① TO FORM ALLOYS → CRYSTAL STRUCTURE OF BOTH SHOULD BE SAME.

Hume-Rothary Rule : (i) Atomic size (difference < 15%) (ii) same valency (iii) e^--vety, Affinity (close).

② phase diagram : Temp. - Composition (Tell melt. pt. of alloy at particular composition)

Phase : the homogenous, Phy distinct, mech. separable state of matter.

Type of ϕ diag ① uninary → (E.g. carbon, water) Graphite $\xrightarrow[125\ bar]{3000^\circ C}$ Diamond.
(on no. of components)

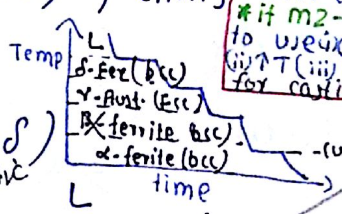
② Binary → I liq. comp. soluble, sol comp. sol : Cu-Ni (Iso morphism ϕ-diag)
→ II " " " " Partia " : Pb-Sn, Fe-C
→ III " " " " Insoluble : Bi

(i) Cu-Ni : Isomorphism (1085, 1452°)

If only 1 melting pt. then in casting cooling & solidification will start from out towards in. Thus all shrinkages will accumulate at centre & solved by Riser at centre. | Riser vs chills

mushy zone : ↓ fluidity (use ↑ Temp. or top gate), Chills
↳ if Tmelt is a range of T then transition zone is called MZ.
* if MZ - Then hv to use chills. (ii) ↑ T (iii) Top gating for casting

(ii) Pb-Sn : (232, 183, 327) within it a homogenous mixture of L & S called dendrites



(iii) Fe-C : Earlier : (768, 910, 1410, 1535°) (α, β, γ, δ)

(no ϕ change. Curie pt. : 767°C only microstructure, mag. prop (number)) 4th, 5th ϕ of Fe = cementite, marten site

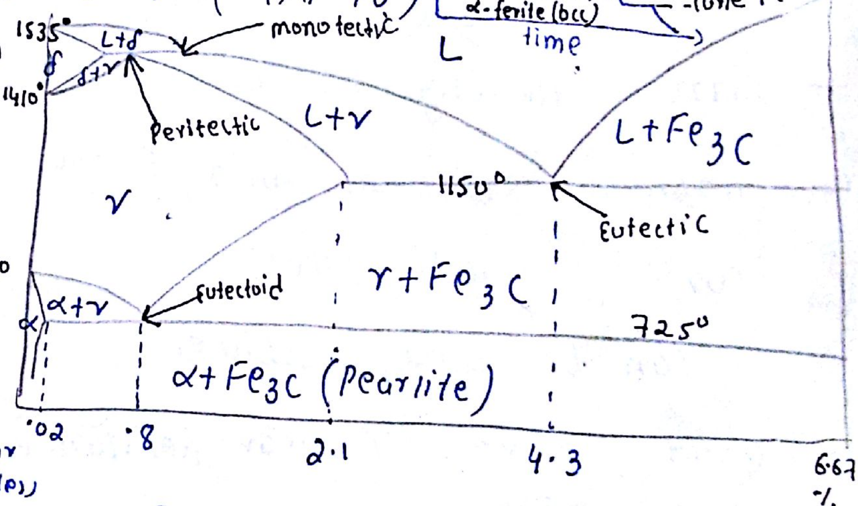
Eutectic L → 2S (1150, 4.3)

Eutectoid S → 2S (725, 0.8)

Peritectic S+L → S (1493, .18)

Peritectoid 2S → S

Monotectic L → S + L



Para mag - unpaired e^-, $\mu_r > 1$, weak attract, colour

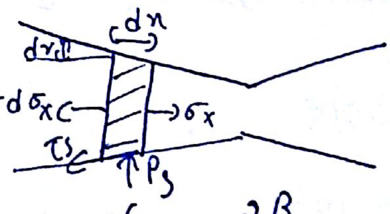
Di mag - Paired e^-, $\mu_r < 1$, " Repel, (colorless)

Ferro mag - depending on T P or D
E.g. Fe. $\mu_r \gg 1$ strong attract

① wire drawing : $\sigma_d = \sigma_0 \left[a + b \ln R\right]$

R = Extrusion Ratio $= \frac{A_i}{A_f}$

$\sigma_d = K_1 \cdot \ln R$



$B = \mu \cdot \cot\alpha$

$\sigma_d = 2K'\left(\frac{1+B}{B}\right)\left[1-\left(\frac{r_f}{r_i}\right)^{2B}\right] + \sigma_b\left(\frac{r_f}{r_i}\right)^{2B}$

$2K' = \sigma_0$

$\sigma_d = \sigma_0 \ln \frac{A_i}{A_f}$ [Frictionless]

Force: $\sigma_d (A_i - A_f)$

Problem with ↑ T : H_2 embrittlement b/c moisture in molten metal breaks & forms H_2.
" " Top gating : will cause sand Erosion & Si Erosion along with it. Si at ↑ T with Fe will form ferrite.

② Tube Drawing use $K' = \sigma_0/\sqrt{3}$.

③ Extrusion $\sigma_d = \sigma_0\left(\frac{1+B}{B}\right)\left[\left(\frac{R_i}{R_f}\right)^{2B} - 1\right] + \sigma_f$ [in forward]

$\sigma_f \cdot \frac{\pi}{4} \cdot D_i^2 = K' \cdot \pi \cdot D_i L_i$ $\left(K' = \frac{\sigma_0}{\sqrt{3}}\right)$ Force = $\sigma_d \times A_i$

① Carbon steel: → FOR ↓ speeds (5-10 m/min) ∵ can't withstand ↑ Temp

→ Used for wood, soft ductile material (Brass, Mg, Ca).

→ Use: hand drills, Tool shanks.

→ made by: Forging

② HSS: → (10-30 m/min), 650°C

→ used for: Interrupted cutting (milling) b/c highest Toughness.

→ made by: Forging

→ Type: T, M

③ Diamond: → Hardest

→ problem: → oxin start at 450°C ; → Allotropic Transformation 720°C

→ soln: Heavily flooded with coolant

→ problem: Reaction with Ferrous materials.

can't be used: steels

can be used: carbides

→ Good: Hard, ↑ wear Resistance, ↑ K, ↓ μ, ↓ α

→ Bad: Brittle, ↓ Toughness

suitable: light cut at ↑ speeds.

④ CBN

→ 2nd hardest

→ For steels

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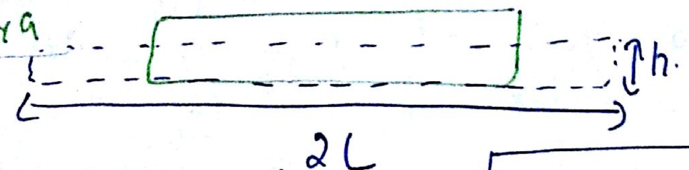
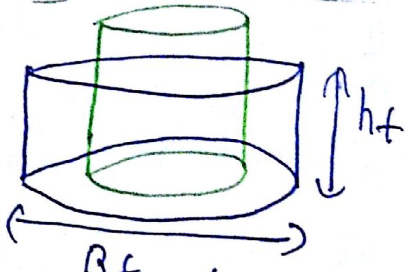
① FORGING





Slab		Cylinder
$P_{x_1} = 2K' \cdot e^{\frac{2\mu}{h}(L-x)}$	All calculations on final dimensions	$P_{r_1} = 2K' \cdot e^{\frac{2\mu}{h}(R-r)}$
$x_s = L - \frac{h}{2\mu} \ln \frac{1}{2\mu}$		$R_s = R - \frac{h}{2\mu} \ln \frac{1}{\sqrt{3}\mu}$
$P_{x_2} = \frac{K'}{\mu} + \frac{2K'}{h}(x_s - x)$		$P_{r_2} = \frac{K'}{\mu} + \frac{2K'}{h}(R_s - r)$
$K' = \frac{\sigma_0}{\sqrt{3}}$ $L = 2\int P \cdot w \cdot dx$		$K' = \frac{\sigma_0}{2}$ $L = \int P \cdot 2\pi r \cdot dr$

(1) POWDER METALLURGY:

To mix materials: which does not form an alloy.

Applications: Nozzles for AJM, Bulb and Tube filament, cutting Tool and grinding wheel, fricn material in ABS, self lubricating bearings

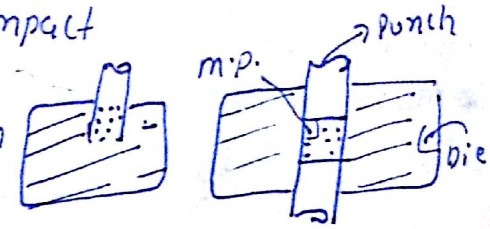
Metal powder → metal crushing, pulverising (Brittle)
→ Atomisation (Ductile, Rot. disc, centrifugal acn)
→ corrosion (steel in H_2SO_4, $CuSO_4$)

↓

Blending → mixing lubricant with powders
→ Now called green compact

↓

Compaction → Iso-static pressing
→ single acn, double acn



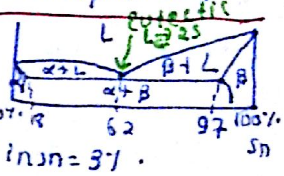
↓

Sintering → pre-sintering: Heating clubbed with compaction
→ sintering:

↓

Sizing

Type II ϕ diag: Sn → ← Pb
max. Sn can be dissolved in Pb = 18%.
max. Pb can be dissolved in Sn = 3%.
* 3 numericals.



MBCSS

- $m_s + m_l = 1$
- $C_s m_s + C_l m_l = C_0$

(1) Lever Rule: C_0% of Ni in (L+S) of Cu+Ni

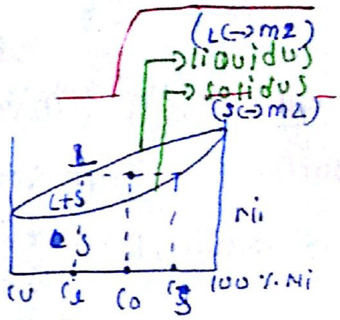
liq. mass fracn = m_l solid mass fracn = m_s

$m_l = \frac{C_s - C_0}{C_s - C_l}$ $m_s = \frac{C_0 - C_l}{C_s - C_l}$

* opposite fuel

Solid part C_s%(Ni) $(100-C_s)$% Cu
liquid " C_l% Ni $100-C_l$% Cu

To find at pt. O
- Draw hori line at pt. O.
- Drop verticals C_s & C_l.



* Hypo, Hyper Eutectoid (.8%) → STEEL - < 2.1%.
(2) Classification of steel * " " Eutectic (4.3%) IRON - 2.1 - 6.67 %.

* (0 - .3%) (.3% - .7%) (>.8%) LCS, MCS, HCS.

* Grey CI - Some C in Fe appears in free or flake form. [> 6.67%. Thus due to insolubility it appears as flakes]
  ↳ application (i) m/c beds (graphite act as vibration damper)
  (ii) self lubricating bearings due to solid lubrication (iii) piston rings.

White CI. (C < 6.67%) Entire C appears in combined form.

Chilled CI Normally its C should freeze as GCI but due to rapid cooling forced to appear as WCI. % of C in CCI > WCI.

* SGCI > NGCI > GCI > WCI > CCI.

→ Solubility more in liq < Cooling - Extra C appears as flake; Rapid " - No time for extra C to come out.
→ Purpose of CCI To make ductile CI.

For making ductile CI, heat CCI little below 1150°C, Then
(i) Slow cooling in furnace - At 1000s of places C diffuses towards centre to form spheroids which have ↑ ductility (C is interstitial impurity having size ↑ than voids thus not stable ∴ does this on ↑ing temp, ↓C in outer). (A combined form of C having ↑ ductility)
(ii) To ↑ cooling Rate add Mg & Ce - This des cost and needle like form will appear in microstructure.

① DIE CASTING

(i) Gravity DC → liquid metal poured under gravity force

Application: CI, sometimes Al small parts.

(ii) Pressure DC → water cooled dies

A- Hot Chamber: Furnace integral part [For ↓ melt pt. Pb, Sn, Zn]

Al X ∵ it may pick some iron oxide

Application → piston Ring, Carburettor, Crank

B- Cold chamber: ↑ melt pt. Fe or Non Fe metals.

Impurities in Fe-C system ① Sulphur: Sulphur Embrittlement or hot shortness. (→ forms FeS at grain boundaries; M.Pt. FeS < Fe)

② Mn: (i) prevents ① by capturing S, MnS (↑ m.pt., ↓ shear strength) ∴ ↑ m/c bility (ii) further Mn ↑es strength Hadfield steel. (12%)

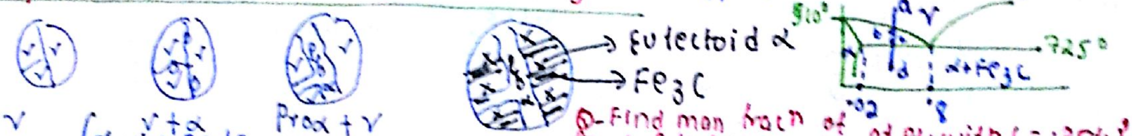
③ Si < → on steel - Removes O_2, SiO_2 settles down as sludge (↳ difficult to cast BLC ∵ it change many times (i.e. tendency to capture O_2)); → on CI - graphitising agent. C-equivalent = %C + $\frac{1}{3}$(%Si + %P)

- shifts Fe-C diagram towards left

- KISH: Si added in liq. Iron. ∵ graphite has ↓ρ compared to Fe, ∴ Jumps over surface liq. (→ will be discharged.)

- Killed & semi killed steel: complete & partial deoxidisation of steel.

Development of microstructure in Fe_3-C: Hypo Eutectoid Cooling γ, α+γ, α+γ, α+Fe_3C.



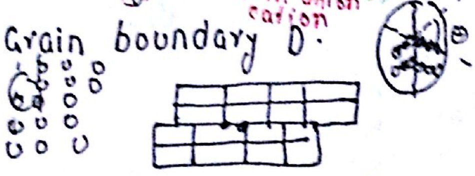
(own occupies Interstice)

Q- Find mass fracn of Pro-α, Eutectoid-α, Total α at Pt. with C = .35%?

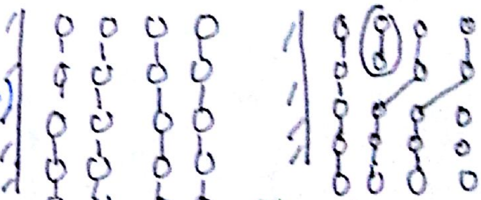
Point Defects: ① Vacancy D. (Schottky) (if in anion cation) ② Substitutional ③ Interstitial ④ Frenkel

Surface " : ① Grain boundary D. → (i) Tilt boundary D. θ = 1/2 - 20; (ii) Twin " " (mirror image)

② Stacking D.



Line " : < Edge dislocation (B.v. is ⊥r to dislocation line); Screw " (∥)



- unit plastic deformation is called slip which is always in direcn of load. Direcn of slip is called Burger vector.

- E.D. is the boundary b/w slipped and unslipped region

- on applying load: Dislocations come out in form of plastic deformation.

Thus to ↑e strength: introduce hindrance in movt. of dislocations

* Dislocations have larger I. void. [Y.P. Phenomena not in M/s or HCP: Here C at all I-sites & not only at dislocation site.]

Yield pt. phenomena in LCS: ↳ * C is I impurity * Cottrel atm * Strain aging → Time period after which Y.P. Phenomena reappear.

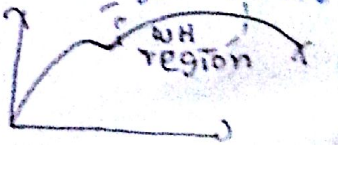
Strengthening: ① Alloying < → Interstitial - compressive strain; → Substitutions < larger incoming Then comp. strain; smaller " Then Ten. strain

② Grain Refinement: < Fine grain (↑ no. of grain boundaries); Coarse " (↓ ")

(G. Boundaries adv - ↑ no. of G.B. ↑es the strength but ∵ bond length ↑ at G.B. Reactivity & corrosion ↑es)

At the grain boundary E.D. has to change orientation

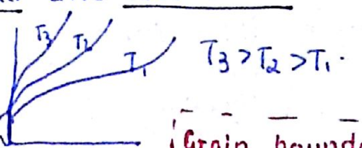
③ Work or Strain hardening: upon cold working, dislocation multiplication takes place. These pile up at grain boundaries and create Dislocation forest. Repulsive acn creates back stress.

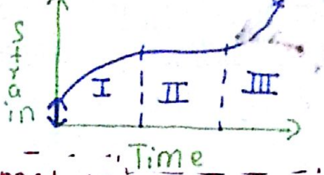


* Bauschinger effect - In this case when reloaded in opp direcn then E.D. supports. Yield pt. appears premature.

Creep curve: slow deformation under load and above T_R.

I primary region (work hard > Recrys)
II secondary " =
III Tertiary "





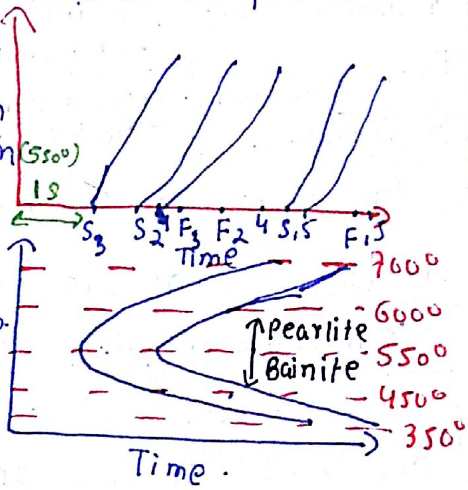
Grain boundary material has tendency to flow at ↑T ∴ finer GB structure has ↑ creep.
Super alloys - No GB. Ni based allows casted in protective env. → space craft, missiles, rockets.

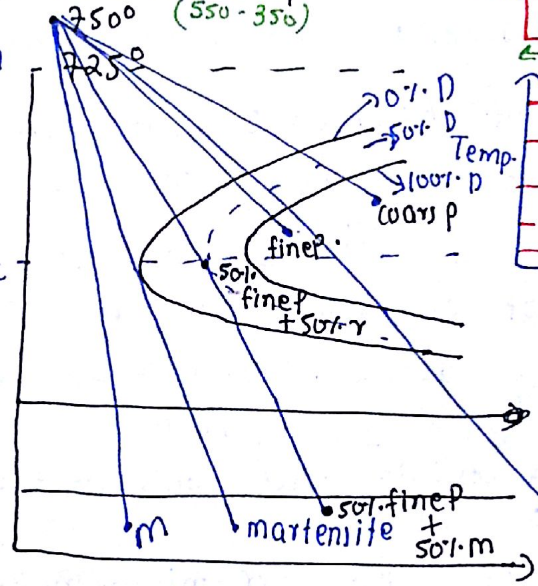
TTT Diagram: Austenite γ(FCC) eutectoid (725°) heated +50°C then quenched

- Decomposition did not start instantaneously (incubation time) - Took time to complete
* projected start & finish pts. of % decompo - Time on Temp. - Time
* Driving force $\Delta G \propto \frac{1}{Temp.}$ (700-550) * Diffusion ∝ Temp. (550-350)
* pearlite purely by diffusion
Bainite By D + shear

Martensite (BCT) (hardest)

*All lines on TTT diagram are that of decomposition of Austenite to some other micro structure.
* Never reconverts

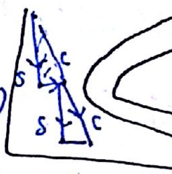




Austempering: To form Bainite. not by continuous cooling.

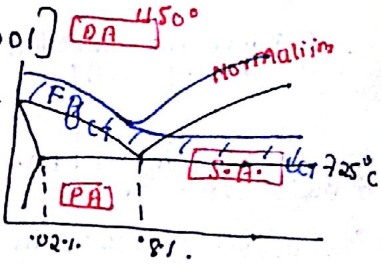
Austenite ⟶ Martensite: why cracks appear: (i) surface Ms, core γ (ii) when core Ms (iii) Expands ∴ Ms (BCT) has less ρ than γ.

To avoid cracks: ① Austempering (but produce Bainite) ② martempering (does not totally eliminate) (less T. gradient & hence ρ gradient)
③ Alloying: Shifts TTT curve to Right. Atomic strains due to Alloying makes diffusion of C atoms difficult. ∴ Can produce Ms even at less cooling rates. (Thus ↑es incubation time)



Heat Treatment: H, N, A T [fast Quench, Air quench, furnace cool]

① Annealing: (i) Full A - Hyper eutectoid (50° above LCT) / Hypo " (" " UCT)
* ↑ Duc., ↑ Tou., ↓ hard., ↓ brittle - Cooling in furnace - Resultant coarse pearlite



(ii) process A - To Remove after effects of Cold working
→ only for LCS ∴ Cold working on MCS, HCS will produce fracture.
→ Heat - Till Recryst. Temp. = ·5 Tm = ·5(1535+273)-273 = 630°C · furnace cool.
→ Resultant structure - No change

(iii) spheroidise A - only for MCS, HCS - To ↑se mlcability of MCS, HCS
- Heat little above or below LCT - formation of spheroids ↑se mlc ability.

(iv) Diffusion A - use for structures having many welds. - Homogenise by diffusion.

② Normalising: - used for wide variety of materials. Heating - T where Austenite stable. Cooling - Air quenching.
* surface cooling > core cooling ∴
(Fine grain hard) (coarse grain Tough) * considered as Final HT Process.

③ Hardening: → Heat where Aus stable > 725°C / → cool ↑ with > CCR. } Purpose: To produce Ms
(i) cooling medium - water, Brine, oil bath.
(ii) For which Material - close to eutectoid composition only produce Ms. Thus only MCS. Use case hardenings for MCS.

CASE hardening: outer surface hardened, core remains same.

(i) carburising: Diffusion of C into surface of MCS speciment. 950°C T.
Pack, liquid, gas — Cheap, Easy, manual, Time ↑, qty. ↓ — 20% -costly, NaCN - Poisonous, use diluted NaCN ↑ CH_4 — Thickness, automatic control
50% charcoal + $BaCO_3$ + $CaCO_3$

(ii) Nitriding: 650°C = gas carburising, circulating NH_3. more strength than carburising. (∵ Te-very ∴ ↑ Strain field)

(iii) cyaniding: 850°C 30% NaCN + NaCl + H_2SO_4 liq. carburising. Strength N > C > C.

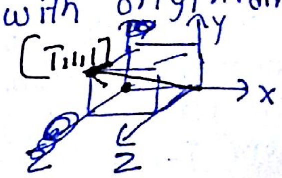
* These 3 only for mild steel.

Flame hardening - cam shafts, Then water quench | Induction hardening: -cranks, conn. Rods (Specimen, induction coil, oil bath)
inner core, Acetylene feather, outer envelope;

(4) TEMPERING: - Earlier produced Ms is brittle - To introduce Toughness in it
High Temp. (550°-600°, SORBITE) medium temp. (350-500°, Troosite) ↓ Temp. 250° (- no change in structure, - only Thermal σ Removed)

Hexagonal: 6 at edge pt. $\frac{1}{6}\times 12 = 2$ 1 at centre of face $\frac{1}{2}\times 2 = 1$
3 in centre of prism = 3 PF = .74 C.N. = 12.

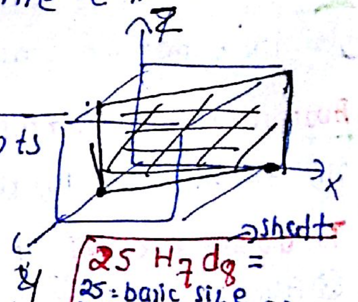
Crystal direction: [x y z] 3-D coordinate of pt., Join this pt. with origin to get crystal direcn.
max [x,y,z] as size of unit cell. ‾ Indicates -ve. T11



linear density: $\frac{\text{no. of atoms in a direcn}}{\text{length of that direcn}}$. 2r = 1 atom.

Family of directions: All possible direcn within unit cell with same C.D.
<100> (6) <110> (12) <111> (8).

Crystal planes: (h k l) h k l are miller Indices = $\frac{1}{\text{Intercepts}}$
Take cell size 1 (1,2,0)



Planar density: $\frac{\text{no. of atoms by area } (\pi R^2)}{\text{area of that plane}}$

Family of planes:

25 $H_7 d_8$ = 25: basic size, Hole: H7, shaft alpha: FD, num: FT

Interplanar distances: $\frac{a}{\sqrt{h^2+k^2+l^2}}$ = min. distance b/w planes drawn with (hkl) in adjacent unit cells. → Parallel.

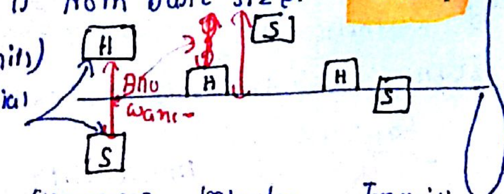
→ Then No inspection needed → Adv: (H.s at diff. places) (Stdarisation) (Cheap, Easy maintn) Desired
Interchangability - Process capabilities of m/c producing holes, shafts same = Tolerance.
$(6\sigma)_H = (6\sigma)_S$ = D.T.
S.P. - Achieve 5 even when m/c not ↑ P.C. = 4 (desired Tolerance) fail
-Divide N-d's into 4 Equal Parts - variation in Each Part = D.T. - Choose H.s from corresponding parts - inspecn

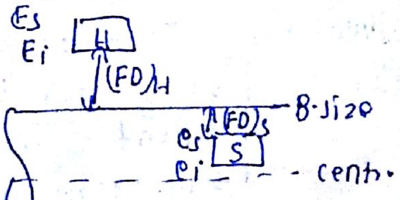
* Basic size - Targeted value Nominal size - Nearest Round no. as per std. size

Tolerance - variation in Required Tolerance zone.
F.D. - How far this T. zone is from basic size.

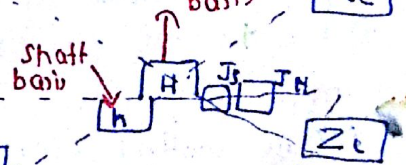
CIT

Allowance - diff. (b/w max. m. limits) b/w UL of (S) and LL of (H) max. material limit
→ min. clearance or max. interfer..





* Bilateral, unilateral Tolerances. (wrt 0 line)
Unilateral ✓ [allows T. change while Retain same (All, Type of fit)] (Js, JH are bilateral)

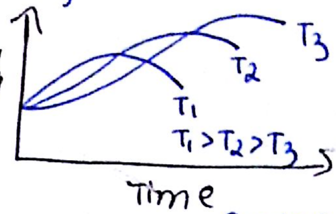


* FD 25 std. size (H) (h) are on zero line.

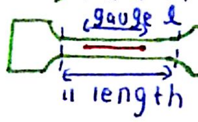
* width of Tol zone $i = .45D^{1/3} + .001D$ $D = \sqrt{D_1 \cdot D_2}$ 0-3, 3-6, 6-10, 10-18, 18-30, 30-50, 50-80, 80-120.
Fun. Tol = i D(mm) i(μm)
(18) - IT 01, IT0, IT1 --- IT 16
(i) - multiply every 5th by 10 (01, 0, 1) - Emp. formula (1-5): G.m. (5-16): series
- In b/w g.m.
6 = 10i 11 = 100i 16 = 1000i

Analysis of work hardening Region: $\sigma_T = K \cdot \varepsilon^n$ [True σ, strength coefficient, True ε, work hardening Exponent]
n decides level of dislocation multiplication ($\uparrow n \rightarrow \downarrow WH$)
if e = Engg. strain $\sigma_T = \sigma_0 (1+e)$ $\varepsilon = \ln(1+e)$ Q- UTS = 400 MPa elongation till max. load = 35%. find Rel^n. Ans $\sigma_T = 774.92E^{3}$
n = True strain at UTS which is also max. -

Age hardening or precipitation hardening and over aging: occurs in: Alloys of Al with ϕ diagram similar to Al-Cu
Cond^n - Heat sample → quench → so that Cu locked in Al structure
Process - Cu starts coming out & forms ppt. of Al_2Cu → These create obstacle in dislocation motion → ↑es strength → Peak strength (limited Cu)
overaging - smaller ppt. combine form larger ppts. → interdistance ↓es → strength ↓es.
Effect of T↑ < ↑Rate of Nucleation : Peak strength earlier; Rate of small → large also ↑ : ↓ P.S.



Tensile Test: - on UTM



- 1 neck appears at UTS - cup & cone fracture (under microscope → dimples)
- This neck can occur anywhere

Strength with Temp: Generally with T, ductility ↑es & strength ↓es.
But with Cr impurity: 1st strength ↑es then ↓es (E.g. stainless steel) → 550°
| As T↑, diffusion ↑es. but mobility of Cr ↑er than that of edge dislocation. - beyond 550°: Recrystallisation dominant

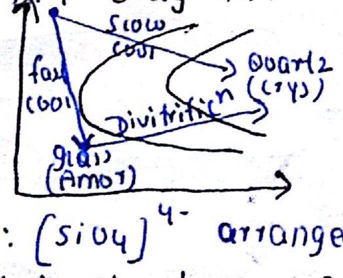
Grain boundary: At meeting pts. of solidification fronts there is orientation mismatch. These regions of O mismatch are called G.B.
Corrosion, Reactivity ↑er at G.B. b/c here bond length is ↑er ∴ O_2 1st attacks at G.B.
Use of Cr in steels: $Cr + O_2 \rightarrow Cr_2O_3$ settles at G.B. and prevents attack from O_2.

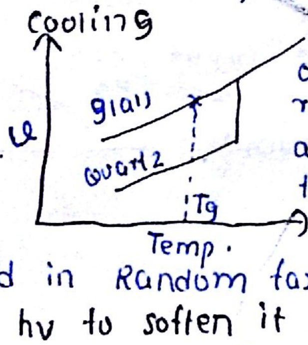
UNIT CELL: - building block of crystal system - 7 types of unit cells
Cubic ($a=b=c$ $\alpha=\beta=\gamma=90°$) Tetragonal ($a=b\neq c$ $\alpha=\beta=\gamma=90°$) Hexagonal ($a=b\neq c$ $\alpha=\beta=90°$ $\gamma=120°$)
Orthorombic ($a\neq b\neq c$ $\alpha=\beta=\gamma=90°$) Rhombohedral ($a=b=c$ $\alpha=\beta=\gamma\neq 90°$)
monoclinic ($a\neq b\neq c$ $\alpha=\beta=90°$ $\gamma\neq 90°$) Triclinic ($a\neq b\neq c$ $\alpha\neq\beta\neq\gamma\neq 90°$)

3 Types of CUBIC:	No. of atoms	a, r	Atomic PF	C.N.	Edge atoms
(i) SIMPLE	1	$a^2 = 4r^2$	.52	6	contact with each other
(ii) BCC	2	$3a^2 = 16r^2$	.68	10	not in " " (with body atom)
(iii) FCC	4	$a^2 = 8r^2$	.74	12	(with face atom) "

CERAMICS: DEF: (-ve) (not metal, non metal & organic polymer) E.g. < Silica SiO_2, Alumina Al_2O_3
Properties: hard, Brittle, bad conductor, comp.↑, Ten.↓, ↑ Tmelt, ↑corrosion Res.

SILICA: TTT diagram

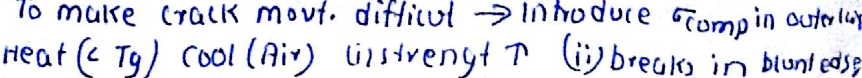




Tg = glass Transition Temp. on ↓ing T. of liq. silica rapidly, viscosity ↑es & at a Temp. Tg it is difficult to decide whether it is solid or liquid.

Tensile strength $\propto \frac{1}{size}$ as it depends on crack propogation

GLASS: $[SiO_4]^{4-}$ arranged in Random fashion. To process the glass, as it has long chain structure we hv to soften it by breaking long chain structure.
(i) ↑ Temp. (costly) (ii) Soda lime glass:



Strength of glass: ∵ fails by fracture ∴ To make crack movt. difficult → introduce σ_{comp} in outer layer
(i) Thermal Tempering or Air quenching: Heat (< Tg) Cool (Air) (i) strength ↑ (ii) breaks in blunt edge
(ii) Ion Exchange: - hot bath of KNO_3 - K^+ Replace Na^+ - size $K^+ > Na^+$

CRYSTAL STRUCTURE OF CERAMICS: 1- AX (NaCl, 6) 2- Cesium-chloride (8) 3- Zinc blende (4)
4- A_mX_p (CaF_2) 5- $A_mB_nX_p$ ($BaTiO_3$)

METROLOGY OR INDUSTRIAL INSPECTION

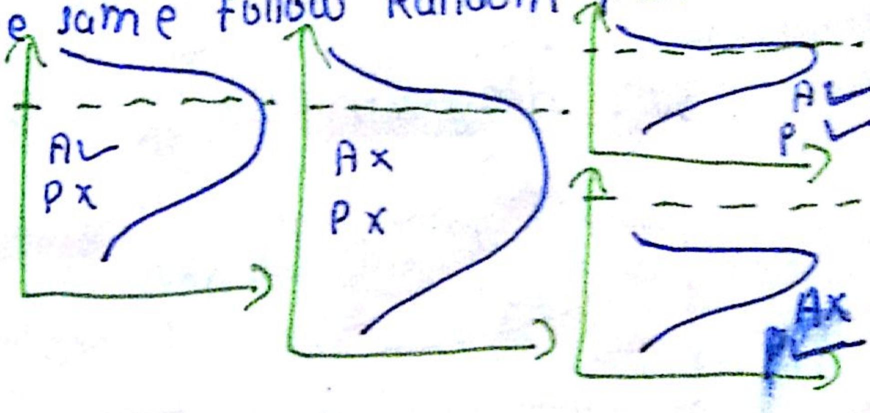
All m/c Env. follows N-distribution ∴ product coming out follow Random pattern.

6σ process Capability: Though no 2 product would be same but in 6σ 100% products within 6σ Range.

Accuracy → close to Target, single product, mode

Precision → Repeatability, group, σ

Desired Tolerance: Acceptable variations in dimn as specified by consumer.



LIMIT GAUGES: < Plug for holes / Ring for shafts

* Emphasis on comparison in metrology.
* GO, NO GO gauges to check whether specimen is in limits.

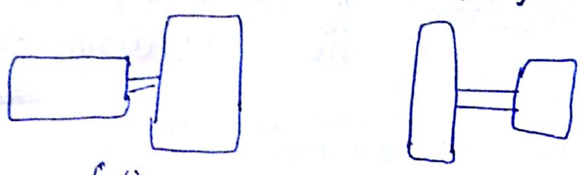
Taylor's Principle:

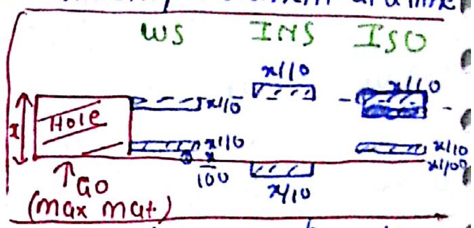
(1) GO → max. material limit condn — if GO < inside hole - fine / don't go - undersize hole

NO GO → min. " " — if NO GO < don't go - fine / goes - oversize hole

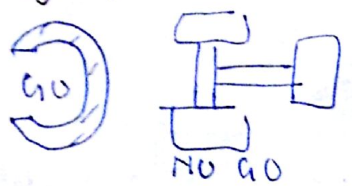
(2) GO gauges to check both shape & size and should be in full form. NO GO gauges check only 1 element at a time

PLUG GAUGE -

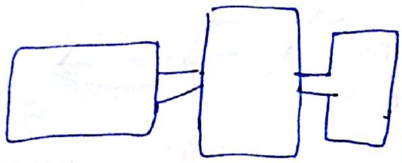


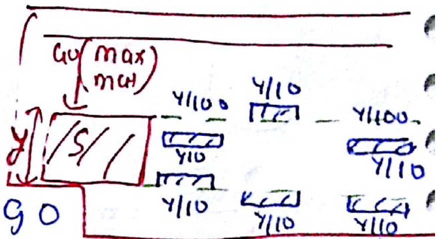


Ring gauge -



* Snap gauge - when both on common handle





+ ↑ hardness, ↑ wear Res., ↓ α, ↓ C, machinability, ↑ corrosion Res.

Invar, glass gauges, En-24

Gauge Tolerance - 1/10th of work tolerance. (hole for plug & shaft for Ring)

wear allowance - 1/10th " gauge " . [only for GO] ∵ only GO gauges move in & out, suffer wear

(if WT < .1mm then no W.A.)

Workshop gauge - Towards work Tolerance (No defective produced - some good Rejected)

Inspection gauge - away from " " (" good Rejected - " defective produced) (No W.A.)

ISO gauge < GO use workshop (with allowance towards WT) / NO GO use Ins. gauge. (w/o " away from ")

Straightness: St. edge, spirit level, Auto collimator.

→ In 3 direcn for flatness

Surface finish: < long λ fluctuation WAVINESS / short " " ROUGHNESS

→ To Est. datum M-system, E-system (25 mm dia)

Tolerance sink: Design Engg. → producn Engg. (1 secn of part w/o Tolerance). This secn becomes T. sink & all T. can be dumped on it. It becomes most inaccurate part. * only link minded T can be added. (Equally Bilateral or Equally unilateral)

E.g. $P = Q + R + W$ $P = 35.0 \pm .08$ $Q = 12 \pm .02$ $R = 13^{+.04}_{-.02} = 13.01 \pm .03$ $W = P - (R+Q) = 9.99 \pm .13$

Slip gauges: - To Est. datum for length in industries

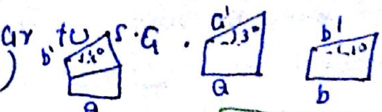
- Available in 2 sets: (i) Normal M-45 (ii) Special M-87 ∴ better → needs less no. of gauges

* use min. no. of gauges (b/c of Tolerance) - Top & bottom surface highly polished

- put 1 over another - Temporary welding by broken bond

Angle blocks: - Build up ∠s. - hardened steel blocks similar to S.G.

- 13 blocks (deg: 1, 3, 9, 27, 41) (min 1, 3, 9, 27) (sec .05, .1, .3, .5)



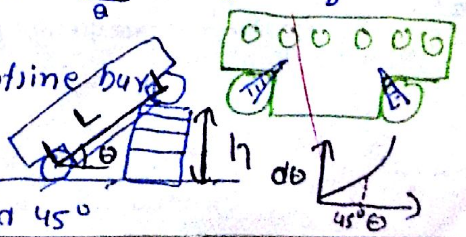
SINE BAR: - Indirect measure ∠ of a m/ced surface

- 2 Rollers of exact size are attached to body of sine bar (by Allen screws)

Initially dimn is being build by S. gauges

$\sin\theta = \frac{h}{l}$ $\cos\theta \cdot d\theta = \frac{l \cdot dh - h \cdot dl}{l^2}$ ∵ dh b/c of S.G. ∴ dh → 0

$\cos\theta\, d\theta = -\sin\theta \cdot \frac{dl}{l}$ $d\theta \propto \tan\theta$ ∵ don't use beyond 45°

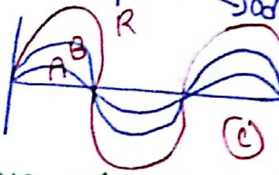


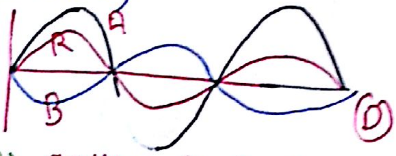
Precision ball measurement SCHEMES ② along with vernier tapen of any
- std. size balls & Rollers - with these ^ component can be measured.

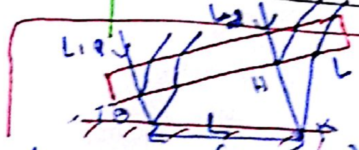
Vernier callipers & micrometer: - VC less accurate ∵ Area contact b/w V. & main scale ∵ Ref. plane keeps on changing.

ERRORS: ① In measuring instruments:
(i) System or systematic E - Follows a certain pattern - eliminate by calibrating.
(ii) Short period E - Due to change in Env. - neglect the irrelevant data
(iii) Erratic E - Due to incompleteness of any link - Inspect instrument before experiment.
② Mathematical Errors during measurements: (i) Sine Error: = d·δθ (considerable)
(ii) Cosine Error: = m·cos δθ - m ≅ 0

Interferometry in measurement: A = monochromatic light source
~~Bo=Eo: BB~~ B/c = openings
Diff. in paths → Even × λ/2 (Construc) ; Odd × λ/2 (Destruc)



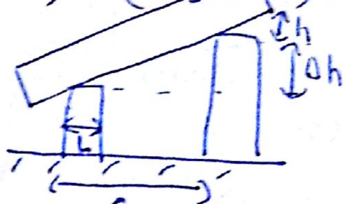




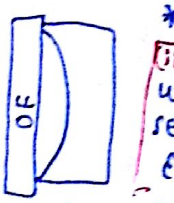
if n = no. of white fringes
$n\lambda = HK + KL$
$HK = \frac{n\lambda}{2}$ ∵ HK ≅ KL

Use of this principle: Optical flat: A disk of quartz (8-10 mm) & (25-300 mm) dia
- || Top & bottom surfaces.
- $\tan\theta = \frac{HK}{L} \cong \theta$ find surface inclination

Of as comparator: Difference in slip gauge from a master
Reference = Δh. $\frac{\Delta h}{a} = \frac{h}{l}$ $\Delta h = \frac{a}{l}\cdot h$ $h = \frac{n\cdot\lambda}{2}$

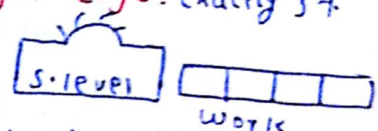


Of over convex & concave surface: Principle: on ↑ing ∠ b/w OF & surface → no. of fringes over surface will ↑se & their thickness will ↓se.
Convex surface - ∠ ↑ing outwards
- fringe thickness ↓in

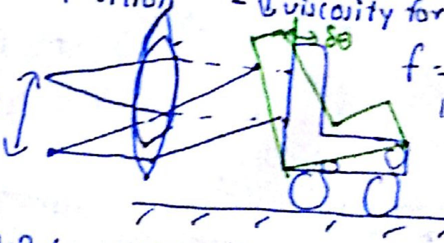


*opposite

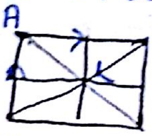
(i) Straight Edge: - surface exactly st.
(ii) Spirit level: - Divide work into no. of segments - Each width equal to that of s.level - Keep s.L on each segment & note bubble position - Note deviation of bubble from centre position - ↓ viscosity for spirit



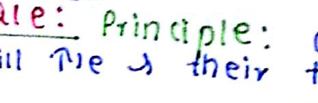
STRAIGHTNESS: Defined as deviation of surface from a ideal st. line - 3 methods to quantify:
(iii) Auto collimator: - Reflector moved on surface
- Note deviation δθ noted in terms of $\Delta S = 2\cdot f\cdot\delta\theta$



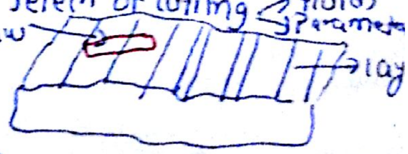
Flatness: - Departure of any surface from a Ref. plane.
- Initially move Autocollimator in 3 diff. direcn AB, BC & AC - will identify 3 Ref pts. A, B, C. - plane can be defined by 3 these pts. - Now move A.C. in all direcn to check flatness.



Surface finish: A mlced surface will have 2 Irregularities.

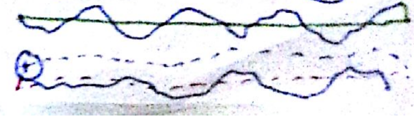


(i) Waviness: ↑λ (secondary Texture) b/c of m/c vib., chatter, Error in guide ways
(ii) Roughness: ↓λ (primary Texture) b/c of improper selecn of cutting fluids / parameters
LAY → Predominant surface pattern produced by feed marks
Flaw → Random surface irregularities



Parallel: = shaping, planing   Crossed: X
⊥r: ⊥ shaping planing   Knurling
Multi direcnal: M Grinding   Circular: C   Facing   Radial: R

Methods to est. datum: (i) M (mean line) system: - plot surface characteristics
- Draw mean line so that Areas ↑ or ↓ it are same
(ii) E (Envelope) system: - 25 mm sphere Rolled over - Centre locus
- This envelope shifted down till areas ↑ & ↓ line are same



Numerical values for surface finish: 1- Peak to valley height: 

- Distance b/w best peak, best valley - R_t, R_{max}, H_{max} - Limitation (sudden Jerk)

2- centre line avg. value: 

(i) Indi hts: $R_a = \frac{\Sigma y}{n}$ (ii) Area) $R_a = \frac{\Sigma a + \Sigma b}{L}$

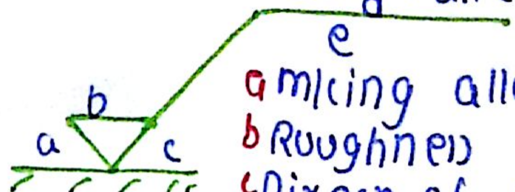
(iii) Ht. at func^n of x $R_a = \frac{1}{L}\int_0^L y \cdot dx$ * Approx $R_a = \frac{H_{max}}{4}$ $H_{max} = \frac{f^2}{8r}$ L = cut off length

$H_{max} = \frac{f}{\cot c_e + \tan c_s}$

3- Rms: $R_q = \sqrt{\frac{\Sigma Y^2}{n}}$ 4- 10 pt. value R_z = Avg. of 5 best peaks & 5 best valleys.

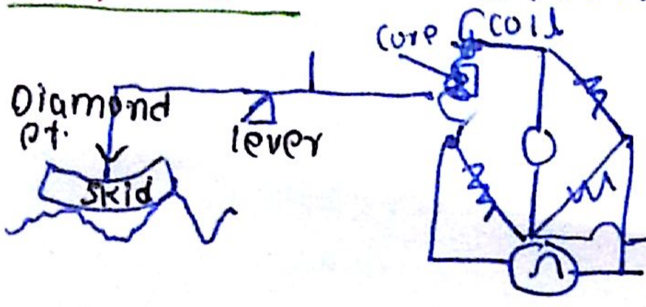
Representation of surface finish:

1- ▽ (8.25 µm) (1.6-8) (.025-1.6) (< .025) CLA

2- 

a machining allowance
b Roughness value
c Direc^n of lay
d Sampling/cut off L
e Produc^n method

TALY SURF: - measures surface irregularities



- Diamond pt. at end of lever
- Skid to protect D. pt.
- As D. pt. moves in valley position of core in coil changes,
- Resistance changes - use wheatstone bridge.