Mechanical Properties K.L Narayani

The characteristics of material under the influence of External load (or) forces are called mechanical properties.

Strength: is the property of the metrial to resist load without failure.

Tensile Strength: The ebility of material to resist stretching load without frachur

it is / ebility

Compressive strength: it is cbility of material compressive load without factor

Shear strength: ebility of material to resist shear load (transverse)

Stress: can be defined as the load per unit area

Stiffness: It is a ebility of meatrial to resist deformation (or) deflection under load is called stiffness

Elasticity:- The ebility of material to deform under load and regain its original shape after remove the load

plasticity:- It is ebility of material to deform under load not regain its original shape (retain)

Ductility:- The ebility of meatrial to deform pastically without rupture

malleability:- It is ebility of meatrial of deform plastically without rupture under compressive load

Toughness:- It is a ebility of meatrial due to rupture due to impact loads

Resilience:- The amount of energy is obsrebed in stressing a meterial up to the elastic limit is called Resilience.

Metallurgy :- is a science and technology of ~~oo~~ metals

METALS

Engineering materials

- Metals
  - Ferrometals (Contains Irons)
    - Wroght iron, Carbon steels, Alloy steels, cast Irons
  - Non-ferros metals (does not contain Iron)
    - Aluminium, copper, lead, silver, tin, zinc etc.
- Non-Metals
  - Polymers
    - Thermosetting plastic (polymers)
      - Phenol formaldehyde (Bakelite / polyster)
    - Thermoplastic
      - PVC (Polythene, Acrylic, Resins)
  - ceramic
    - Refractors, glass, cement and concrete

1. Wroght Iron :- It is the pure iron used for components
2. Cast Irons :- used for casting (moulding)

Pig iron : It is used to produce to cast iron

steel : is used for structures

Aluminium : is used for aeroplane structures

copper : copper is used for electrical wiring and utsinues

Gold : is used for ornaments

sliver : is used for engineering application as well as ornaments

Applications of non metals :

1. plastics : are used for scale, comebox bottles and computer

2. polimars : used for plastics and PVC

brittleness : It is the property of material of sudden facture without and deformation eg:- spice of chock, wood, tiles and Bricks

hardness:- is the ability of material to resists sckruching intentation, connecttration

Creeb:- The slow and progressive ditoormation of a material with time at constants stress is called creeb

fatigue:- can be difind as the failure of material under the application of repeated stresses is called fatigue.

structure of metals

space laties is 3 dimenstonal network of imaginary lines connecting the atoms is called space laties is also called crysstal laties

Unit cell:- can be defined as smallest volume but contains the full pattern of repetition

Metalic structure can be clasified cubic, tetragonal, ~~orthorhombic~~, Hexagonal

→ The metalic structure can be divided into mainly three

1. BCC
2. FCC
3. HCP

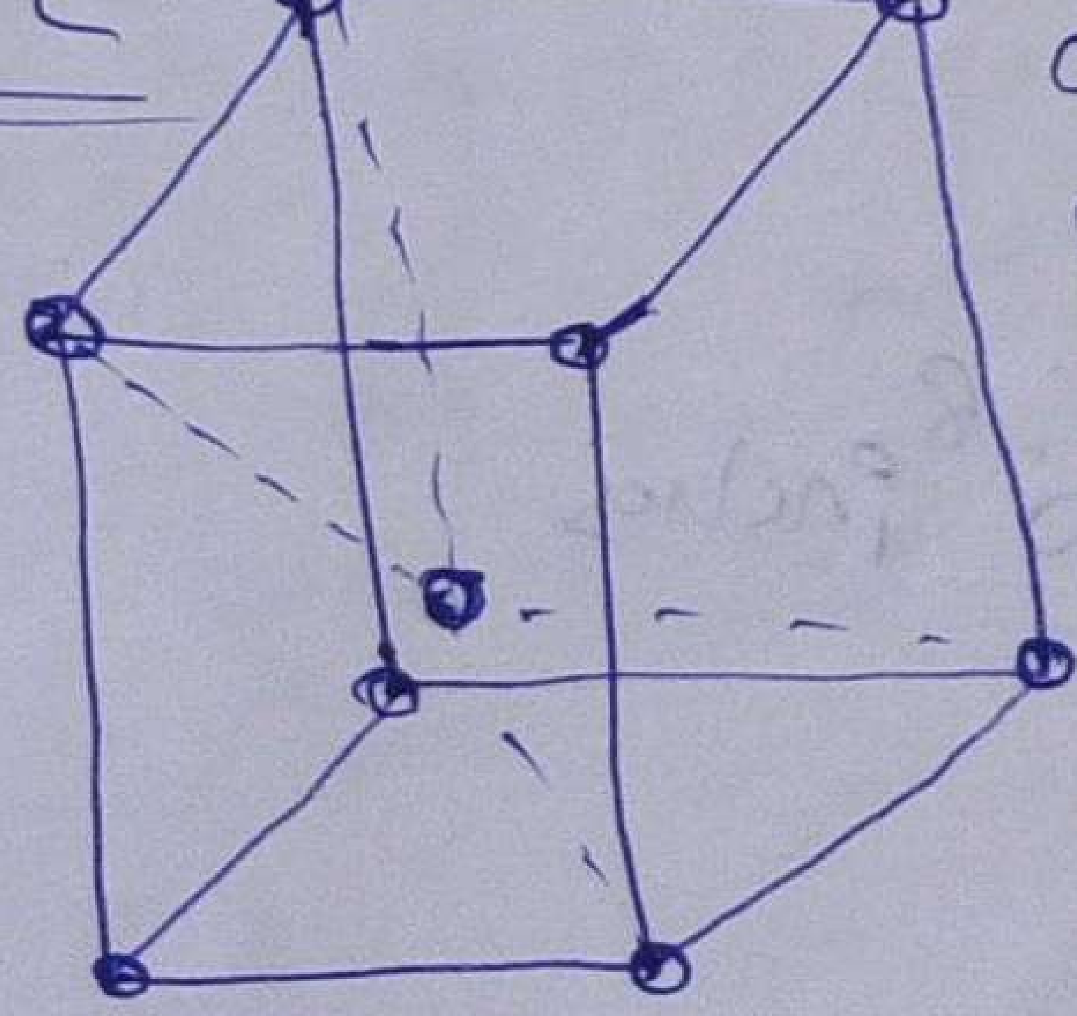
Body centred cubic lattice → BCC

FCC → Face centriod cubic

HCP → Hexagonal closed packed lattice

***

BCC



The effective no. of atoms in BCC unit cell can be explained as; central atom = 1

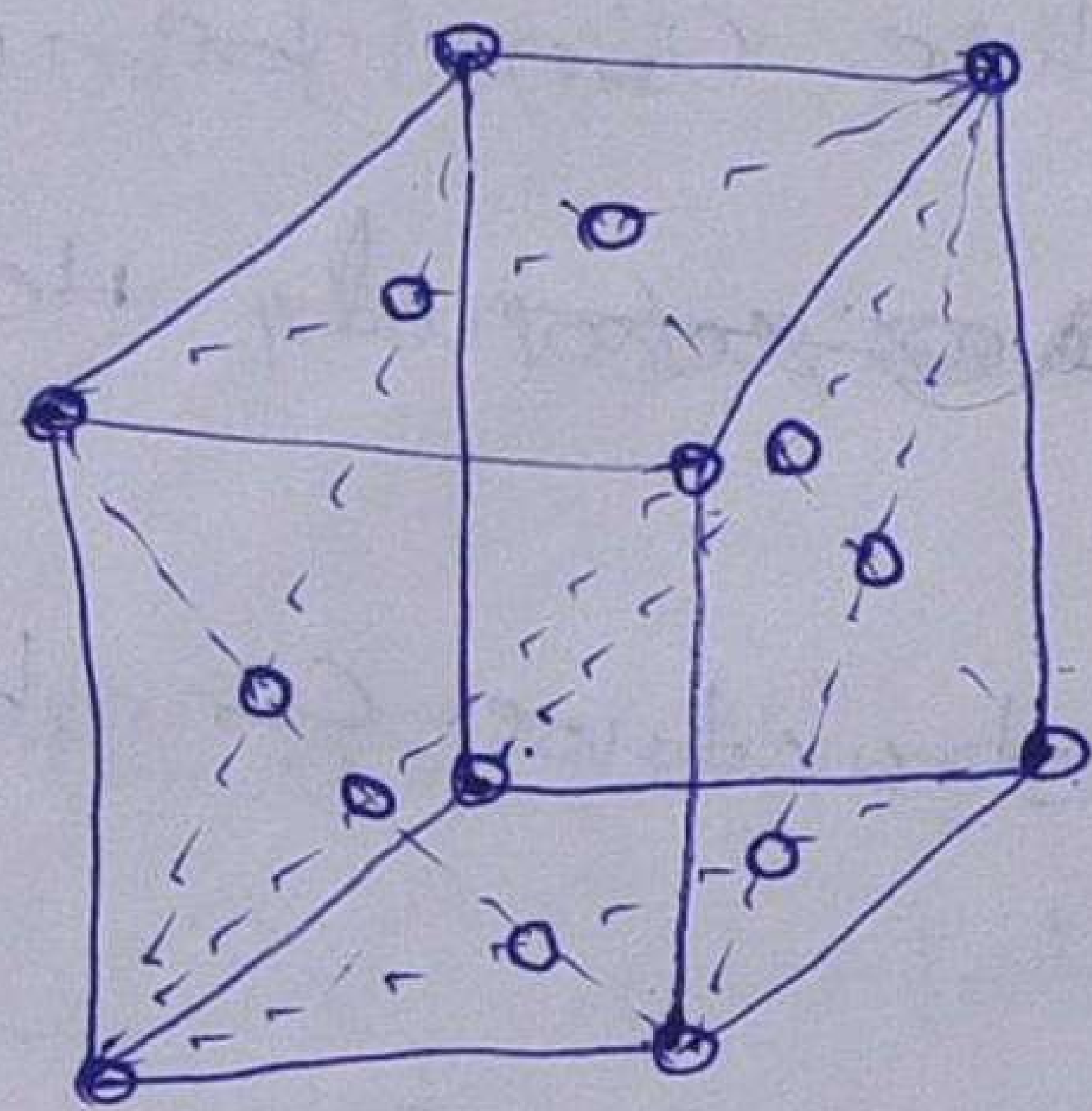
corner atoms shared by 8 adjacent cells

$= 8 \times \frac{1}{8} = 1$

* Total effective no of atoms $= 1 + 1 = 2$

Example : Alpha iron, chromium, molybdenum, vanadium

FCC



The effective no. of atoms in FCC unit cell can be explained as; corner atoms (shared by 8 adjacent cubes)

$= 8 \times 1/8 = 1$

face atoms (shared by 6 faces)

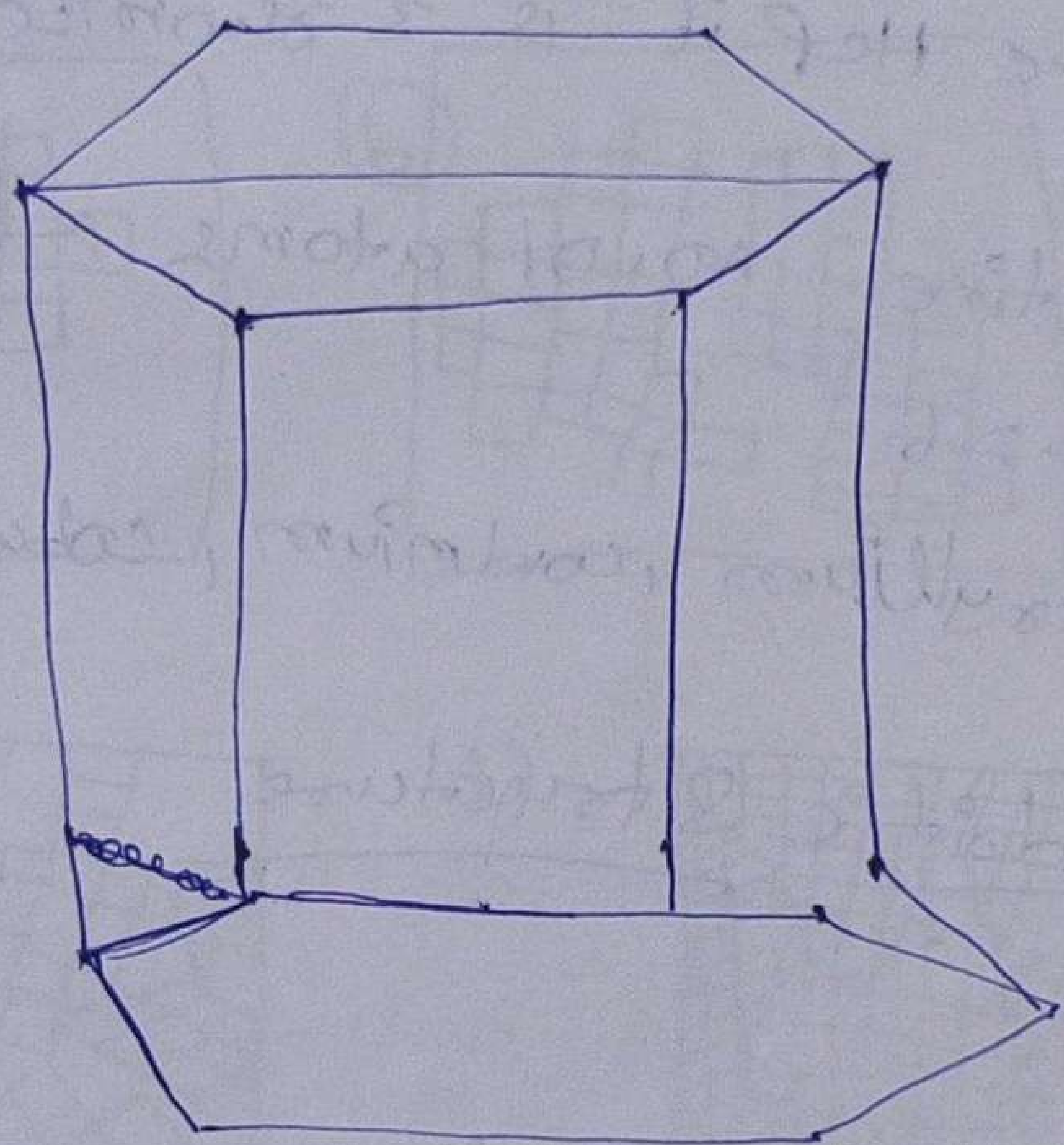
$= 6 \times \frac{1}{2} = 3$

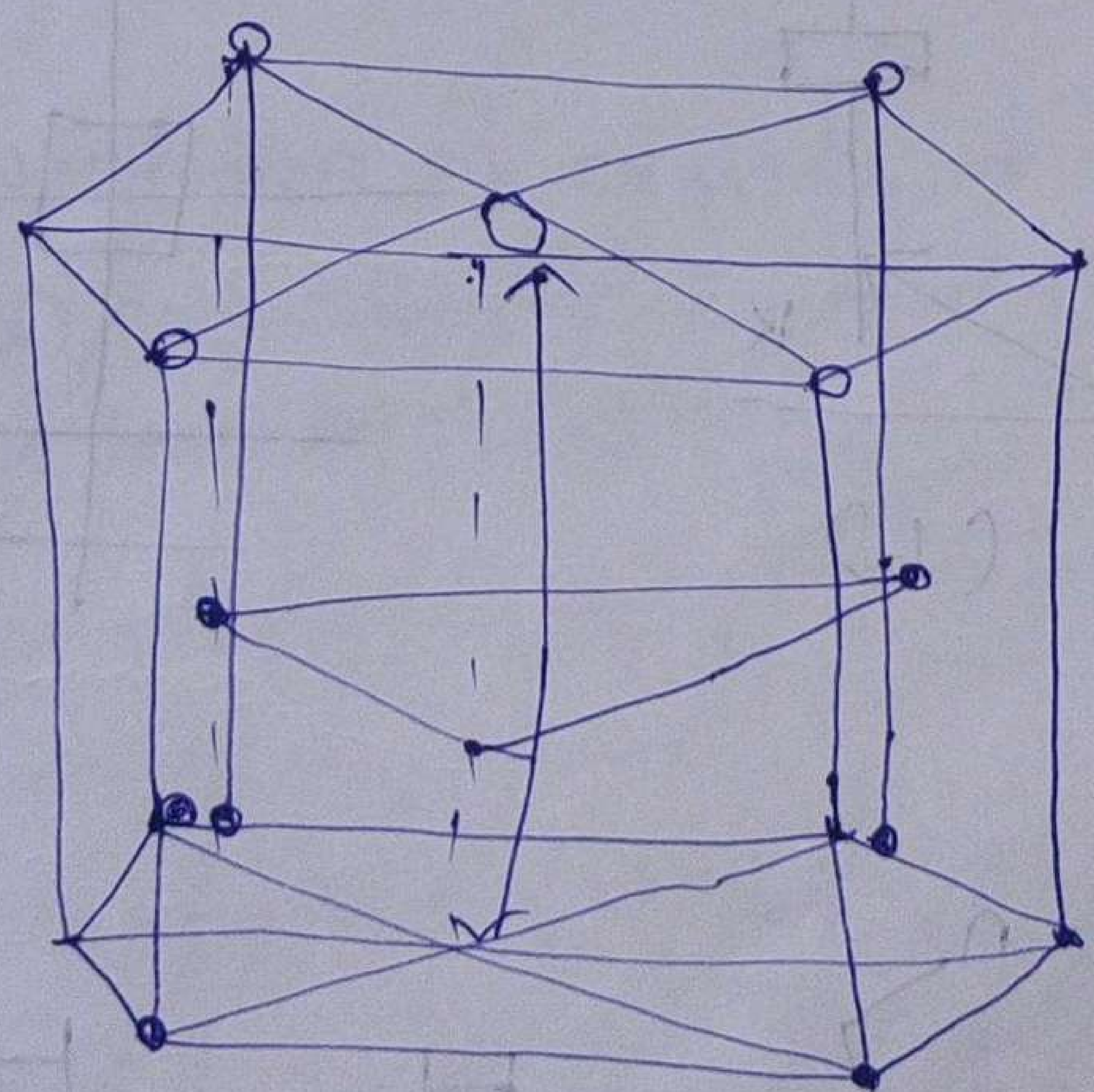
Total effective no. of atoms $= [1+3] = 4$

Ex: Gamma iron, Aluminium, copper, Nickel lead, silver, Gold and Platinum

atom to atom space $\div 10^{-8}$ inches

HCP → Hexogonal closed packed cubic lattice





Centoal atom = 1

Corner atom (shared by 8 adjecent rhom bohedrons

= 8 × $\frac{1}{8}$ = 1

Effective No. of atoms for each one drom bohedrals

$= 1+1 = 2$

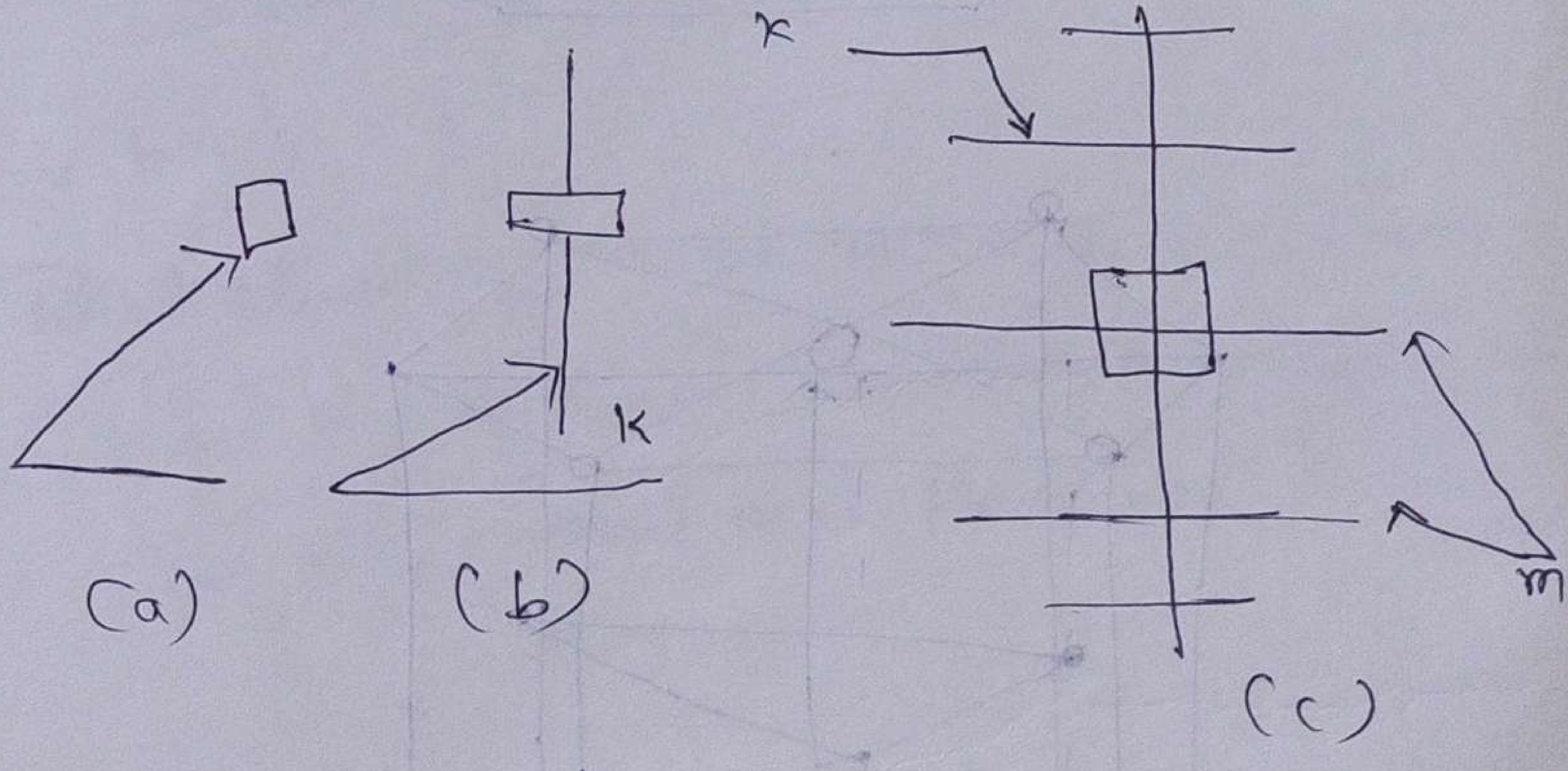
for the HCP it is 3 rhombohedrals

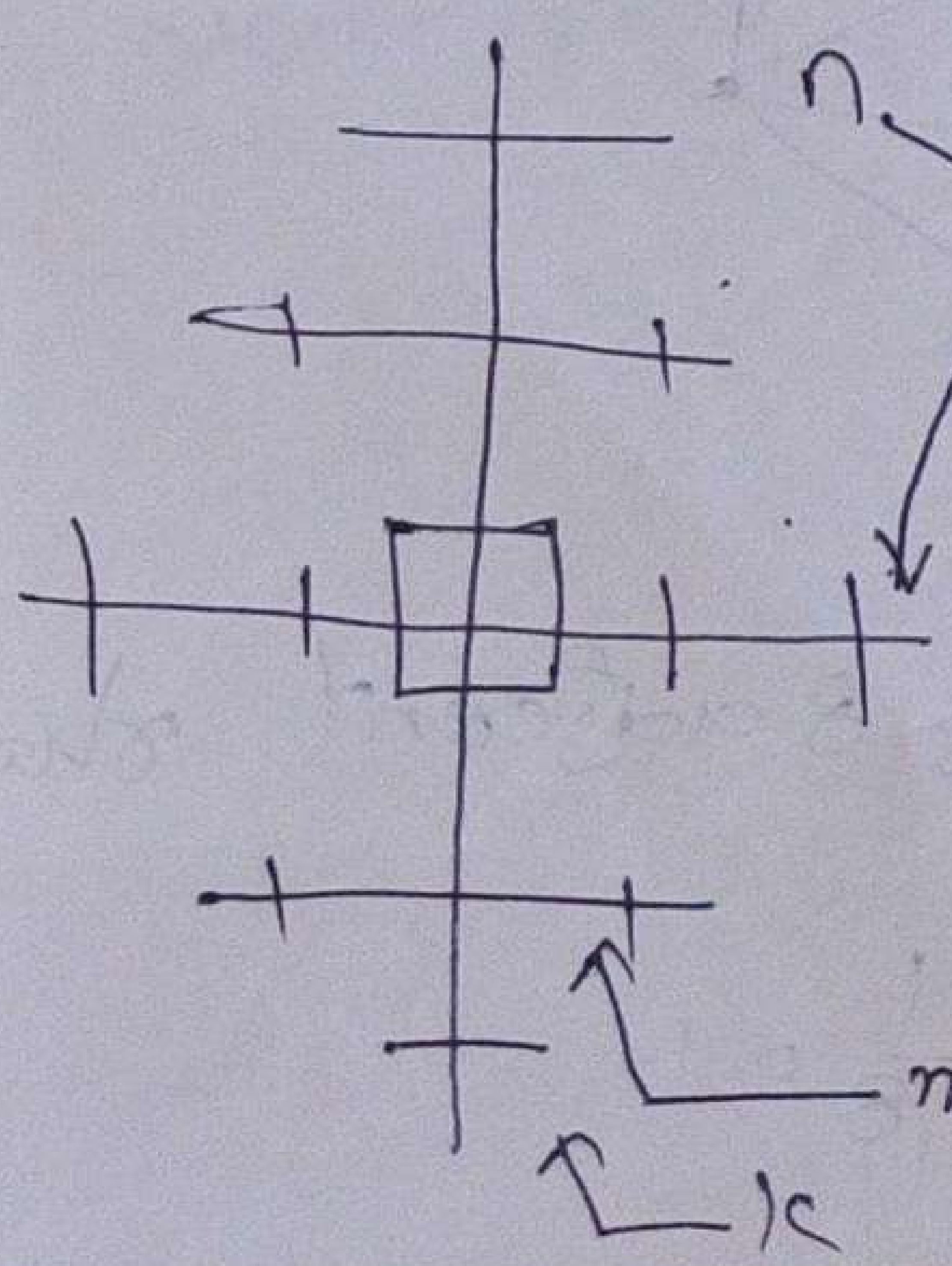
$\therefore$ Effective no. of atoms for HCP is

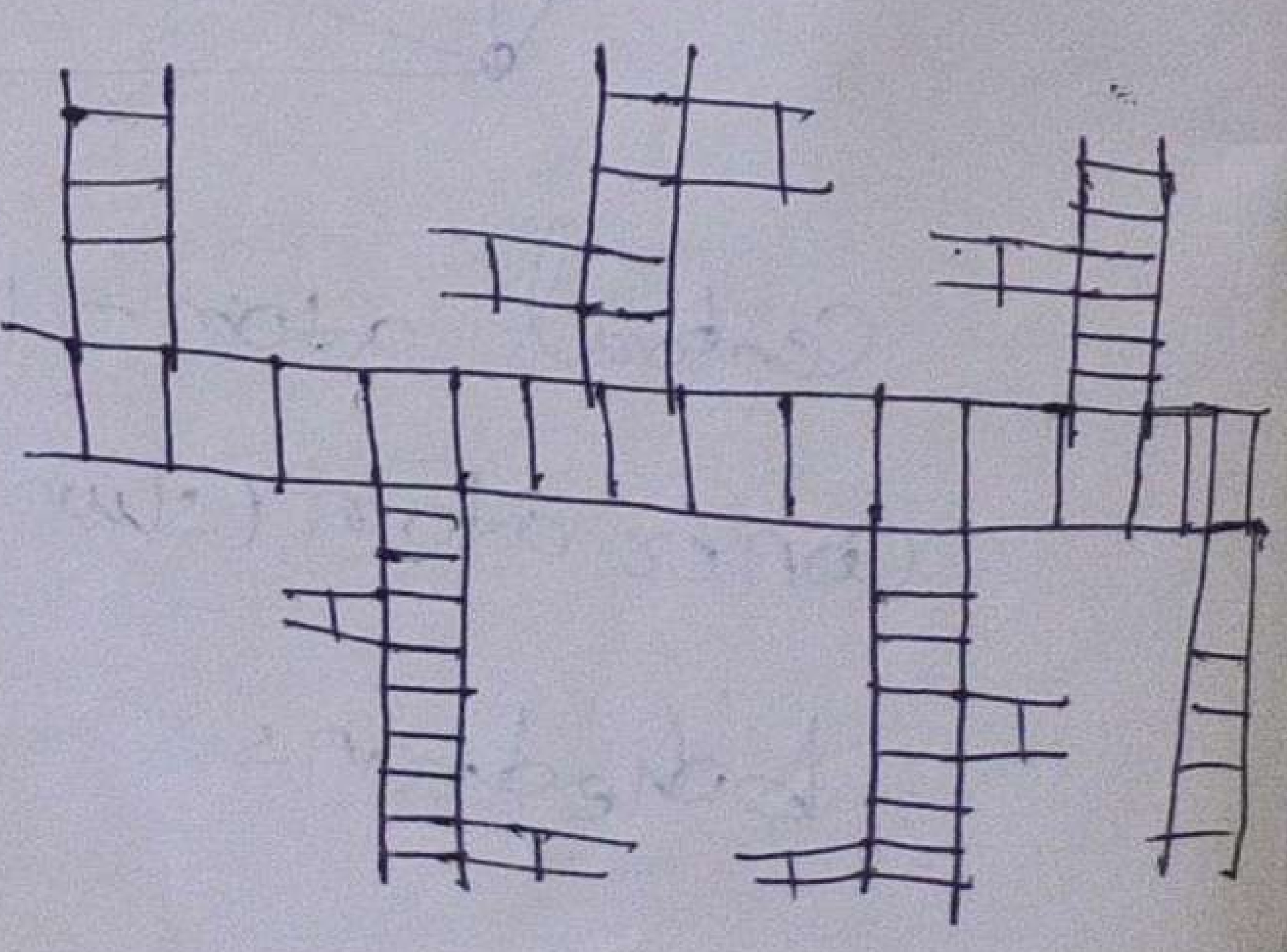
$= 2 \times 3 = 6$

Ex = Beryllium, cadmium, cobalt, zinc.

Dendritic Structure

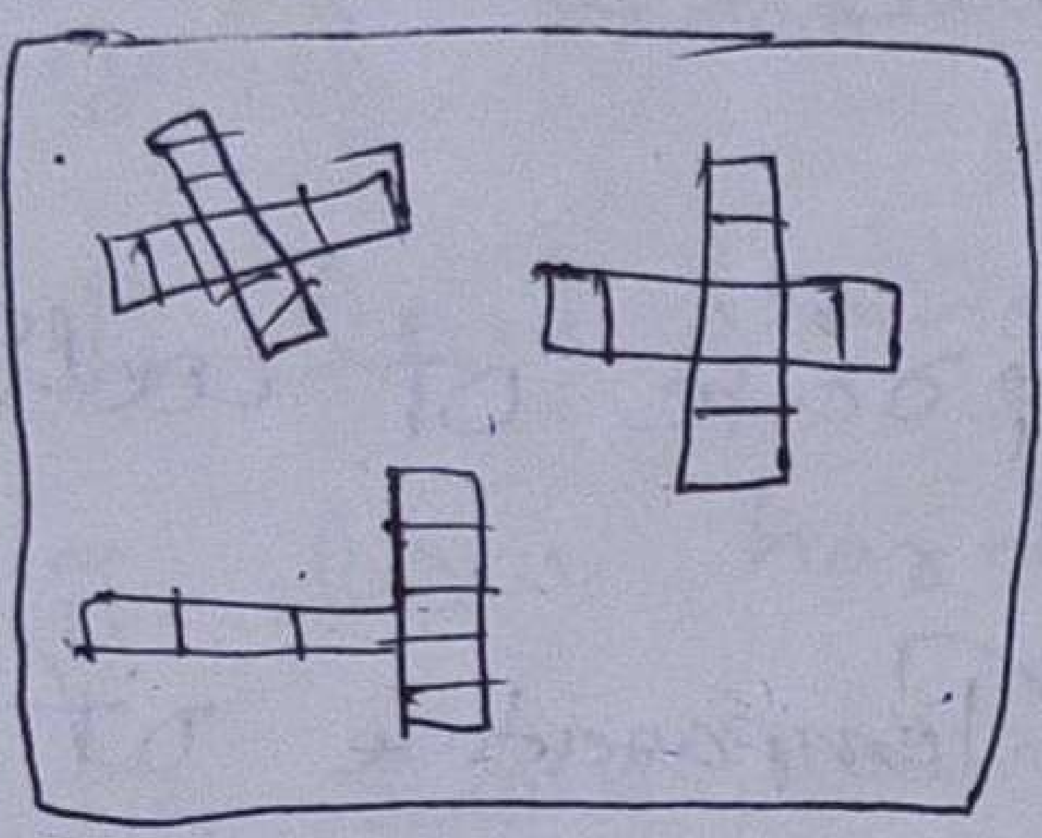




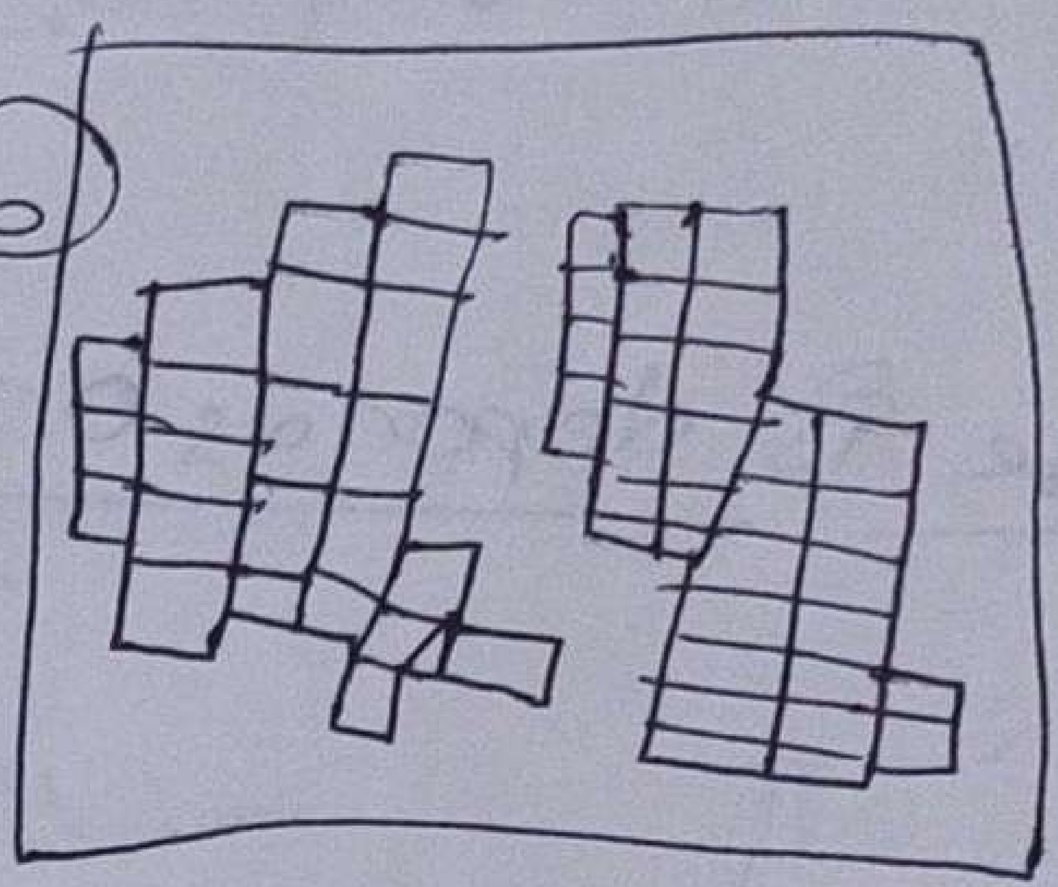


k - Primary Axis
m - secondary Axis
n - ternary Axis

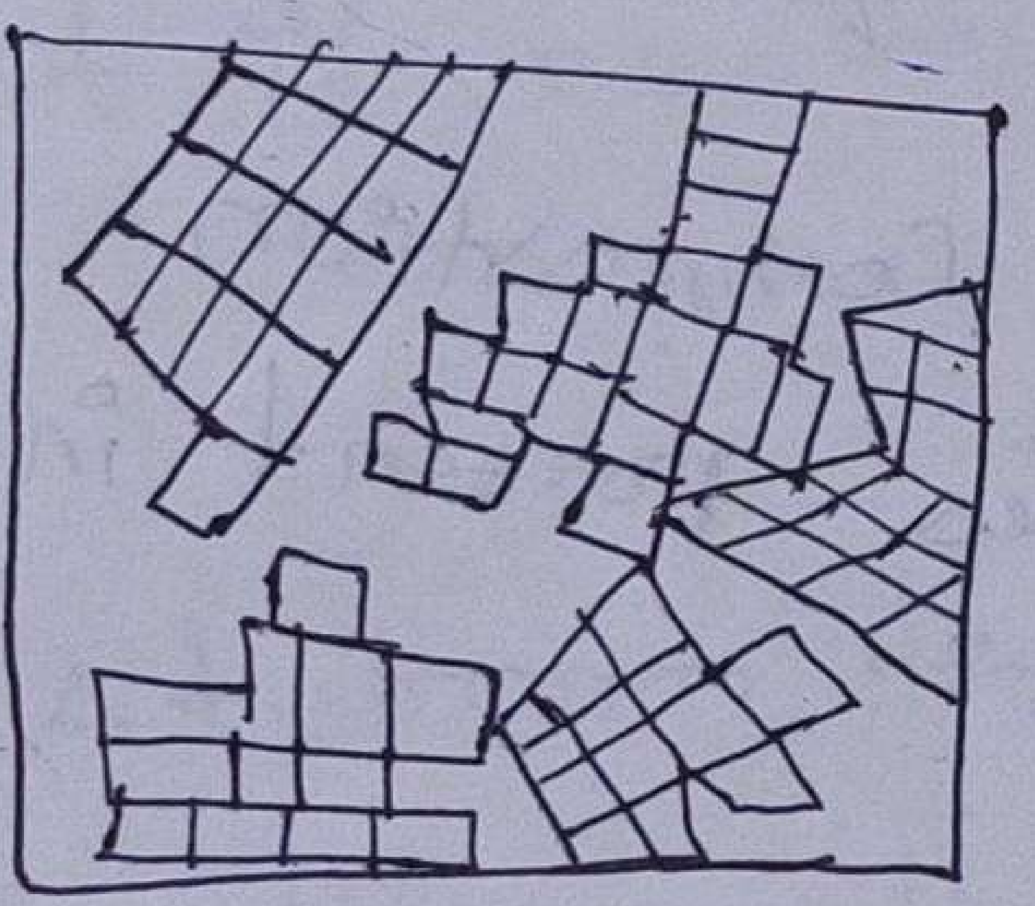
(a)



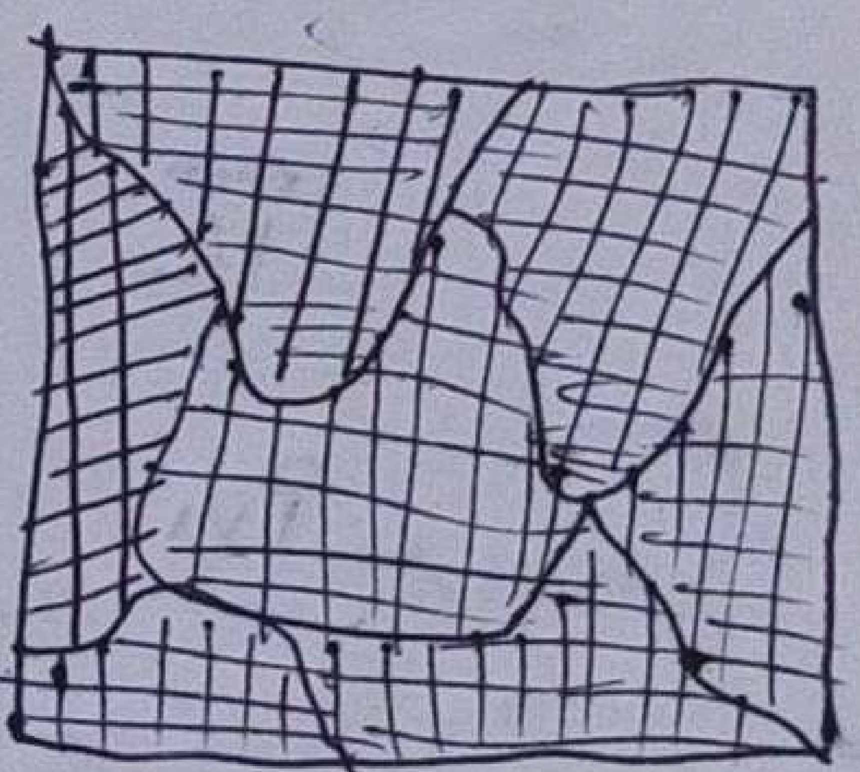
(b)



c



d)



a. Nucleation of crystals of random location, crystallographic orientation is different from one location to other

(b)&(c) Growth of crystals as solidication continous.

(d) individual grains & grain boundries.

Grain size :- is determind by

i: rate of crystal growth

ii rate of nuculation

Grain size is deponds on :- i rate of cooling

ii. Temparature of liquid metal

iii. Chemical composition

iv. impurities present in the metal.

Two types grain sizes are there

1. Course grain
2. Fine grain

1. when the grain size is small it is knoow as fine grain

2. when the grain size is large it is knoow as course grain

Iffluence of mechanical propoties on grain size

1. At room temparature a large grain size is generally (C.G)

i. low strength
ii. low hardness
iii. low ductlity

But it as high mechinability

2, At room temparature a small grain size is generally (F.G)

i. High strength
ii. High hardness
iii. High duclality

But it has low mechinability (or) poor mechinability

* Grain size is ~~usually~~ usually measured by counting the no. of grains in the given area

* Grain size number (n) is related to the no. of grains.

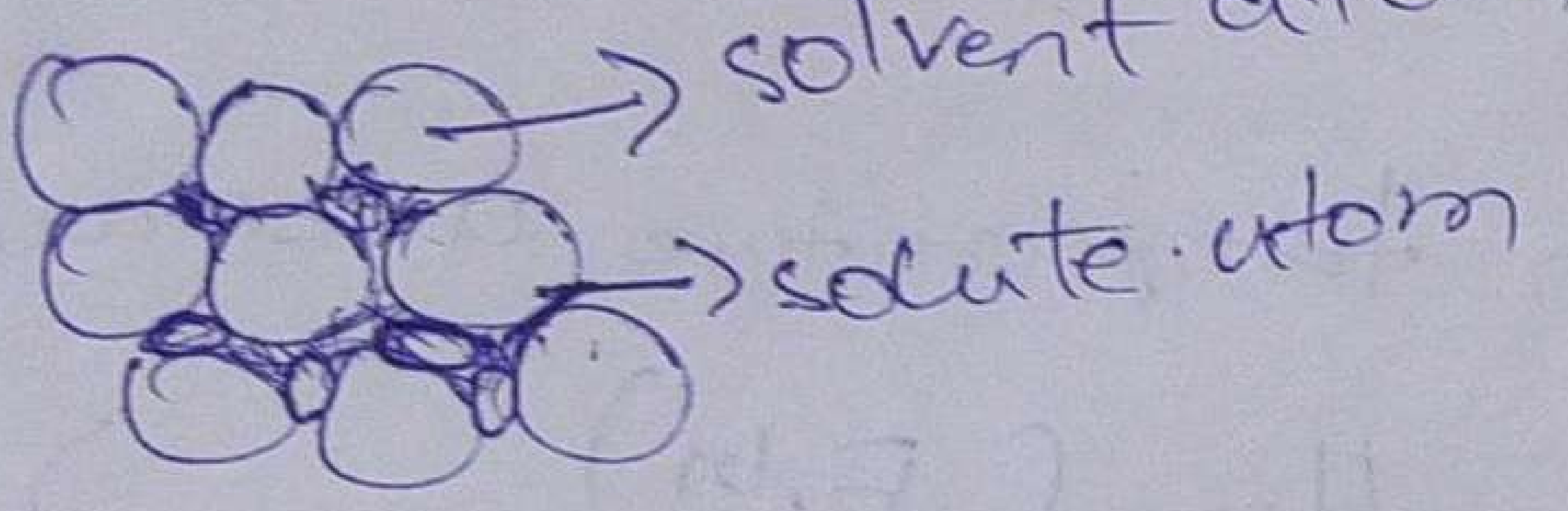
N is for no. of grains per square inch at 100X magnification

$$\boxed{N = 2^{n-1}}$$

↓ grain size

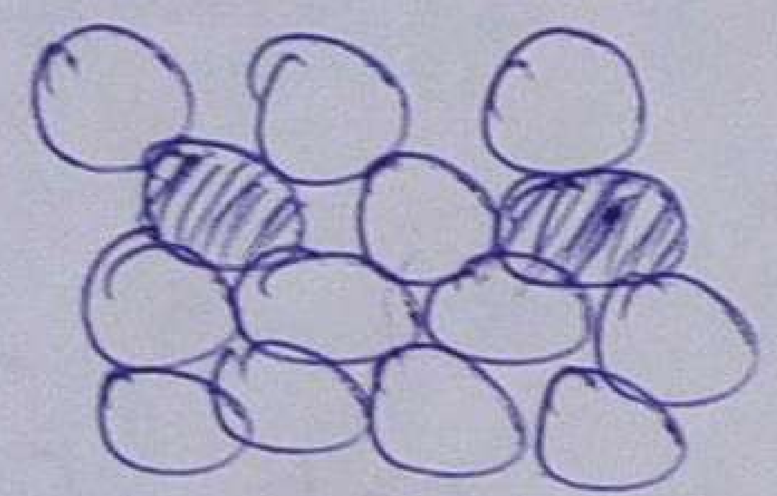
Types of solid solution

Interstitial solid solution

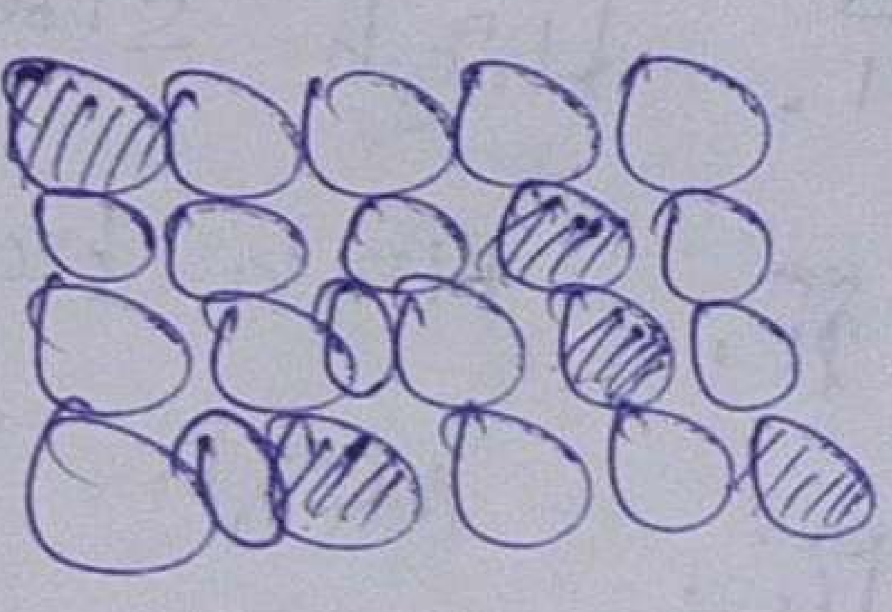


substitutional solid solution

a

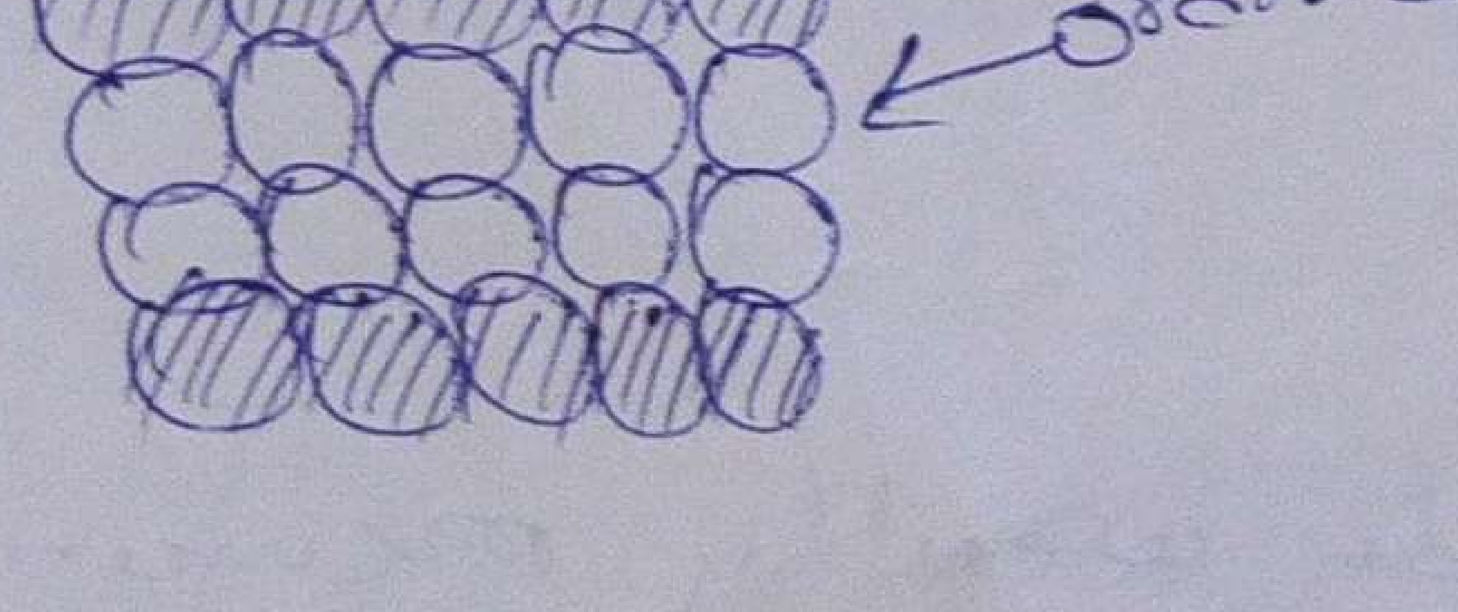


b)



Disordered

c.



Brown River

Gibbs – phase rule

$P+F = C+2$ or $C+1$

P → Is the number of phases

F → No of degrees of freedom (or) No of physical variables

C → Is the no of components in the system

2 → Represents two external variables temperature & pressure.

** phase → is a process of variation

Eg:- milk to curd

Variables :- Pressure, Temperature

$\boxed{\text{iron melting point :- 1539}}$

Iron-carbon Equilibrium diagram

P -> Pearlite

F - Ferrite

C — Cementite

TL - Transformed ledeburite

L - Ledeburite

A - Austenite

EUDTD -> Eutectoid (E)

EUTC -> Eutectic (EUT)

Iron carbon Equilibrium Diagram

a) Peritectic Reaction at Point J:
The formation of the austentenite (0.18% C) at constent temperature (1492°C) from the liquid & solid phase is called peritectic reaction

Delta iron (S) + Liquid $\underset{\text{heating}}{\overset{\text{cooling}}{\rightleftharpoons}}$ Austenite

Eutectic Reaction at point C: The solidification of liquid (4.3% C) of constant temperature (1130°C) into two phase mixture is called eutectic reaction

$$\text{Liquid} \underset{\text{heating}}{\overset{\text{cooling}}{\rightleftharpoons}} \underbrace{\text{Austenite} + \text{Cementite}}_{\substack{\text{Eutectic mixture} \\ \text{(ledeburite)}}}$$

Eutectoid Reaction at point 'S' :-

The decomposition of austenite Eutectoid rection. solid (Austenite)

solid Austenite S $\underset{\text{heating}}{\overset{\text{cooling}}{\rightleftharpoons}}$ ferrite + cementite

The eutectoid mixture of ferrite and cementite is called pearlite.

Hume - rothery rules

formation of substitutional solid solution b/w two metals is governed by a set of roles known as Hume - rothery rule

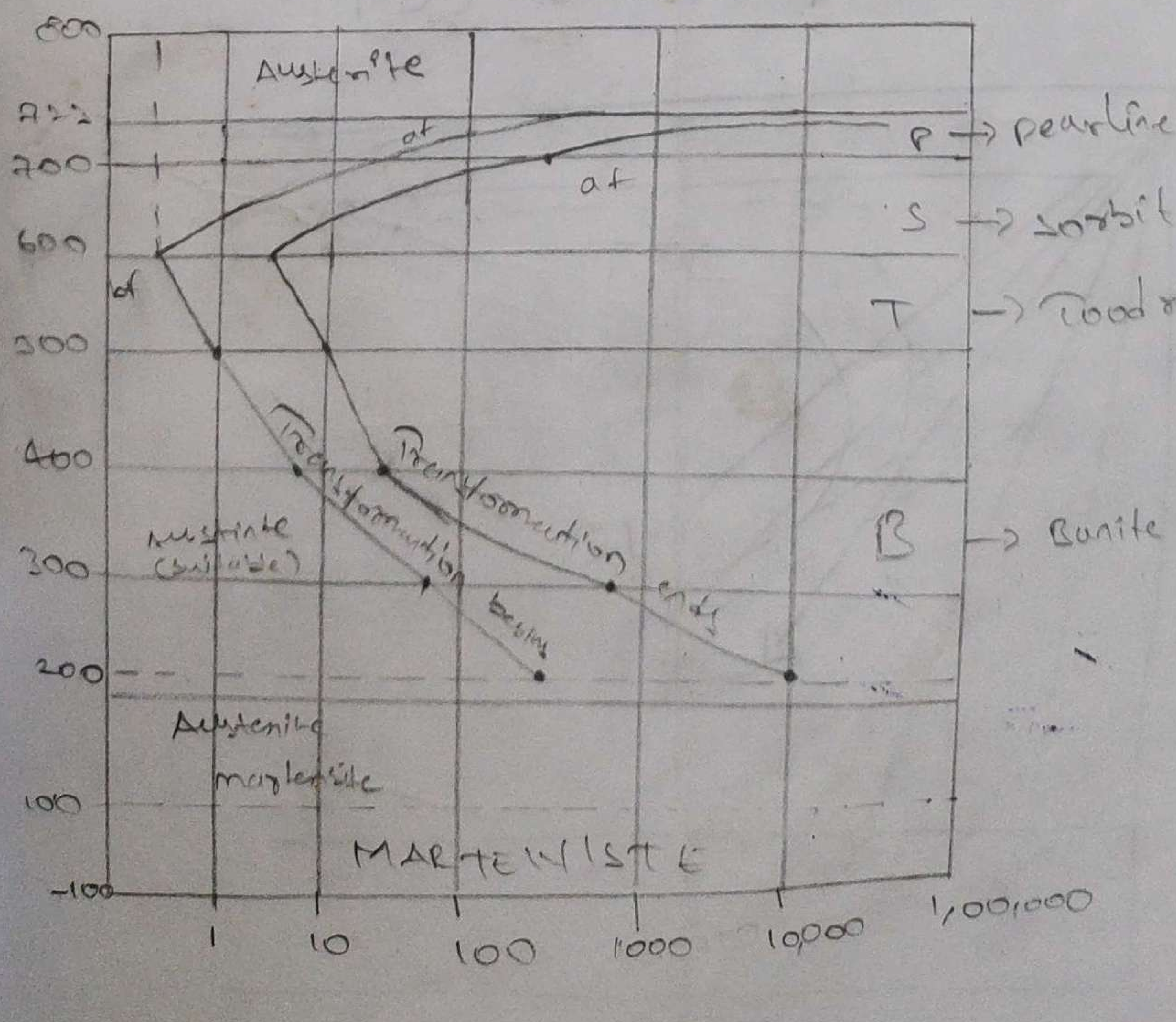
→ size difference b/w the atoms of solute and the parent metal should be less then 15%

Purpose of heat treatment:-

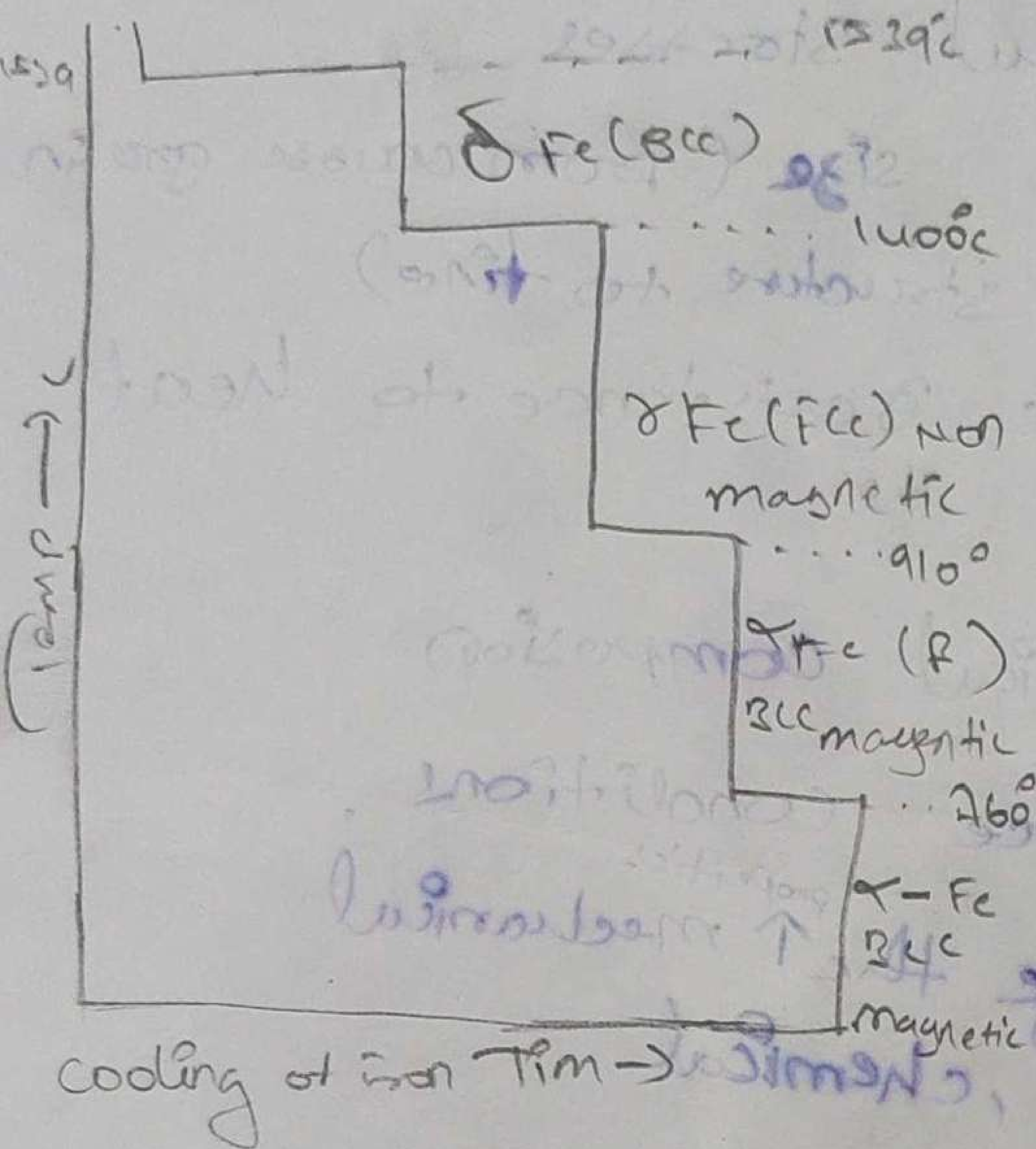
1. improve the machinability → (drilling)
2. Retine the internal stresses
3. change the grain size (from coarse grain structure to fine)
4. To enhance the resistance to heat and corrosion.
5. change ~~the~~ chemical composion
6* Altering surface conditions.
7. To ~~[illegible]~~ change the ↑ mechanical properties
   thermal, physical, chemical

3rd unit

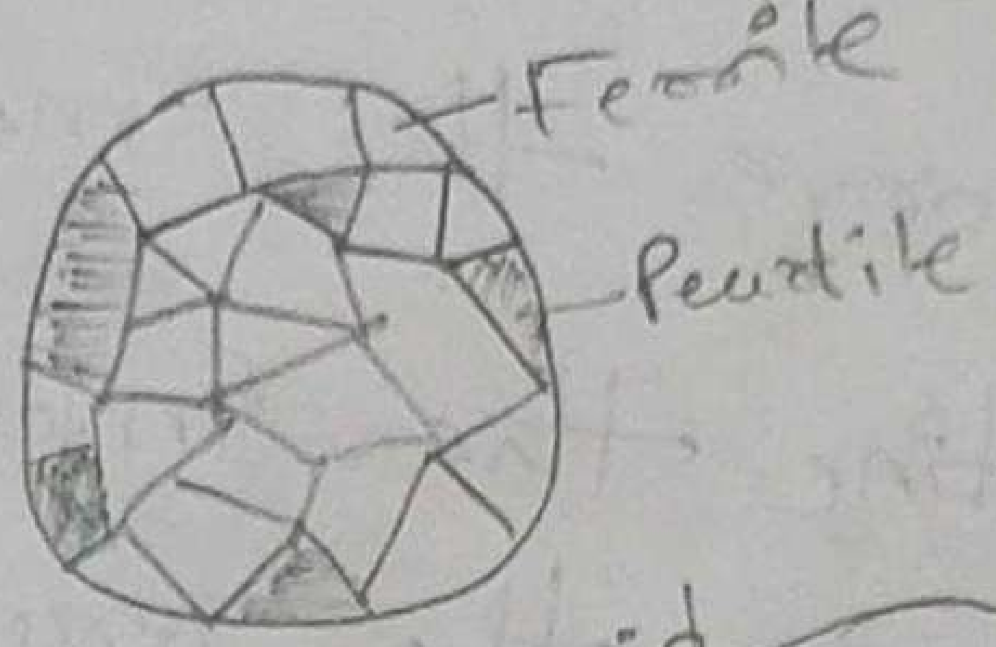
Time Temparature Transformation (T, T, T)



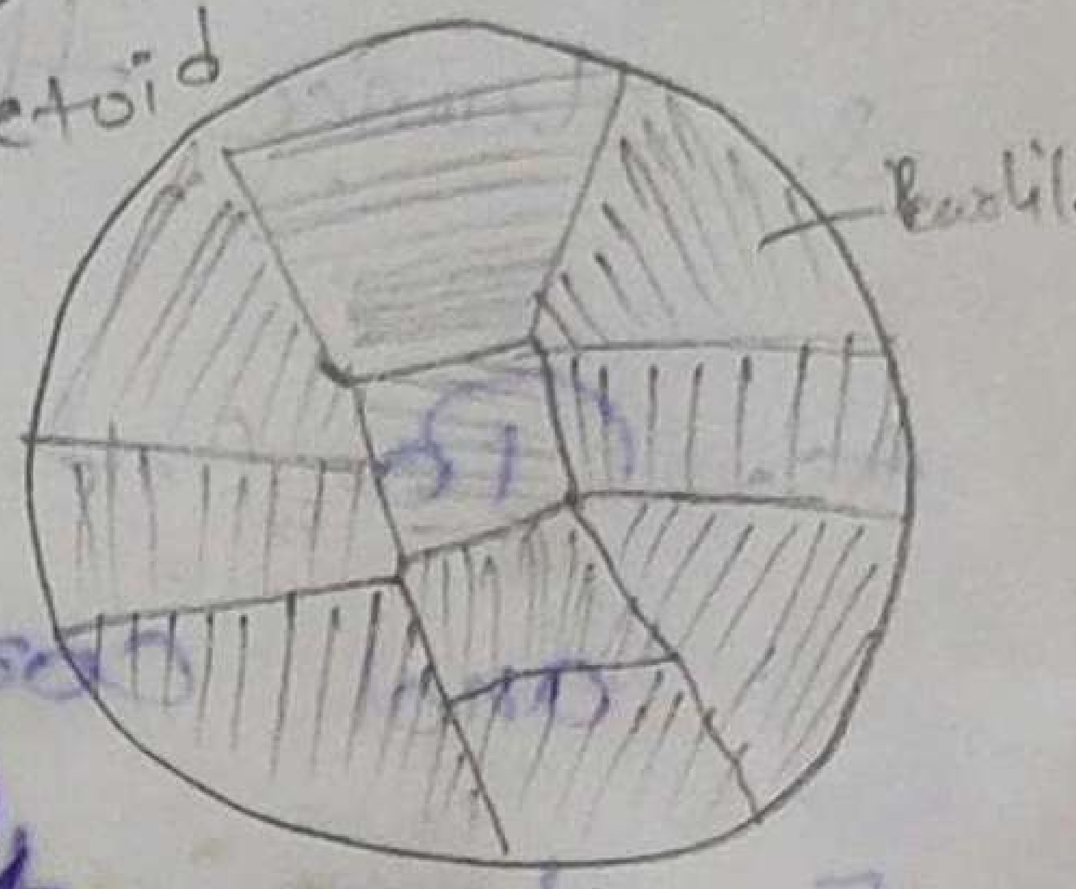
Allotropic forms of Iron



Micro structure of steel



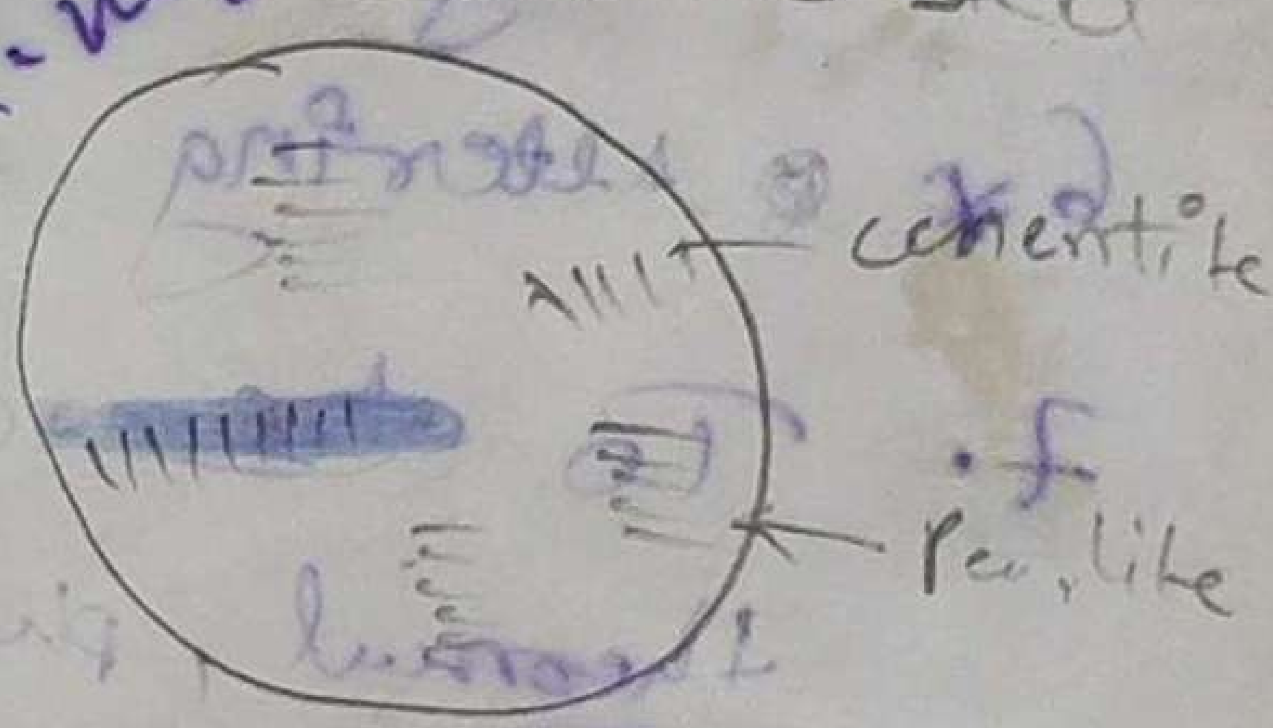
Hypo eutectoid steel



1

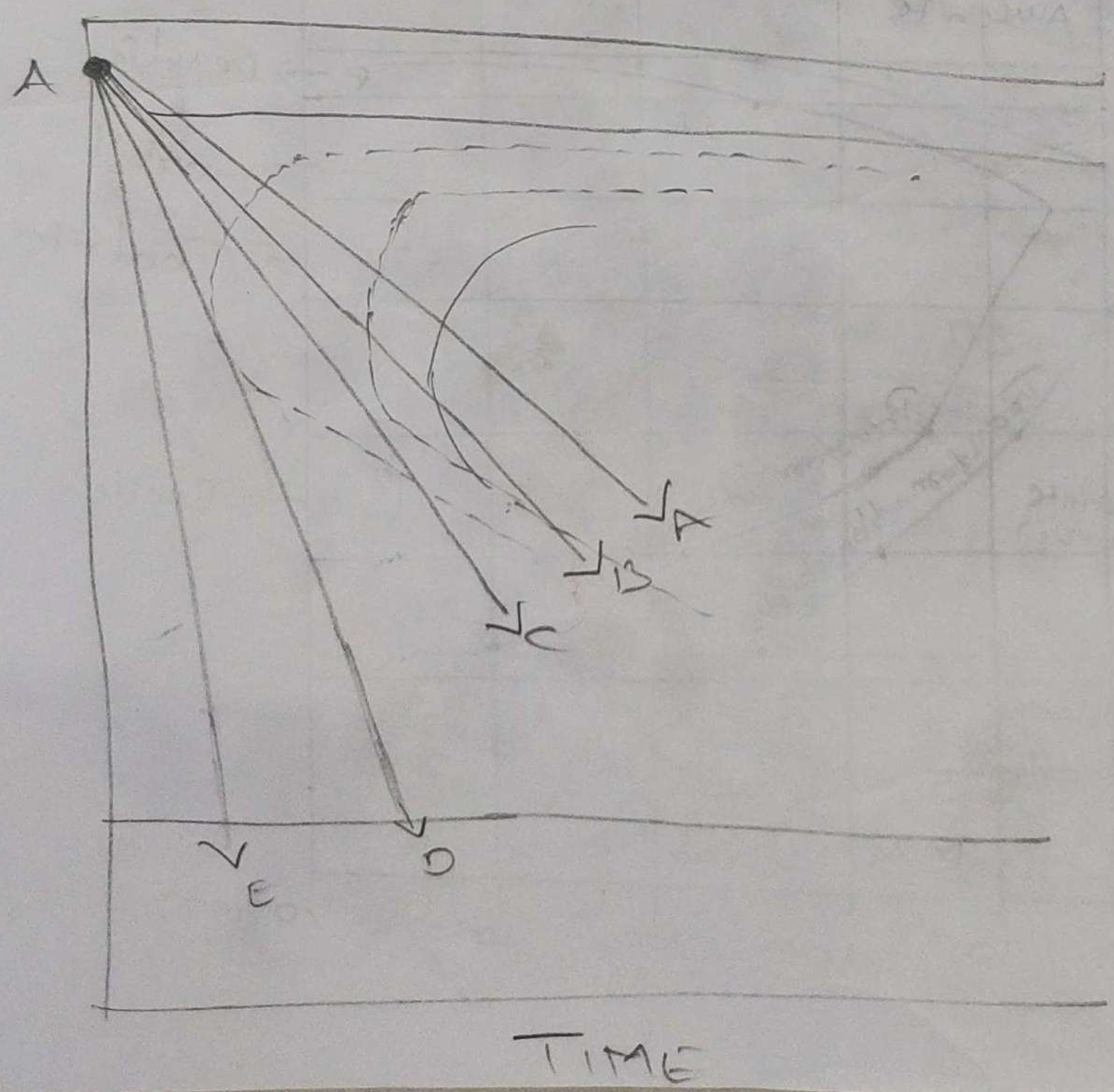
Q. imp

Eutectoid steel



Hyper eutectoid steel

Austenite decomposition on CCT



H-T principle.?

Heat Treatment Principle

Existing structure & properties of steels

↓

(Q) imp

Heat (723°)

↓

Existing structure & properties are wipe out metal is ready to receive new condition (structure) & properties.

↓

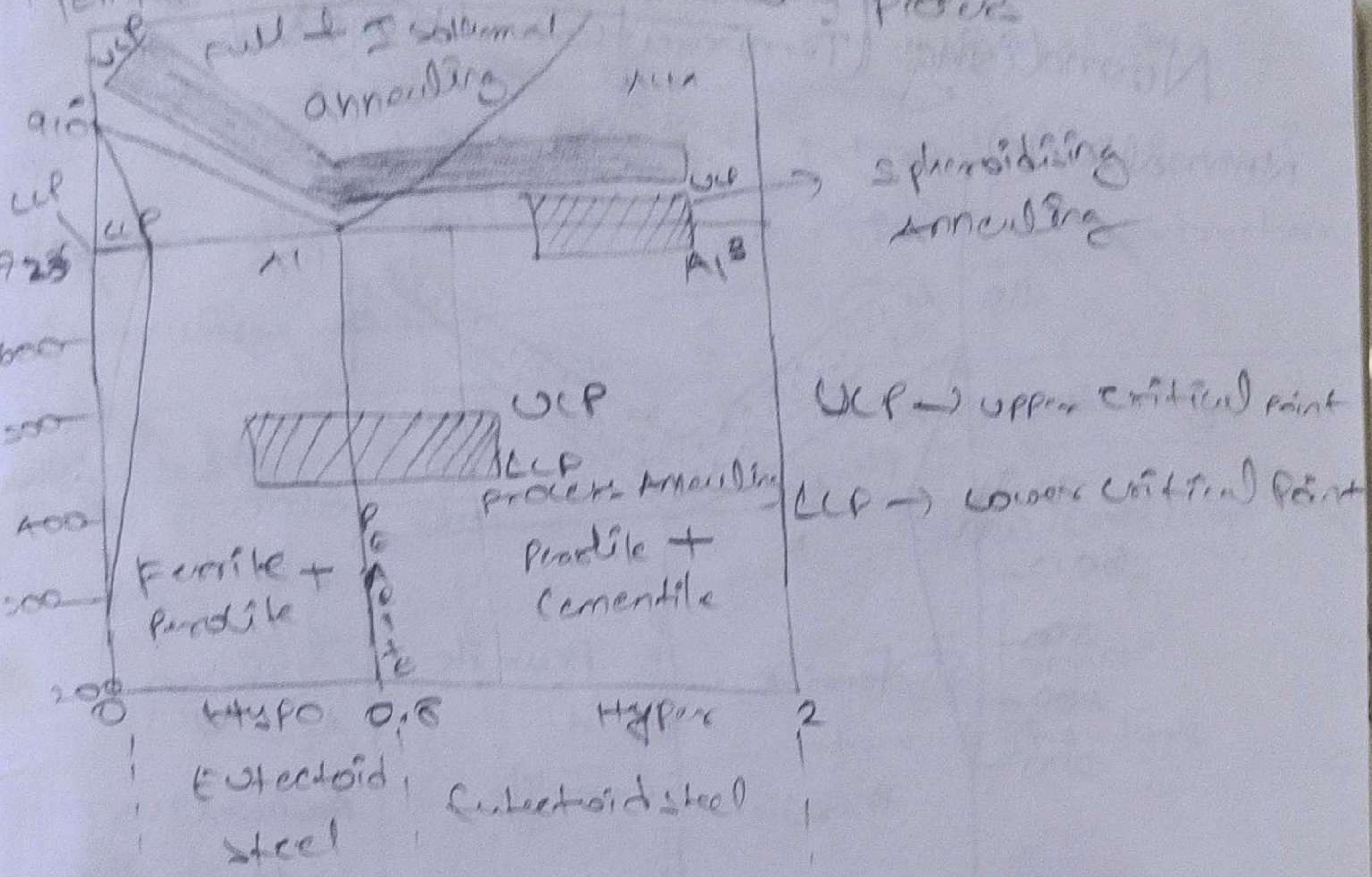
- Very slow → Annealing (To soften steel)
- Slow cooling → Normalising (To refine structure)
- Very rapid cooling → Hardening (To enhance hardness)

Annealing ↓ Tempering (To eliminate brittleness in hardened steel)

Types of Annealing

1. Full Annealing
2. Process Annealing (Recrystallisation annealing)
3. Spheroidise annealing
4. Isothermal annealing

Temperature ranges for annealing process



Carbon content — Annealing temp

→ < 0.12 - Dead MS ⟶ 875° - 925°

→ 0.12 — 0.25 - MS ⟶ 840° - 970°

MCS ⟶ 815 - 840°

→ 0.25 - 0.55

→ 0.55 — 0.8 - HCS ⟶ 780° - 810°

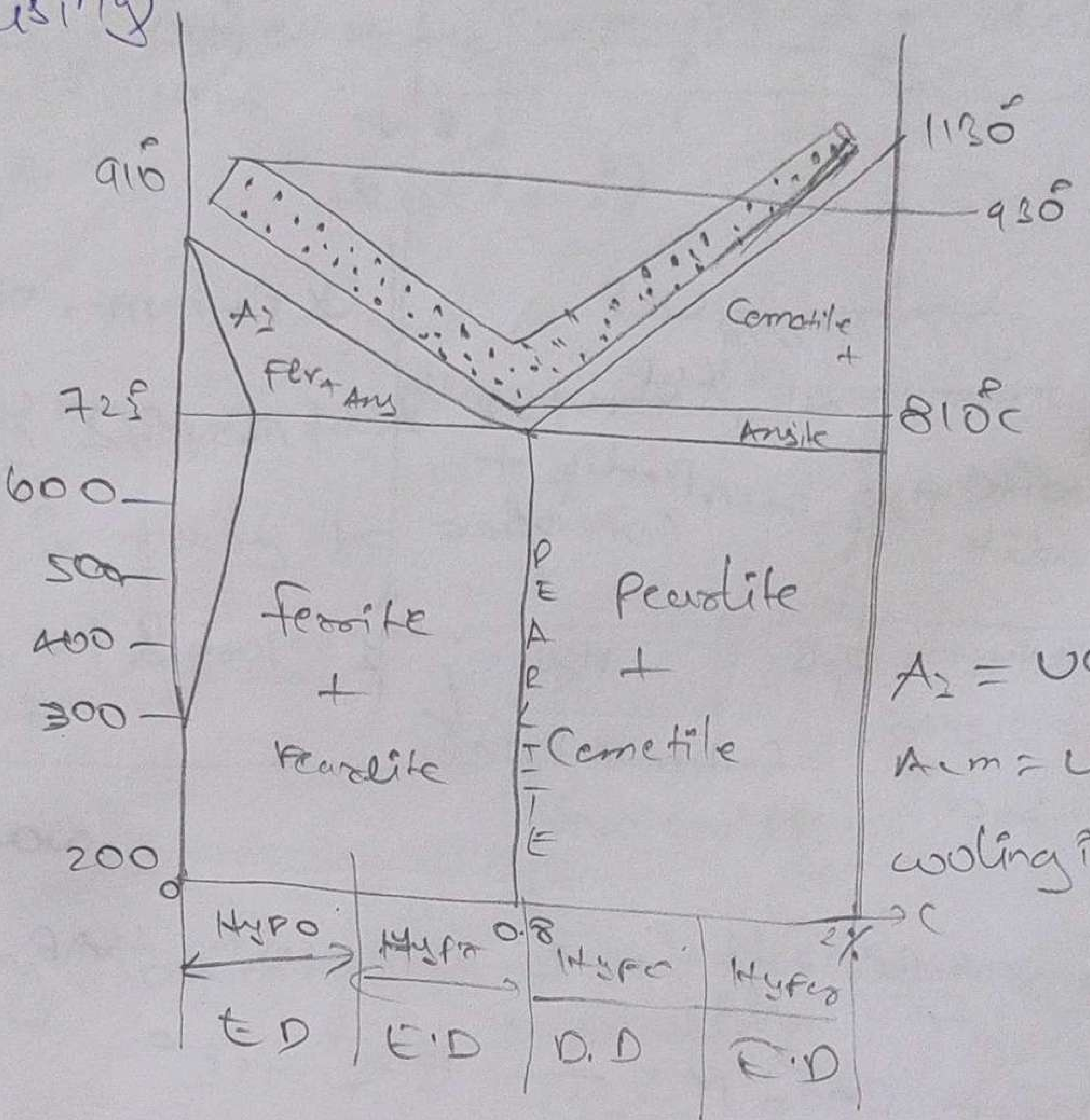
→ 0.8 - 1.4 - HCS ⟶ 760° - 780°

↓

(tool steel)

MCS ⟶ Medium carbon steel

Normalising (Temperature Ranges for Normalising)



A3 = UCT

Acm = UCT

cooling in still Air

Purpose:

To relive Internal stresses

To refine grain structure

To improve machinability

To improve strength and Toughness

→ It is Applicable (G) and MCS

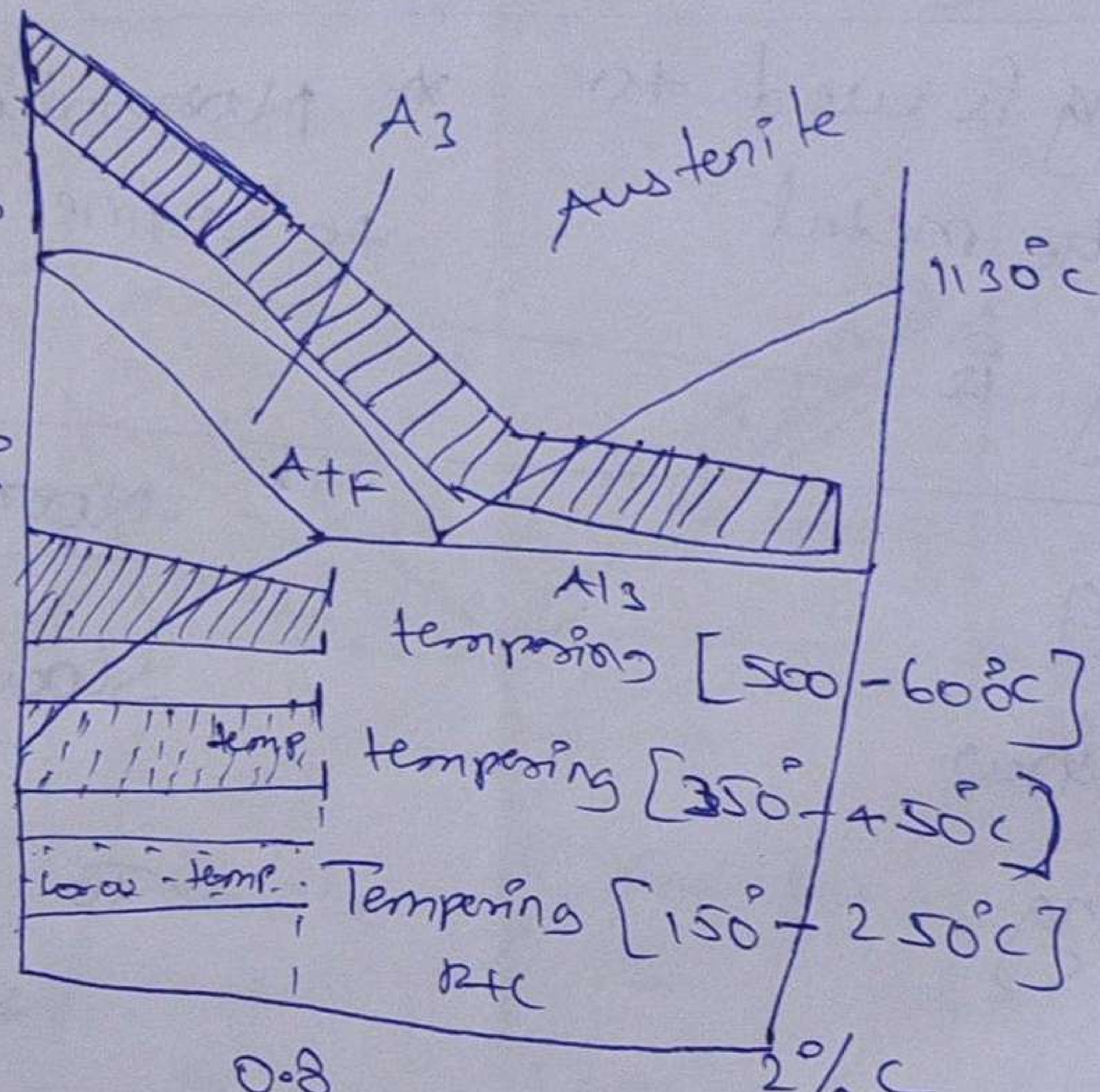
→ Alloy steels may also be Normalised

→ It gives More hardness, U.T.S and Impact strength.

Annealing	Normalising
* Annealing is used to sosten the metal	* Normalising is used to refine the structure
* Annealing is	

Annealing	Normalising
Very slow cooling	slow cooling
	To refine structure
To soften steel	
	No types
4 types	
To improve machinability	To improve machinability
To decrase	To improve strength & Toughness
Applicable for LCS & MCS & HCS	Applicable for LCS & MCS
internal stress	more internal stress
less hardness	more hardness
course grain structure	fine grain

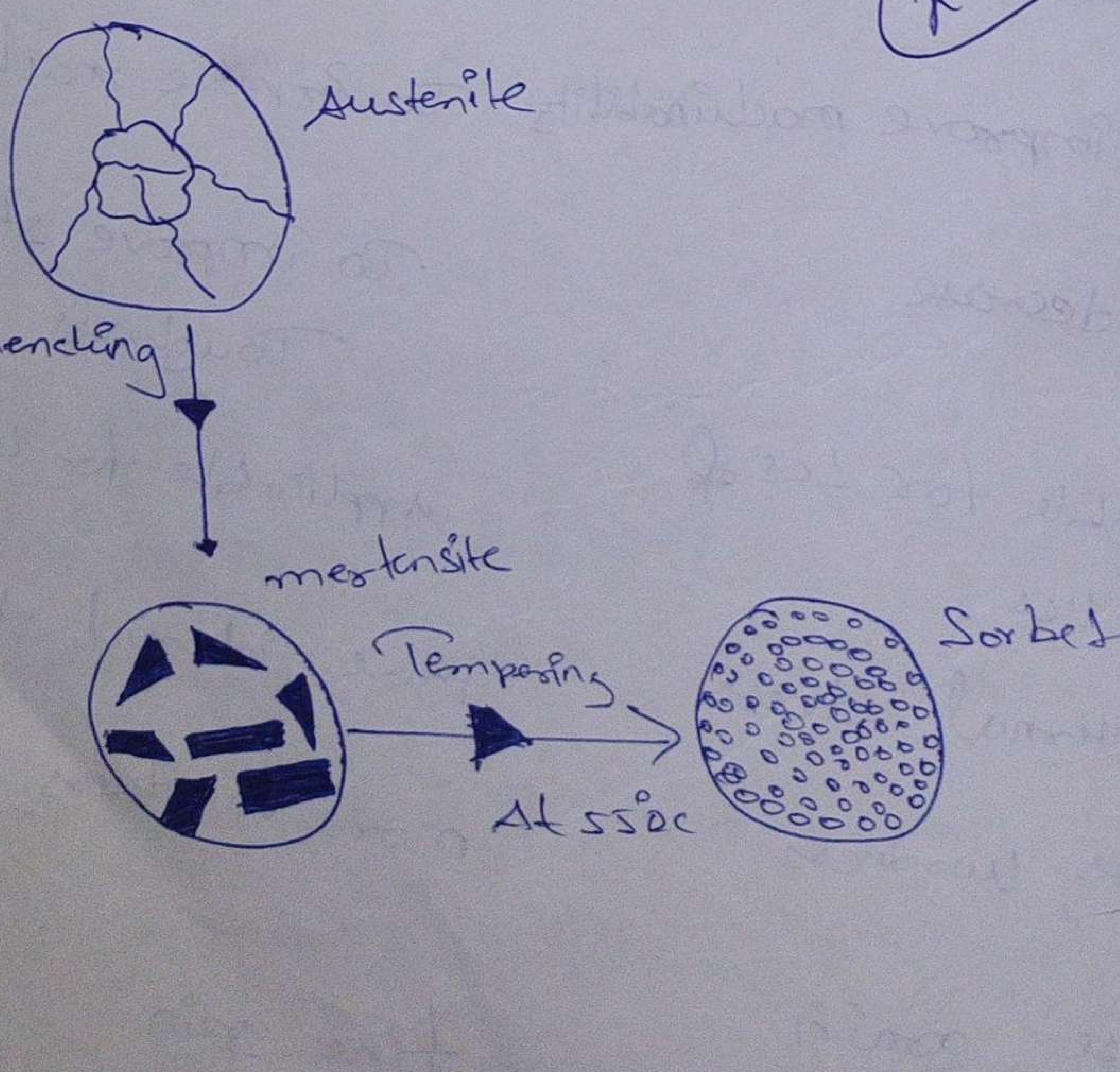
Harding (Temperature range for harding & tempering)



Microstructures of Austenite

Martensite & s-orbit

2nd unit



Tempering

Tempering can be defined as to eliminate brittleness & internal stresses (Thermal stress) by heat treatment (~~to temp,~~ stress) by ~~that~~ by heat treatment low temp, medium temparature, high temp is called Tempering process.

Purpose :-

* To reduce the thermal stresses
* To increase the ductility by reducing the brittness of the metal.
* To stabilise the structure of metal

17-Dec-2021

AN

→ plain Carbon Steel composition

Carbon → 0.08 – 1.7%

silicon → 0.05 – 0.3%

manganese → 0.3 – 1%

sulphar → 0.05%

Iron → Remaining

steels

Based on carbon content
- Low carbon
- Medium carbon
- High carbon

Based on structure
1. Hypo eutectoid
2. Eutectoid
3. Hyper-Eutectoid

Based on degree of deoxidation
1. Killed
2. Semi-killed
3. Rimmed

Based on methods of manufacture
1. Open Hearth
2. Bessmer furnace
3. Electric

Application

1. Structural
2. Machinery
3. Tool steel
4. Spring steel

Type	Application
DMS	chains
MS	Structure, screw machine parts, shaft lever cranks axles
MCS	C.R (connecting Rod) shaft, crane hooks, Rifle barrels, Locom
HCS	Drop hammer, screwdriver, Anvil faces, hammer, spanners, gears
Tool steel	spring knives, files, bearings, d

-> The cast iron refers to a family of forous alloys
-> cast iron is an alloy Iron and carbon percentange more than 2

Cast iron contains:

Carbon - 2.5% to 0.5%
silicon - 0.1 to 3.0%
manganese - 0.5 to 0.1%
phosphores - 0.1 to 0.9%
sulpher - 0.07 to 0.1%

Advantanges

-> low meltting point 1200°C
-> Good fluidity & low shrinking on cool
-> Good machinability
-> Better resistance to corrosition f
-> High compressive strength
-> High damping capacity
-> free graphite in castiron acts as lubricant
-> Inexpensive

Dis Advantages

-> Brittle

-> cannot be bored (or) hardened

-> Not malleable

-> weak in tension

Types of castiron

1. white castiron

2. Gray castiron (or) grayiron

3. Ductile cast iron (or)

White cast Iron

→ Introduction

The white cast Iron structure is very hard wear resistant, and brittle because of the presence of large amounts of Iron carbide

→ Composition

Carbon - 2.9%
silicon - 1.15%
manganese - 0.15%
sulpher - 0.5%

→ Application :-

Iron - Remaining used in parts subjected to expensive wear used interior casting used too making malleable casting also.

Gray cast Iron

Introduction :- In this structure graphite exists largely in the form of flakes It is called gray cast iron because when it is broken the fracture path is along graphite flakes, & has a gray sooty apperence

Composition

Carbon - 2.8 to 3.6%

silicon - 1.0 to 2.75%

Manganese - 0.4 to 1.0%

phosphours - 1.0 to 1.0%

Application:

machine tool structures frames for Electric motor

Madhu

Applications const:

→ Rolling mill & general machinary parts

→ cylinder blocks & heads for Internal compression engines

→ Gas (or) water pipes for underground purposes

information

Ductile iron

not

Introduction

In this structure. graphite appears as round particles (or) Nodular (or) spheroid form instead of flat flakes formed in grey cast iron

Composition

Carbon - 3.0 to 3.5 %

silicon - 2.0 to 2.5 %

Manganese - 0.15 to 0.6 %

Phosphorous - 0.025 to 0.4 % (max)
Sulphur - 0.015 to 0.09
Iron - Remaining

Application

→ steel mill rolls and mill equipment
→ Power transmission equipment
→ values and fittings
→ ~~Engi~~ Internal compression engines
→ pumps and compressers
→ paper Industirres and Machinary

Malleable iron

Introduction :-

It is obtained by anneling white cast iron in an atmosphere b/w 800-900°c for upto 60 hours depending on the size of part

Composition :-

Carbon - 2.0 - 2.8 %

silicon - 0.7 - 1.4 %

Manganese - 0.4 - 0.6 %
Sulphur - 0.1 % max
phosphorous - 0.2 - max)

Iron - Remaining

Application :-

Differential and steering gear housing.

~~Brake~~

→ Brake pedals

→ Tractor springs

→ Agriculture implements

→ Universal joint yoke

→ Automotive crank shafts

Applications

→ Used for manhole covers and pipes

→ Also employed for making fire plugs and lamp posts.

Chilled cast iron

white
gray
ductility
malleable
nodular cast

composition

graphite : 1.75%

Combined form : 1.75%
(Cementite)

Remaining : Iron

Impurity :
silicon, manganese, sulphur, phosphorous

Properties :-

→ Mixture of the two states, grey & white CI

→ strength and hardness vary according to the ratio of free carbon to combined carbon

→ Fluidity is good

→ Hard and brittle

Applications :

→ used for manhole ~~[illegible]~~ covers & pipes

→ Employed for making fire plugs and lamp posts.

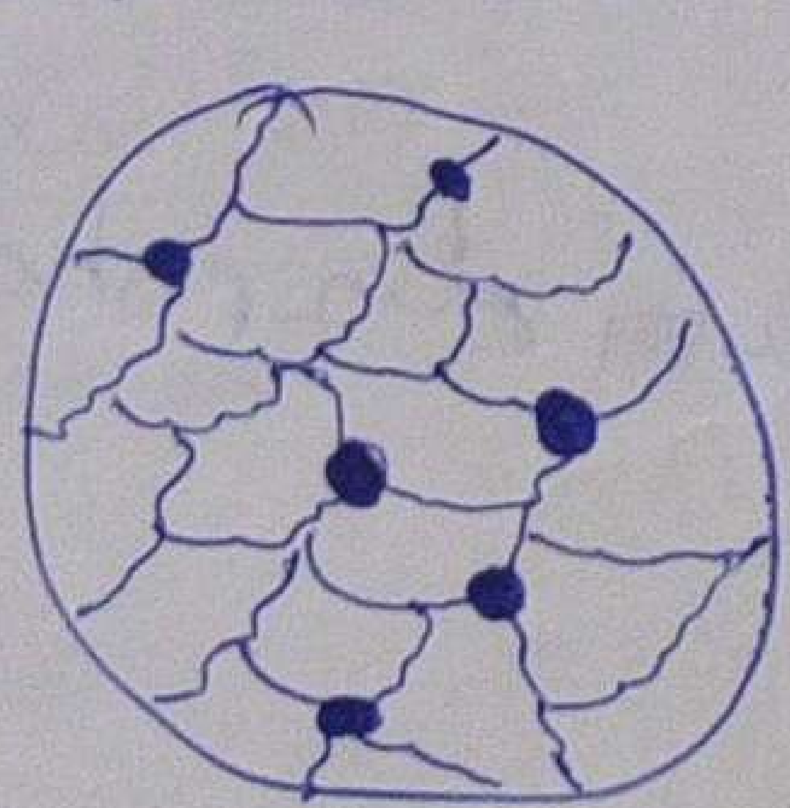
White C I

Cementite

Gray C I

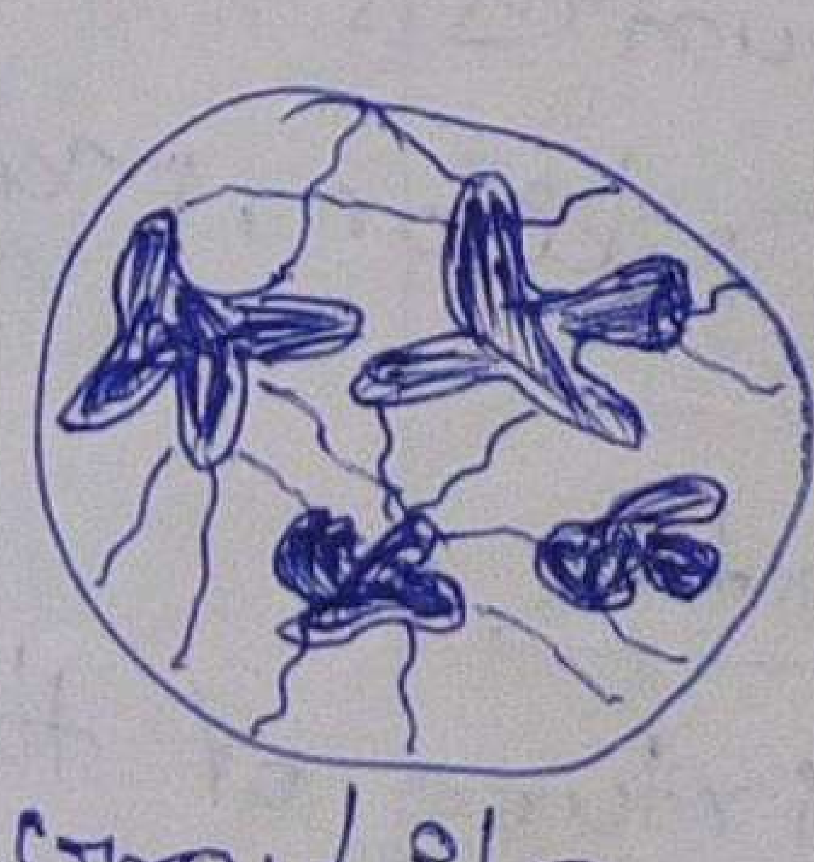
Graphite Flakes

Ductile C I



Graphite Nodules

Malleable C.I



Graphite Rosettes

Summary of C. I

cooled quickly
↓
White - C I
↓
Carbon present as cemmtile Hard, brittle very difikult to
↓
Heat treated
↓
Malleable C. I

cooled slowly
↓
grey - C. I
↓
Carbon present as the graphite soft, easil machined
↓
Inoculed (Addition of mg)
↓
Nodular & spheratio

↓
Addition of graphite
↓
Chilled cast iron

→ **complex Alloy** . HSS [High speed steel]

It is used as a cutting ~~tool~~ Rod at high speed at cutting temp 600°c to 620°c

4 - types → 18 - 4 - 1 tungten, chromium, vandium,

0.7% carbon

Here Tungsten provide red hardness

chromium provides ↑ the depth of hardness

and some wear Resistance
Vanadium ↑ toughness and abrasion Resistance
18-4-1 is used for the sharper tools, drills and milling cutters.

→ cobalt H.S.S
→ Tungsten - 20%
→ chromimum - 4%
→ Vandum - 2%
→ cobalt - 12%

→ Vanadium HSS :- vanadium percentage more than 1

→ Molybdenum HSS - Molybdenum - 6%
Tungsten - 6%
chromuim - 4%
Vanadium - 2%

Special Alloys

1. Stain less steel

→ certain elements added to plain steel increases the corrosion resistance of steel. Alloy steel which resists the corrosion is called stainless steel or corrossion resistance steel.

→ Stainless steel can be classified into three groups :-

i) Ferrite Stainless steel (Cr = 12 to 20% C = 0.09% (max)

ii) Martensite Stainless steel (Cr = 10 to 14% C = 0.3%)

iii) Austenite stainless steel (Cr = Ni = 8%, C = 0.06 - 0.12%)

Non-ferrous metal and alloys

Properties (1) corrosion resistance
(2) high thermal conductivity
(3) high electrical conductivity
(4) low density
(5) ease fabrication

Ex:- Al, Cu, Tungsten, titanium and molybdenum

General characteristics of non-ferrous metals.

Alloys:-

Materials

Non ferrous alloys: More Expensive than steel and plastics wide range of mechanical physical and electrical properties good corrosion resistance high temperature applications

Aluminium: High strength to weight ratio of high thermal & eletrical conductivity corrosion resistance & good manufacturing properties.

Titanium: High strength to weght ratio all metals Good corrosion resistance at high tempardure High strength

Copper: High electrial and thermal conductivity high corrosion resistance Good manufacturing properties.

Magnesium: Lightest metal good stength to weight ratio

Superalloy: Good strength & resistence corrosion at elevated temparature canbe iron, cobalt and nickel

Refractory metal: Molybdenam, tungsten and titanium high strength at elevated temperatures

Aluminium - Alloys

A few popular aluminium alloys their composition properties and uses are tabulated as follows:

MP

1: single peace pattern

2. split pattern.

3. cope drag pattern.

4. ~~cope~~

4. sweep pattern.

5. skeleton pattern

6. Grated pattern

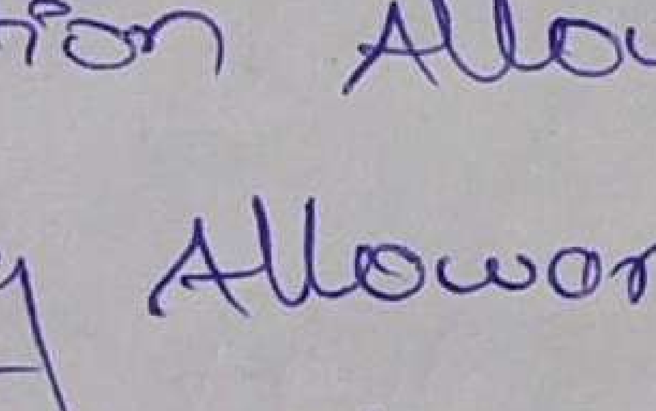
shell pattern.

Types of Allowance.

1. shrinkage Allowances
2. Draft Allowances
3. Distortion Allowances.
4. shaking Allowances
5. finishing Allowances.

SAND casting process

(1)

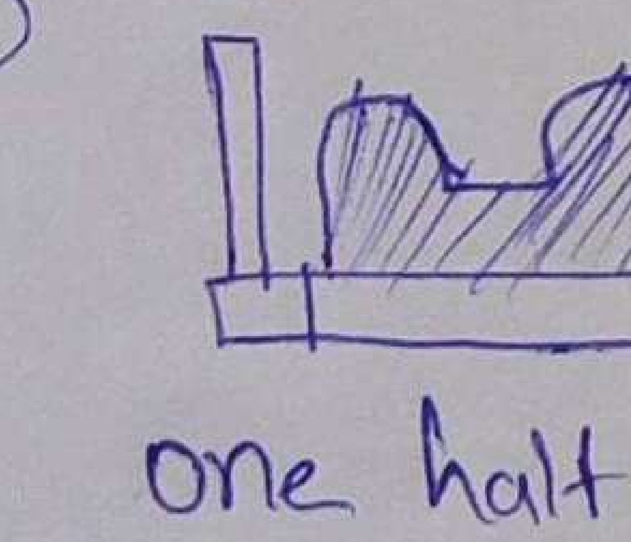


one half of the patter

(2)

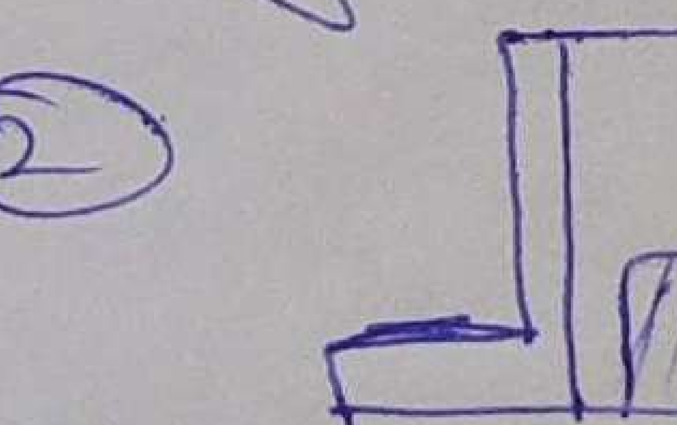
first placed over 1st patter.

(3)

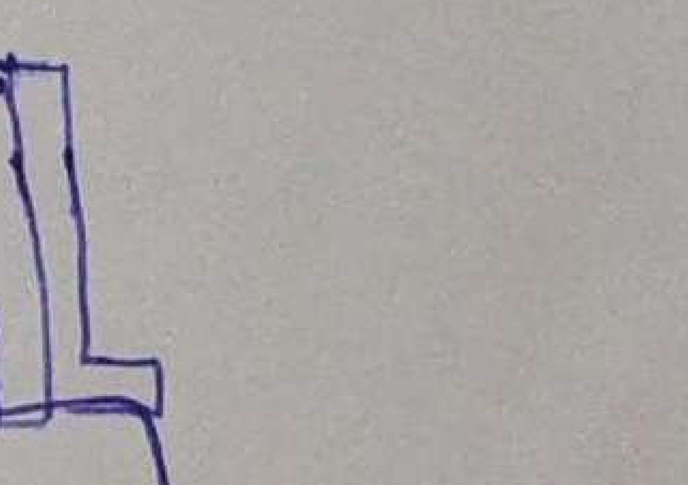


one half the mold.
(cope)

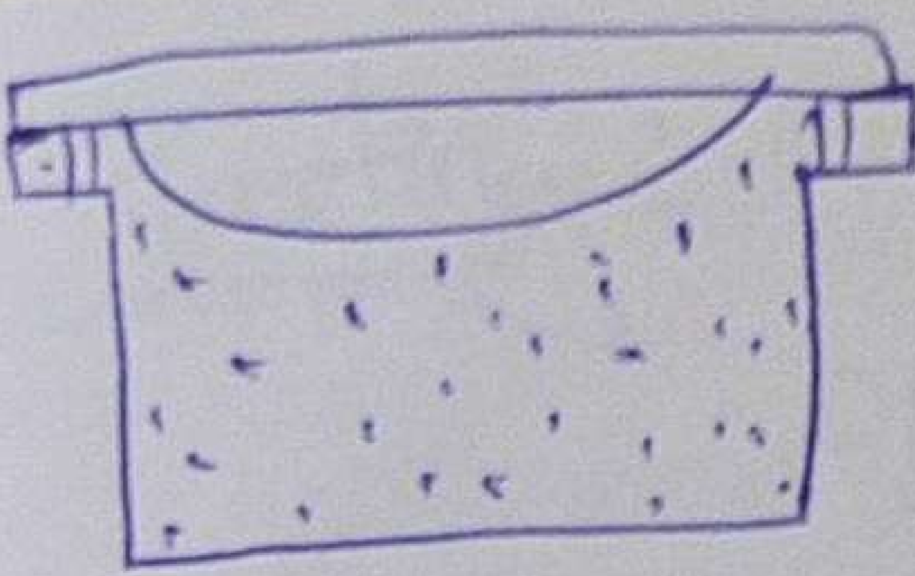
(4)



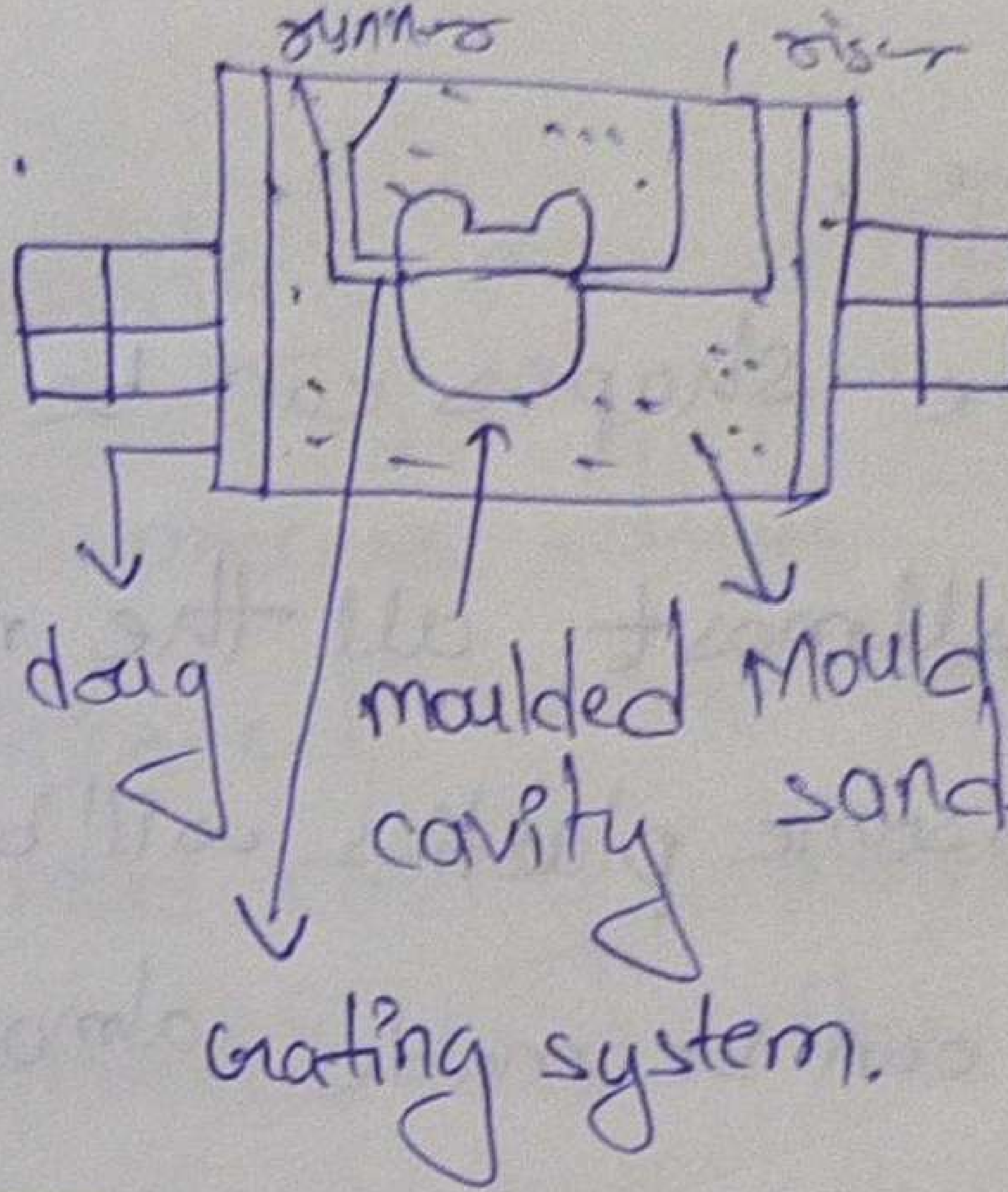
(5)



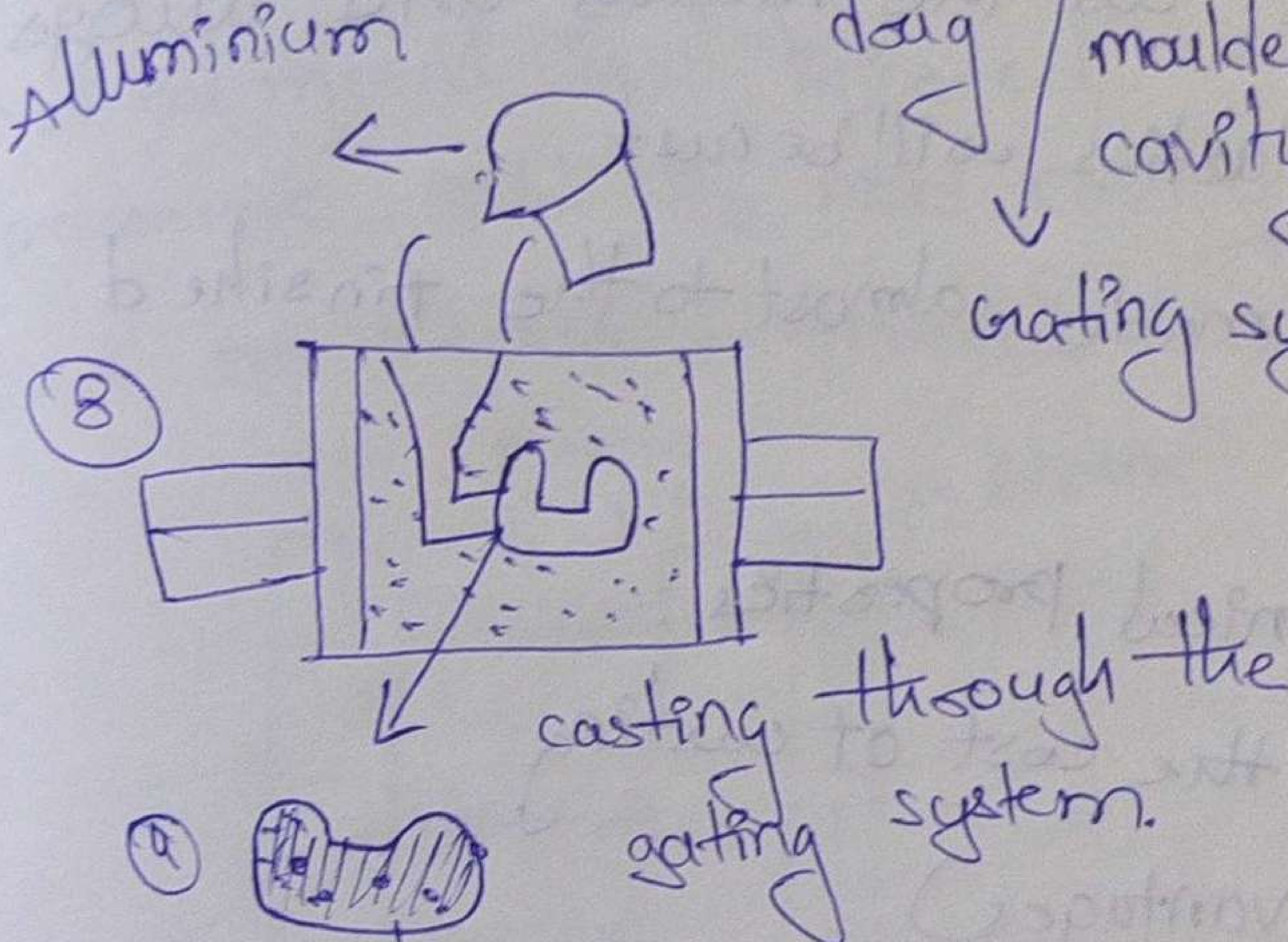
6.



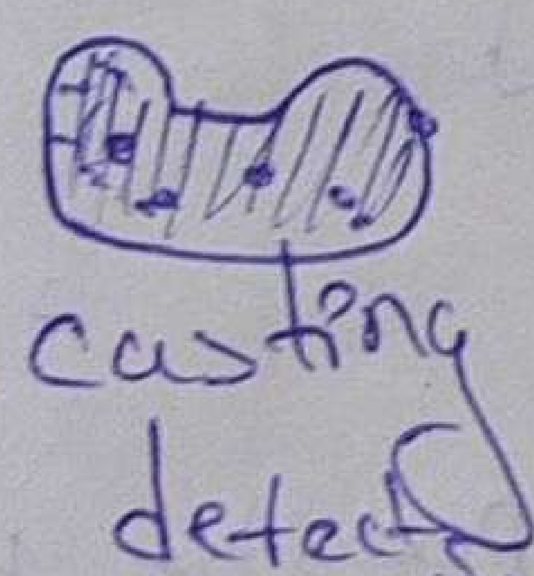
7.



(8)



(9)



sand casting ~~[illegible]~~ process steps

1. preparation of moulds.
2. preparations of ~~material~~ pattern.
3. Melting of material
4. pouring of the liquid metal.
5. solidification
6. futher cooling at room temperature
7. Defects
8. inspection

Advantages.

1. Intricate shapes can be cast
2. ~~Alom~~ Allmost all the metals and alloys and ~~pl~~ some plastics will be cast.
3. parts can be made almost to the finsihed shape.
4. good mechanical properties.
5. It decrease the cost of casting

limitations (disadvantages)

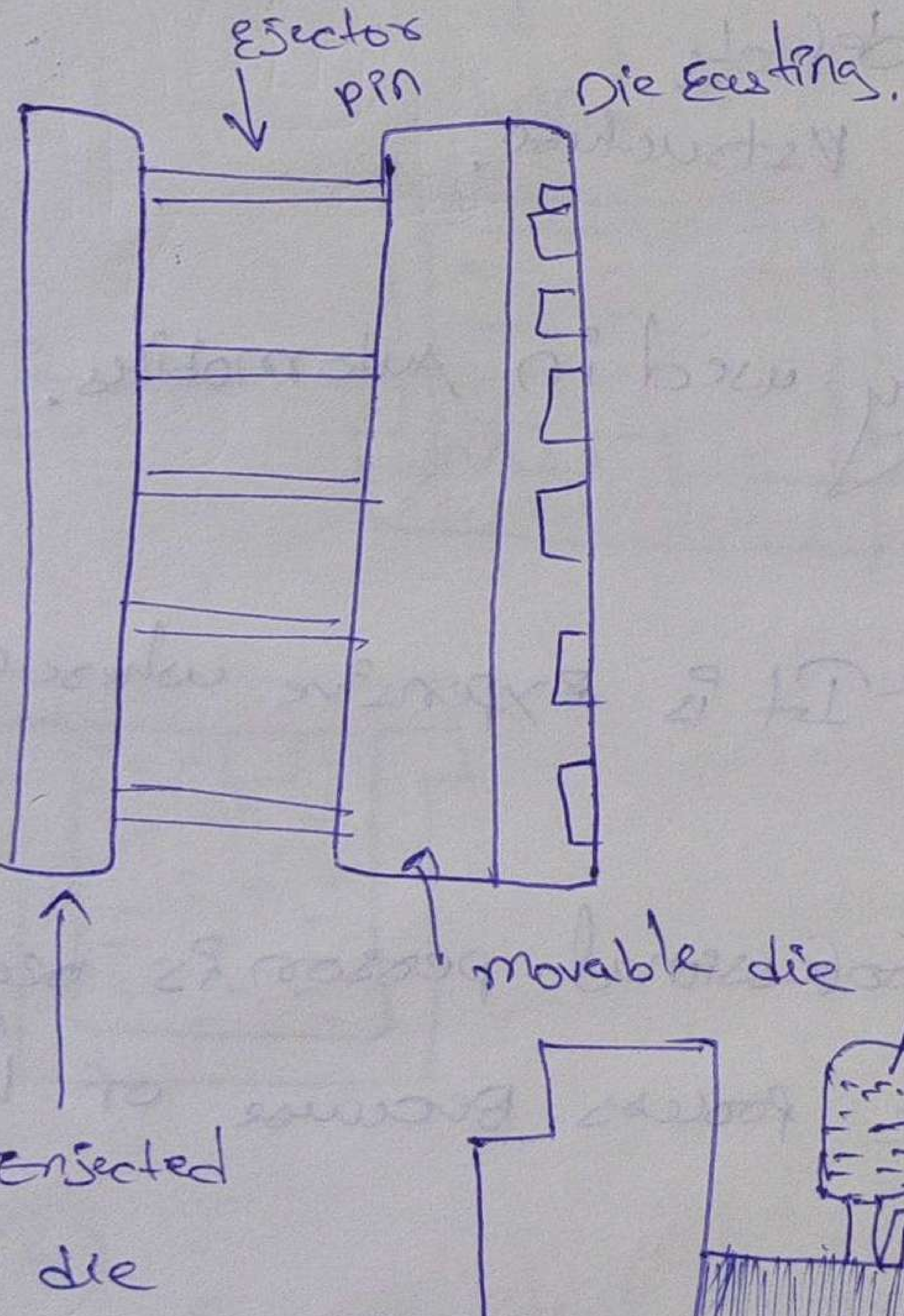
1. Dimensional accuracy are not possible by Normal sand casting process.
2. surface finish not possible by Normal and casting process.
3. To overcome the defects of casting was developed.

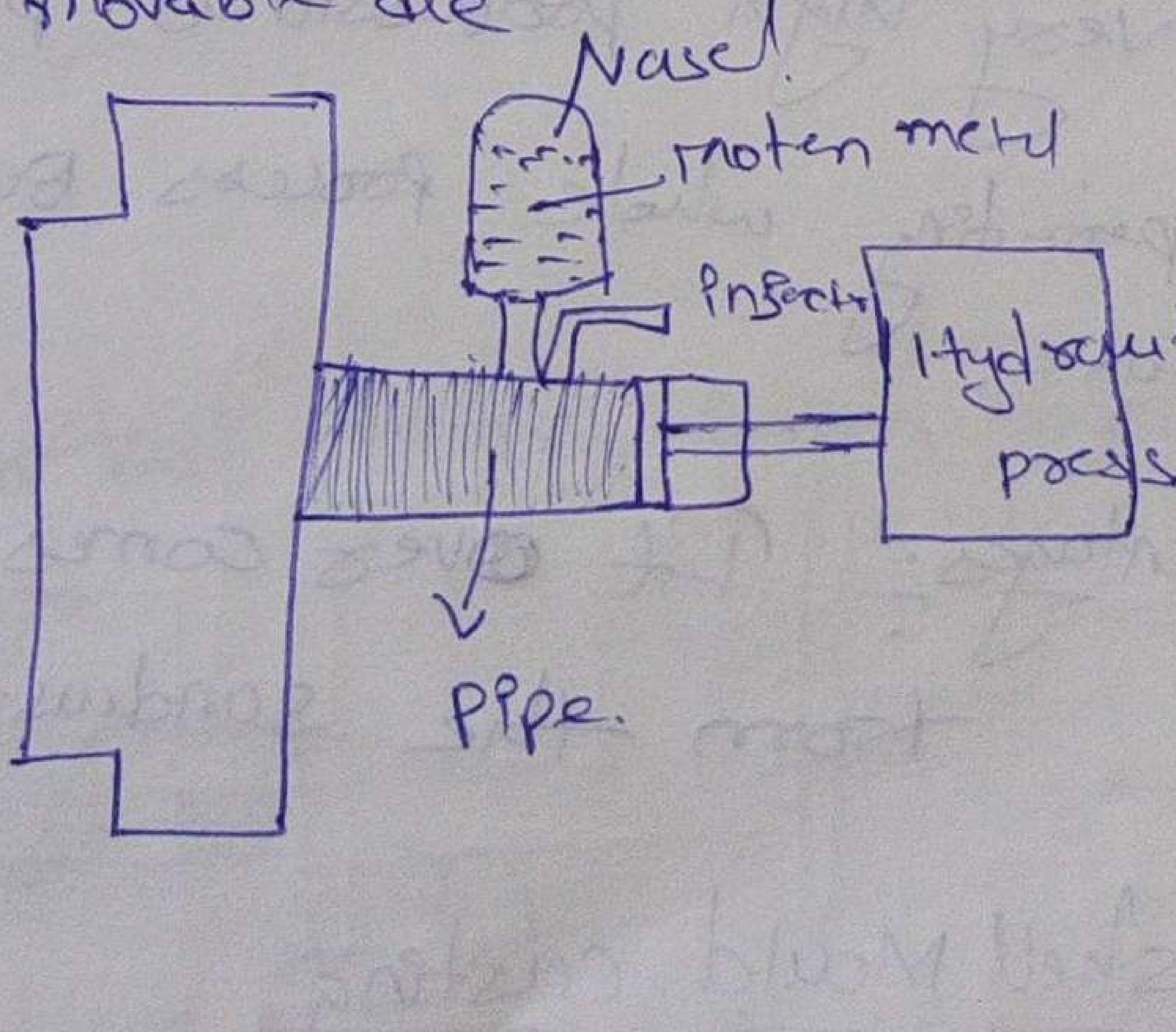
Applications:

1. Liners
2. Machine tool bets
3. pistons
4. piston rings
5. Mill rolls
6. cylinder blocks
7. automobile parts etc.

Die Casting:-

Die casting process is a special casting process where the molted metal is injected under high pressure into the mold cavity formed by a set of reusable metalic dies this phenomenon





sandcasting

Die casting

investment casting

shell casting

Centrifugal casting

Moulding Materials defects

sand properties such as:- i. strength
ii. permiability
iii. Refractivity

→ pouring metal defects:-
i. Turbelunce.

→ Metallurgical defects.
i. ~~Ø~~structure.

Application:- Mostly used in Automobiles.

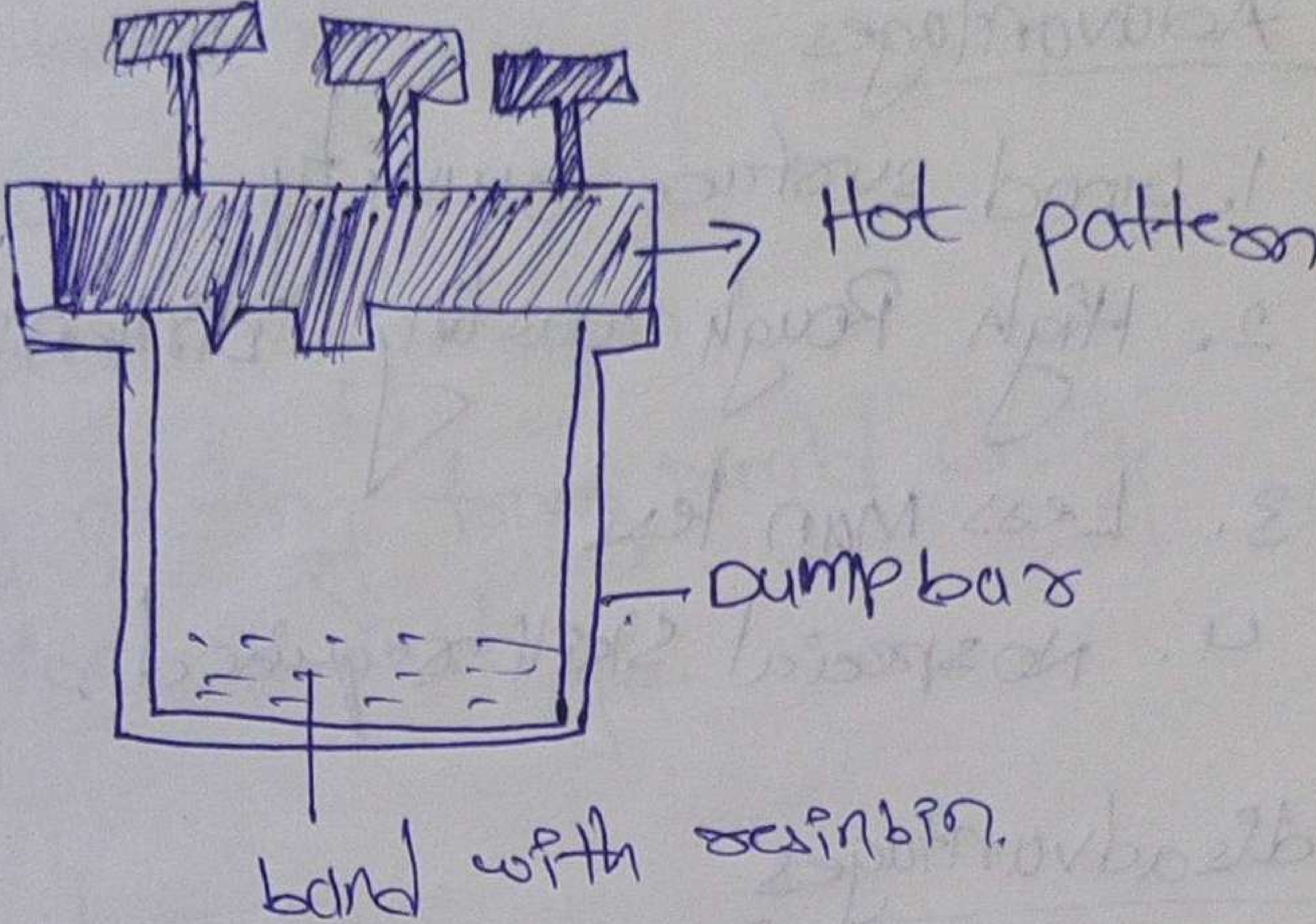
~~Disad~~
Dis advantages:- * It is expensive where compared to sand casting
* very high professional person is required.
operating whole process because of high pressure.

Advantages:- It over comes all the disadvantages from the sandcasting.

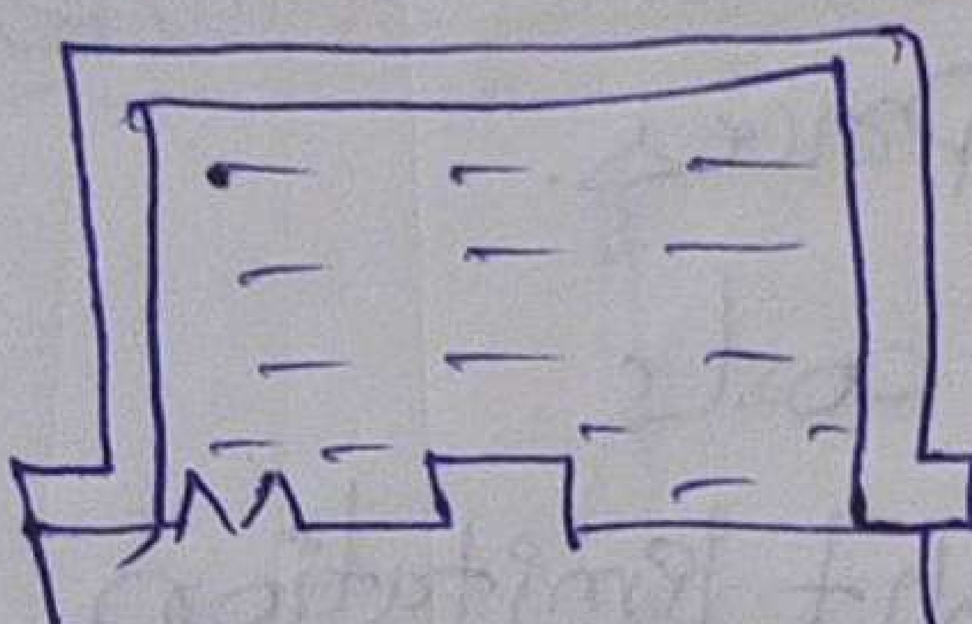
shell Mould casting

1. sand preparation
2. pattern creation
3. Mould creation
a moudi..
b. pour..
c cools
d ..

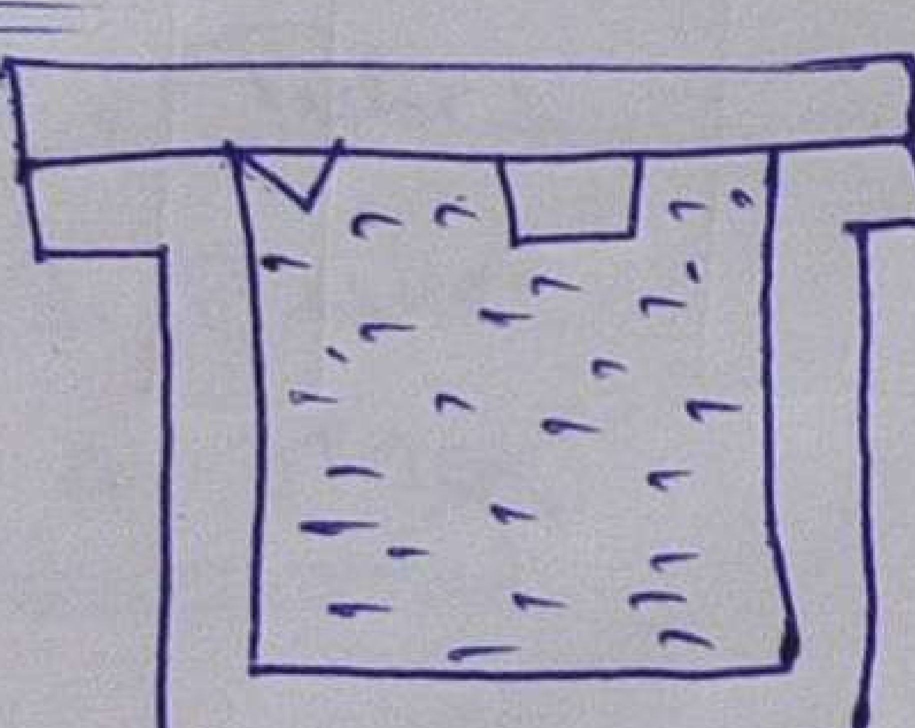
set - 1



step - 2

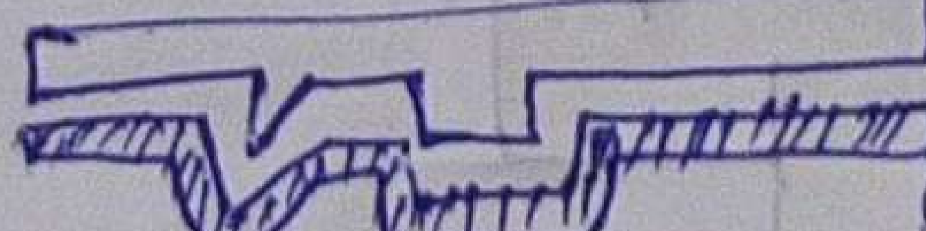


step 3

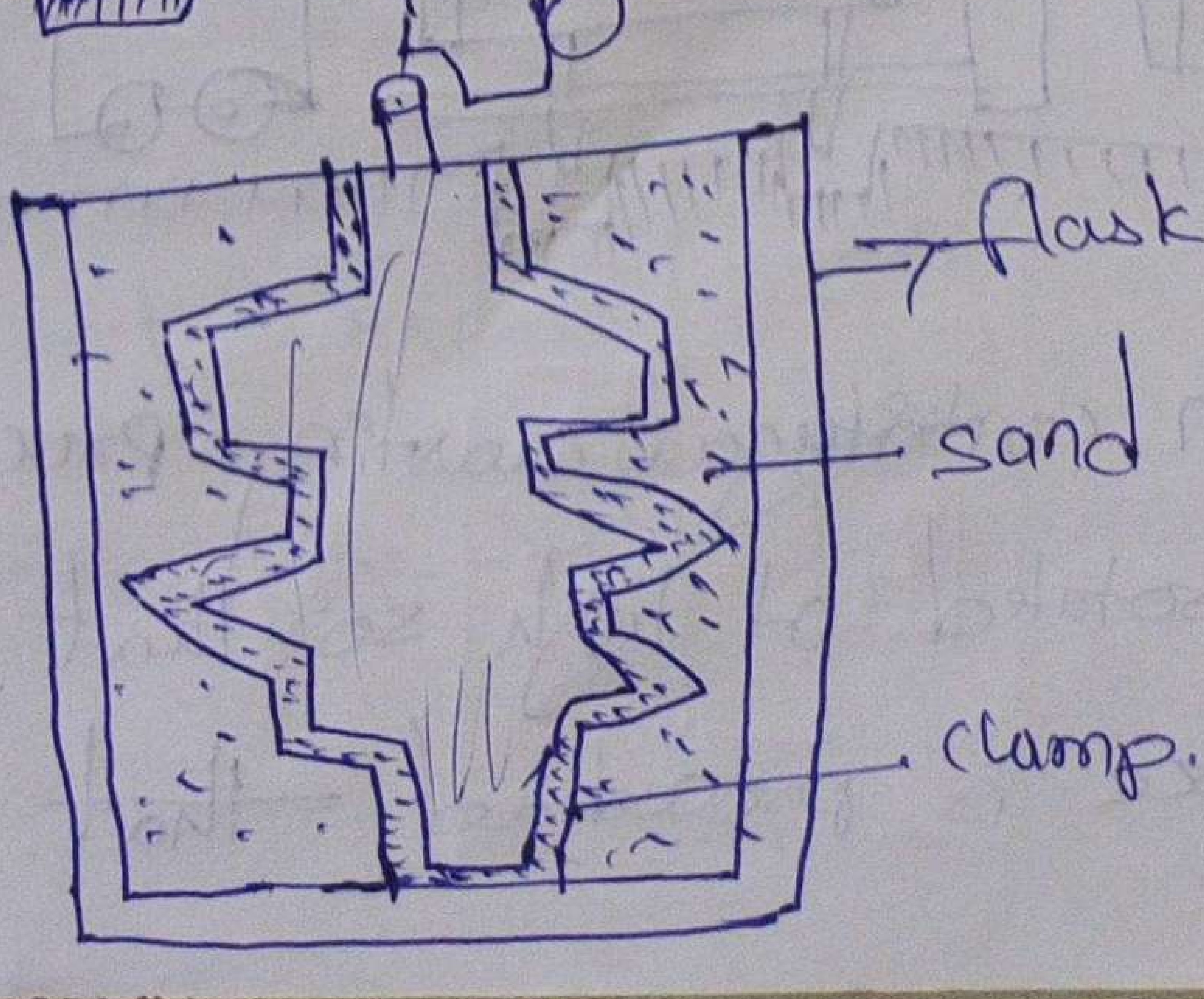


step (4)

Removing hot pattern from shell.



step(4)



Advantages

1. Good surface quality
2. High Rough casting Dimensional Accuracy
3. Less Man less
4. No special skill required.

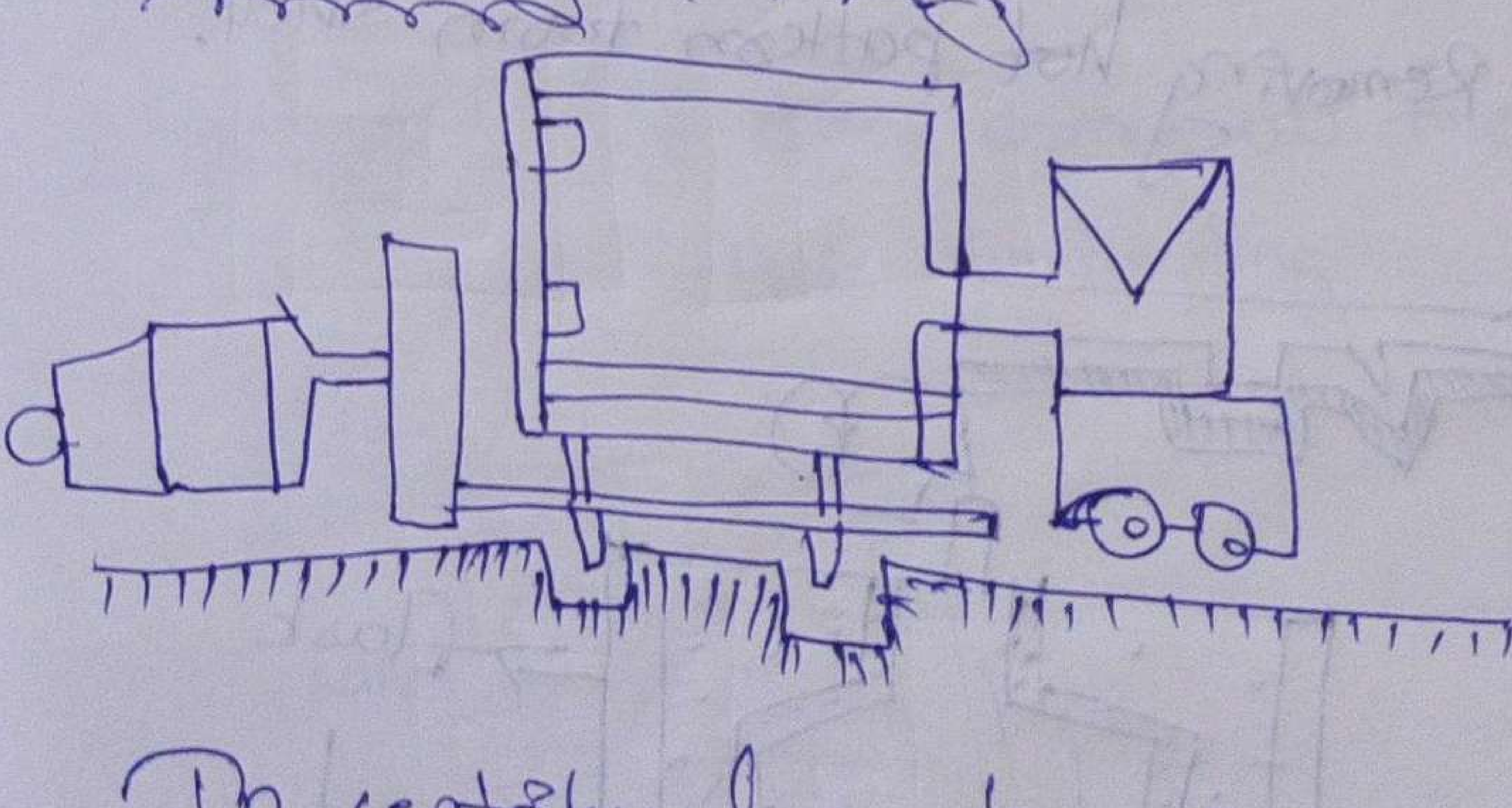
disadvantages

* High casting prices.
* High pattern costs
* size and weight limitation.

procedure

1. prepare.

centrifugal casting



In centrifugal casting process the mould is rotated at high so that centrifugal force is produced that distributes

1. Pattern selection
2. pouring the moulten metal.
3. Drum speed regulation.
4. removing casting from mould cavity.
5. Inpection of castings.

~~Mould creation~~

Applications

1. pipes
2. Tubes
3. Bushes
4. rings.

Advantages

* No cores are required
* No runners and raise gaes

Disadvantages

1. The euipment is expensive.
2. It is for large scale production.

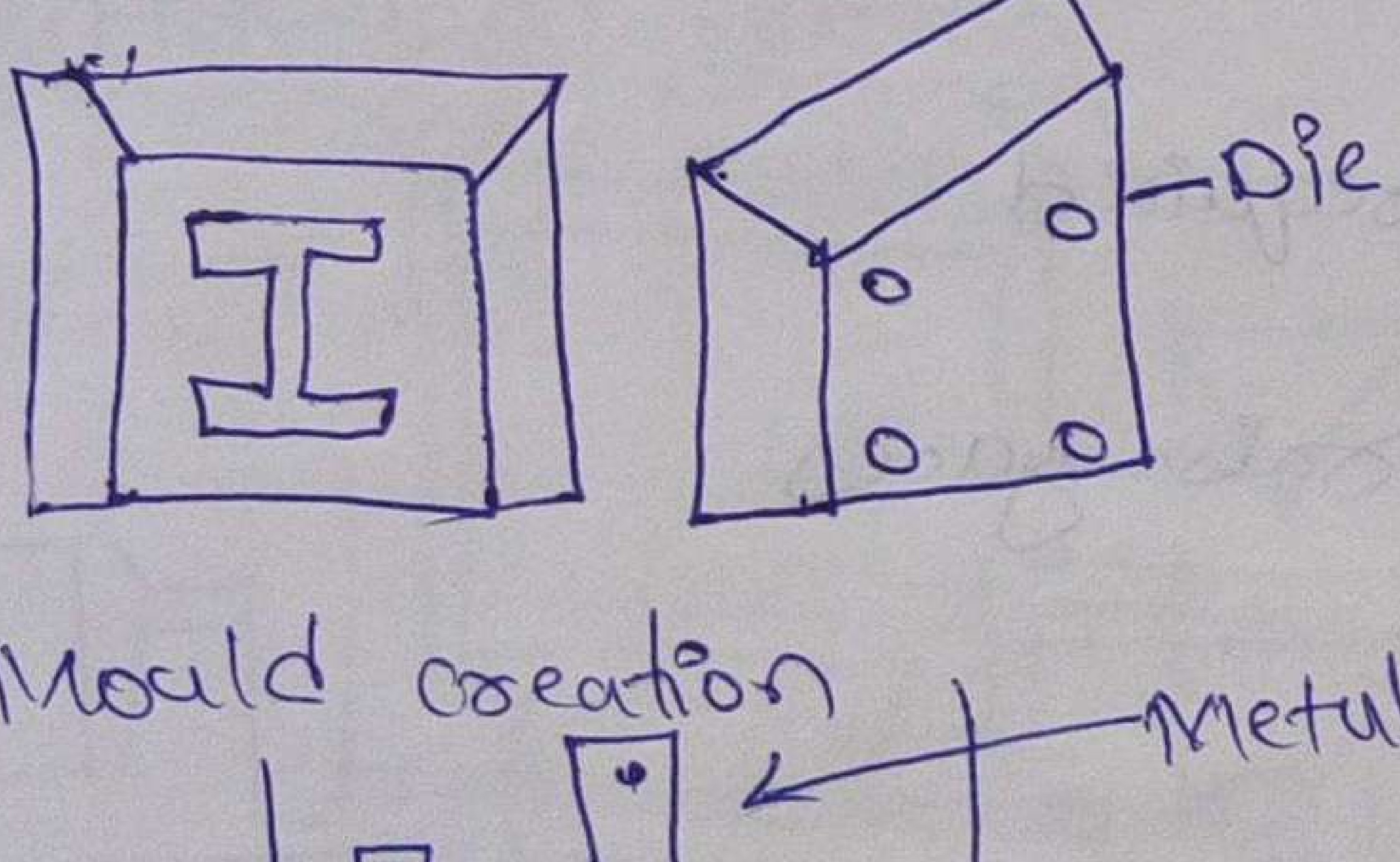
Investment casing / precision casting.

→ Investment casting is a special casting process in which is prepared by pouring the hot metal into the mould formed by cooling.

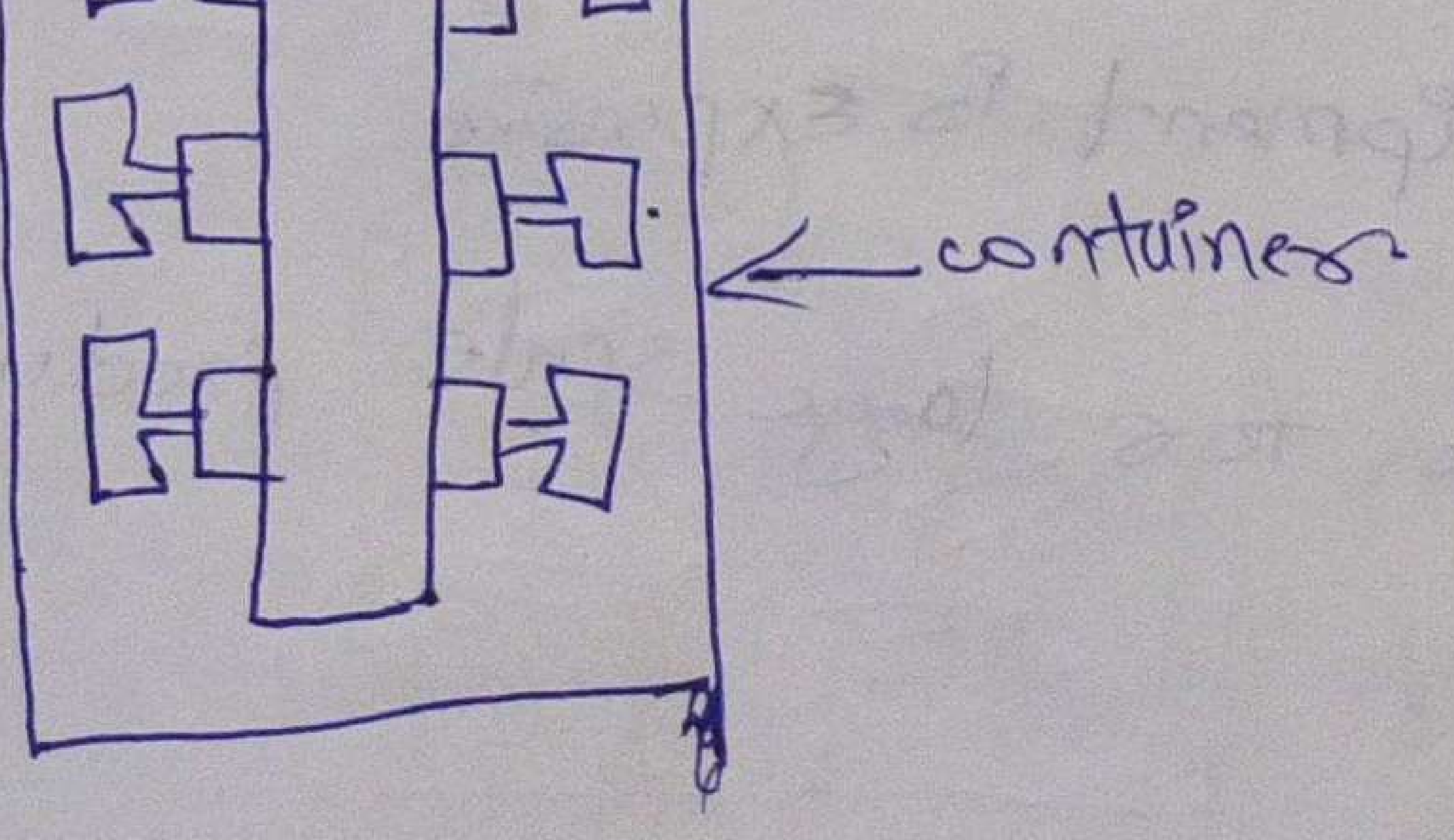
→ Investment casting there are 5 types.

1. pattern creation.
2. Mould creation
3. pattern removal
4. casting preparation
5. Mould removal.

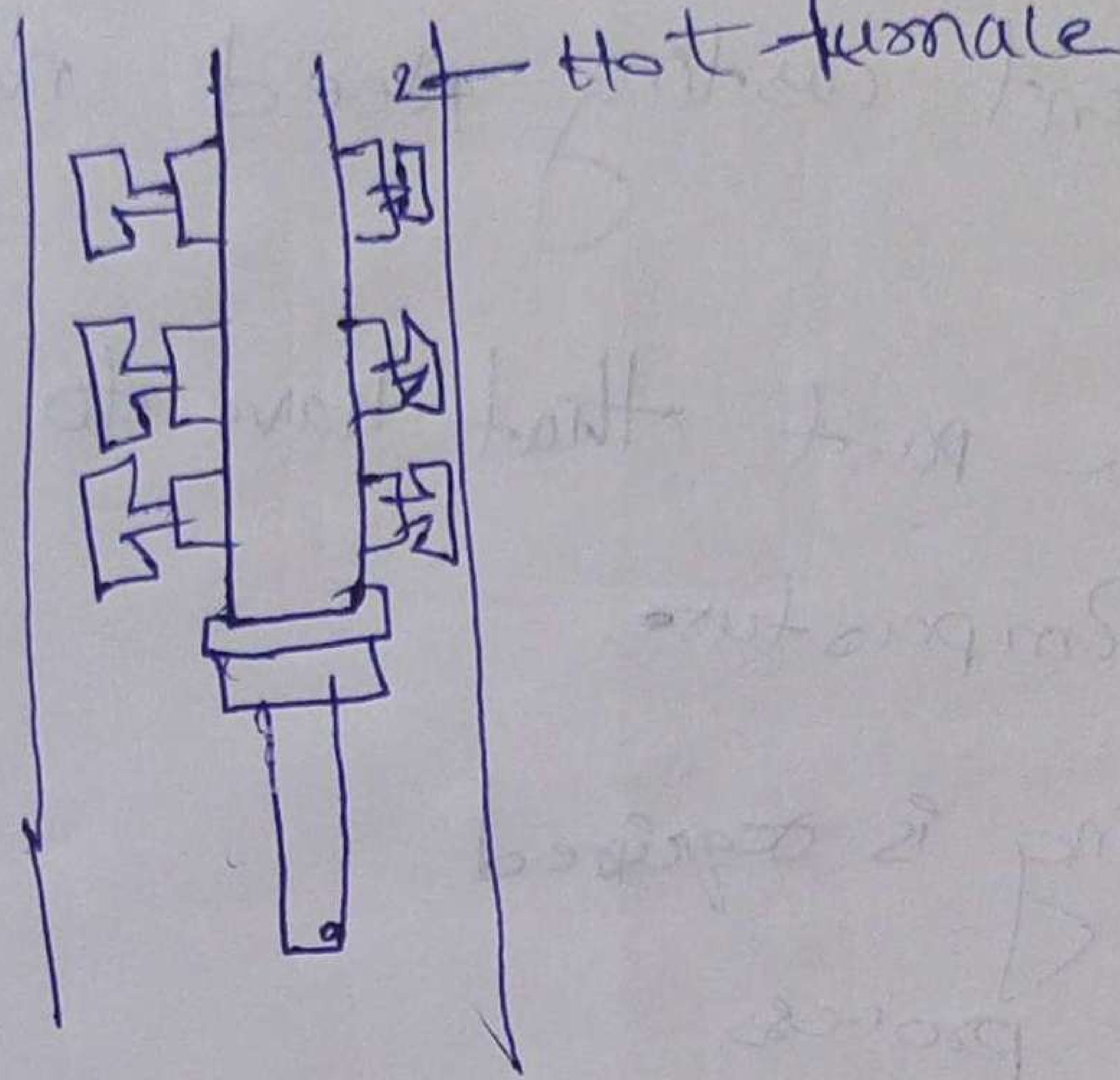
1. PATTern creation



Mould creation

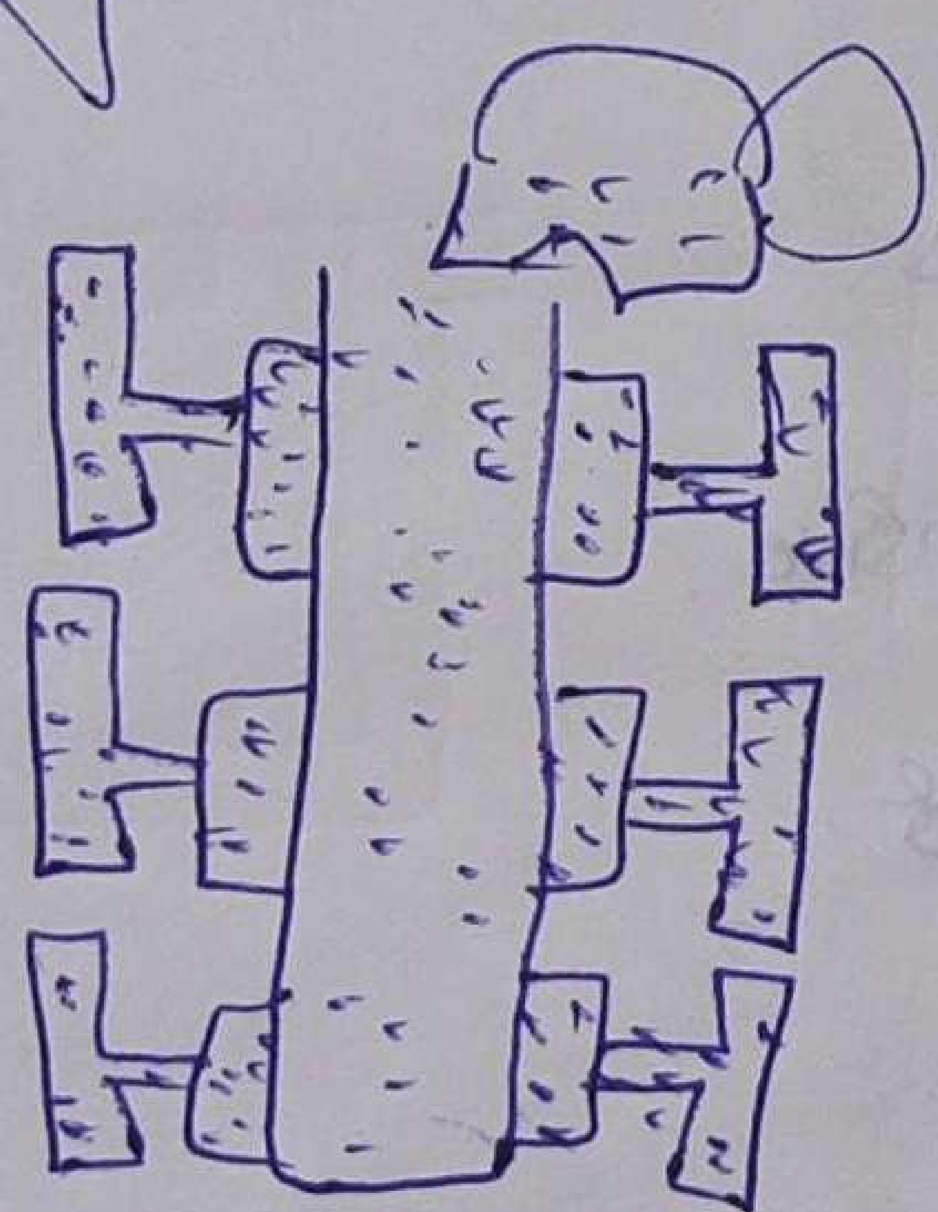


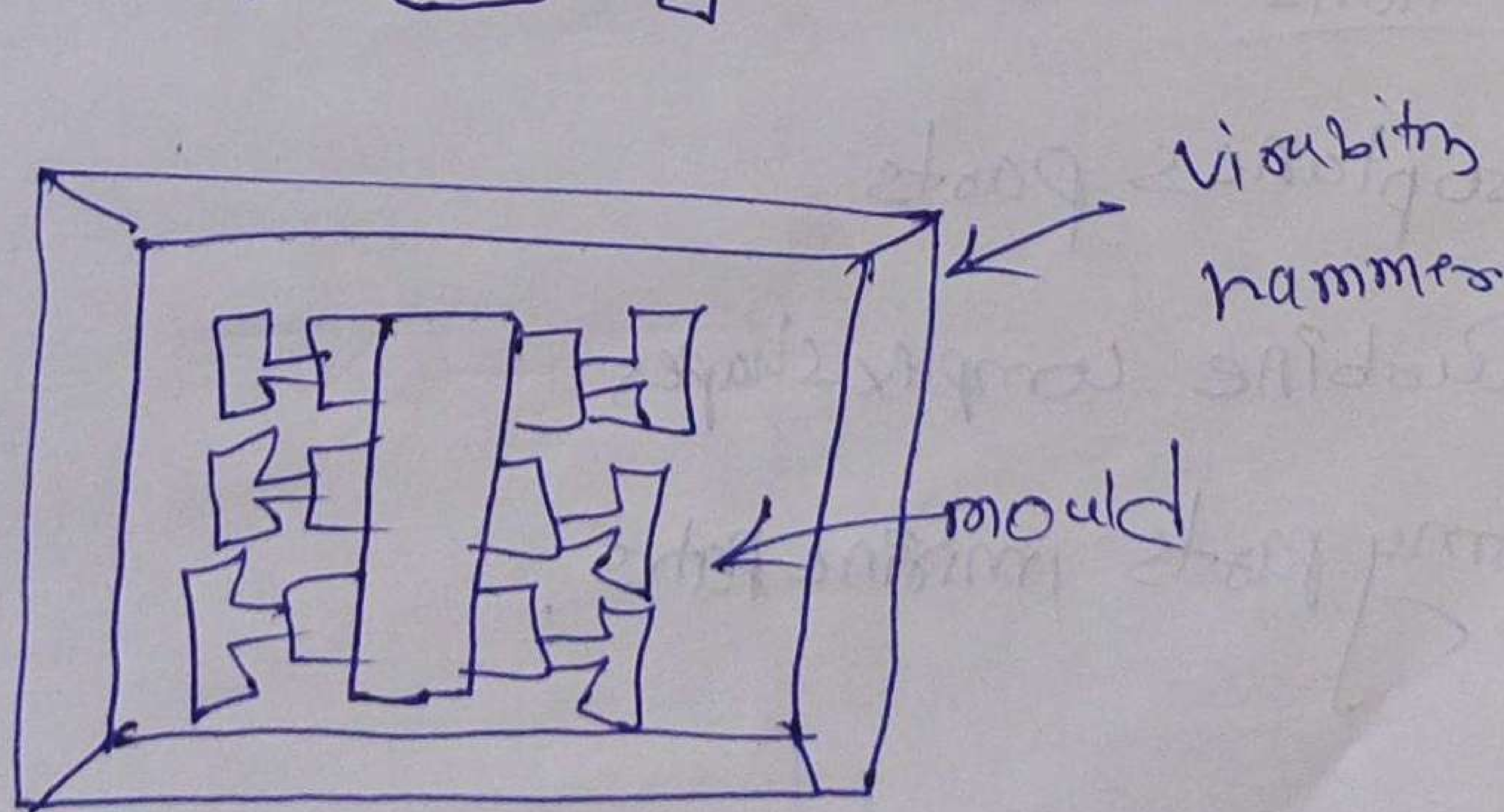
pattern removal

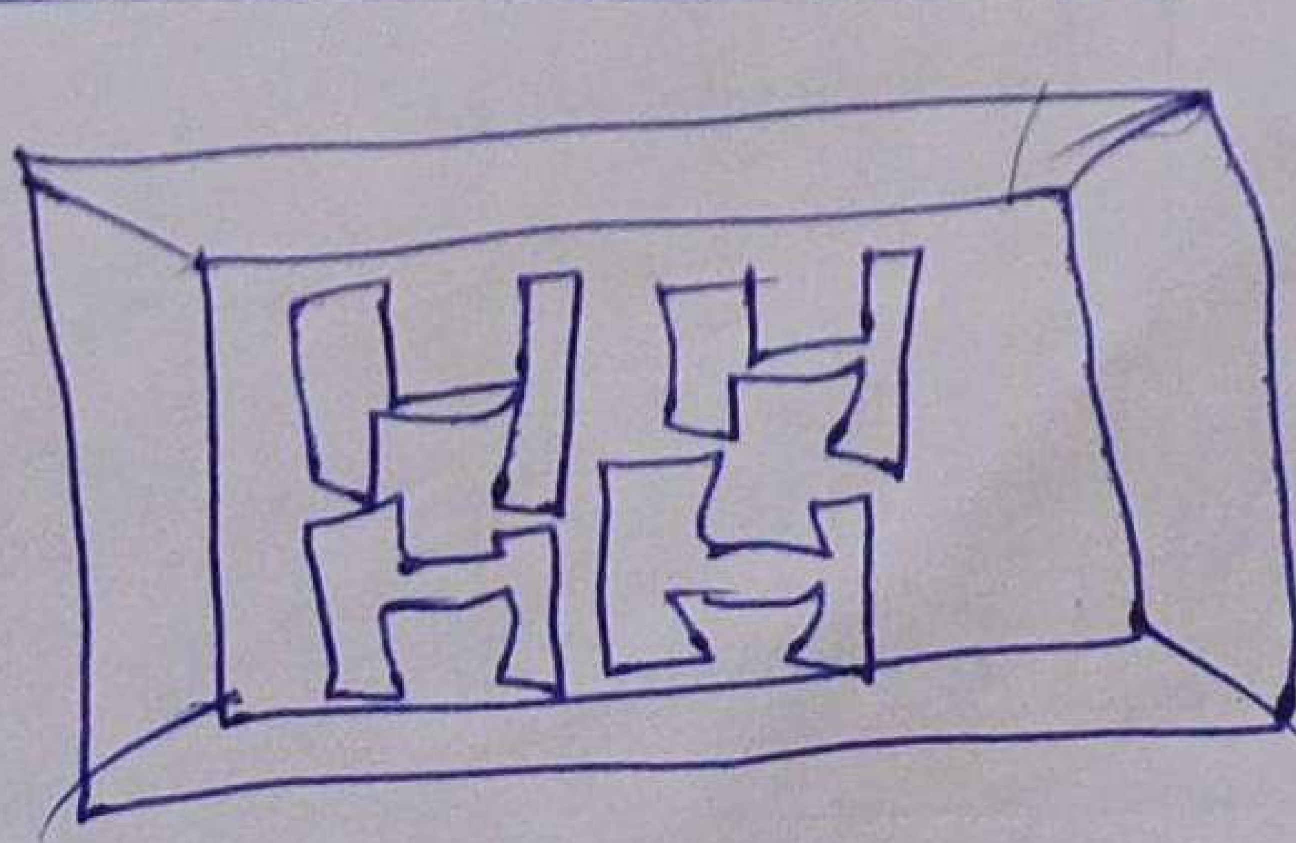


④. casting preparation

1.







→ Advantages

→ Investment casting Need not normal pessoran.

→ Airplane part that have to with stand High Temparature.

→ No melting is required

→ Exllance process.

Disadvantages

1. time consumed process

2. labour cost expensive.

3. limited casting size.

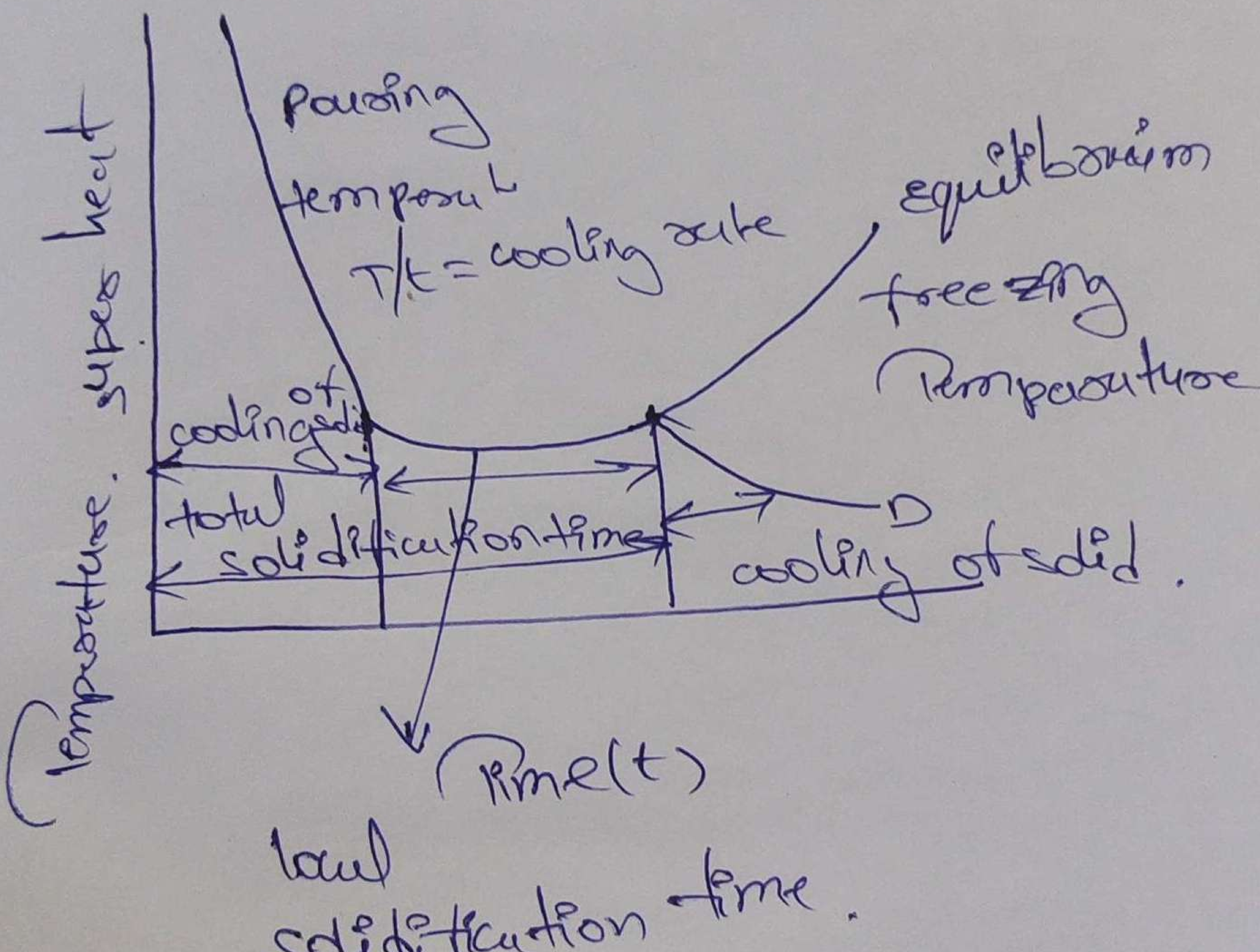
Applications

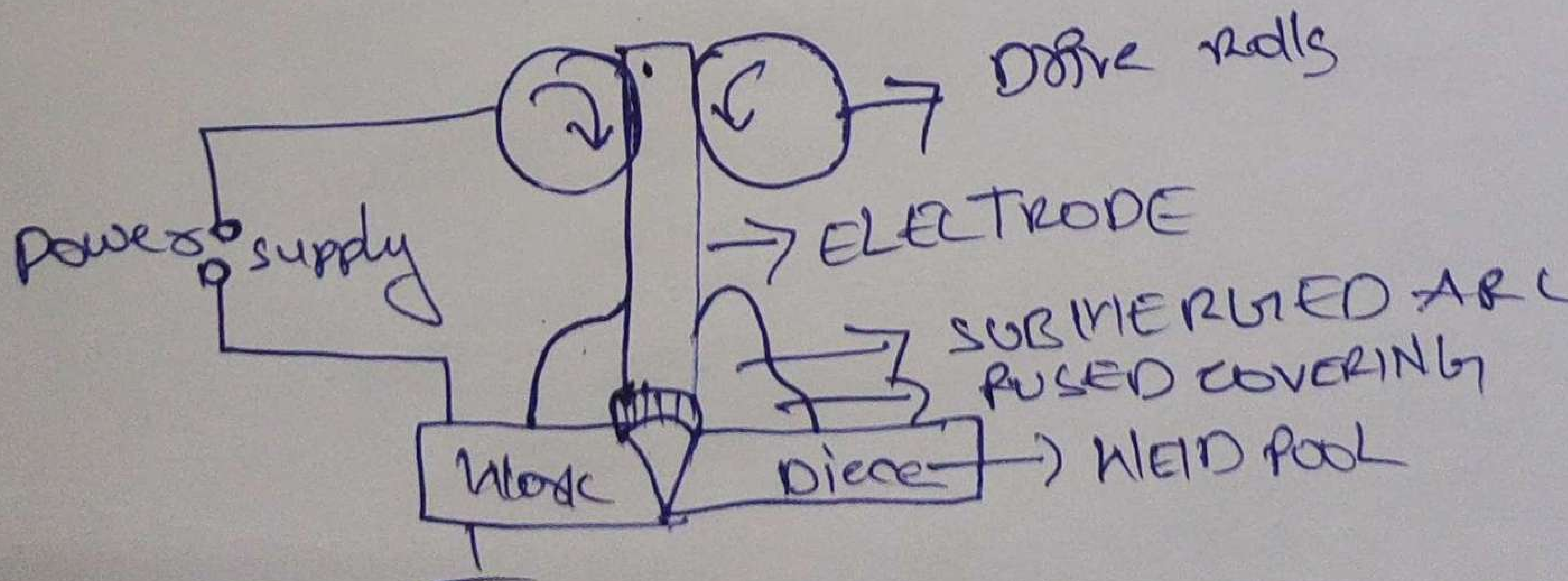
1. Aeroplanes parts

2. Turbine complex shapes

3. army parts imrine patrs.

solidification curve for metals.





Advantages of the gas welding

1. oxyacetelene flame is vesatile.
the.. cutting and heating and weld.

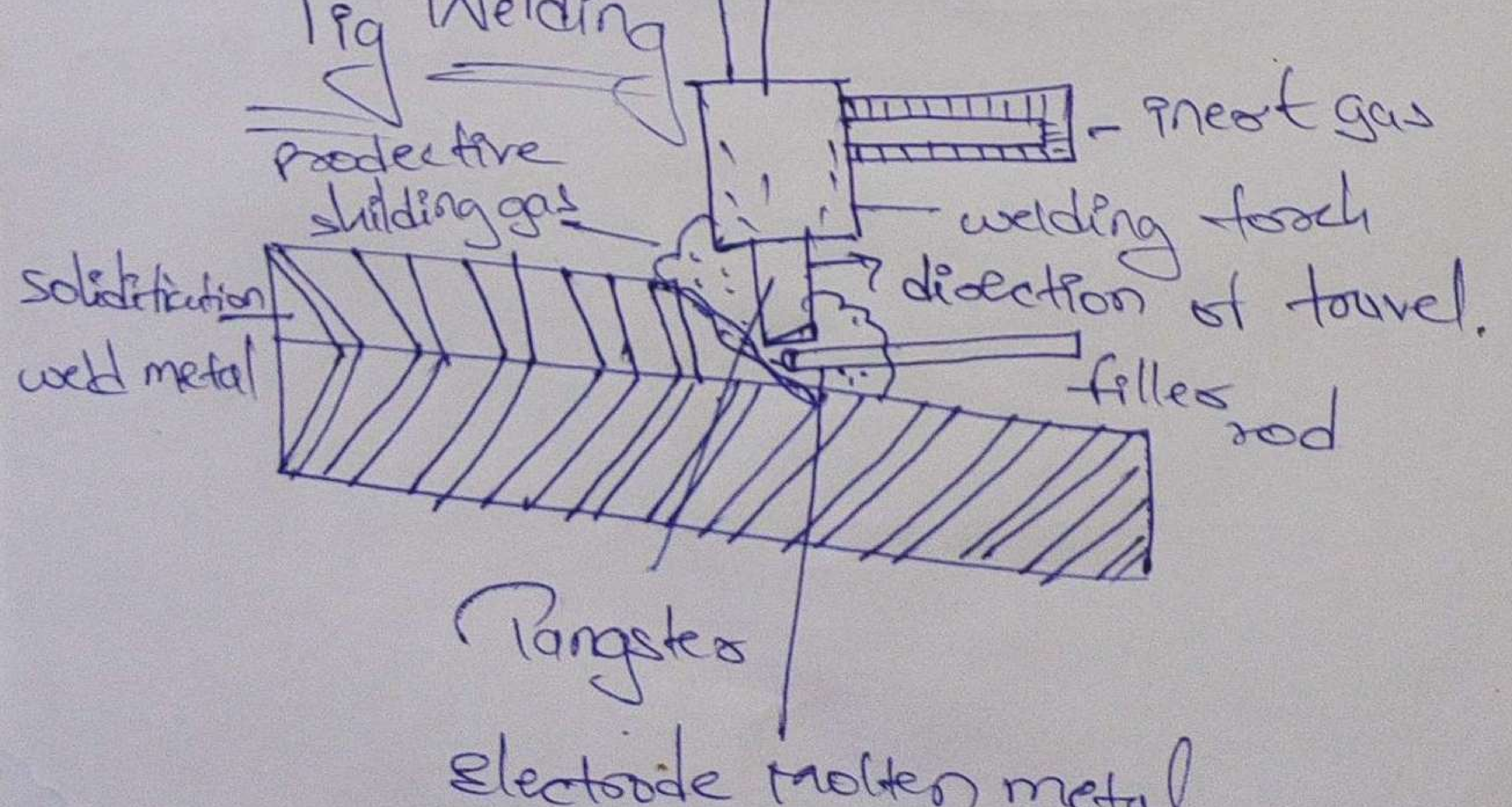
disadvantages

1. It is slower than Arc welding
2. Heat effect zone (HEZ) and distorsion is,
3. gase welding are expensive were compare to arc.
4. se... ... to ... ...

Aplications.

i. mostly used in sheet metal fabrication
ii. Before going to welding we can pre heating the
iii. ... ... 3mm thickness.

Tig Welding

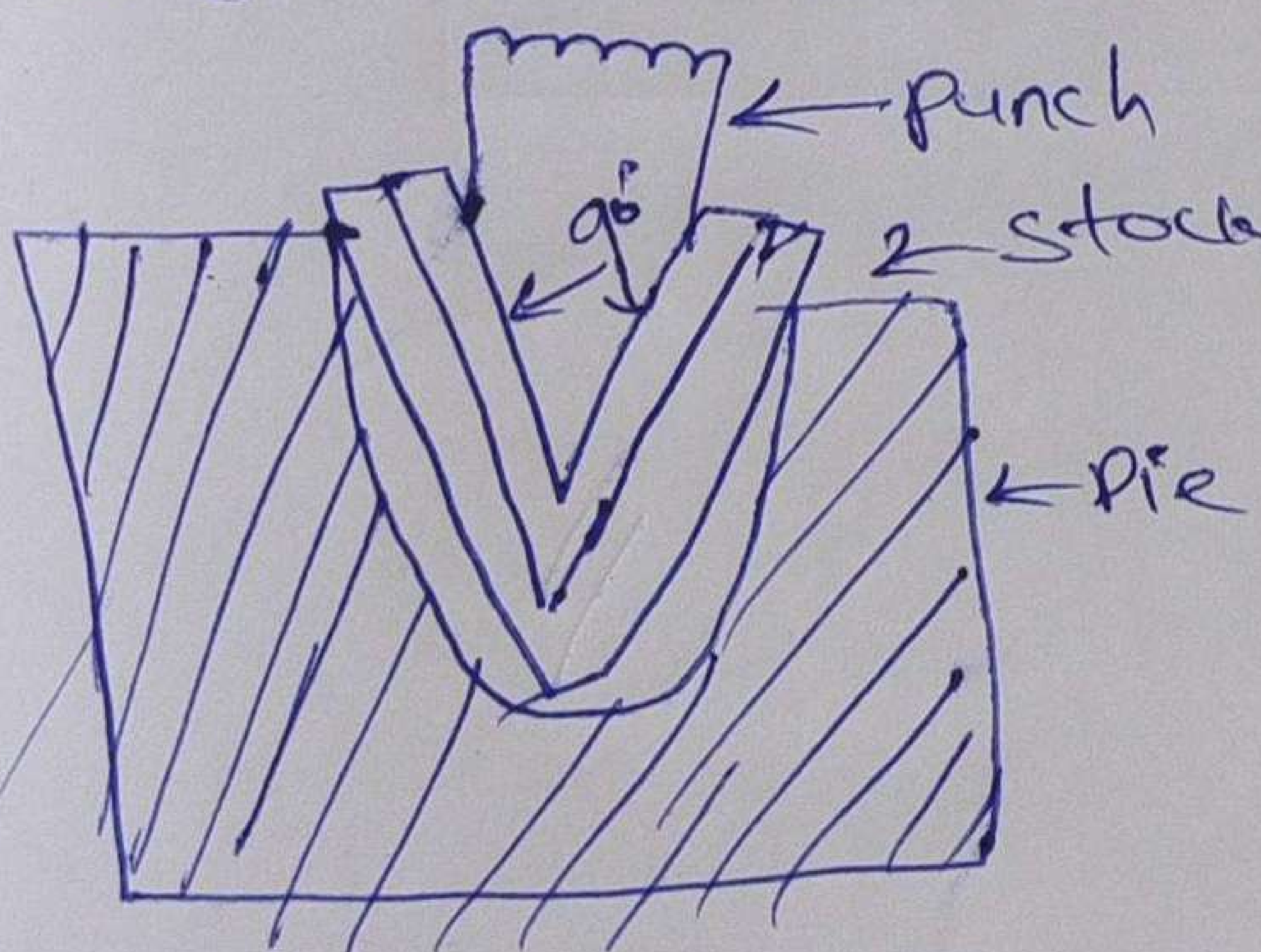


The setup of W.TAW

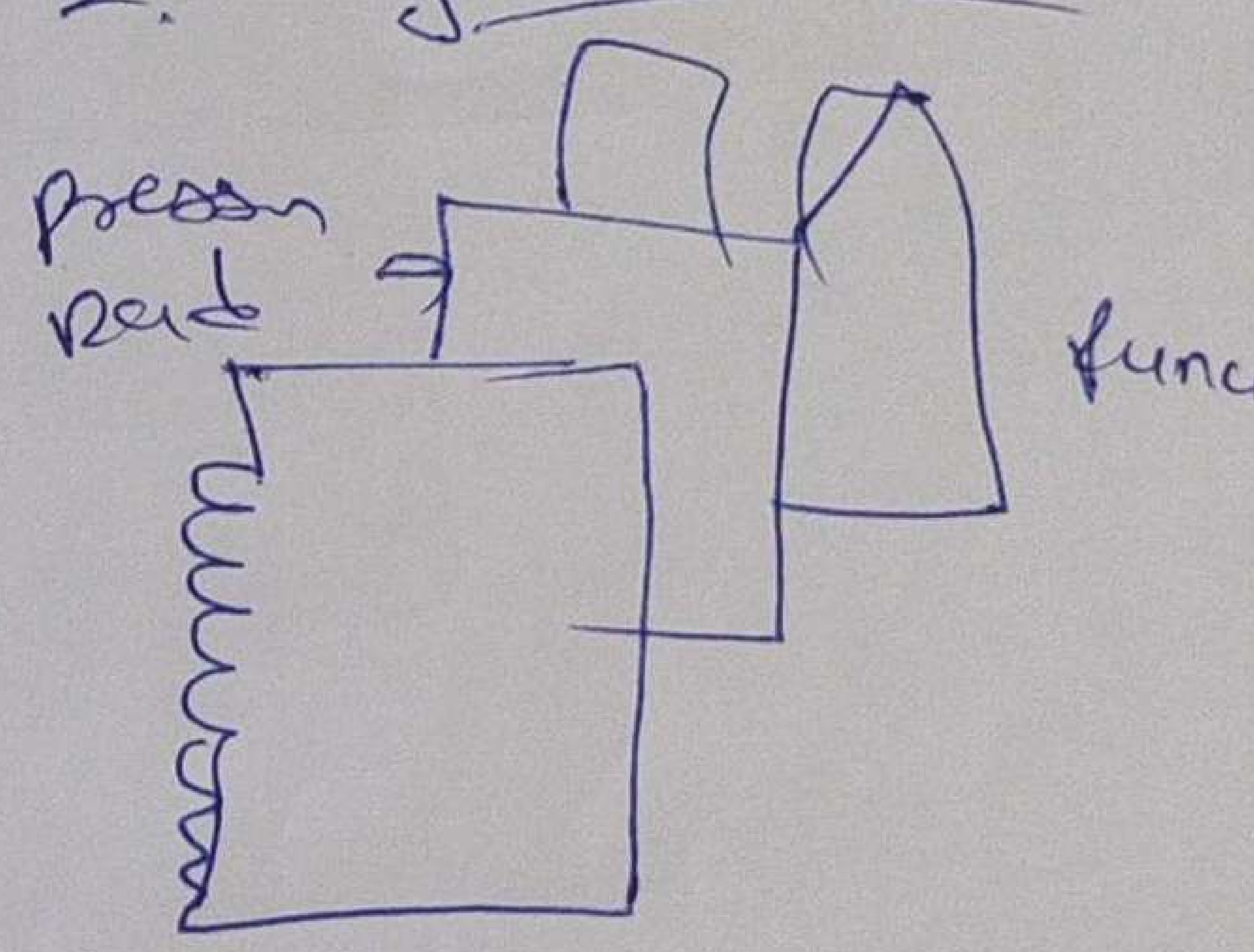
Embossing

It can be defined as the process of imprinting raised figures

Types of Bending



2. Edge Bending



3. U-bending