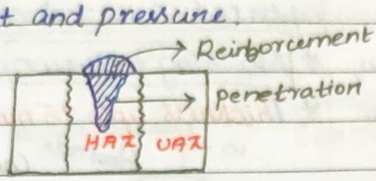
# PRODUCTION TECHNOLOGY

## CHAPTER 1 WELDING

**Welding**

Welding is the process of joining two similar (or) dissimilar materials with the application of heat (or) pressure (or) both heat and pressure.




Weld bead = Reinforcement + Penetration

Weld bead - Alloy.

**Weldbead > UAZ > HAZ.**

For HAZ to be minimum, welding speed must be maximum.

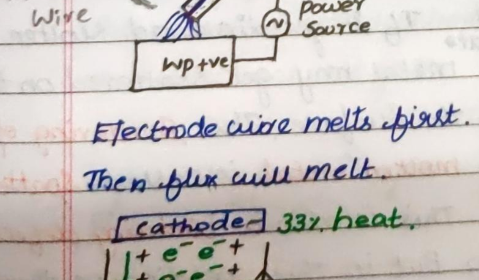
$$\% \text{dilution} = \left(\frac{A_P}{A_P + A_R}\right) \times 100$$

## ARC WELDING

1) Shielded metal Arc Welding

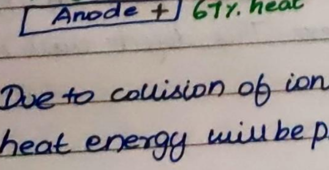
Low current high voltage.

[300-1000 A] [60-80 V]

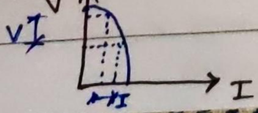



Electrode wire melts first.

Then flux will melt.




Due to collision of ions, heat energy will be produced.



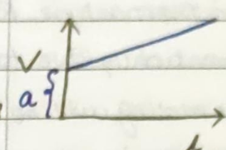

**Function of flux coating**

1) It provides alloy content to the weld bead.

2) provides converge Arc.

3) Flux is lighter it makes a slag on the weld bead and it protects from the atmospheric oxygen.

**Numericals:-**



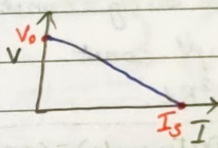

$V = a + bl$

If $l\uparrow$, $V\uparrow$

If $l$ vary, $V$ vary

If $V$ vary, $I$ vary.

If $I$ vary, $H_g$ vary




For small voltage change, current change will be more.

$$\frac{V}{V_0} + \frac{I}{I_s} = 1$$

$$V = OCV - \frac{OCV}{SCC} I$$

OCV → open circuit Voltage

SCC → Short circuit current

$P = VI$

For $I_{opt}$ $dP/dI = 0$

put $I_{opt}$

We get $V_{opt}$.

**Shortcut:-**

$$V_{opt} = \frac{OCV}{2} \qquad I_{opt} = \frac{SCC}{2}$$

**Drooper:-** This is constant current transformer. If we use manual metal Arc Welding / Shielded metal Arc Welding it has to be used with drooper.

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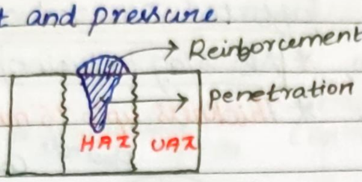


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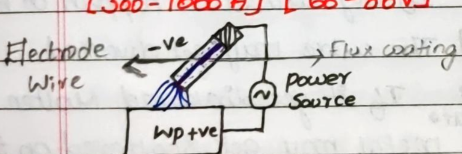


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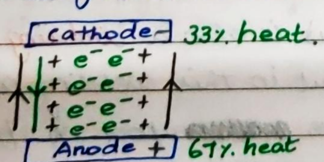


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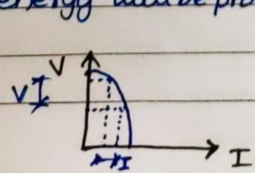


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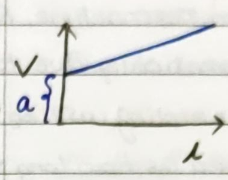


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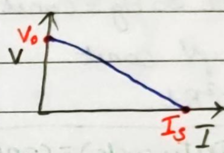
If $l$ vary, V vary

If V vary, I vary.

If I vary, $H_g$ vary

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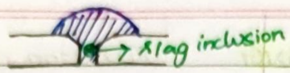
Note:




If $H_g$ is less, slag inclusion will take place.

DUTY CYCLE

Duty cycle = $\frac{\text{Arc on time}}{\text{Total welding time}}$

If welding done for 10 min, 7 min we on the machine, Rest 3 min automatically due to high heat welding will be done. It is defined as how long the welding takes place continuously before the wire catches fire. So wire have some constant melting point. So $H_g$ = const, R is always const.

$H_g = I^2 R t$.

$I^2$ (Duty cycle) = const

Std Arc on time: 10 mins.

2) Submerged Arc Welding [SAW]

→ LPG cylinder. → This welding most appropriate for this.

→ Ship plate.

Normally electrode size small. So we have to change electrode frequently while welding. So this is discontinuous welding. So leakage chances are more. So we need to use continuous wire electrodes to avoid discontinuity. As leakage cause problem in both LPG cylinders and ship plates.

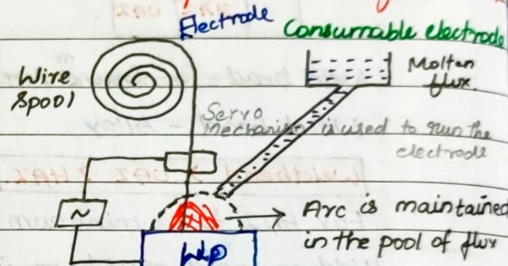
Since the electrode will be in the wire spool so we cannot keep flux like in earlier case. So we use molten flux.

* It is a semi automatic welding.

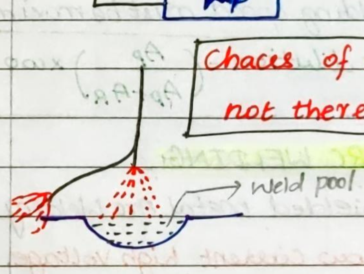
* Welding speed is higher so heat affected zone reduces.

* No slag inclusion.

* Thickness upto 75 mm only be welded.




Chaces of Spatter is not there.

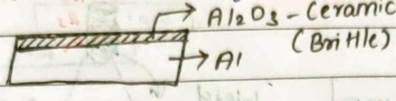



If any disturbance happen in between the wire may get diverted. If it get diverted. Molten metal may get scattered on to the surface. This scattering of molten metal is called spatter. This is also a welding defect. But in this welding as there are pool of flux are there. This defect will not happen.

→ Tungsten Inert Gas Arc welding.

## 3) TIG and MIG Welding

4) All metals in high Temp will form Metal oxides. But Aluminium, Magnesium and their alloys even at room temperature it will form oxides. So it is difficult to weld brittle layer.

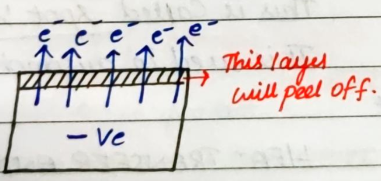



So Submerged Arc welding cannot be used here.

Till now we use DCSP - Direct current straight polarity.
Here we use Wp(+), Elec(−)

DCRP - Direct current Reverse polarity
Wp(−), Elec(+)

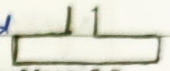
### Cathodic Cleaning



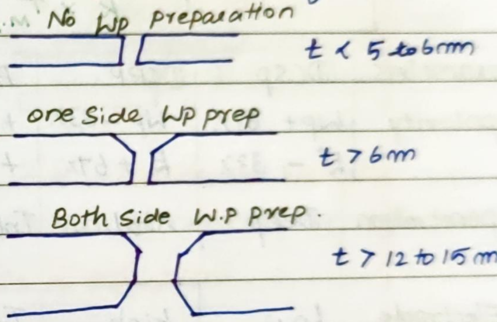

This is called cathodic cleaning. Now more heat will go to cathode electrode. So we use high melting point [Tungsten Electrode]. So this is non-consumable electrode.

So here we use filler rod. [Same as W.p material]. Here we are not using flux. But we have to restrict the air and high Temp metal contact. So here we use inert gas.

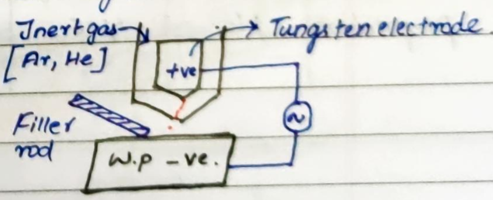
Due to unavoidable reason if temp goes beyond 3500°C even tungsten melts. So droplet of tungsten will make weld bead brittle. So shape of electrode will be changed




This is called electrode preparation
* Due to less heat to W.p, thin plates can only be welded.

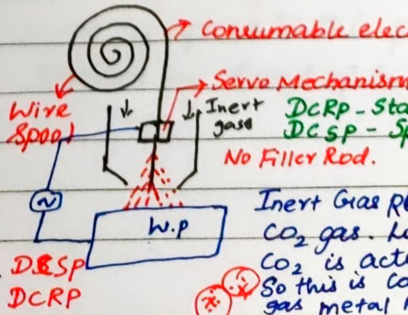



Two drawbacks
* Tungsten droplet.
* Only thin plates can be welded.
* Inert gas increases cost.




## 4) MIG - Metal Inert Gas Welding

Tungsten electrode is replaced by metal wire similar to SAW.




DCRP - Stable Arc
DCSP - Spatter.
No Filler Rod.

Both polarity used.

Inert Gas Replaced by $CO_2$ gas. Low cost. $CO_2$ is active gas. So this is called active gas metal Arc welding.

## Weldability

Ease towards Welding.

When Carbon increases, Weldability decreases.

| High carbon Steel < Medium carbon Steel < Low Carbon Steel |
|---|

Note:-

Aluminium and Magnesium weldability is poor.

Not imp

$$\%\text{ Weldability} = \frac{\text{Resistivity} \times 100}{K \times T_{M.P.}}$$ (K = const)

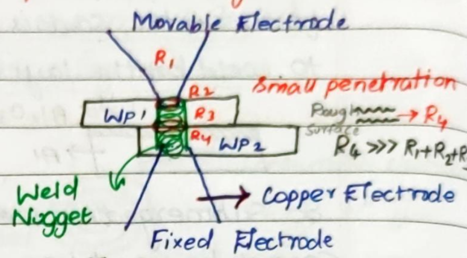
| parameters | DCSP | DCRP | AC |
|---|---|---|---|
| 1) polarity | Wp + 67%<br>E − 33% | Wp − 33%<br>E + 67% | + − 50%<br>+ − 50% |
| 2) penetration | Deep | Shallow | Intermediate |
| 3) Electrode Deposition rate | Low | high | Inter |
| 4) Thickness | More (Thick) | Thin plates | Int |
| 5) Electrode preparation | No | yes | depends |

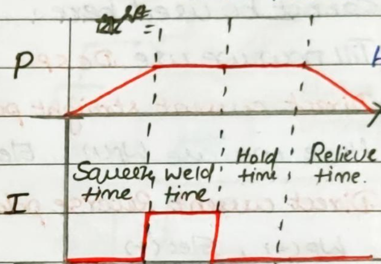
## 2) RESISTANCE WELDING

→ Low voltage

→ High current I > 10000

This is firstly used Welding technique of Lap joint configuration




$H_g = i^2Rt$

R ↑ at $R_4$

$H_g$ ↑ at $R_4$

a) Spot Welding

This is Called spot Welding.

It is used in automobile industries.

## HEAT TRANSFER AND EFFICIENCIES

1) Heat generation $H_g = I^2Rt$

2) Heat Supplied $H_s = H_g - (loss)_1$

3) Heat Required $H_R = mc_p\Delta T + m(LH) + mc_p\Delta T$

($\Delta T = T_{M.P} - T_{ROOM}$: Increase upto M.P temp; $\Delta T = T_{sup} - T_{MP}$: Superheat)

1) Heat transfer efficiency

$$\eta_{H.T} = H_s / H_g$$

Total loss = loss1 + loss2

2) Melting efficiency

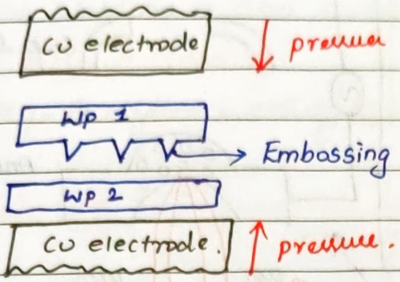
$$\eta_{melt} = \frac{H_R}{H_s} \qquad loss_2 = H_s - H_R$$

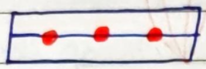
3) Overall efficiency

$$\eta_{overall} = \frac{H_R}{H_g} = \eta_{H.T} \times \eta_{melt}$$

(b) PROTECTION RESISTANCE WELDING

This is called multi spot welding.

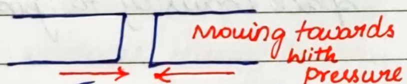


(c) FLASH BUTT WELDING

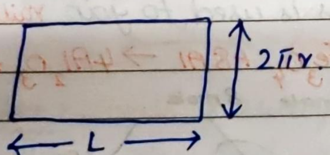
It is used in joining Railway tracks.

It requires current we cannot get current in rual areas easily. So we use thermit welding.




$10^5$ A is passed.

(d) HIGH FREQUENCY RESISTANCE AND INDUCTION WELDING.




This is used to make Steel pipes.

It used AC current.

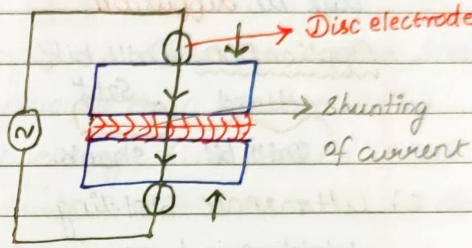
Seam means joint

Seamless means no joint.

Welding itself a joint so we cannot get seamless pipe here.

Seamless pipe can be made only in centrifugal casting.

(e) SEAM WELDING.



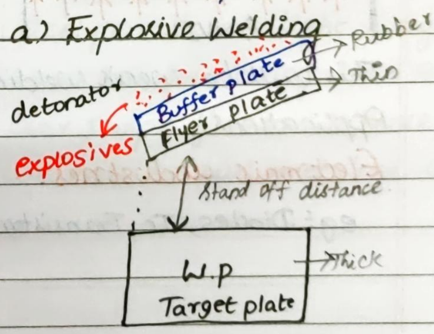

It is continuous welding.

As this is continuous it provides leakproof joints.

3) SOLID STATE WELDING.

Here we are using large amount of pressure.

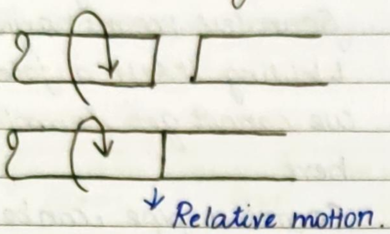
a) Explosive Welding




Cladding of cylinder: Application

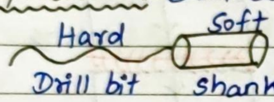
Welding speed in this process is limited by Speed of sound.

b) Friction Welding



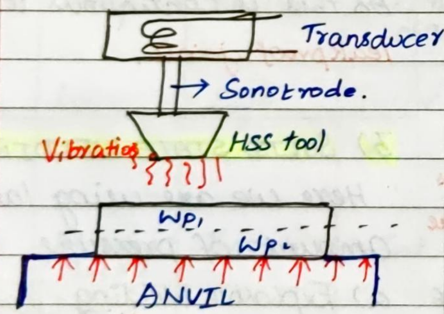

So heat produced.
This welding is takes place due to diffusion.

Application:- Drill bit




c) ultrasonic Welding

Welding is happening due to Vibration.



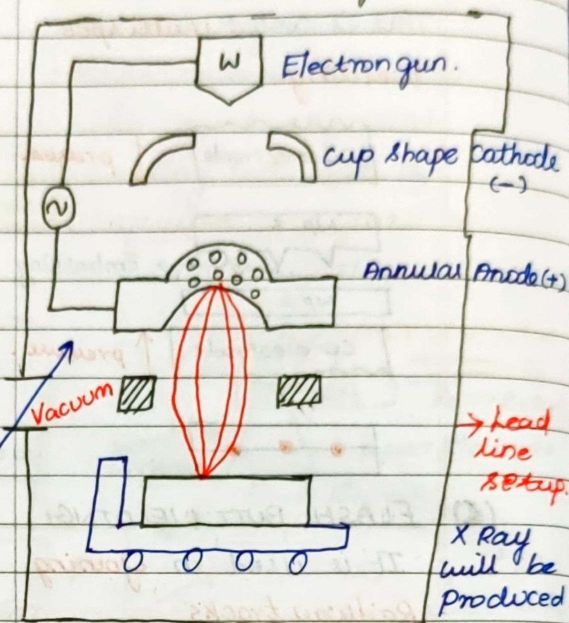

This will be weak welding.

Applications:-

Electronic industries.

eg:- Diodes, Ic, Transistors.

Electron Beam Welding




X Ray will be produced. This has to be protected from Surroundings.

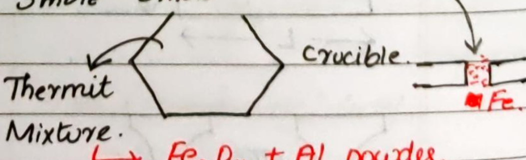
Applications:- It is used in Space industry to join superalloys.

Thermit Welding.

This welding is based under the principle of exothermic Reaction. This is used to join railway tracks in India.

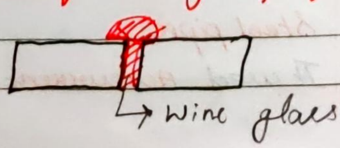
$3Fe_3O_4 + 8Al \rightarrow 4Al_2O_3 + 9Fe + Heat.$

3 mole 8 mole




Thermit Mixture. → $Fe_3O_4$ + Al powder.

Wine glass type of welding is performed.



## GAS WELDING

It is also a chemical reaction type of Welding.

Gas Welding is also known as oxyfuel Welding.

Oxy-Acetylene Welding ($C_2H_2$)

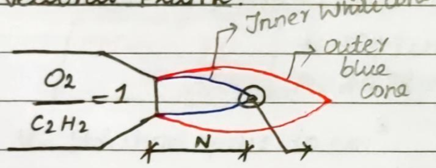
$\rightarrow 2.5 O_2$

$C_2H_2 + \frac{5}{2} O_2 \rightarrow 2CO_2 + H_2O + Heat$
[Steam]

Combustion is the principle of the above reaction.

Types of Flame

1) Neutral Flame.



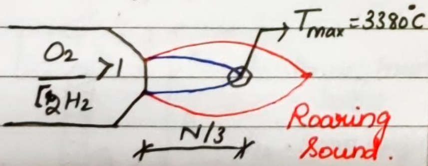

Deficit : $1.5O_2$  $T_{max} = 3260°C$

outer cone used for preheating.

Inner Cone used for Welding

It produces Hissing Sound.

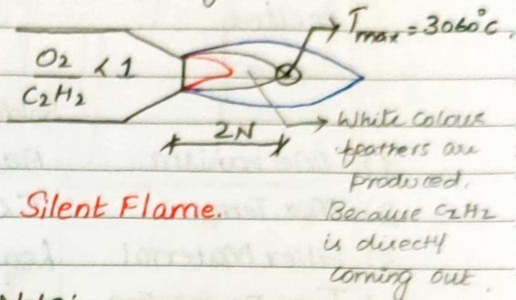
2) Oxidising Flame.




>1 Means 1.15 to 1.5

Note :- Brass is always welded using oxidising Flame. [If we weld brass which contains zinc, which has low Vapourisation temp using Neutral Flame Zinc will evaporate]. When we use oxidising it forms ZnO so it protects Zinc from Vapourising.

3) Carburizing Flame

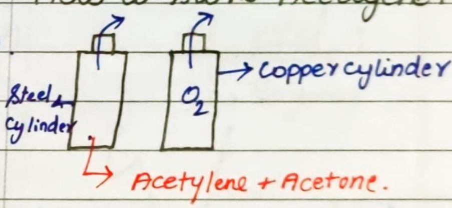



Silent Flame.

Note :-

If we weld low carbon steel due to more carbon in this welding, low carbon steel will aborsb carbon. So we don't use. It is used to weld high carbon steel, CI, and low Carbon non Ferrous.

How to store Acetlyene Fuel.




Acetylene due to light weight it comes out for welding. When Acetylene over purple flame will come. So we have to fill Acetylene again.

classmate
Date
Page

→ W.p not melted
→ Filler rod Melted.

Allied Processes. [ solid / liquid type ]
We are not melting workpiece, instead filler rod will be melted.

| | Soldering | Brazing | Braze Welding |
|---|---|---|---|
| 1) Mechanism | Adhesion | Adhesion | Adhesion |
| 2) Max Temp | T < 427°C | T > 427°C | T > 427°C |
| 3) Filler Material | Lead + tin | Copper + Zinc [Brass] | copper + tin [Bronze] |
| 4) Joint preparation (W.P prep) | No | No | yes |
| 5) Flow of Filler Material | capillary | capillary | gravity |
| 6) Application | Electronic circuits | Hydraulic circuits | Weld / join cutting tool tip [2 diff mat can also join] |

# CHAPTER : 2 CASTING.

## Shrinkage Allowance.

→ Liquid and Solidification Shrinkage are maximum for Aluminium

→ Total Shrinkage is maximum for steel.

→ For Gray Cast Iron

- $1^{st}$ stage → Contracts
- $2^{nd}$ stage → Expands. } No Riser Needed
- $3^{rd}$ stage → Contracts

## Permeability Number.

$$PN = \frac{VH}{\Delta PAT}$$

$H = 5.08\,cm$

$A = 20.28\,cm^2$

$V$ = Volume of air in $cm^3$

$H$ = Height of std Specimen (cm)

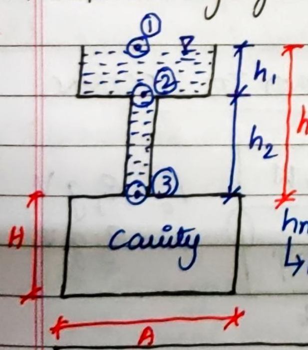
$\Delta P$ = Pressure difference ($gm/cm^2$)

$A$ = Area of std Specimen ($cm^2$)

$T$ = Time in minutes

## Gating Design

### a) Top Gating System.




$h_1$ = Pouring basin height

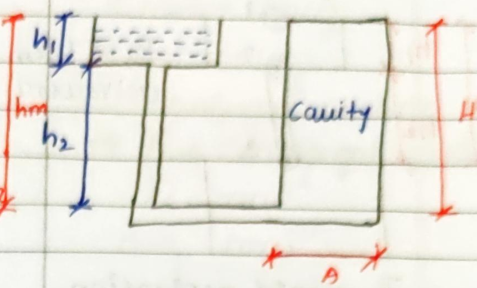
$h_2$ = Sprue height

$h_m = h_1 + h_2$

↳ height of Molten Metal.

$$(t_f)_{top} = \frac{A \times H}{A_g\sqrt{2gh_m}}$$

### b) Bottom Gating System




$$(t_f)_{bottom} = \frac{2A}{A_g\sqrt{2g}}\left[\sqrt{h_m} - \sqrt{h_m - H}\right]$$

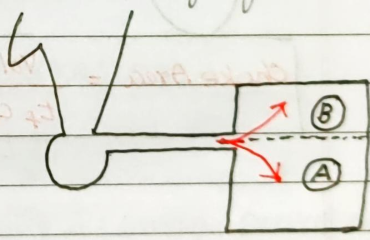
When $h_m = H$

$$(t_f)_{Bottom} = 2\,(t_f)_{top}.$$

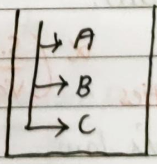
### c) Parting line Gating System

$$t = (t_A) + (t_B)$$

$t_A$ ↳ Top gating; $t_B$ → Bottom gating

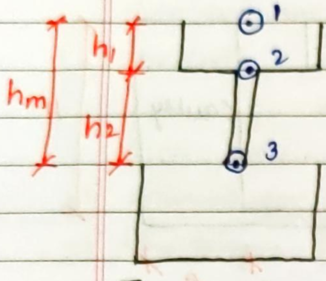



### d) Stepped Gating System.




It is used to produce large components.

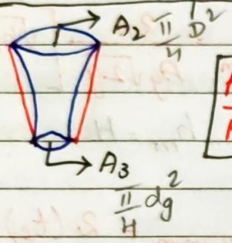
## Aspiration Effect




$P_2 < P_{atm}$
(ie) Vacuum

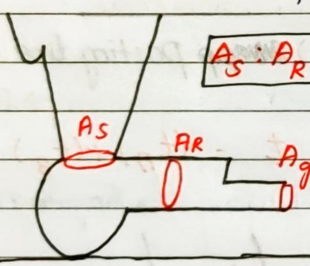
### To avoid aspiration.

Sprue design




$$\frac{A_3}{A_2} = \sqrt{\frac{h_1}{h_m}}$$

Choke Area → Minimum Area of all 3.




$A_s : A_R : A_g$

$$\text{Choke Area} = \frac{\text{Vol} \rightarrow m/e}{t_f \, C_d \sqrt{2 g h_m}}$$

$C_d$ → coefficient of discharge

## RISER DESIGN

1) Caine's Law.

$$\text{Cooling characteristics} \propto \left(\frac{S.A}{Vol}\right)$$

2) Chevorinov's law.

$$t_{solidification} = K \left(\frac{Vol}{SA}\right)^2$$

$t_s \propto (1/_{sc})^2$

K → Solidification const.

$$Sec = K \times \left(\frac{m^3}{m^2}\right)^2$$

$K = Sec/m^2$ unit of K.

4) Shape Factor Method.

plate - $l+w/t$

cube - $\frac{a+a}{a} = 2$

Sphere - $\frac{r+r}{r} = 2$ (or) $\frac{d+d}{\frac{d}{2}} = 2$

cylinder - $\frac{d+h}{d}$ If $d=h$ Then 2.

5) Modulus Method.

$$M_R = 1.2 \, M_c$$

$M_R = \left(\frac{V}{SA}\right)_R$

$M_c = \left(\frac{V}{SA}\right)_c$

$M_R > M_c$

6) Shrinkage Method.

$$V_{Riser} = 3 V_{shrinkage}$$

$V_{Riser}$ → $\frac{\pi}{4} D^2 H$

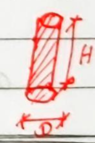
Find casting Vol

Find shrinkage vol.

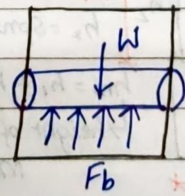
Then Find Riser Vol.

Relation between D and H

| Top Riser | Bottom Riser |
|---|---|
| $r = h$ | $D = H$ |




## CORE AND ITS DESIGN.




$F_b = \rho_f g V$

$W = \rho_s g V.$

$$F_{net} = (\rho_f - \rho_s) g V.$$

## Non-Conventional Casting Process.

1) Shell Moulding
- → IC engine cylinder head.
- → Cylinder Block.
- → Value plate of Refrigerator.
- → Rocker Arms.

2) SLUSH CASTING.
- → Lamp Shades
- → Toys
- → Statues
- → ornaments.

$t$ = thickness.

$$t_{Soli} = K\left(\frac{V}{SA}\right)^2 \Rightarrow t_{Soli} = K(t)^2$$

$$t_s \propto t^2 \text{ (or) } t \propto \sqrt{t_s}.$$

$$t = a\sqrt{t_s} + b$$

For $t_1$ — $t_{s1}$ } will be given

For $t_2$ — $t_{s2}$ } find a and b here.

For $t_3$ — $t_s = ?$

3) Investment casting → expandable pattern and expandable Mould

It uses wax pattern which is made by Sand Moulding (or) Centrifuging.
- → Gas turbines Blades.
- → Jet engine parts
- → Surgical parts.

pattern tree.

4) Full Moulding Technique
- * Motor casing
- * Tool casing.

5] Centrifugal casting.
- → True centrifugal casting

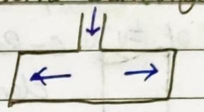
$$F_c = mr\omega^2$$

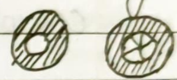
$$ma_c = mr\omega^2$$

$$\boxed{a_c = r\omega^2}$$ r = outer Radius of pipe.

- → Propeller shafts.
- → Seamless pipes, hollow cylinder pipes

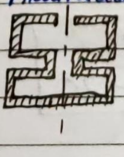
Semi centrifugal casting






Centrifuging
- → It is used to make pattern for Investment Casting.
- → Large number of Small products can be made.

6) DIE CASTING.
- Gravity Die casting
  - ↓ Simple shapes
  - ↓ Aluminium piston
- pressure die casting
  - Hot Chamber → Low melting Point Metals → Lead (Pb) → tin (Sn)
  - Crank case, Carburettor, Value bodies, Fuel Inject pump
  - Cold chamber → high Melting point metals → Al, Cu, brass



7) CONTINUOUS CASTING.
- → Rods
- → propeller Shaft.