MANUFACTURING PROCESS

Date

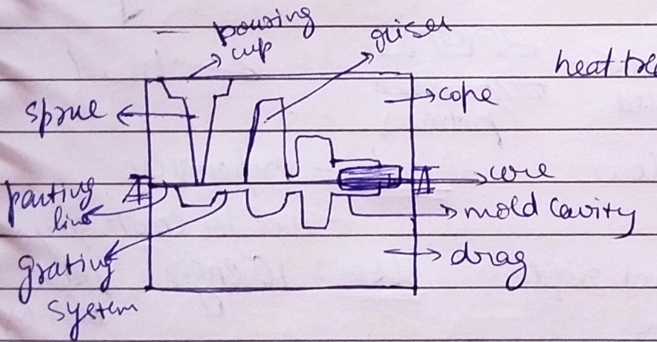
→ sizing, shaping, imparting properties to material so that it can be produced to perform certain function for design life.

Types: Casting (zero process) } involve shifting of metal
Forming (") } in controlled way
Machining (negative) → unwanted material removed
Joining (positive process)

Welding : joining 2 similar/dissimilar comps with/without heat energy
Mechanism (motion can be transmitted) mechine (~~mechanism~~ & motion)

Casting: object formed by solidificatn of a fluid poured in a mould.
Metal casting → expendable mould processes (mould is sacrificed)
→ complex shapes
→ permanent mould (mould is reused)
→ higher productn rate, limited geometry

Sand Casting → all alloys, all sizes, multiple qty
L steps → prepare mould → pour molten metal → let solidify → break mould → clean casting → heat treatment

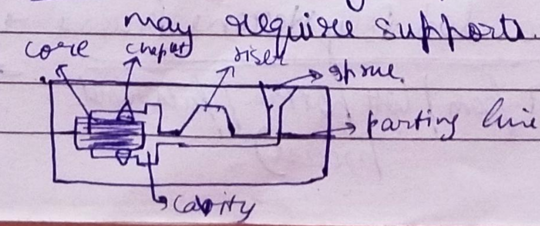


Riser: feed casting
runner: channel for metal
cores: create openings
gate: channel for molten metal
Sand: binds strongly

parting line – joint for both halves
binders: hold mold together

pattern: full size model of part (wood, metal, plastic)
→ solid
→ split
→ match plate
→ cope and drag

core inserted before pouring, may require supports.



Spiral

mold properties → strength, thermal stability, collapsibility, reusability

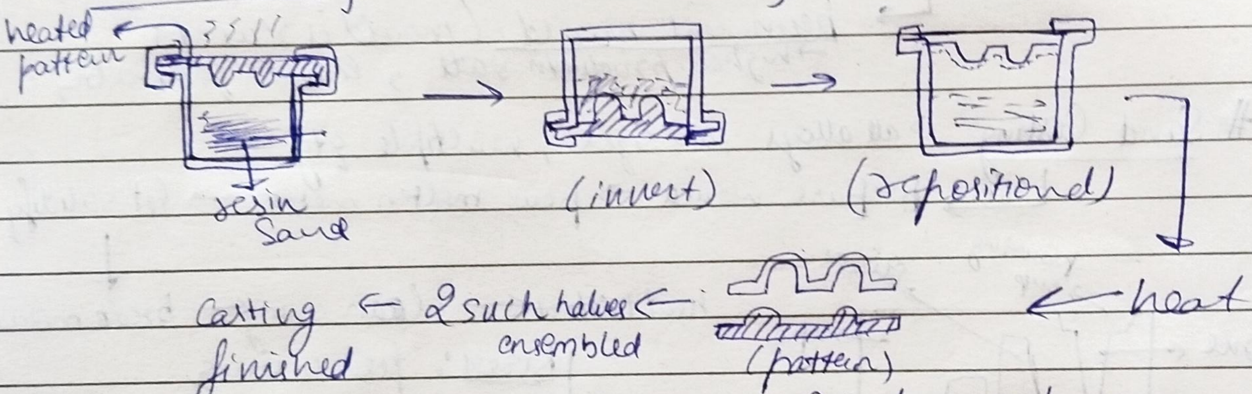
foundry sands → Silica (endure high T, small grain size for better finish, large grain size for permeability)
↳ binders → sand by mixture of water and clay
↳ organic resins, inorganic binders

Sand molds → green (sand + clay + water)
→ dry sand mold (baked)
→ skin dried (skin is heated)

bouyancy → can cause defective casting

$$F_B = W_m - W_c$$

shell molding → thin shell held by thermosetting resin binder



Advantages → easy metal flow
→ accuracy
→ machining not reqd.
→ mass production

Disadv. – expensive
– not for small qtys

Use : IC engine, Gear blanks

Vaccum molding

adv : easy sand recovery
: no mechanical recondit^n
: no moisture defects

disadv : slow
: not adaptable

Expanded Polysterene Process (lost foam / lost pattern / full mold process)
→ mold packed around polystrene
→ mold need not opened.

Date ______

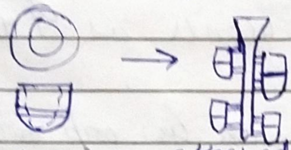
Steps: → polystyrene pattern coated with refractory compound → foam pattern placed in box, sand compacted → molten metal poured

adv: pattern not removed
→ 2 molds not reqd.

disadv: new pattern for every casting
: expensive

applications: engines

Investment Casting (Lost Wax process) : wax coated with material, then melted
→ accuracy, detail.



pattern → attached to sprue → coated with layer of material → coated tree covered with rigid material → heat, wax melted → molten metal → mold is broken

adv: complex products
→ surface finish
→ wax recovered

disadv: many steps
→ expensive.

Uses → compressor

Plaster mold casting → similar to sand, plaster made (Gypsum)
adv: accuracy
disadv: not for high T

* Permanent Mold Casting → mold reused, ~~[illegible]~~
→ basic, die casting, centrifugal casting.

Basic Permanent mold casting → metal have lower melting pt alloys

Steps ① mold is preheated (hydraulically move one side) → cores inserted mold closed → molten metal poured

adv: surface finish
rapid solidification

disadv: simple geometry
high cost

applicatn: automotive parts, air craft missiles

Date ________

Die Casting → molten metal injected to cavity
→ pressure maintained (molds called dies)

machines → **hot chamber** metal melted, high pressure, high production
zinc, tin lead.

→ **cold chamber** molten metal in unheated chamber →
faster Al, Brass, Mg

Hot chamber → molten metal flows into chamber (heated) → plunger forces metal chamber in die, maintaining pressure

Cold chamber → molten metal poured, ram forces it in cavity

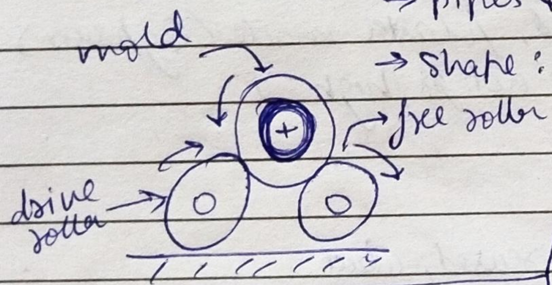
Tungsten and Molybdenum used, lubricants used to prevent sticking

adv → economical
→ accuracy
→ cooling fast

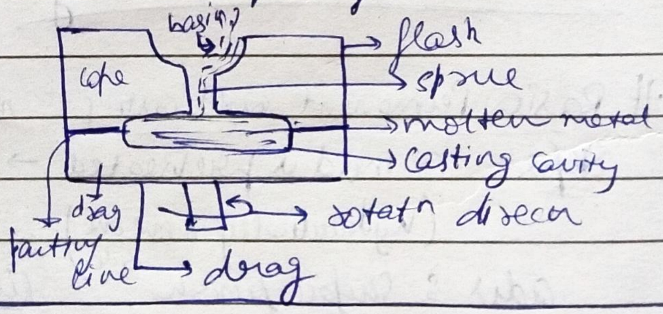
disadv → metal with low mp only

Centrifugal Casting → mold rotated to distribute metal in outer regions

① True centrifugal → metal poured and then rotatn starts
→ pipes tubes, rings
→ Shape: outside (round, hexagonal) inside (round)



② Semicentrifugal Casting
→ molds with risers at centre
→ eg: wheels and pulleys



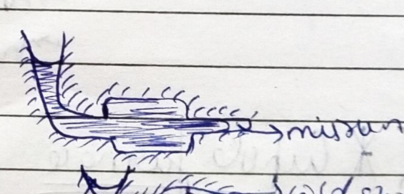
③ Centrifuge Casting
→ cavity away from axis of rotatn
→ Small parts, non symmetric

Furnaces ① Cupola → for cast iron, largest tonnage of cast iron melted
② Direct fueled ⇒ hearth is heated
→ roof has reflectⁿ flame, bottom has hole to release metal
③ Crucible furnace → container, used for non-ferrous metals.
(types) ↳ lift out crucible, stationary pot, tilting pot.
④ Electric Arc furnace → heat by electricity, for melting steel.
⑤ Inductⁿ furnace → use AC passing thro' coil, EMF causing mixing actn in metals

⑥ Ladles : moving metal from furnace to mold

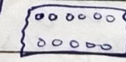
* Steps after solidificatⁿ → Trimming : remove sprue, runner, risers, excess metals
appendages broken, else hammering.
→ remove core → usually fall out, removed by shaking
→ rarely by chemicals
→ Surface Cleaning → removal of sand (tumbling, air blasting)
→ imp. for sand casting
→ Heat Treatment → Giving desired property

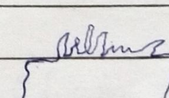
* Casting Defects



① Misrun - casting solidify before filling
② Cold Shut - premature freezing
③ Cold Shot → solid globules become trapped.
④ Shrinkage Cavity → depression in surface by solidificatⁿ shrinkage

⑤ Sand blow → balloon shaped gas cavity
⑥ pin holes → small gas cavity





⑦ penetration → high fluidity, metal penetrates in mold
⑧ Mold shift → step in cast caused by displacement of mold and drag

Causes → distortion, roughness, porosity, missing detail.

Spiral

* Foundary Inspection Methods → inspectn to detect defects
→ dimensional measurement

Metals for Casting → alloys (ferrous/non ferrous)

Ferrous ① cast iron → most imp.
→ 1400°C pouring temp
② Steel → mechanical properties
→ complex geometrics
difficulty: poor fluidity, oxidising
③ Aluminium → castable
→ low casting temp.
→ light weight
→ easy machining

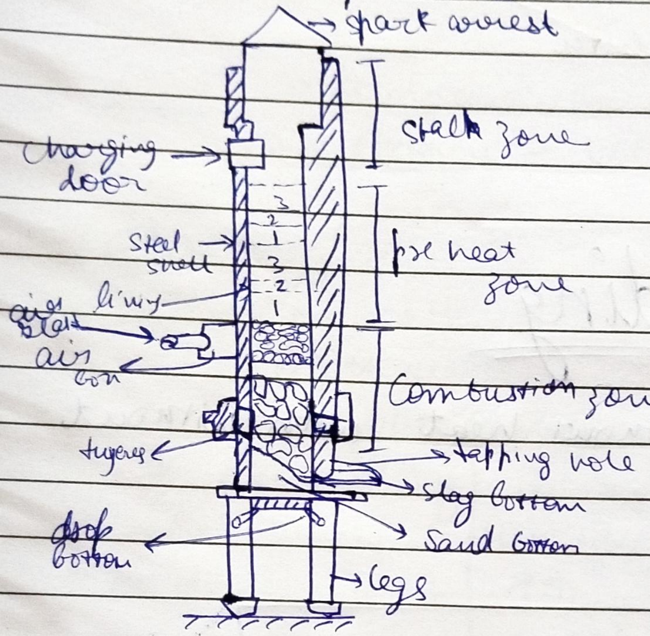
Non Ferrous ① Cu alloys → bronze, brass
→ corrosion resistance, good appearance
lim:- high cost
② Zinc alloys → for die casting.
→ good fluidity

Production Design Considerations → geometric simplicities
(reduces need for core, ↑↑ strength)
→ corners (sharp corners avoided, blended corners)
→ draft guidelines (simpler taper allowed)
→ dimensional tolerance
→ machining allowance (extra margin)

** Cupola furnace → melting device for forging, old equipment
→ melt cast iron, bronze and alloys.

Descriptn → vertical cylindrical steel sheet, ~~clay~~
→ charging door
→ tuyeres
→ hot gases' bottom drop
→ slag hole
→ top conical cap, spark arrest.

Operatⁿ → charged with wood, layers of metals
→ flux to eliminate impurities
→ air blast opened
→ slag hole opened to remove slag
→ tap hole to collect metal.



1. coke
2. flux
3. metal

→ diameter 1.5-13 ft
→ furnace supported on cast iron legs
→ cast doors
→ sand bed above
→ slag hole for impurities
→ spark arrest cap
→ charging door to feed into furnace

Working principle → wood ignited → burned → coke is thrown → when properly burnt → alternating layers of limestone charged → airblast

$C + O_2 \rightarrow CO_2 + heat$ (exothermic)

$CO_2 + C \rightarrow 2CO$

$3Fe + 2CO \rightarrow Fe_3C + CO_2$

→ flux removes impurities ∴ first molten iron after 5-10 mins
→ rate of charging = rate of melting
→ not used for more than 4 hours
→ CO_2 produced from C.
→ iron melts and flows downwards

adv → simple construction
→ less floor space
→ not skilled operators
→ low operatⁿ cost
→ low main repair cost
→ low constructⁿ cost

disadv → used to convert pig iron to metal
→ in base allow also manufactured

* Pattern → made larger than final part
  - → allows shrinkage
  - → draft allowance
  - → core print
  - → distortion allowance
  - materials → wood / metal / plastic / plaster
    - ↳ durable is mahogany

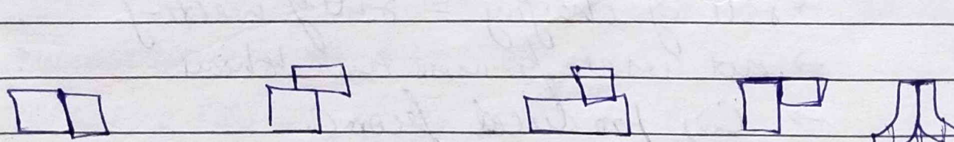
Welding

→ joining metals with / without heat with / without application of filler

Welding

- Solid state Welding
  - → explosive
  - → ultrasonic
  - → friction
  - → forge
  - → diffusion
- Solid / Liquid
  - brazing
  - soldering
- Liquid state welding
  - arc
    - flux
    - shielded gas → TIG, MIG, PAW
    - submerged
  - resistance
  - chemical
    - gas
    - thermit

Joints



Butt Lap Tee Corner edge

commonly weldable metals → mild steel
→ stainless steel
→ aluminium

Date ________

arc welding → used to join 2 metal pieces
→ electric arc created and let fuse

STEPS

base material chosen → right welding process → right filler material → safe Equipments → proper techniques → inspect the weld

Circuit → power source, arc, base

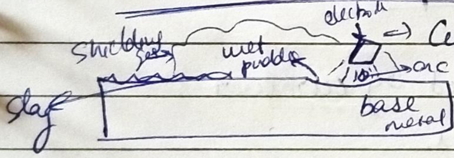
base electricity → voltage, current, polarity (DC+, DC-, AC)

adv → efficient
low cost
light weigh
design flexibility

disadv → manually, labour cost
→ high energy
→ defects hard to detect.

AC arc welding	DC welding
→ more efficiency	→ less efficiency
→ cost of Equipment ↓↓	↑↑
→ not safe	safe
→ not for thin section	for thin section.

SMAW (STICK welding) → manual



→ Current flow from electrode cable
- electrode: consumed, gets melted.
- arc: electrode in contact with workpiece
- wet puddle: melted flux
- shielding gas: flux melts, gas forms

- Slag. - weld metal

work angle, travel angle, arc length, travel speed

Striking arc to start → scratch start
→ tap start

maintain 1/8th distance b/w electrode and workpiece.

Restart → strike → move back → start ahead

adv → low cost
→ portable

dis → difficult with thin materials
→ frequent restarts

Types → SMAW, plasma arc welding, submerged, flux cored

Spiral

fusion welding → joining 2 or more similar/dissimilar materials
→ no melting takes place
→ solid state welding.
→ faying surface of filler and parent material melt

adv → filler easily applied, large lamina covered
→ no extra pressure
→ more than 2 comp easily welded.

disadv → distortion
→ mechanical properties affect.

Submerged arc welding

→ bare consumable metallic electrode
→ arc heats and melts work piece and electrode wire
→ electrode submerged into flux, arc is invisible
→ flux melts and forms slag.

adv
high quality
suitable for automation

disadv
contain slag
for welding horizontally

use: ship building, beam production

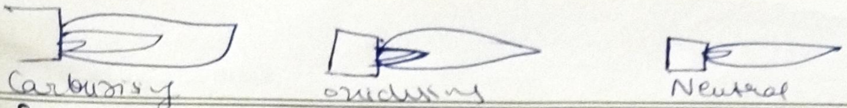
Electroslag welding heat generated by current
use: ship hulls, frames.

gas welding → melts & joins metals by heating with flame caused by fuel gas
↳ oxy acetylene / oxy hydrogen / oxy gasoline.

→ commonly used, high flam T.
→ O_2 and C_2H_2 from cylinders, mixture passed thru nozzle
→ and burning gives flame

$C_2H_2 + O_2 \rightarrow CO + H_2 + heat$
$CO + O_2 \rightarrow CO_2$

Spiral



Date ____________

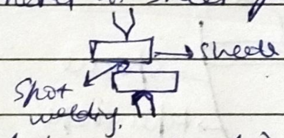
flames → Neutral → white cone by blue envelop (3200°C)
(more O_2 added)
→ oxidising → more O_2, darker cone (3400°C)
→ Carburizing → white inner area surrounded by blue envelope (3000°C)

SMAW	GMAW
→ short diameter rod used up till 60 cm length	→ small diameter but long length
→ flux coated electrode	→ bare electrode
→ coating disintegrates and provides shielding gas	→ gas delivered additionally
→ flux produces slag layer	→ no slag layer
→ not continuous	→ continuous

resistance welding → fusion welding
→ force applied before during after application of current.

Heat produced → $H = I^2RT$

Spot welding : clamping pieces of metal in sheet form placed b/w electrodes



butt welding, seam welding (overlapping sheets)

* Soldering → joining of metals using filler material of low mp.

process → (1) heat both items → apply mm of solder → remove iron allow solder to cool

good solder joint → smooth, shiny, clean, concave fillet.

adv → low power
→ low T
→ easily automated
→ dissimilar metals joined

disadv → toxic comp. in flux
→ low joint strength

Date

* Brazing → alloy heated >450°C, no workpiece metals
→ directly heated.

adv → any metals
→ quick
→ less heat & power

disadv → less strength
→ heavy T
→ colour may not match

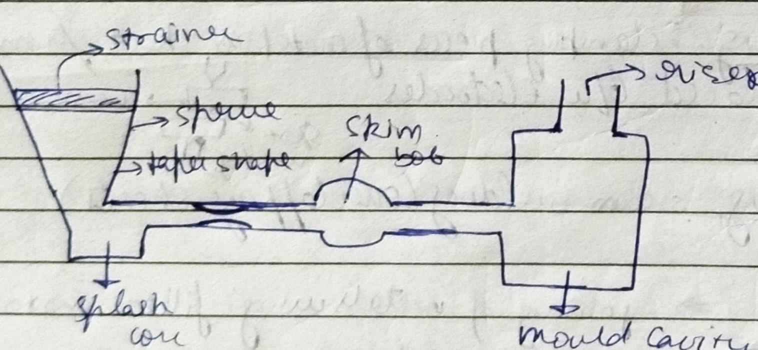
Stress-Strain

$$\text{Stress} = \frac{\text{External deforming force } (F)}{\text{area } (A)}$$

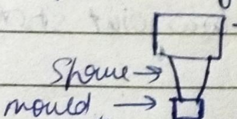
$$\text{Strain} = \frac{\text{Change in dimension}}{\text{original dimension}}$$

Gating system → ~~xx~~ metal pouring system that conducts molten metal in mold cavity
→ shortest time, no heat reqd

Cupola ⇒ pig iron → cast iron

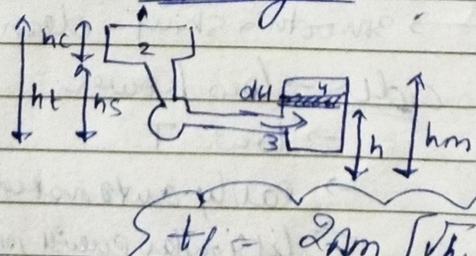


Top Gate
molten metal fed from top of cavity



$$T_f = \frac{A_m \times H_m}{A_g \times v_g}$$ (time)

Bottom Gate



$$t_f = \frac{2A_m}{A_g\sqrt{2g}}\left[\sqrt{h_t} - \sqrt{h_t - h_m}\right]$$

Spiral

FORMULAE

① Gating System

Ⓐ Top Gate

$$t_f = \frac{A_m \cdot H_m}{A_g \cdot V_g} \Rightarrow \frac{A_m \cdot H_m}{A_g \sqrt{2g H_g}}$$

t_f = time of filling
A_m = area of top of given casting
H_m = Casting height
A_g = gate area
H_t = manometric height

Ⓑ Bottom gate

$$t_f = \frac{2A}{A_g \sqrt{2g}} \left[\sqrt{H_t} - \sqrt{H_t - H_m}\right]$$

H_t = manometric height (g = 981)
H_m = Casting height

Under limits =>

$$t_f = \int_a^b \frac{A \, dh}{A_g \sqrt{2g(h_t - h_m)}}$$

(a and b are height levels)

$$= \boxed{\frac{A}{A_g \sqrt{2g}} \int_a^b \frac{dh}{\sqrt{h_t - h_m}}}$$

② Green Sand → permeability number

$$PN = \frac{VH}{PAT} \xrightarrow[\text{std values}]{\text{on solving with}} \boxed{PN = \frac{3007.2}{T}}$$

V = volume, H = height,
P = pressure, A = area,
PN = permeability number

↳ T is time in sec. for 2000 cc of air to pass thro' specimen.

Spiral

Date

* **Arc welding**

for linear power source, arc voltage;

$$V_{arc} = V_{oc} - \left(\frac{V_{oc}}{I_{sc}}\right) I_{arc}$$

$V_{oc} = V_{open\ ckt}$
$I_{sc} = I_{short\ ckt}$
I_{arc} = arc current

for stable arc in constt. voltage transformer,

$$V_{arc} = V_{transformer}$$

For stable arc in constt. current transformer,

$$I_{arc} = I_{transformer}$$

for linear power source,

$$V - V_1 = \left(\frac{V_2 - V_1}{I_2 - I_1}\right)(I - I_1)$$

* Heat required for melting → Vol. melted × rate of melting

Vol melted = area of joint × melting speed.

Net heat supplied = $\boxed{\eta_{HT} \times V \times I}$

η_{HT} = heat transfer efficiency

Melting efficiency; $\boxed{\eta_{melt} = \frac{\text{Heat reqd.}}{\text{heat supplied}}}$

* Resistance welding ⇒ $\boxed{H = I^2 R t}$

* Heat for melting: $\boxed{mL + mC_p(T_m - T_a)}$

m = mass of metal
L = latent heat of fusion
C_p = specific heat of metal
T_m = melting temp
T_a = ambient temp.

UNIT - 2

Date ____________

* **Welding** → joining metals with heat, with / without pressure
  ↳ fusion and non fusion | pipelines, towers, cars
→ **Joints** → butt, tee, edge, lap, corner

→ **Weld parts**: face, throat, toe, leg, joint root
→ metals ⇒ mild steel, stainless steel, aluminium
→ **arc welding**: arc melts base metal and filler metal
→ electricity flow: voltage, current, polarity (DC^+, DC^-, AC)

adv.
efficient, cheap, light weight, design flexibility

disadv → labor cost, high energy, defects.

→ **SMAW** | **SAW** | **TIG** | **MIG**

(shielded metal arc welding)

↳ stick welding | manual arc welding
→ current flows thro' cable to holder and across arc
→ 1. **electrode** ⇒ gets melted during welding
2. **flux coating**: produce shielding gas and forms slag
3. **Arc**: when electrode in contact with metal
4. **Weld Puddle**: melted part
5. **Solidified metal**: with joint
6. **Slag**: slows cooling rate, cleaned with brush

→ **Starting SMAW**
↳ scratch start, tap start
→ **work angle**: angle b/w electrode and work
→ **travel angle**: for movement of electrode
→ **arc length**: distance of $\frac{1}{8}$" b/w electrode and workpiece
→ **travel speed**: constt., not slow not fast

→ **adv.**: cheap, portable, varied positions

→ **disadv.**: less efficient, frequent restarts

fusion welding → joining similar or dissimilar materials
→ both surface and filler material do melt.
→ heat applied, pressure not required, filler material optional
→ **adv.**: easy application of filler | no external pressure | joint design not crucial | more than 2 comps easily welded
→ **disadv.**: distortion | mechanical properties affected | expansion

Spiral

Date

Submerged arc welding (SAW) → bare consumable metal electrode producing arc
→ electrode submerged in flux
→ adv. → high welding rate, suitable, quality
→ disadv. → slag, limited applications
→ applications → railroad tank cars / beam product^n / ship building

Electro Slag welding (ESW) : heat generated by current, steels
adv. → low slag, less distortion
disadv. → coarse grain structure, low toughness

Gas welding → oxy acetylene
→ oxy gasoline
→ oxy hydrogen
} use regulator, O_2 gas hose, C_2H_2 hose, welding torch, protective clothing
→ principle : gases released with high pressure, velocity ↑, easy arc
⇒ Flames → carburising → 3000°C, long white feather shape
→ ~~nat~~ neutral → whitish core (3200°C)
→ oxidising → darker and pointed (3400°C)

Tungsten Inert Gas welding (TIG) → more protect^n of air,
→ for thin comps of stainless steel/aluminium
→ Ar and He used, less H_2 but not CO_2 at all
adv: wide range of metal / less distortion / no slag
disadv: hand eye coordination, arc rays produced
applicat^n: aerospace/aircraft frames/pipe works in chemical industries.

SMAW v/s GMAW ⇒ (ppt pg 81)

Resistance welding : type of fusion welding, force applied before after and during applicat^n of current ($I^2RT = H$)

Spot welding → clamp metal piece and weld as single dot

butt welding → joining ends thro' welding transformer (end to end)

Seam (linear joints) / projection welding (joint at fixed point)

Soldering and Brazing (lie b/w fusion and solid state welding)

Soldering:
joining using filler material
→ smooth / shiny / clean joint
adv ⇒ low power, easy automat^n, variety, low temp.
disadv ⇒ low strength, toxic flux, careful removal of flux

Brazing:
→ filler metal heated @ ~~450~~ 450°C
→ heat to base metals
adv → dissimilar joints / fast / thin walled parts
less heat
disadv → less strength, weak joint, colour may not match

Spiral

UNIT - 4

Date ______

Powder metallurgy → forming parts by compacting metal powders
→ high quality

Metal powder, additive → mixing → compacting → sintering → secondary operation → finished products

→ shape / size / chemical comp / ppt. size etc. managed
→ properties : ductility / porosity / conductivity
→ produc^n of powders → atomisat^n / chemical decomposit^n / electrolysis / milling / crushing

blending ⇒ 1st process → same chemistry but diff. size
→ coarse with fine texture / special properties / lubricants / wax added to ↑ strength

compacting ⇒ pressing using hydraulic / mechanical to get shape / size.
⇒ pressed powder called 'green compact'.

sintering ⇒ heat treatment to bond metallic parts ~ 80% of melting point
⇒ part shrinkage due to pore size reduction
→ compact bonds to strong metallic bonds.

PM merits ⇒ precision / mass production / less loss / choice of alloys / economical / less wastage

Limitations ⇒ cost / not geometric / varied density / porous / not for big comps

applications ⇒ auto / industrial machines / electrical machines / aerospace / medical equipments / computer parts

→ Organics → natural / synthetic
natural ↓ wood / coal
synthetic ↓ plastic / rubber / glass

→ polymers: built on repeating units in process called polymerisation
→ plastics ⇒ desired shape / liq. plastic as resin / modifier to ↑ strength / lubricants to ↓ friction / fillers / elastomers to ↑ elastic properties..
→ density / rigidity / heat, chemical resistance
→ thermosetting: don't change shape / 3D network
thermoplastics : change shape / bonds break
resins: polyethylene / teflon / nylon / PVC (uses & properties)
→ polypropylene / PVC / polycarbonate / polyurethanes / PET / polystyrene / ABS
→ general purpose or high impact polystyrenes

Processes ⇒ injection molding / extrusion / blow moulding / vaccum forming / compression
(plasting formation)

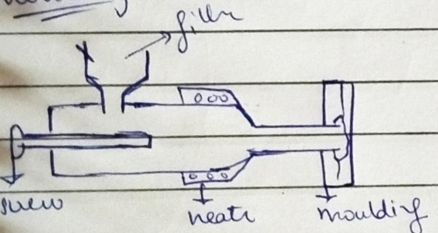
Date

Injection moulding ⇒ versatile / complex shapes / low per part cost
extrusion → for thermoplastics / granules as raw matrial / for long pieces parts as stock for other products. (Pg-82)
blow moulding ⇒ hollow parts / melting plastics and then air passed (Pg-78)
rotational moulding → hollow parts, no pressure, inexpensive, many sizes
↳ charge → heat & rotate → cool → demould.
film blowing ⇒ tubes / film width fixed / biaxial orientation (Pg-80)
thermoforming ⇒ plastic sheet heated (vaccum forming) ⊕ (buttons)

→ Moulding → compression: raw matrial in mould / heated / closed using pressure
↳ transfer: matrial in cylinder / hole at bottom / semi solid plastic pushed
↳ ~~inject~~ injection moulding ⇒ plunger type (diagram Pg-76)
↳ screw type (Pg 77)

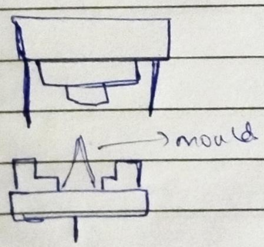
Bonding in thermoplastics ⇒ welded / conventional heating / pressing / cleaning with solvent and water
thermoplastics → screw type / blow mould / film blow / sheet making / extrusion / vaccum forming
thermosets ⇒ compression moulding / transfer moulding

Injection moulding



(complex matrials)

2) Compression moulding



Forging → open & closed
↳ hot & cold
↓ (operations)

upsetting / bending / drawing down / flattening / cutting

Shearing
blanking
punching
} methods of deformati