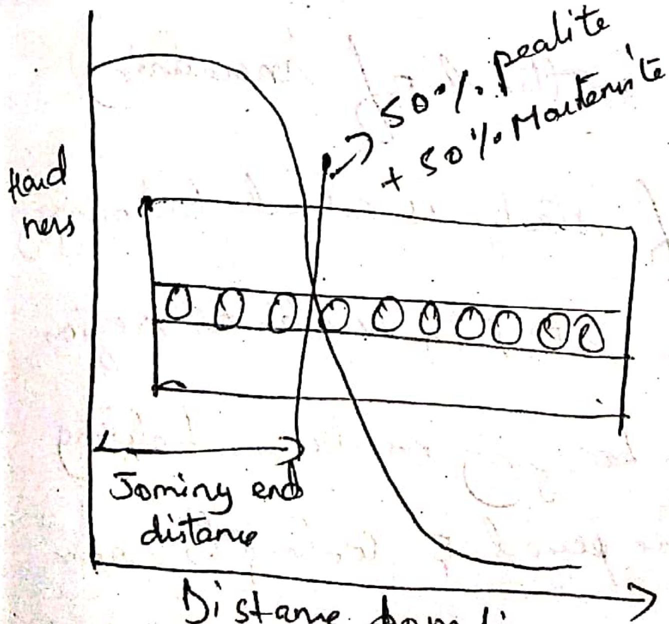
In this process ~~process~~ the Austinite steel is cooled rapidly avoiding the nose of C-curve to a temp b/w the nose & ~~Mart~~ Martensite Start, soaked at this temp for sufficient time for equalization of temp but not long enough for the formation of bainite and then cooled to room temp in air.

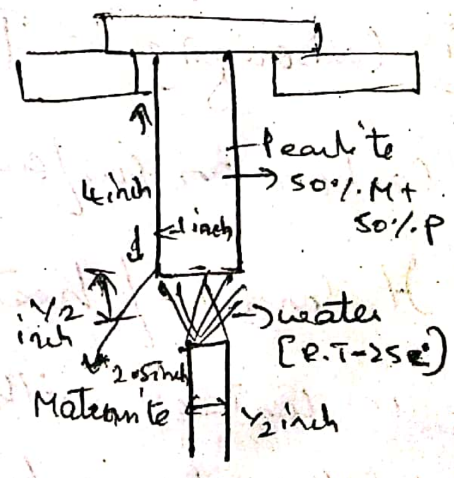
Purpose :-

1.) It produces less ~~distor~~ distortion, warping since Martensite formation occurs at the same time throughout the cross section of component.

2.) There is less possiblity of quenched cracks.

Hardenability :-





It is the ease with which a steel piece can be hardened by martensitic formation.

Case Hardening :-

In a many applications hard & wear resistance surface is required with tough core to withstand impact loads. Such requirement is difficult to achieve by using a steel of uniform composition. These requirements can be achieved by case hardening techniques like

1. Carburizing.
2. Nitriding
3. CarboNitriding (or) Cyaniding.
4. Induction Hardening
5. flame Hardening

(1) Carburizing :- The method of increasing Carbon on surface of steel is called Carburizing. It consist of heating steel in austinitic region in contact with carburizing medium, holding at this temp for some period & cooling to room temp.

In Austinitic region Solubility of Carbon is more and hence carbon ...

into steel, depending upon medium used it is classified as

(i) Pack Carborizing

(ii) Liquid Carborizing

(iii) Gas Carborizing

(2) **Nitriding :-**

It is accomplished by heating steel in contact with the source of atomic nitrogen at a temp about 550°c. The Atomic nitrogen diffuses into the steel & combines with iron & certain alloying elements forming Nitrides of which are hard & wear resistant.

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Effects of Alloy steels :-

1) solid solution strengthening

2.) Formation of carbides

3.) Formation of intermetallic compounds is not desirable

4.) Shifting of transformation temp, eutectoid carbon

5.) Better hardenability by lowering critical cooling rate

6.) changes in vol during γ to martensite transformation.

Ni –
→ Increases Hardenability
→ Solid soln in α - ferrite

γ - Stabilizers – Lowers the transform temp
→ Soft, ductile, mallable
→ improves impact resistance lowers at temp
→ Reduces the co-efficient of thermal expansion

Cr

Corrosion resistance
↳ Cr_2O_3

→ Carbide formation – Hard & wear resistant
→ Resistance to tempering – Hardness at high temp
→ Hardenability.
→ added in tools steels

Mn

→ solid soln strengthening
– Y.S, UTS, toughness
→ Least expensive element
→ Forms compound with Sulphur MnS

Scanned with CamScanner

which helps in soft machineability

10-12 - Hadfield steels

Mn → γ - stabilizers

Silicon

→ Ferrite solid soln strengthening

↳ Y.S, U.T.S, without loss of ductility

→ Strong de oxidizer - added in molten state

→ pump, ball bearing etc

5% of Si - Magnetically soft materials

Tungsten

~ 4

→ Carbide formation - Hard/wear resistant

→ Resistance to tempering

→ Resistance to grain coarsening

→ Opposes decarbonization

→ added in tools steels

Titanium

→ Strong carbide formation

→

Stainless steels

- → don't corrode easily
- → 'Cr' - corrosion resistance
  - → Cr_2O_3 - film - passive
  - → Chromium carbides
    after that solid soln strengthening
  - → Good Machinability
- → creep resistant.

S.S
- ~~Martensi~~ Martensitic S.S
- Austenitic S.S
- Ferritic S.S

S.S

	Martensitic S.S	Ferritic S.S	Austenitic S.S
1) Chromium	12-18%	13-25%	atleast 18%
2) %C	0.15-1.2%	0.2%	0.03-0.25%
3) phases	γ - austenite at higher temp	→ 'γ' disappear only ferrite at Room temp	→ γ - at Room temp
4) Properties.	→ Hardened by martensitic transformation. Martensite at Room temp → Hard, wear resistant	→ Better ~~CR~~ Corrosion Resistant ~~[illegible]~~ than MSS. Magnetic in nature → ~~[illegible]~~ Soft Ductile & malleable	→ Soft Malleable → Non magnetic in nature → Better CR as compare to MSS, FSS → 18.8SS

5.) Designations	→ AISI 400 Series	AISI 400	AISI 200 - 300 Series
6.) Application	Springs, Ball Bearings.	chemicals, food industries	engines, utensils

High speed steels (HSS):

→ High hardness upto 500°C

→ High hardness, wear resistance, so that can be used at higher cutting speed.

2 categories :-

1.) Tungsten H.S.S :- W, Cr, V, Co

— T-series

2.) Molybdenium H.S.S : Mo, W, Cr, V, Co

Relatively cheaper

— M-Series

→ Carbide formers

→ V - increases resistant to softening

→ 'Co' - tries to maintain hardness even at Higher temp - Red Hardness

→ Drills, Tappers, punches -

Maraging Steel

→ Hardened by martensitic formation
& further Hardened by ageing

→ So Maraging steel :

→ Composition <0.03 % C → to avoid graphite formation

18-25 % Ni

3-5 % Mo

3-8 % Co

0.2 %-1 Ti

C % is very less - So Soft

→ Further harded by aging

⇓

during aging

↓

ppt of some phases

↓

Ni_3TiAl

Ni_3Mo

→ Good T.S, Hardness, Fracture toughness

→ Application

Rocket casings

engine manifolds