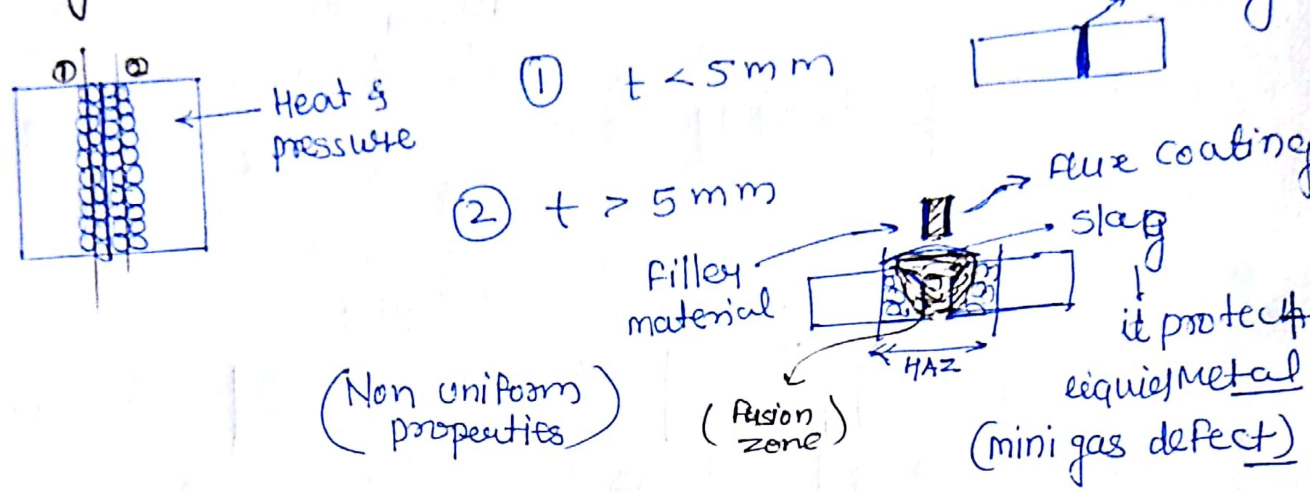
Welding:- Joining process (Permanent joints)



Welding:- it is a process in which localized permanent joint can be produced with or without application of heat, with or without application of pressure or pressure alone and with or without application of filler material for joining of similar or dissimilar material.

Advantages:-

1) Welding is a permanent joint, strength of joint will be equal to or more than the strength of base materials
2) leak proof joint can be possible
3) It can use for similar of dissimilar material.
4) Welding can be done in any position

Limitation :-

① skilled operator is require
② Setup Cost is More.

③ Internal stress can be develope in the joint. due to this crack will be formed and weld distortion will be takes place.

④ There is a possibility of Heat affected zone (HAZ)

Classification of welding

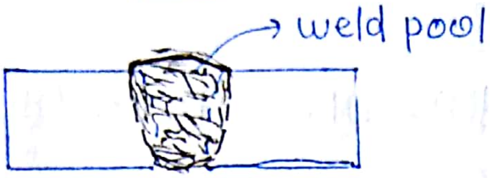
Imp

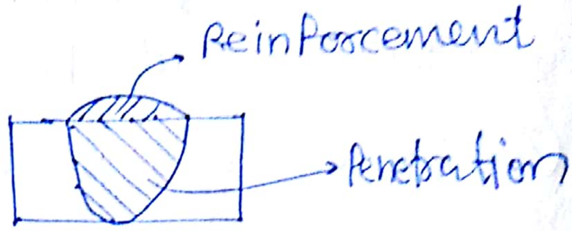
- Welding
  - Solid state (Autogeneous)
    - Explosive
    - Ultrasonic
    - Friction
    - Forge
    - Diffusion
  - Fusion — liquid state (Homogeneous)
    - Arc
      - Flux cored
      - Shielded Gas
        - TIG
        - MIG
        - PAW (Plasma arc welding)
      - Submerged
    - Resistance
    - Chemical Reaction
      - Gas
      - thermit
  - Solid / Liquid (Hetrogeneous)
    - Brazing
    - soldering

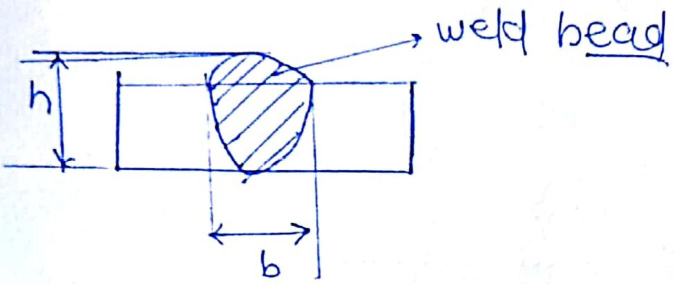
    base metal – Solid
    Filler material – liquid
    (diff material)

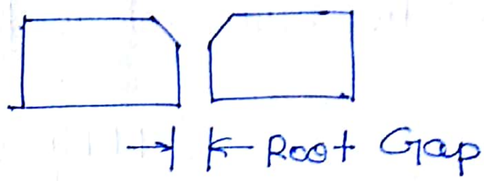
Terminology :-

① Butt Joint :-

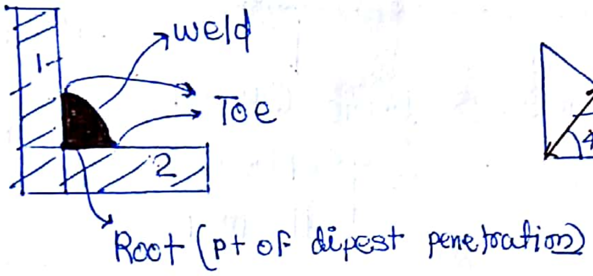


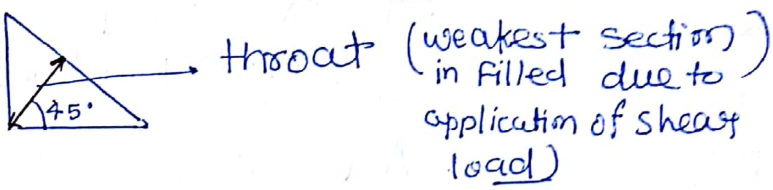






② Fillet weld :-





$$\% \text{ Dilution} = \frac{A_p}{A_p + A_R}$$

A_p - Area of penetration

A_R - Area of reinforcement

Weld Pool :- Amount of liquid metal between the two surfaces before solidification.

Weld bead Amount of material which is added into the work piece in a single pass

Reinforcement :- Amount of material which is projected from the base material.

Penetration:- It is a depth upto which weld Metal can be penetrated in base material.

Root gap:- shortest distance between two workpieces before joining.

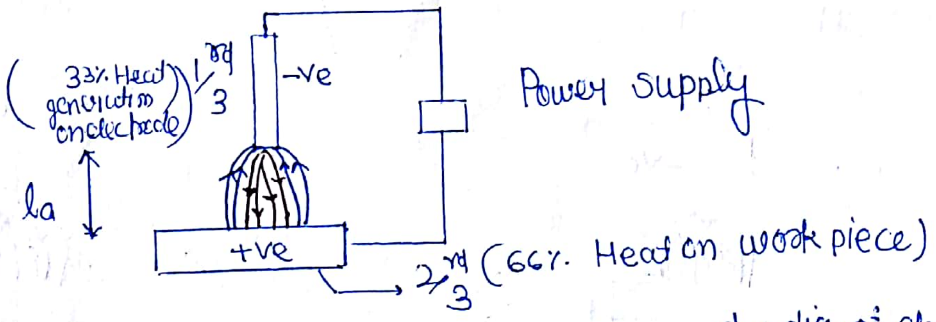
Toe:- It is a junction ~~the~~ between weld face and workpiece.

Root:- Point of deepest penetration in a fillet.

Throat:- shortest distance between weld face and root.

Arc Welding:-

Principle:-



d → dia. of electrode

l_a - Arc length (0.5 - 1.5) d

work piece

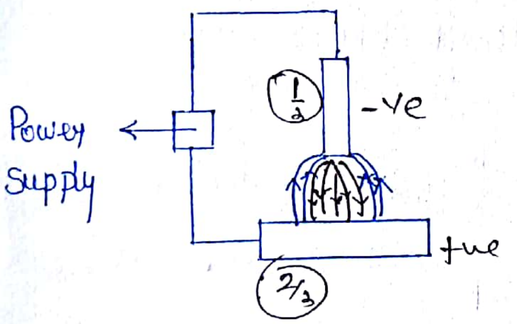
* +ve side more heat generation due more k.e. high velo. of e^-
* Due to Collision b/w e^- & +ve ions spark will generated
* In a cycle uniform heat & heat generation

When the electrode is in contact with workpiece due to short circuit arc will be generated. In order to ~~continue~~ Continue the arc some gap is maintained between electrode and workpiece know as arc length.

* When the e⁻ are moving from −ve to +ve, 2/3rd of heat will be generated on anode and due to moment of +ve ions from +ve to −ve, 1/3rd of heat will be generated on cathode (−ve) side.
* Due to continuously changing the polarity uniform heat will be generated on the electrode and workpiece in AC arc welding
* In order concentrate more heat on the electrode and workpiece DC arc welding can be used.

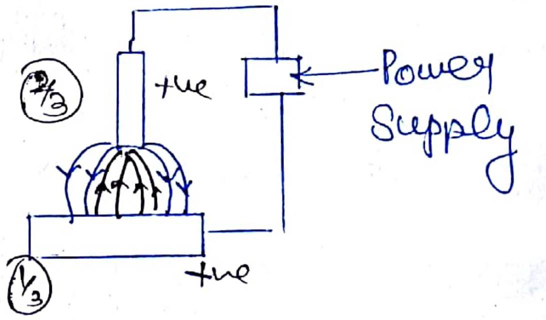
DC Arc welding :-

① straight polarity (DCSP, DCEN)



- Direct current straight polarity (DCSP)
- e⁻ −ve → +ve

② Reverse polarity (DCRP, DCEP)



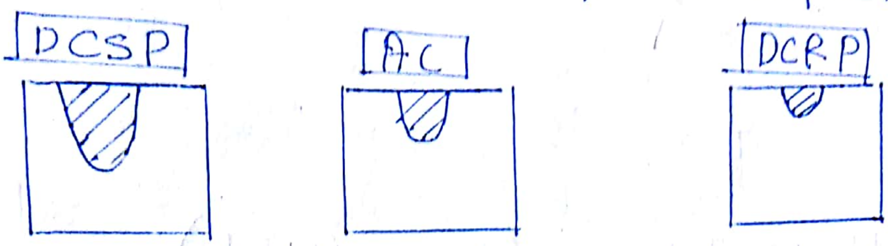
- Direct current reverse polarity (DCRP)
- e⁻ +ve → −ve

Straight Polarity :- ① electrode is −ve, workpiece is +ve more heat will be on the workpiece when compare to electrode.
② used for welding of high thickness and high melting point materials.
③ depth of penetration is more, weld deposition rate less.

Reverse polarity :- ① Electrode is +ve , workpiece will be -ve.

② More heat will be on the electrode when compare to workpiece.

③ Depth of penetration less, weld deposition rate is more



weld d penetration.

Welding Techniques :- $P = VI \Rightarrow V_a = A + B l_a$

if V ↑, I ↓, Heat ↓.

There are two movement for electrode

1. linear movement of electrode wrt workpiece know as linear welding speed.

2. Downward movement of electrode to maintain constant arc length.

* If two movement of electrode are controlled manually then it is called manual arc welding technique.

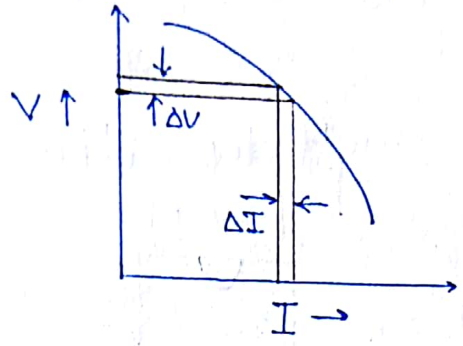
* If two movement are controlled by automatic machines then it is called automatic welding technique.

* If one of the movement is manually & one is automatic, then it is called semi automatic welding technique

Type of welding machines:-

① Constant current Type:- (Droop)

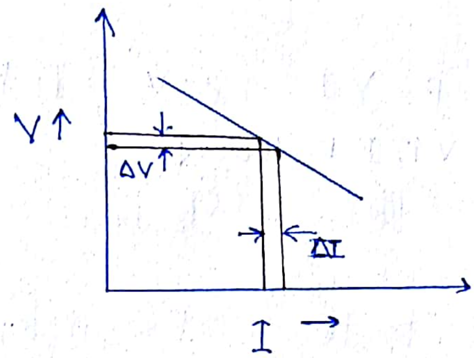
(used in manully)



* Small change in ΔV
Small change in ΔI

② Constant Voltage Type:- (linear/Flat)

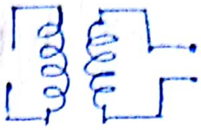
(used in Automatic)



① For a small change in arc voltage the corresponding change in current will be very small these are used in manual arc welding technique.

② For a small change in arc voltage the correspondin change in current is large. These are used in automatic welding technique.

① Open circuit Voltage: (V_o)



It is the max. rated Voltage that can be measure b/w two open terminal under no loading conditions

② Short circuit current:. (I_s)
It is the max. rated current which is require to generate the arc.

③ Duty cycle:- It is the % of time during which ~~ac~~ arc will be on without over heating element in a welding machine

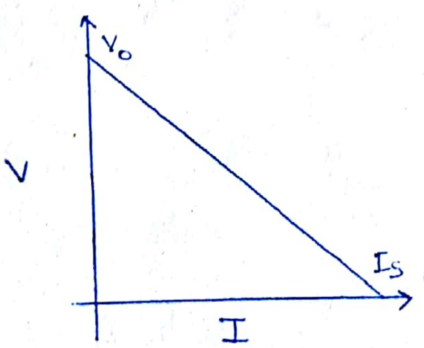
$I^2 D$ = Constant
D - duty cycle
I = current

$$\text{Duty cycle} = \frac{\text{Arc time}}{\text{Arc time} + \text{idle time}}$$

AWS → 10 min. (American welding society)

BIS → 5 min (Burro (ब्यूरो) of indian standard) eg. $\frac{3}{3+2} = 60\%$

⟹



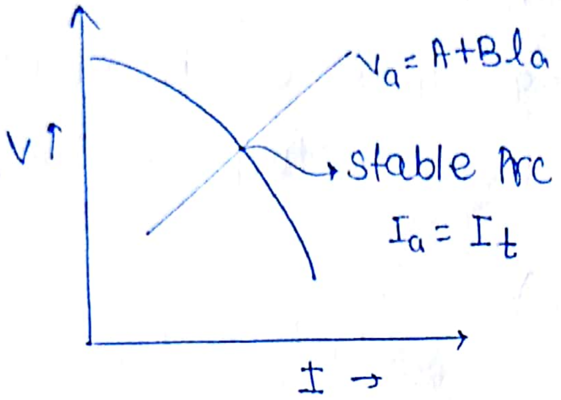
$$\frac{x}{a} + \frac{y}{b} = 1$$

$$\frac{I_t}{I_s} + \frac{V_t}{V_o} = 1 \quad —①$$

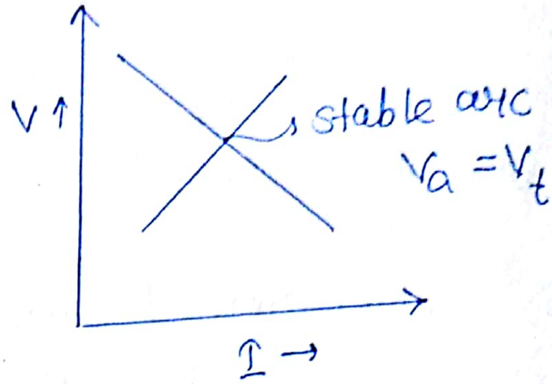
$$V_a = A + B\, l_a \quad —②$$

Stable Arc Generation Condition

★ Constant current type



★ Constant Voltage type



Problem :- Arc length voltage characteristic are given by $V_a = 24 + 4 l_a$, V-I characteristic assumed as state line with open circuit voltage $V_o = 80$ V & short circuit current $I_s = 600$ A determine optm arc length for maxm power.

solⁿ

$$V_a = 24 + 4 l_a$$

$$V_o = 80 \text{ V}, \quad I_s = 600 \text{ V}$$

$$P = f(l_a) \Rightarrow \frac{\partial P}{\partial l_a} = 0 \Rightarrow (l_a)_{opt.}$$

$$\frac{I_t}{600} + \frac{V_t}{80} = 1$$

$$V_t = 80 - \left(\frac{I_t}{600}\right) 80$$

For stable arc $V_a = V_t$

So

$$24 + 4 l_a = 80 - \left(\frac{I_t}{600}\right) 80$$

$$I_t = (4 l_a + 24 - 80) \frac{600}{80}$$

$$I_t = 420 - 3 l_a$$

$$P = VI$$

$$P = (24 + 4 l_a)(420 - 30 l_a)$$

$$\frac{\partial P}{\partial l_a} = 0 \Rightarrow \{24 + 4 l_a)(0 - 30) + (420 - 30 l_a)(4) = 0$$

$$4 \times 30 (l_a + 6) + (30 l_a - 420) 4 = 0$$

$$120 l_a + 720 + 120 l_a - 1680$$

$$240 l_a = 960$$

$$l_a = 4 mm$$

$$P_{max} = (24 + 4 \times 4)(420 - 30 \times 4)$$

$$P_{max} = 12 kW.$$

Problem: V − I characteristic of power source given by $I_t^2 = -600(V-60)$ arc characteristic given by $I_a = 20(V-16)$, determine power of stable arc.

Soln

$$I_t^2 = -600(V-60)$$

$$I_a = 20(V-16)$$

For stable arc $I_a = I_t$

$$-600(V-60) = \{20(V-16)\}^2$$

$$2V^2 - 61V + 332 = 0$$

$$V = 7.09\ V, \quad 23.4\ V$$

✗ ✓

$$I_a = 20(V-16) \quad ; \quad V > 16$$

$$I_a = 20(23.4-16)$$

$$I_a = 148\ \text{Amp}$$

$$\text{Power} = VI$$

$$= 23.4 \times 148$$

$$P = 3.436\ \text{kW}$$

Problem :- Arc length Voltage characteristic is given by $V_a = 20 + 4 l_a$ Arc length in welding process change from 4 mm to 6 mm and current changes from 450 Amp to 550 Amp Assuming a linear power source characteristic determine V_o & I_s

★ Low length high current
★ High length low current

Sol^n

$$V_a = 20 + 4 l_a$$

$$l_{a_1} = 4\text{ mm} \rightarrow I_{t_1} = 550\text{ A}$$

$$l_{a_2} = 6\text{ mm} \rightarrow I_{t_2} = 450\text{ A}$$

$$= V_{a_1} = 20 + 4 \times 4 = 36\text{ volt}$$

$$V_{a_2} = 20 + 4 \times 6 = 44\text{ volt.}$$

$$\boxed{V_a = V_t}$$

$$V_t = V_o - \left(\frac{I_t}{I_s}\right) V_o$$

$$V_{t_1} = V_o - \left(\frac{550}{I_s}\right) V_o = 36 \quad \text{—(1)}$$

$$V_{t_2} = V_o - \left(\frac{450}{I_s}\right) V_o = 44 \quad \text{—(2)}$$

$$V_o = 80\text{ Volt}$$

$$I_s = 1000\text{ Amp.}$$

Problem:. A DC Welding machine with linear power source characteristic provide $V_0 = 80$ Volt & and $I_s = 800$ Amp. During welding arc length changes from 5 mm to 7 mm and current changes from 500 to 460 Amp what is the linear voltage characteristic of welding arc.

Sol^n $V_0 = 80$ Volt $I_s = 800$ Amp $V_a = a + b\,l_a$

$l_{a_1} = 5$ mm $I_{a1} = 500$ Amp

$l_{a_2} = 7$ mm $I_{a2} = 460$ Amp

$$\frac{V_t}{V_0} + \frac{I_t}{I_0} = 1$$

$$\frac{V}{80} + \frac{I}{800} = 1$$

$$V_t = 80 - \frac{I_t}{10}$$

$$V_t = V_a = a + b\,l_a \qquad I_t = I_a$$

$$a + b\,l_a = 80 - \frac{I_a}{10}$$

$$a + 5b = 80 - \frac{500}{10} \Rightarrow a + 5b = 30 \quad (1)$$

$$a + 7b = 80 - \frac{460}{10} \Rightarrow a + 7b = 34 \quad (2)$$

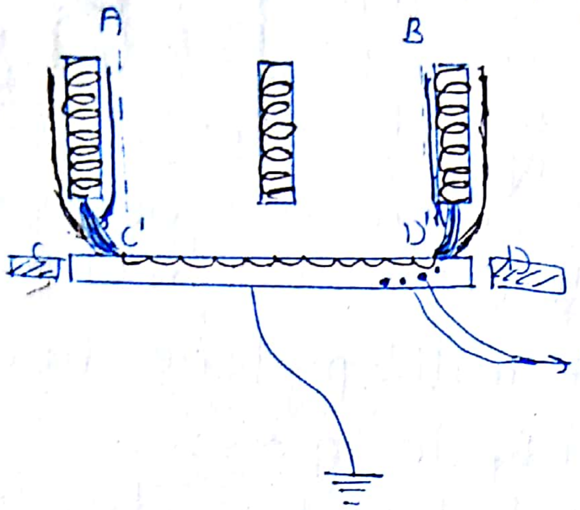
From eq^n (1) & (2)

$$2b = 4 \Rightarrow b = 2$$

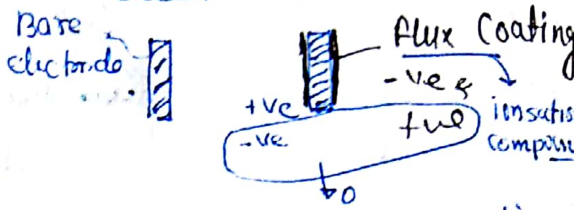
$$a = 30 - 5 \times 2 \Rightarrow a = 20$$

$$\boxed{V = 20 + 2L}$$

Arc Blow:-



* without Flux Coating electrode called Bare electrode



Defleration of electric arc towards the workpiece at the begaining and end to workpiece due to deflection of magnetic flux lines is know as ~~ac~~ arc blow or magnetic arc blow.

Due to arc blow heat consantraation on workpiece at the begaining and end will be reduce and weld spatter will be formed

Remedies:- ① Provide some extra material at the begaining and end of workpiece known as Tab in & Tab out

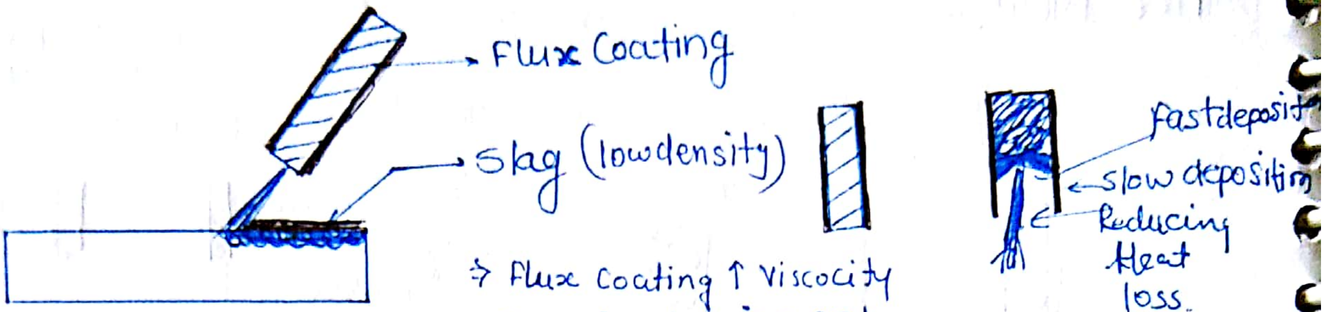
② Reduce the intensity of currenet.

③ Use small arc length at the begaining and end of workpiece.

④ Provide flux coating on the electrode.

Bare electrode में Arc Blow ज्यादा होता है।

Functions of Flux Coating:-



→ Flux Coating ↑ Viscocity
So surface tension act
opposite to Gravity in case of overhead welding

① Flux coating material will act as deoxidizers.

② By forming the slag it will protect the liquid metal from the atmospheric gasses.

③ slag will control the heat transfer rate of liquid metal in the weld pool

④ it will increase the strength of joint.

⑤ it will control the viscosity of liquid metal by

⑥ By reducing the heat transfer looses from arc heat consentration on the workpiece will be increase.

Flux coating Materials:-

① De-oxidizing Elements:-
Graphite, Alumina, Ferrosilicon, Ferro magnis

② Slag formation Compound:
Iron oxide, Silicon di-oxide, titanium oxide, silica Flor and Calcium floride (CaF_2)

③ Arc stabilizer:-
Sidium oxide, calcium oxide, potasium silicate.

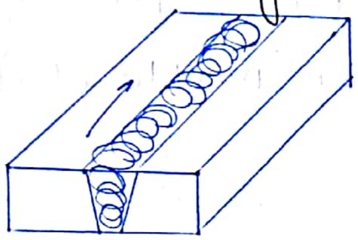
(4) Alloying element:- Cr, Ni, Co, Vd (Venedium)

(5) Gas forming Materials:-

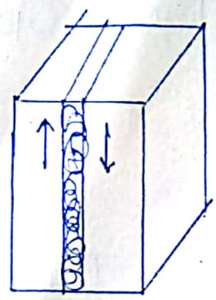
Cellulose & $CaCO_3$ (calcium carbonate)

Welding Techniques based on Position:-

(1) Flat welding:-(F)

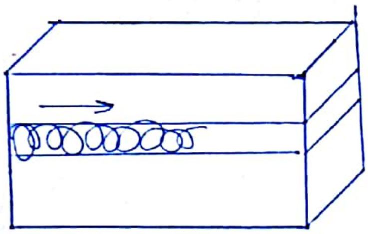


(3) Vertical (V) (V.D)

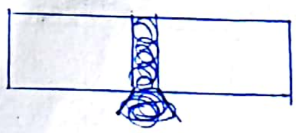


Gravity ↓
Surface tension ↑
weld pool reduce
Most preferred

(2) Horizontal welding:-(H)



(4) overhead (O)



Electrode specification: (Designation)

As per BIS standard

E	1	2	1	322	P
I	II	III	IV	V	VI

(V: 3 – T.S., 2 – Y.S., 2 – %.)

I - Type of electrode manufacturing (E = Extrusion)

II - type of flux Coating (1 - high cellulose, 2 - TiO_2 or Rutile Coating)

III - position of electrode (0 - F, H, V, D, O
1 - F, H, V, D
2 - F, H

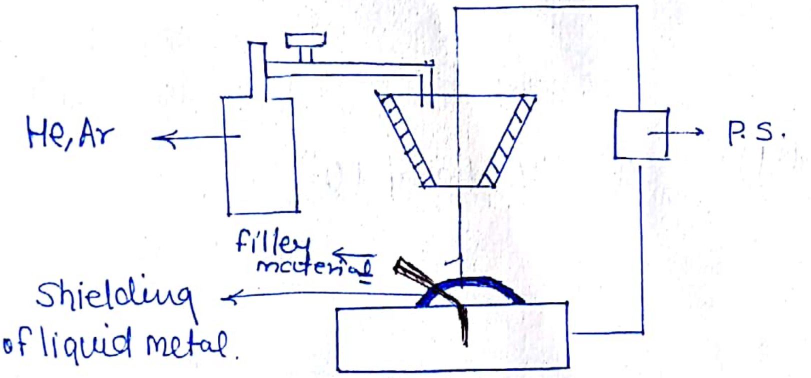
IV - Polarity (1 - D^+ direct current electrode +ve Reverse polarity
2 - D^+V90 direct current electrode +ve with V_o = 90 Volt

V - strength of electrode (a) tensile strength (3 = 300 series)
(b) Yield strength (2 = 200 series)
(c) % of elongation (2 ⇒ 2%)

VI (P) → specific information regarding electrode
P - deep penetration

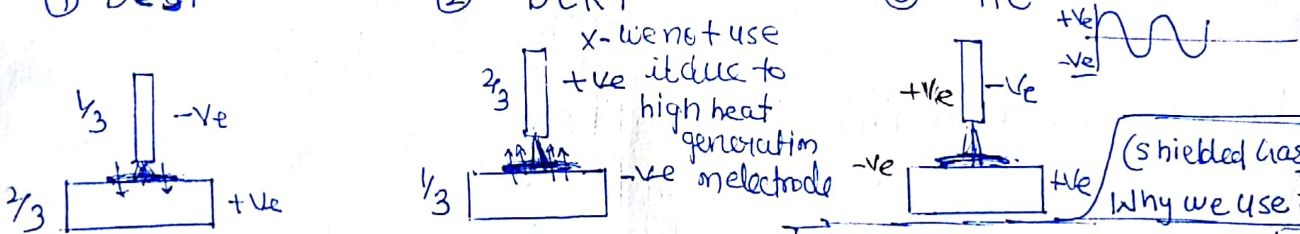
Shielded Gas arc welding :-

① Tungsten Inert Gas (TIG) :- (TIG, GTAW)
Non-Consumable electrode



① t < 5 mm
② t > 5 mm

① DCSP ② DCRP ③ AC



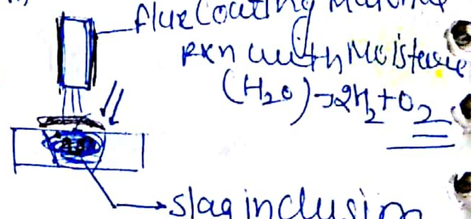
(Shielded Gas) Why we use this?

① possibility of oxide formation so we can't do Al, Mg, Alloy welding

③ First half of cycle e^- -Ve to +Ve & 2nd half of cycle e^- +Ve to -Ve so Metal Oxide Clean we can use AC. for welding of Al, Mg, Alloys.

② Initial oxide layer present but due to e^- movement from -Ve to +Ve so Oxide layer also move with e^- oxide layer can be remove by providing inert gas this process called Cathodic Cleaning

defect in Flux Coating



* In Flux Coated we can not do welding ~~of Al~~ Al, Mg Alloy because it form Al_2O_3 it will not allow metal to go inside.

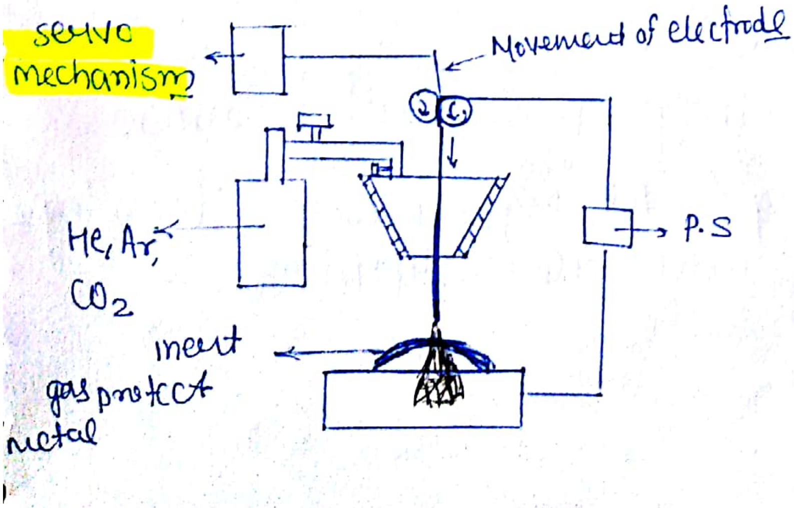
Arc is generated between a non-consumable tungsten electrode and workpiece. For welding of less then 5mm thickness of workpiece material without using filler material joint can be produced. For more then 5mm thickness of workpiece material filler material is supplied externally. and the movement is controlled manually.

Liquid metal in the weld pool can be protected by providing inert atmosphere.

For welding of Al, Mg Alloys AC power supply can be used in which 1st half of cycle due to straight polarity more heat will be on workpiece and oxide layer can be formed. In the reverse polarity movement of e^- from workpiece to electrode oxide layers cleaned from work surface this is know as cathodic cleaning.

Application:- ① welding of Al, Mg & its alloyes in automobile, aerospace and chemical industries.

② Metal inert gas:- (MIG, GMAW)

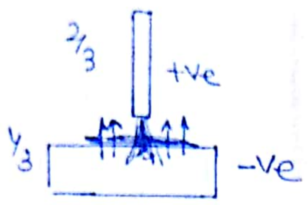


preferred for

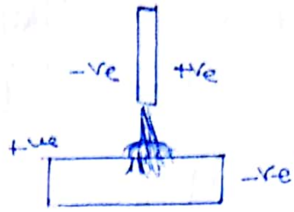
$t > 5mm$

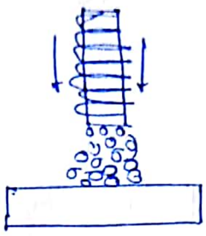
$I \rightarrow 150 - 350A$

① DCRP :-



② AC





① Droplet transfer / ② Globular transfer → due to Gravity

③ spray transfer → due to electromag. force.

Arc is generated between a consumable electrode and workpiece electrode is in the form of wire and it will be supply to the workpiece through the movement of roller. Roller movement can be controlled by providing servo Mechanism.

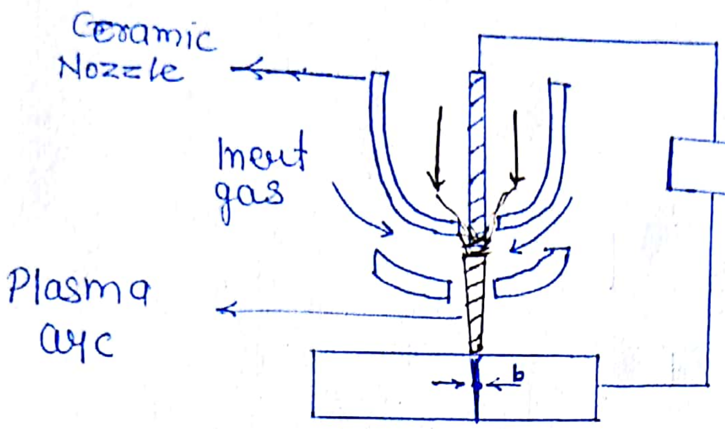
⇒ For welding of Al, Mg alloys and all other material DCRP or AC power supply can be used with high rate of current. Metal can be transferred from electrode to workpiece in the form of spray transfer due to this depth of penetration is maximum.

⇒ It will be used for welding of more then 5mm thickness of workpiece material.

⇒ Weld deposition rate & welding speed will be more

Application :- ① used for welding of Al, Mg, Cu and its alloys in aerospace and automobile industries

③ Plasma arc Welding (PAW)



I ⇒ 100-150 A

max. possible temp.

11,000 °C

Plasma high V → high K.E.

Q = AV↑

so depth of penetration high
width of weld beed low
low HAZ, use for high T_m, t

Arc is generated between a non-consumable tungston electrode and workpiece.

High pressure plasma will be supplied through the ceramic nozzle and it will produce plasma arc. Which is having high K.E. and it will be focus on work piece at a given point due to this heat concentration on the workpiece so is very high high thickness and high melting ~~mate~~ temp. material can be welded.

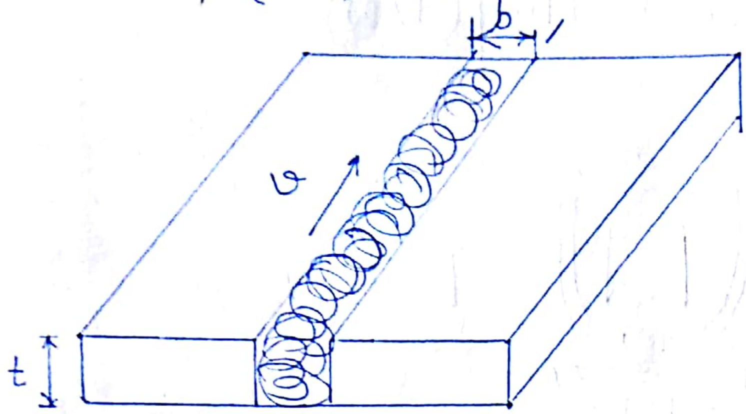
→ Weld beed width and HAZ less.

→ Depth of penetration and welding speed high.

→ Operating and maintance cost will be more.

Application:- ① Welding of Ti, Co, Mb and it alloy in aerospace, jet engine and turbine blades.

Melting efficiency (η_m)



$A_b = b \times t$

$v \to mm/s$

$P = VI \to W$

$\frac{J/s}{m^2 \cdot m/s} = \frac{J}{m^3}$

η_h – Arc heat transfer efficiency

H_m → Heat required to melt (J/mm^3)

H_s → Heat supplied (J/mm^3)

$$H_s = \frac{VI}{A_b v} \; J/mm^3$$

$$H_m = mC\Delta T + mL$$

Actual amount of heat transfer on work piece

$$H_s = \frac{VI}{A_b v}\eta_h \; J/mm^3$$ {per unit Volume}

$$H_s = \frac{VI}{v} \; J/mm$$ per unit length

$$\eta_m = \frac{H_m}{H_s} = \frac{H_m}{\frac{VI}{A_b v}\eta_h}$$

Q.13

$V = 25V$

$I = 300V$ $\quad v = 8$ mm/sec.

$\eta_h = 0.85$

$$H_s = \frac{VI}{A_b v}\eta_h \quad J/mm^3$$

$$\text{per unit length } (J/mm) = \frac{VI}{v}\eta_h$$

$$H_s = \frac{25 \times 300}{8} \times 0.85$$

$$H_s = 796.87 \ J/mm$$

Q.15

$\eta_m = 0.5$ $\quad H_m = 10 \ J/mm^3$

$\eta_h = 0.7$ $\quad P = 2 \ kW$

$A_b = 5 \ mm^2$

$$H_s = \frac{VI}{A_b v}\eta_h$$

$$\eta_m = \frac{H_m}{H_s} = \frac{10}{\frac{2 \times 1000}{5 \times v} \times 0.7} = 0.5$$

$$\Rightarrow \frac{100}{5} = \frac{2 \times 1000 \times 0.7}{5 \times v \times 10}$$

$$v = 14 \ mm/s$$

Q.28

$H_s = 1200 \ J/mm$ $\quad \eta_m = 45\%$ $\quad v = 6$ mm/sec.

$H_m = 15 \ J/mm^3$

$$H_s = \frac{VI}{v}\eta_h = 1200 \ J/mm$$

$$\eta_m = \frac{H_m}{H_s}$$

$$15 = \frac{0.45}{100} \times \frac{1200}{A_b}$$

$$A_b = 36 \ mm^2$$

Q.38

$I = 50\ A \quad V = 60\ V$

$v_1 = 150\ mm/min = \frac{5}{2}\ mm/s$

$v_2 = 120\ mm/min = 2\ mm/s$

$(H_s)_1 = (H_s)_2 \qquad V_1 = V_2$

$\left(\frac{VI}{A_b v}\right)_1 = \left(\frac{VI}{A_b v}\right)_2 \Rightarrow \frac{50 \times 60}{5/2} = \frac{I \times 60}{2}$

$I = \underline{40\ A}$

Q. 41

$v = 300\ mm/min = 5\ mm/s$

$I = 150\ A \quad V = 20\ V$

$L = 900\ mm \quad \eta_h = 0.80 \quad R = 36\ k\Omega$

$H_s = \frac{150 \times 20}{5} \times \frac{0.80}{100}$

$H_s = 30 \times 16$

$H_s = 480\ J/mm$

(42)

$I^2 D = \text{Constant}$

$I_1^2 D_1 = I_2^2 D_2$

$(100)^2 (0.60) = (160)^2 D_2$

$D_2 = \frac{100 \times 100 \times 0.60}{160 \times 160} \Rightarrow D_2 = 0.234$

$\%\ \text{Change} = \left(\frac{0.60 - 0.234}{0.60}\right) \times 100$

$\%\ \text{Change} = 60.937\ \%$

Q.46

$I = 200\,V$

$V = 25\,V$

$v = 18\ cm/min = \frac{180}{60} = 3\ mm/sec$

wire $d = 1.2\ mm$

$f = 4\ m/min \qquad \eta_h = 65\%$

$$H_s = \frac{VI}{v}\eta_h$$

(1) $H_s = \frac{25 \times 200}{3} \times 0.65 \Rightarrow H_s = 1.08\ KJ/mm$

~~$f = vAd$~~

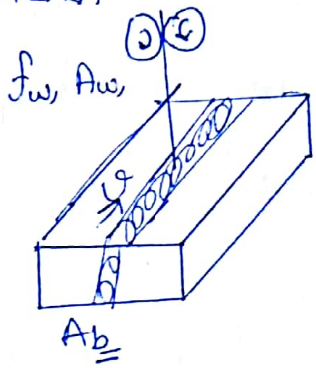
~~$\frac{4 \times 1000}{60} = 3 \times A \times 1.2 \rightarrow A = 18.51\ mm^2$~~

MIG

(2) $A_w \times f_w = A_b \times v$

$\frac{\pi}{4}(1.2)^2 \times 4 \times 100 = A_b \times 18$

$A_b = 25.13\ mm^2$



Q.30 $V_o = 80\,V \qquad I_s = 600\,A$

$V_t = V_o - \left(\frac{I_t}{I_s}\right)V_o$

$V_t = 80 - \left(\frac{I_t}{600}\right)80$

$P = I_t\left(80 - \left(\frac{I_t}{600}\right)80\right)$

$\frac{dP}{dI_t} = 0 \Rightarrow 80 - \frac{I_t}{300} \times 80 = 0 \Rightarrow I_t = 300\,A$

$V_t = 40\,V$

$P = V_t I_t = 300 \times 40$

$P = 12\,KW$

★ **Max. Power Condition.**

$$V_t = \frac{V_o}{2} \quad ; \quad I_t = \frac{I_s}{2}$$

Q.44 $V_o = 80$ $I_s = 300\ A$

$I_t = \frac{I_o}{2}$ For max. power

$I_t = \frac{300}{2} = 150\ A$

Quest Steel blades are welded by arc welding using linear power source characteristic with $V_o = 60V$ & $I_s = 300$ Amp. Arc length is $l_a = 4\ mm$, welding speed $v = 2.5\ mm/s$, & Heat transfer efficiency $\eta_h = 0.85$ arc length Voltage is given $V_a = 20 + 2.5\, l_a$ Heat input per unit length of workpiece is $H_s = ?$

Solⁿ $V_o = 60\ V$

$I_s = 300\ A$

$l_a = 4\ mm$

$v = 2.5\ mm/s$

$\eta_h = 0.85$

$V_a = 20 + 2.5\, l_a$

$H_s = ?$

$$V_t = V_o - \left(\frac{I_t}{I_o}\right) V_o$$

$$V_t = V_a = 20 + 2.5 \times 4$$

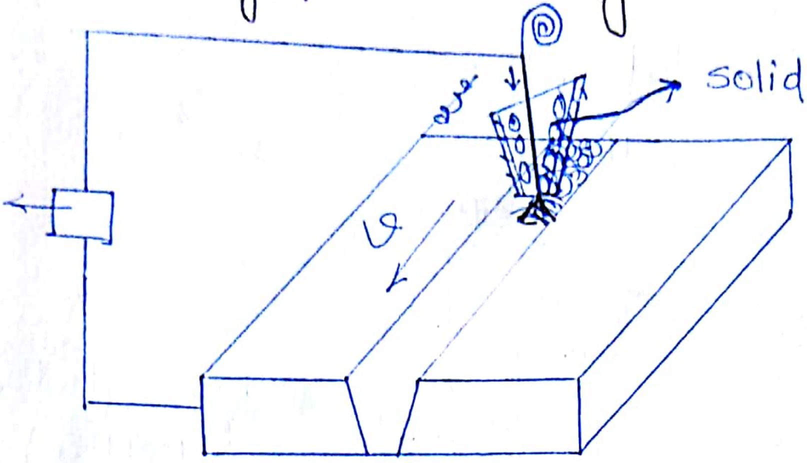
$$V_a = 30\ V$$

$$\Rightarrow 30 = 60 - \left(\frac{I_t}{300}\right) \times 60$$

$$I_t = 150\ A$$

$$H_s = \frac{150 \times 30}{2.5} \times 0.85 \Rightarrow H_s = 1.53\ KJ/mm$$

Submerged arc welding:-



$t = 15 - 50$ MM

$I = 200 - 2000$ A

deposition Rate
≈ 20 kg/hr

$v = 5$ m/min

- Automatic welding technique.
- Granulator flux

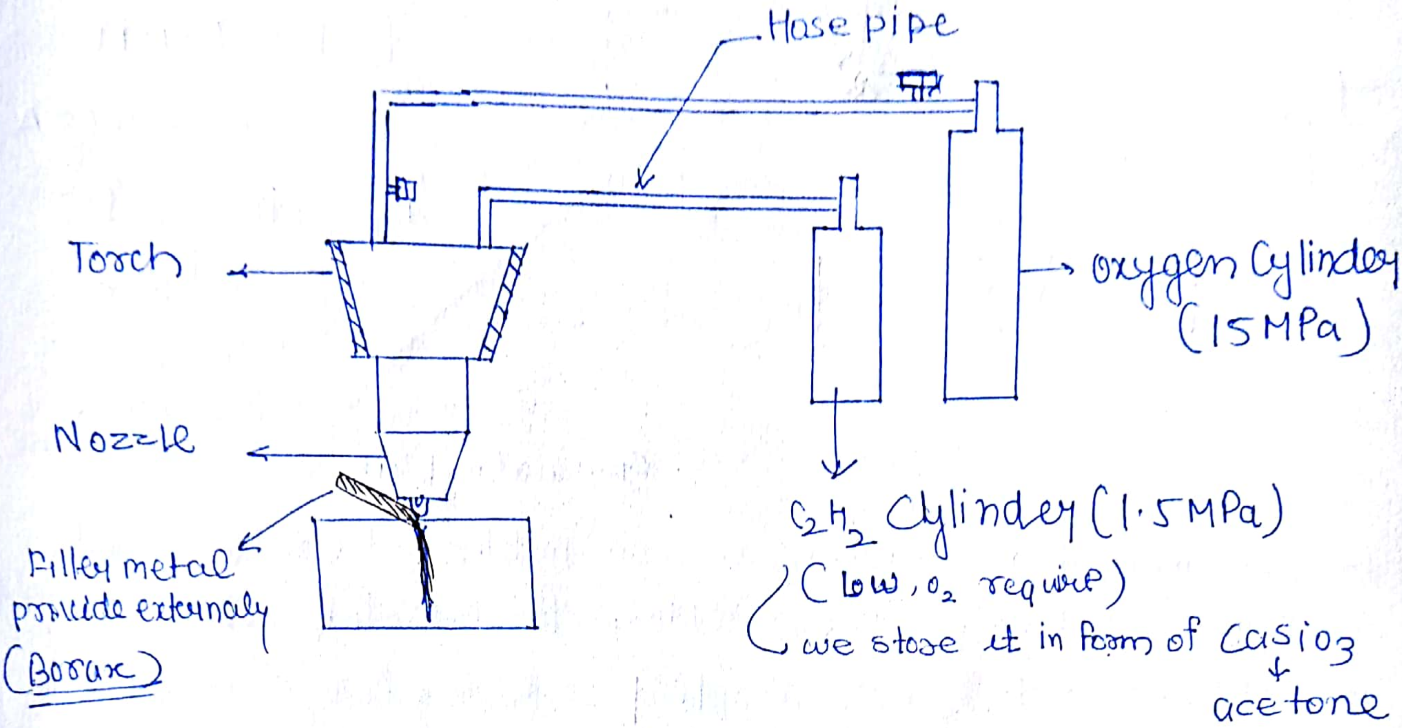
Arc is generated between a consumble electrode and workpiece. Through the welding torch solid form of the flux contineously supplied. it will be covering on the surface of arc. such that arc will be submerged under the flux due to this heat transfer losses from the arc will be reduce, Heat concentration on workpiece is increase and depth of penetration is more.

- Splashing of the liquid metal is less and weld spatter and slag inclusion will be minimum welding speed and weld deposition rate is very high.
- Used for welding of high thickness materials.
- It is used in Flat position only.
- Heat affected zone is more!

Applications!— ① Febrication of pressure vassels, & LPG Cylinder,
② joining of high thick plates in ship building

Chemical Reation Welding:

① Gas welding: (oxy-acetylene)



(Low, O_2 require)
we store it in form of $CaSiO_3$ + acetone

Primary Reaction:

$$C_2H_2 + O_2 \longrightarrow 2CO + H_2 + \Delta h_1$$

Secondary Reaction

$$2CO + H_2 + \frac{3}{2}O_2 \longrightarrow 2CO_2 + H_2O + \Delta h_2 \quad (\Delta h_2 > \Delta h_1)$$

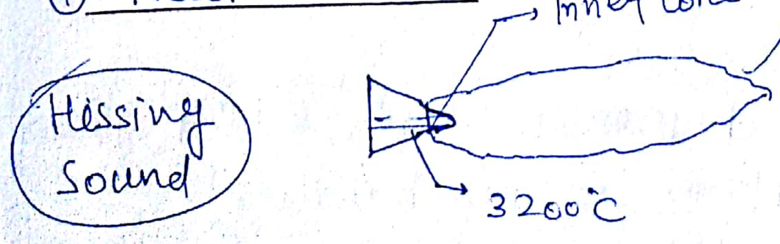
$$✓ \quad C_2H_2 + \frac{5}{2}O_2 \longrightarrow 2CO_2 + H_2O + \Delta h$$

Types of Gas Flames:-

① **Neutral Flam:-**

(white) Inner Cone

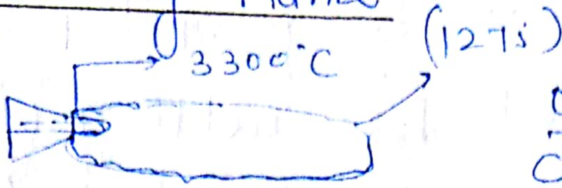
(Blue) outer flame (1275°C) — it cover more area so more heat loss



$$\frac{O_2}{C_2H_2} = 1:1$$

(2) Oxidizing Flame

(Roaring sound)



$\frac{O_2}{C_2H_2} = 1.15 - 1.5$

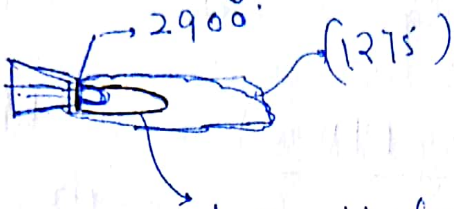
possibility of oxide formation

(High amount of O_2)

Eg. Cu, Zn can welded

(3) Carburizing Flame

(No sound)



$\frac{O_2}{C_2H_2} = 0.85 - 0.92$

Intermidiate Flam
(unburnt carbon in C_2H_2 is represented by this)

(less amount of O_2)

exo - outside
endo - inside

Eg. Ni, High C steel

→ By Burning the C_2H_2 (Acetylene) in the presence of oxyzen (O_2) due to exothermic reaction Heat will be produced and this will be used for melting of base material to produce a fusion joint.

→ For complete combustion of 1 mole of C_2H_2, 2.5 moles of O_2 is require in which 1 mole is consumed from oxygen cylinder and 1.5 mole are consumed from atmosphere.

→ By controlling the volume flow rate of O_2 & C_2H_2 different flame can be produced they will be used for different application.

Application :-

Application of Flames

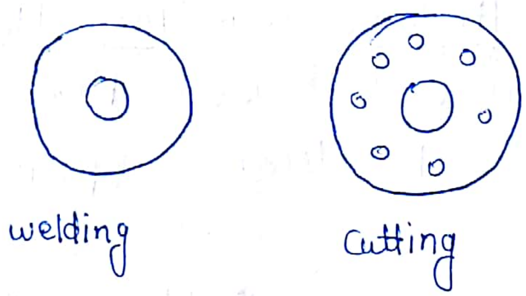
① **Neutral Flame** :- it is general purpose flame used for welding of Mild steel, low carbon steel, medium carbon steel, Al, Cast iron etc.

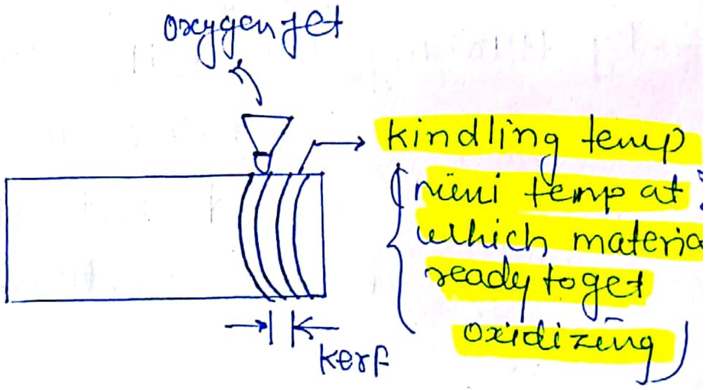
② **oxidizing Flame** - Welding of Cu, Zn, Brass

③ **Carburizing Flame (Reducing Flame)** - welding of high carbon steel and Ni bassed alloy.

Gas Cutting :-

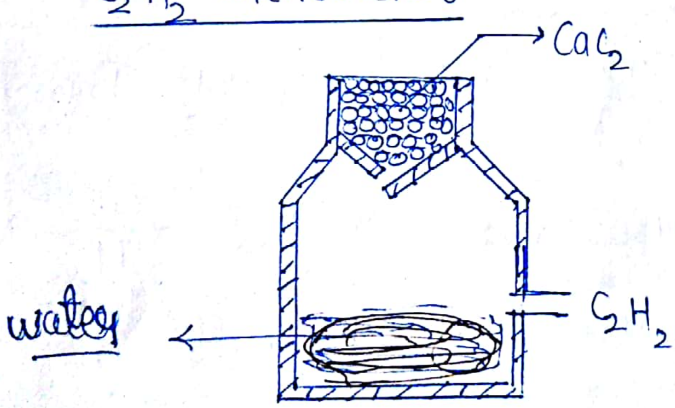
Nozzle tip





* Al oxide have more density

C_2H_2 Generator



* using this we can easly produce C_2H_2 gas

$$CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$$

Same setup which is used for welding can be used for gas cutting except in the form of nozzle tip

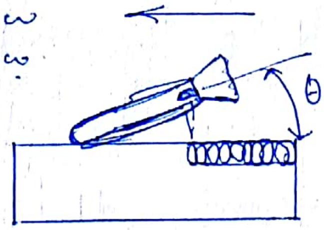
In Gas Cutting through the circumferance hole initially neutral flame is coming it will be used for preheating the base material upto kindling temp. It is a mini. temp at which material is readly to get oxidize.

After this by using high pressure oxyzen jet more amount of ~~meta~~ material is oxidise and remaining material blown in the form of droplet

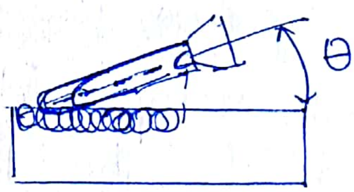
Gas welding technique :-

① Forehand ② Backhand

eg 1w' - 24w
9w' - 24w
(preheat
reduce temp diff.



$\theta \propto$ 't'

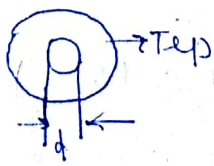


outer flame - preheating the material

- slow rate of cooling
- ~~poor~~ Coarse Grain Ductile property

Outer Flame - Reheating the material
- stress remove due to reheating
- crack formation reduce.

Nozzle



$\theta \propto t$

$d \propto$ 't'

Fore hand :- In this technique inner cone is melting the base material and outer flame is preheating the base material before welding. Due to this by reducing the diff. of temp. slow rate of cooling take place and coarse grain found which is having sufficient ductility.

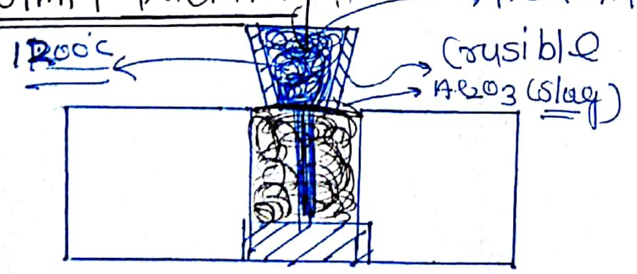
During the contraction process because of ductility by reducing internal stress crack formation can be minimize.

② Backhand:- In this technique inner Cone is melting the material and outer flame is reheating the already welded material due to stress develope in the process can be relived (Annealing)

Cast Iron

In case of cast iron if the diff. of temp is very high due to fast rate of cooling free form of the carbon will be converted into carbides They are very brittle and hard due to this crack will be formed. To overcome this cast iron can be best welded by Gas welding with preheating.

Thermit welding :-



Fe_3O_4 : Al (3:1) By mass

CuO$_2$: Al

Cr_2O_3 : Al

at 1200°C
Reaction

$$3Fe_3O_4 + 8Al \longrightarrow 9Fe + 4Al_2O_3 + \Delta h$$

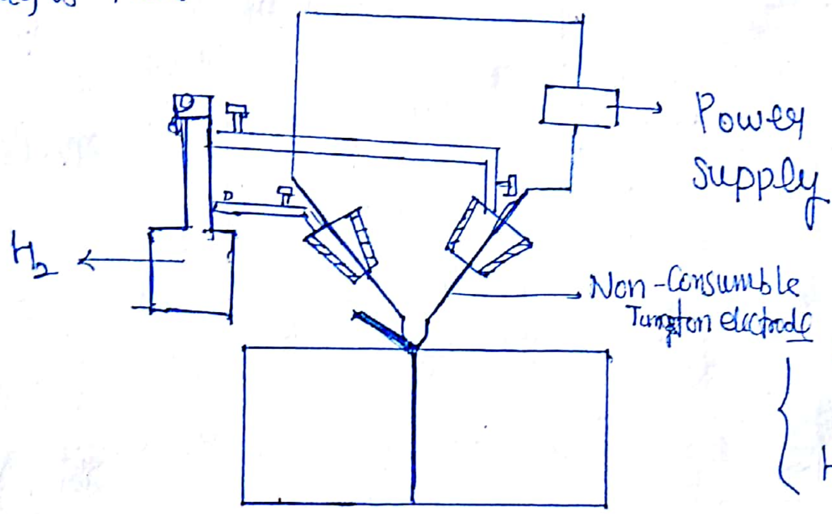
Thermit mixture can be heated in a crusible upto 1200°c by using 'Mg' rods. At this temp due to thermit reaction heat will be produced by using the heat iron will melted and it will be enter in workpiece. By allowing the liquid metal to solidify Joint can be produce, Al_2O_3 will be acting as a slag.

Applications :- Repair works of Railway rails, Joining of broken casting & high thickness plate.

Atomic hydrogen welding :-

Now a day TIG & MIG used instead of this

Heat Generate at 4000°c (No possibility of getting water at high temp)



Die steel, Tool steel can welded

AC power supply

$$H_2 \rightarrow H + H - \Delta h_1$$

$$H + H \rightarrow H_2 + \Delta h_2$$

Arc is generated between 2 Non Consumble tungston electrode. By supplying Hydrogen gas to the arc due to heat from arc Hydrogen moliclues will be dissociated into hydrogen atoms by Consuming heat from the arc. When they will be in contact with cold surface of workpiece due to unstability they will recombine as Hydrogen moliculesduring the process more heat will produced it will

be supply to workpiece for melting of workpiece.
Hydrogen gas will be acting as a heating agent and it will also act as shielding gas to protect the liquid metal from atmospheric gases.

→ AC power supply can be used.
→ Joining of tool steel & Die steel,
→ Repair works of cutting tools & Dies

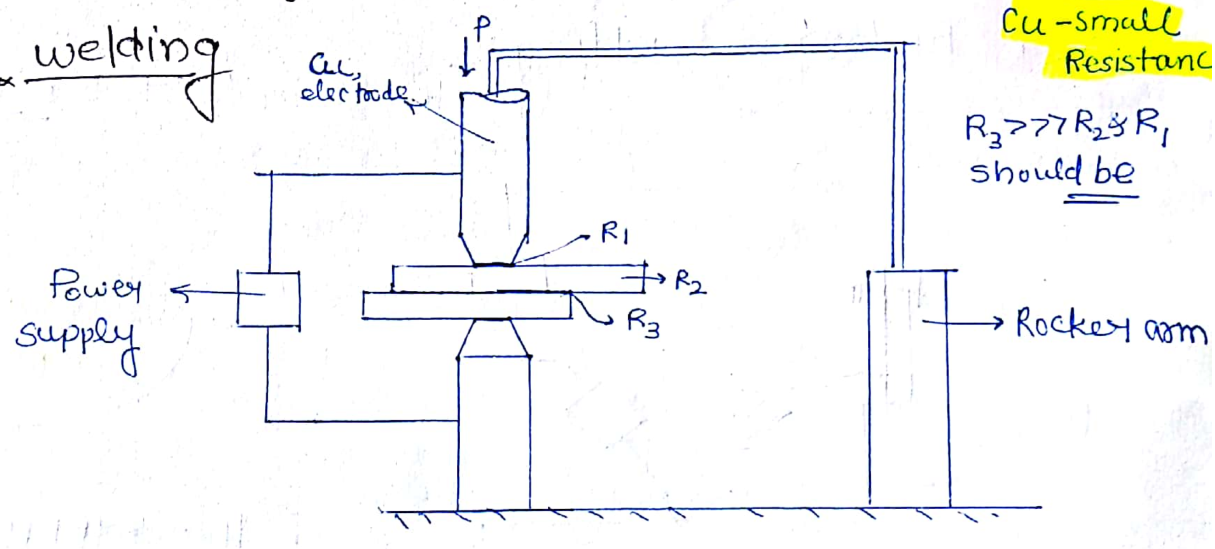
03 Aug 2016

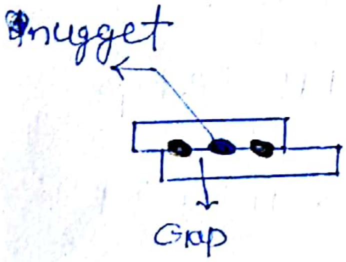
Resistance welding :-

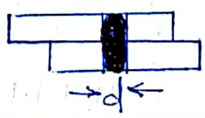
① Spot welding

Cu - small Resistance

$R_3 >>> R_2$ & R_1 should be

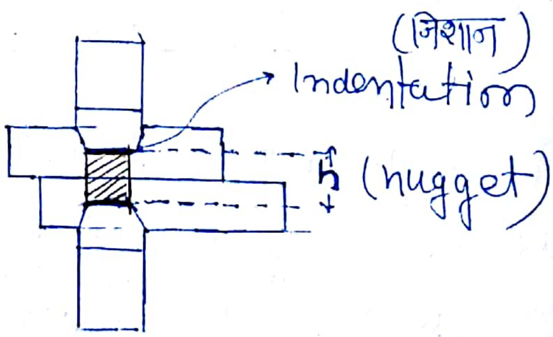


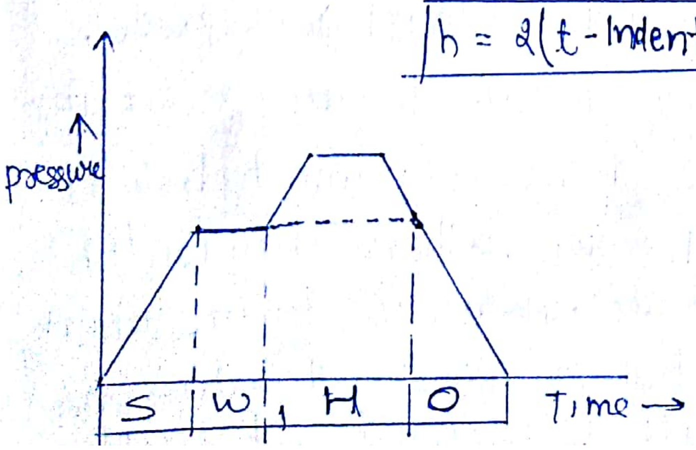




$d = 6\sqrt{t}$

$h = 2(t - \text{Indentation})$





S - squeeze time
W - weld time
H - Hold time
O - off time

} cycle time

Thickness → 1 - 2 mm (sheet)

I → 10,000 - 50,000 A

t → 0.01 - 0.5 sec.

* Cu is highly conductive and low resistive so we use Cu, electrode.

* Due to lifting of electrode again again, leak there is a small gap b/w nuggets so leak proof joint not possibles

mass of nugget $m = V\rho$

Heat require to melt $H_m = mc\Delta T + mL$

Heat supplied $H_s = I^2 RT$ J

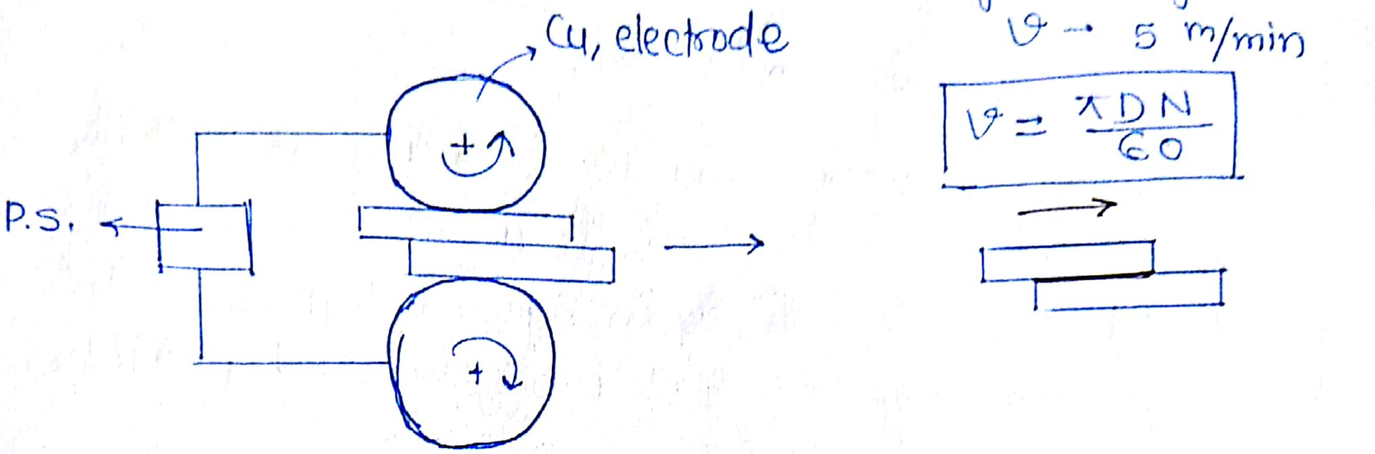
Melting efficiency $\eta_m = \dfrac{H_m}{H_s}$

* If nothing is mention about η_m than $H_m = H_s$

For joining of sheet material in mass production this technique can be use. Two sheets are provided between two Cu, electrodes. By supplying high rate of current for small fraction of time Heat will be generated at contact to two surfaces. After getting sufficient amount of heat by applying pressure joint can be formed between two surfaces below the electrode. leak proof joint not possible there is a possibility of indentation b/w electrode and workpiece.

Application :- Lap joining of sheet metals in automobile and refrigerator bodies

② Seam Welding :-



* contineous spot welding, leak proof joint possible

Two sheet are provided between two electrodes which are in the form of rollers. By supplying high rate of current through rollers heat generation takes place at the contact of workpieces.

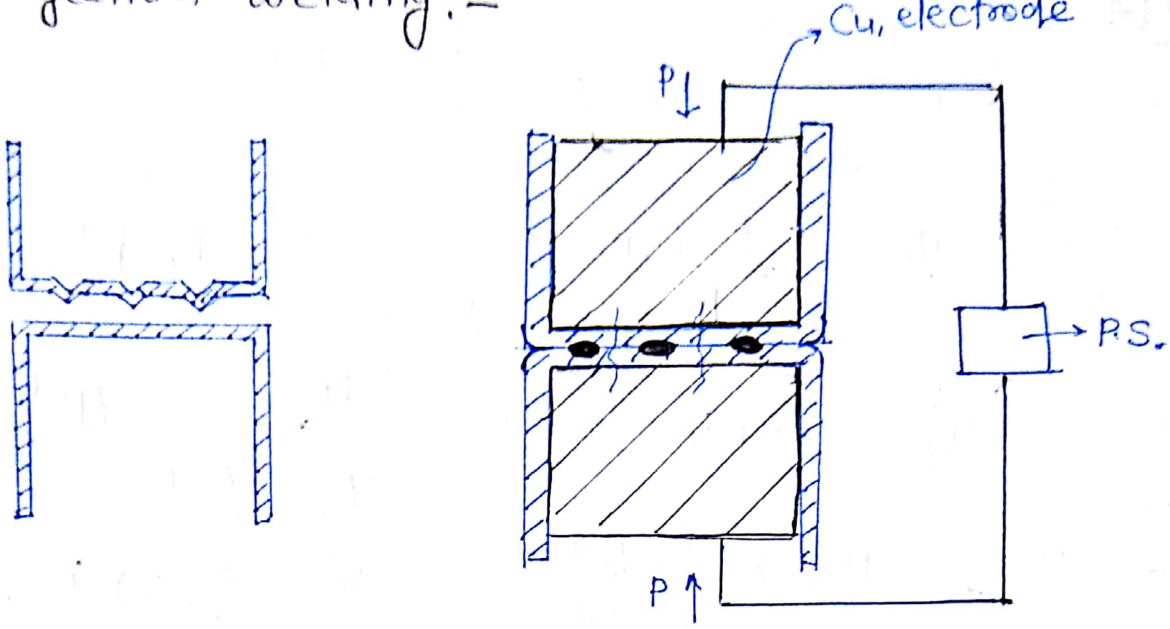
By rotating the rollers rolling pressure can be applied To produce the joint between two surfaces welding speed is more. leak proof joint can be possible.

There is a possibility of indentation between electrode and workpiece material.

Application - – febrication of fuel tanks and radiator bodies

– Mufflers used in exhaust pipe

③ Projection welding :-



* projection are produce by embossing processes

One One of the sheet to be welded produce projection by using embossing technique.

By providing two sheets between large size Cu, electrode High rate of Current can be supply. At the contact of projections due to contact resistance heat will be generated. After getting sufficient amount of heat by switch of power supply external pressure can be applied through the electrode such that nuggest can be pforms at projection. More no. of nugget can be produce in a single cycle. It can be use in mass production.

There is no possibility of indentation b/w electrode & workpiece

leak proof joint is not possible

Application :- Joining of threted screw & nuts to the sheet material

- febrication wire mess & grills.

Q.14

$t = 2\,mm$ $R = 75$ micro ohms.

$I = 6000\,A$

$t = 0.15$ sec.

$H_m = 2.9\ J/mm^3$

$d = 5\,mm$ $h_{nugget} = 2.5\,mm$

Volume of nugget

$$H_s = I^2 R t$$

$$V = \frac{\pi}{4} d^2 h$$

$$H_s = (6000)^2 \times (75\times10^{-6}) \times (0.15)$$

$$V = \frac{\pi}{4}(5)^2(2.5)^2$$

$$H_s = 405\ J$$

$$V = 49.08\ mm^3$$

$$H_m = 2.9 \times 49.08\ (J/mm^3 \times mm^3)$$

$$H_m = 142.35\ J$$

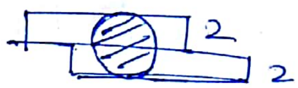
$$\eta_m = \frac{H_m}{H_s} = \frac{142.35}{405} = 35\%$$

(16)

$t = 2\,mm$ $R = 500\ k\Omega$

$I = 10^4\ A$.

time = 10 Milisecond



$m = \rho V$ $V = \frac{4}{3}\pi r^3$

$V = \frac{4}{3}\pi(2)^3 = 33.51\,mm^3$

$$H_s = I^2 R t$$

$$H_m = \rho V (C\Delta T + L)$$

$$H_s = (10^4)^2 \times (500\times10^{-6})(10\times10^{-3})$$

~~$H_m = 7000 \times (800 \times (1500) + 300) \times 33.51$~~

$$H_s = 500\ J$$

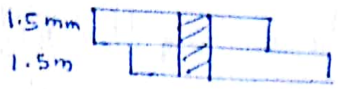
$$H_m = 33.51\times10^{-9} \times 7000\,(800\times1520 + 300\times10^3)$$

$$H_m = 351.85\ J$$

$$\eta_m = \frac{351.85}{500}$$

$$\eta_m = 70.8\%$$

Q.31



Thickness = 1.5 mm

$I = 10000\ A$

$t = 0.2\ sec.$

$R = 100\ \mu\Omega$

$d = 5\ mm$

$\rho = 8000\ kg/m^3$

$$V = \frac{\pi d^2}{4} \cdot h$$

$$V = \frac{\pi}{4}(5)^2(3)$$

$$V = 58.90\ mm^3$$

$$m = \rho V$$

$$m = 8000 \times 10^{-9} \times 58.9$$

$$m = 4.71 \times 10^{-4}$$

$$H_m = mc\Delta T + mL$$

$$H_m = mL$$

$$H_m = 4.71 \times 10^{-4} \times 1200 \times 10^3$$

$$H_m = 565.48\ J$$

$$H_s = I^2 R t$$

$$H_s = (1000)^2 \times (100 \times 10^{-6}) \times 0.2$$

$$H_s = 2000\ J$$

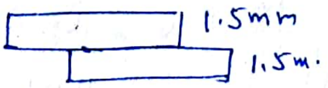
Heat require to melt $\eta_m = \dfrac{H_m}{H_s}$

So Heat supplied to sourrounding $= (1 - \eta_m) \times 100$

Heat supplied to Sourrounding $= \left(1 - \dfrac{565.48}{2000}\right) \times 100$

$$= 71.726\ \%$$

Q.42



$I = 10000$ Amp.

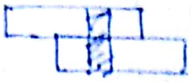
$R = 150\ \mu\Omega$

$t = 0.4\ sec.$

$$H_s = I^2 R t = (10000)^2 \times 150 \times 10^{-6} \times 0.4$$

$$H_s = 6000\ J$$

Q.32



$V = \frac{\pi}{4} d^2 . h$

$V = \frac{\pi}{4} (6)^2 . 4$

$V = 113.09 \ mm^3$

$H_m = H_s$

$V \times H_m/_V = (25,000)^2 \times R \times 0.005$

$113.09 \times 10 = 3125000 \ R$

$R = 3.619 \times 10^{-4} \ \Omega$

$R = 362 \ k\Omega$

Q.45

$\rho = 2700 \ kg/m^3$

$c = 896 \ J/kg$

$T_m = 933 \ K$

$T_a = 303 \ K$

$L = 398 \ kJ/kg$

$H_s = 0.5 \ J$

$A = 0.05 mm^2$

$V = Ah \Rightarrow m = \rho V \Rightarrow m = A h \rho$

$H_m = H_s$

$\rho V (C \Delta T + L) = H_s$

$0.05 \times h \times 10^{-9} \times 2700 \left(896 \times 630 + 398 \times 10^3\right) = 0.5$

$h = 3.84 \ mm$

Problem For a spot welding of two sheets of 3 mm thickness with welding current 10,000 A for 0.2 s Heat disipeated to base metal is 1000 J, Assuming Heat required for melting is $H_m = 20 \ J/mm^3$, Contact resistance $R = 200 \ k\Omega$ what is the volume of weld nugget.

Sol^n

$I = 10{,}000\ A$

$t = 0.2\ s$

$H_l = 1000\ J$ → Heat loss

$H_m = 20\ J/mm^3$

$R = 200\ k\Omega$

$H_s = I^2Rt = (10^4)^2 \times 200 \times 10^{-6} \times 0.2$

$H_s = 4000\ J$

$H_d = H_s - H_m$

$1000 = 4000 - V \times 200$

$V = 150\ mm^3$

Heat require to melt

$H_m = H_s - H_d$

$H_m = 4000 - 1000$

$H_m = 3000\ J$

$\eta_m = \frac{3000}{4000} \times 100 = 75\%$

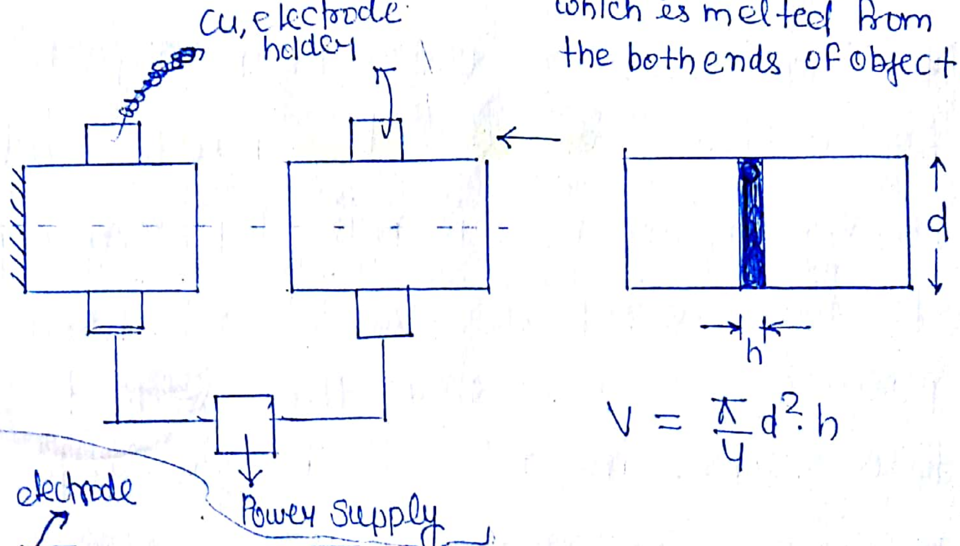
Flash Butt welding :-

h - width of weld beed

h - amount of material which is melted from the both ends of object.

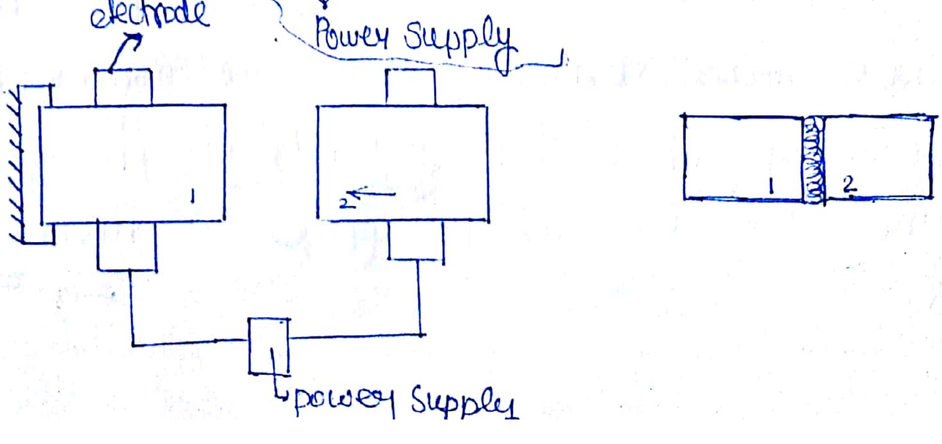
* Heat produce due to contact Resistance.

*Prefffered of object dia $\phi \to 0.2 - 25\ mm$

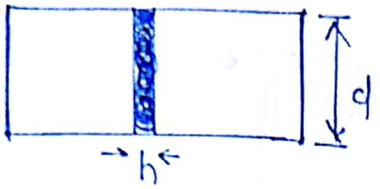


$V = \frac{\pi}{4} d^2 h$

Flash welding :-



Flash Butt welding (Heat generation less)



$V = \frac{\pi}{4} d^2 \cdot h \Rightarrow m = \rho \times V$

$H_m = mC\Delta T + mL$

$H_s = I^2 R T$

$\eta_m = \frac{H_m}{H_s}$

h - amount of material which is melt from the both ends of object.

Flash welding (Heat Generation High)

* Heat generation due electric arc. So it is not resistance welding it is arc welding.

Flash Butt welding

For joining of the object end to end to produce a butt joint between the two surface this technique can be use. Two objects which are to be welded one will be fixed and other is having linear movement. By making the contact of two workpieces end to end flash will be produce. By increasing the contact between the two surface heat will be generated due to resistance between two surface. After getting sufficient amount of heat by switch of the power supply external pressure can by applied a fusion joint

Flash welding

By providing two workpiece between two Cu, electrode holder initially contact is made between the two surface due to short circuit arc will be produced inorder to continuous the arc further some gap is maintain b/w two workpiece. Due to electric arc b/w two surfaces Heat will be generated. After getting sufficient amount of heat by switch off the power supply external pressure can be apply to produce the joint

Application! – Joining of objects end to end which are made up of low carbon steels, high carbon steel, Al alloys ($\phi = 0.2 - 25$ mm)

Problem!– Two hollow of 110 mm outside diameter and 100 mm inside diameter are joint by flash butt welding using 30V power supply at interface 1 mm material melt from each pipe which a internal resistance $R = 42.4\,\Omega$ heat require for melting of metal is $H_m = 64.4\ MJ/m^3$ time taken for welding is,

Sol^n

$V = \frac{\pi}{4}(110^2 - 100^2)(2)$

$Vol = 3298.67\ mm^3$

$V = IR$

$I^2 = \frac{V^2}{R^2}$

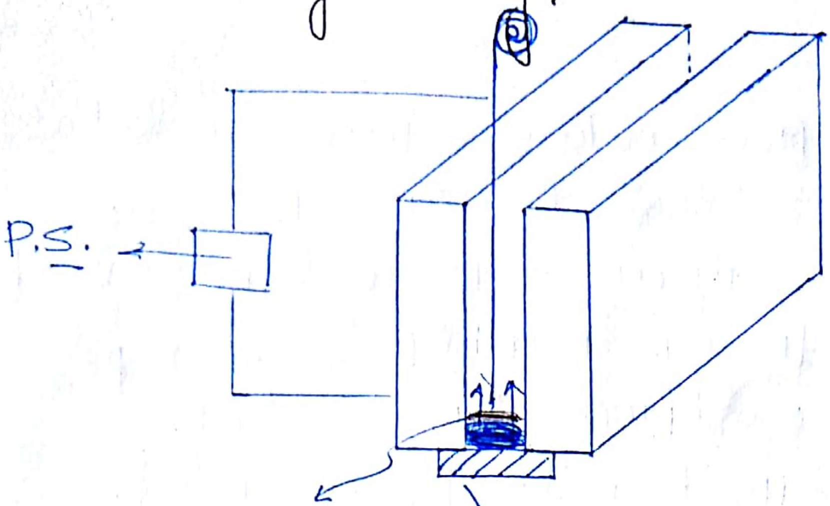
$H_m = H_s = I^2Rt = \frac{V^2}{R^2} \cdot Rt$

$64.4 \times 10^6 \times 3298.67 \times 10^{-9} = \left(\frac{30}{42.4}\right)^2 \times 42.4 \times t$

~~$t = 9.86$ sec. ≈ 10 sec.~~

$t = 10$ Sec.

Electroslag Welding :-



High thickness

$t = 50-200\ mm$

$I = 1000\ A$

DCRP

* Done only in ~~horizontal~~ verticle position

* No. of electrode increase according to width of workpiece.

For welding of High thickness objects edge to edge this technique can be used.

Arc is generated between ~~two~~ workpiece and electrode

By melting the material between electrode and workpiece liquid metal is form and by adding the flux slag will be produced.

When the height of liquid metal is increasing & it will be in contact with electrode due to short circuit arc will be extingash and further heat generation will be continude by supply high rate of current due to resistance of slag.

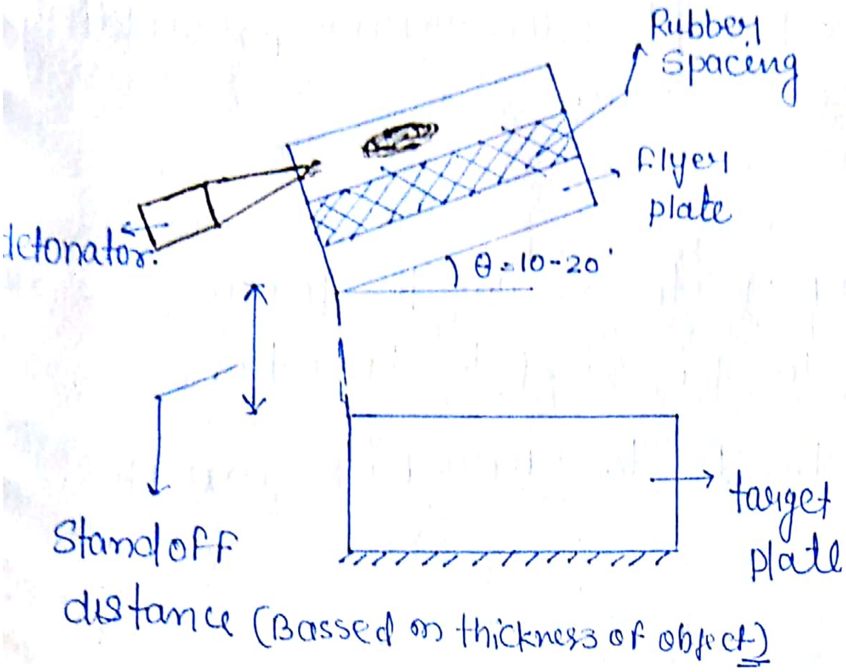
For welding of large width of workpiece more no. of power source are provided by providing more electrode welding will be done ~~in~~ only in vertical upward direction

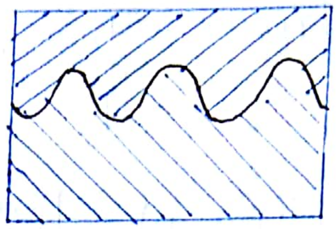
Application :- Ship building, febrication of press frame and rolling mill stand.

Solid State (Autogenous)

Explosive Welding :-

(Low velocity Explosive material)
* TNT
* Dynamites
* Ata Ammonium Nitrate





should have high thoughness (High strength)

* Not adding any filler material
* temp. is not more then T_m (i.e. room temp.)

Cladding – Adding of corrosion resistance material to non corrosion resistance material ~~adding~~ in solid state called Cladding

- For ~~adding~~ welding of high thickness plate surface to surface this technique can be use.

Two workpiece which are to be welded, one will be fixed (target plane) and other is movable (flyer plate)

By exploding low velocity explosive material above the flyer plate it will be forced on to the surface of ~~tag~~ target plate with more impact energy at the contact surface due to plastic deformation joint can be formed.

- Flyer plate is maintain some distance with target plate to gain the momentum.

→ Flyer plate is provided some inclination to Horizontal plane to provide direction for welding ∴ strength of joint is very high.

Application :- ① Disimilar material can be join like Al to Ti, steel to Ti etc.

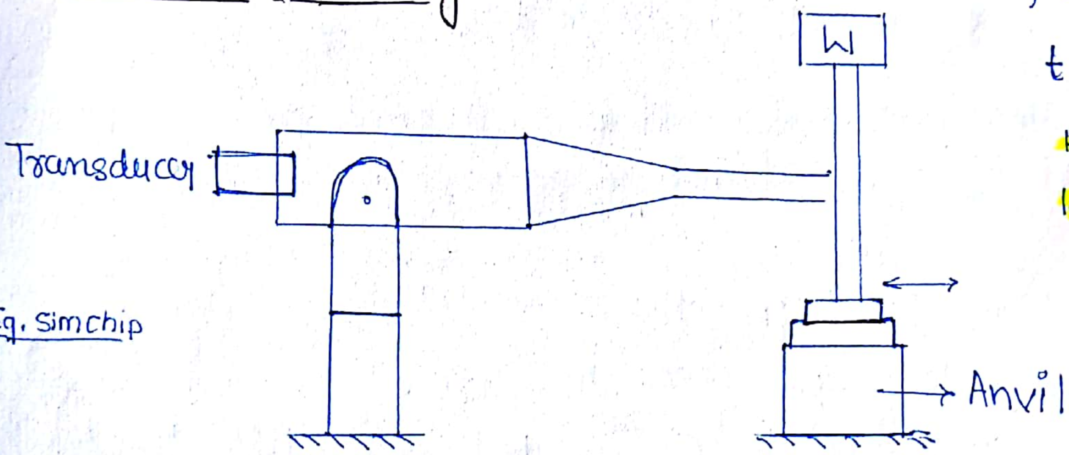
② Cladding of the objects to increase Corroso resistance.

Ultrasonic Welding :-

f → 20-60 kHz

t < 1-2 mm (foils)

High Frequency
low Amplitude



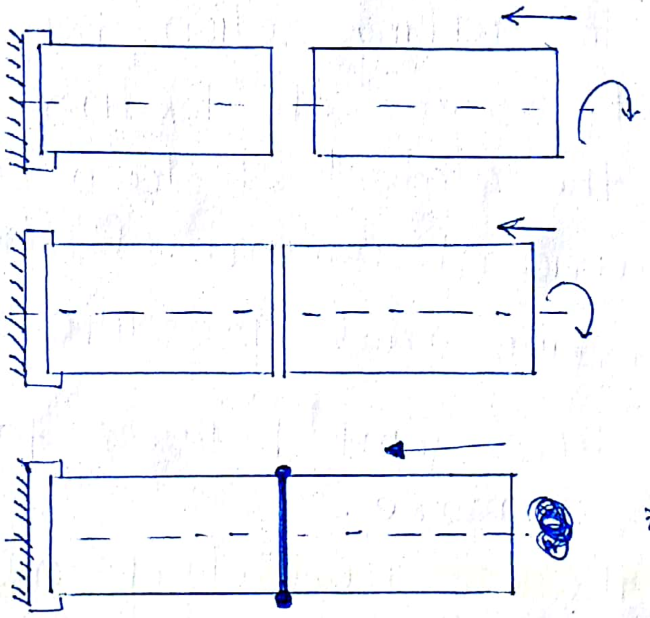
Eg. Simchip

For joining of less thickness object like foils this technique can be use ultrasonic vibration are produce using transduce. They will be transfer to the workpiece through clamp Due to vibration at the contact of two surface due to rubbing action heat will be generated. After reaching 30 – 40 % to melting temp. by applying external load joint can be formed at the contact of two surfaces.

* Heat affected zone is negligible.
* Accuracy and strength of joint is more.

Application :- - Joining of armtaure binding
- febrication of keys
- Joining of similar and dissimilar material like Al to Glass etc.

Friction welding :-



N → 4000 - 6000 rpm

P → 40 - 400 MPa

* object must be co-axial

P < Area, strength } depends on

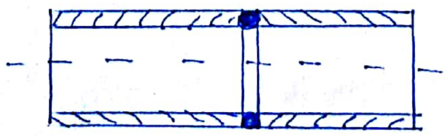
* Stop rotation by seeing colour (Redish cherris colour)

* Hollow object they must be having some thickness.

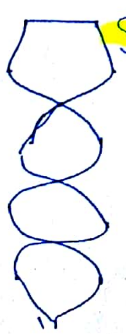
$F = P \times A$

$F_f = P \times A \times \mu$; $T = F_f \times r$; $P = \frac{2\pi N T}{60}$

Hollow object can also weld



* pipes & Valves



For joining of object which are having more strength and large size object in mass production this technequie can be used.

Two objects which are to be welded one will be fixed and other is having rotational and axial movement.

By making the contact of rotating object with fixed object at contact surface oxide layers can be cleaned due to rubbing action. Due to continuous contact because of friction heat will be generated at the contact of two surfaces. After getting sufficient amount of heat by stoping the rotation axial pressure can be increase to produce joint between two surfaces.

* strength of joint is more.
* It is used for the co-axial objects only

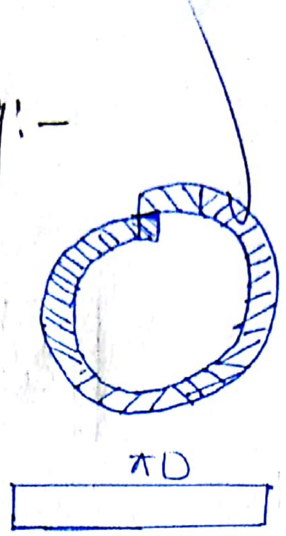
Application :- ① Joining of drill bit to shank

② Axle & hub

③ Pipes and values

122

Forge Welding:-



It is similar to blacksmithing operation object will be heated by keeping inside the forge and hammering force will be applied to deform the object into required shape and size.

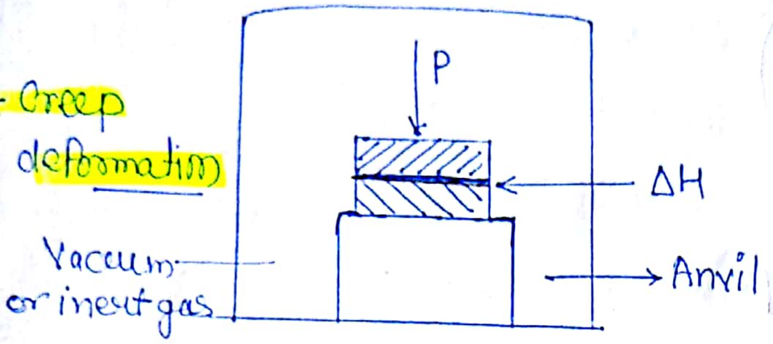
After producing the required shape by applying hammering force required shape of object can be produce by joining two ends.

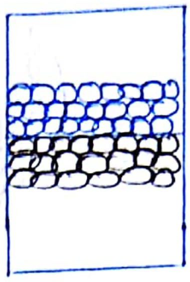
At high temp. there is a possibility of oxide form to overcome this flux material (Borax) will be used.

* Accuracy and surface finish of object will be less

Application:- Generally used for village level agriculture application

Diffusion Welding :-





* applying heat and pressure simuntaneously.
* time taking process. . Costly.
* Use vaccum & inert gas to reduce effect of oxides.

Two objects will be provided in intimate contact. By applying heat and pressure simuntaneously w.r.t. time gradually, time depandent deformation know as creep deformation will takes place at the contact of two surface by deffusing the grain at the contact of surface uniform mechanical properties can be possible.

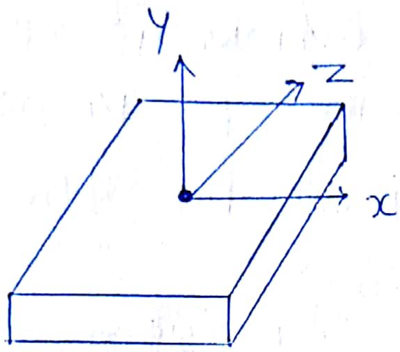
Accuracy and strength of the joint is more

Application :- ① Joining of highly refractory material like ceramic to aluminium, Graphite to Al,

② Febrication of composite leminate.

Heat Flow characteristic:-

① 3-D Flow



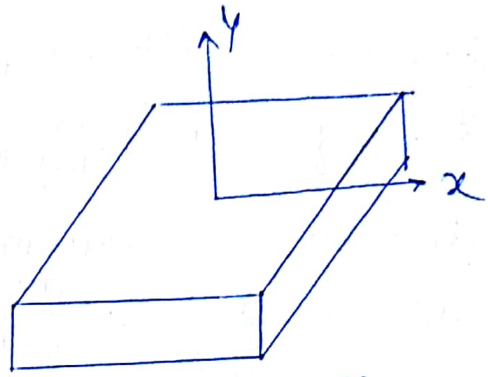
$H = f(x, y, z)$

Point source

Ex:- spot welding

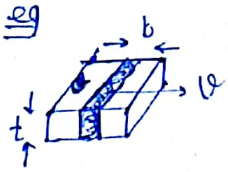
$$Q = \frac{5}{4}\pi b k \theta_m \left[\frac{2}{5} + \frac{vb}{4\alpha}\right]$$

② 2-D Flow



$H = f(x, y)$

eg



line source

Ex: Butt Joint.

$$Q = 8 k \theta_m t \left[\frac{1}{5} + \frac{vb}{4\alpha}\right]$$

★ $v \propto \frac{1}{b} \propto$ cooling rate

★ Heat supplied depend on $k, \alpha, (t_m - t_a)$

★ If welding speed is high, cooling rate is also high. low weld width.

- amound of heat input & strength also low if velocity high.

$$v \propto \frac{1}{b} \propto \text{Cooling Rate}$$

Q = amount of heat input

b = weld beed width.

k = theermal Conductivity

θ_m = diff. of melting & ambient temp.

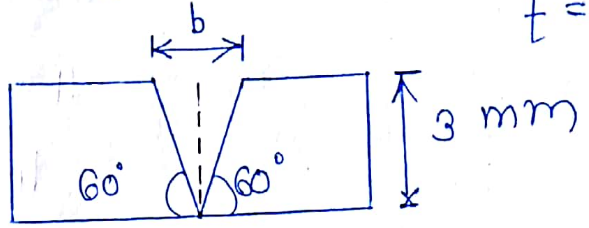
v = linear welding speed

α = thermal diffusivity

t = thickness of workpiece

Problem:- In a butt welding process heat input is given by $Q = 8k\theta_m t\left[\frac{1}{5} + \frac{vb}{4\alpha}\right]$. Two steel plates to be welded with a power source of 2.5 kW with a heat transfer efficiency of 85%. Take $k = 45\ W/m^\circ C$, $\alpha = 1.2\times10^{-5}\ m^2/s$, $\theta_m = 1450^\circ C$ determine maximum welding speed for the joint as shown in fig

t = 3mm



t = 3

Sol^n

$b = ?$ $\tan 30^\circ = \frac{b/2}{3} \Rightarrow b = 3.464\ mm$

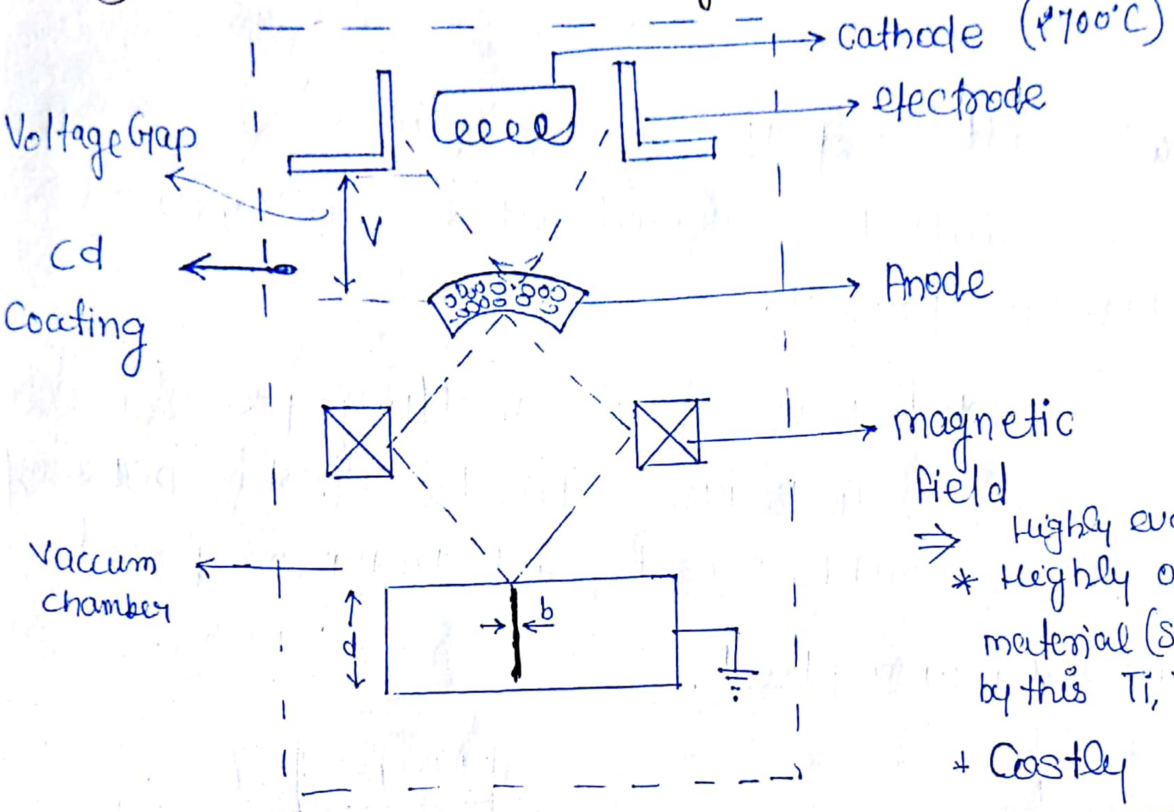
$$Q = 8k\theta_m t\left[\frac{1}{5} + \frac{vb}{4\alpha}\right]$$

$$2.5\times10^3\times0.85 = 8\times45\times1450\times3\times10^{-3}\left[\frac{1}{5} + \frac{v\times3.464\times10^{-3}}{4\times1.2\times10^{-5}}\right]$$

$$v = 16.03\ mm/s$$

Radient Energy technique! –

① Electron Beam welding (EBM)



⇒ Highly evorating &
* Highly oxediring material (Super alloy) welded by this Ti, Tg, Barium
+ Costly
* Vaccum chamber requir

V → 40 – 120 KV

ϑ → 50,000 – 2,00,000 km/s (2×10^8 m/s) Velocity of e^-

d : b (depth : width) b → very small

10:1 → 30:1 ϑ → 10 m/min (Welding speed)

Electron are emitted from cathod at high temp. They will be directed towards Anode by providing electrode. By creating more potential diff. between cathod and anode e^- will be accelarated towards anode by creating the magnetic field e^- coming from difference direction can be converge as a single ray of electrone beam which is having high energy and it will be

Focus on workpiece at a given point. Due to this heat concentration on workpiece is very high

* depth of penetration & welding speed is very high
* Weld bead width and HAZ is minimum.

This process will be carried out under vaccum it is expansive process.

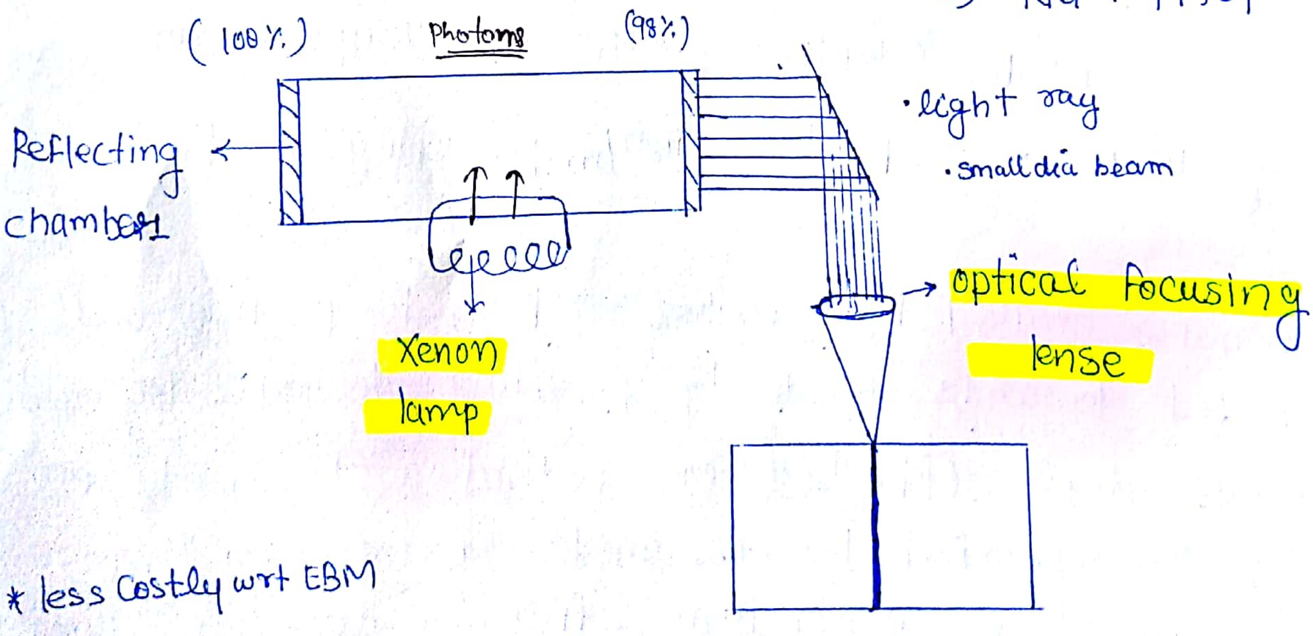
Application:- Joining of high melting point material like Ti, Barium, stainless steel (Super alloy Tungston in aircraft, misel, ~~cast~~ gas turbine part and nuclear power plant.

04 Aug 2016

Laser Beam welding :-

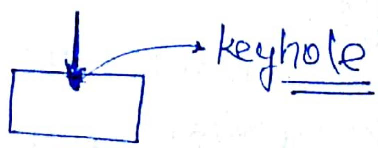
1) CO_2 laser

2) Nd : YAG



* less Costly wrt EBM
* d : b

4 : 1 → 10 : 1



Atoms will be pumped into high energy level by using xenon lamp. At high energy level atoms will emit the energy in the form of photons. From the reflecting chamber monochromatic and cohrent light rays will be coming and they will be directed towards the workpiece by using optical focusing lense. This laser beam will be focus on the workpiece at a given point due to this heat concentration on the workpiece will be very high. Depth of penetration and welding speed will be maximum. weld beed width and heat affected zone will be negligible.

Application:- welding of high carbon steels, Ti alloy super alloy in aerospace and electronic industries.

⇒ CO_2 laser it is gas laser mixture of CO_2, He, Ar

⇒ Nd : YAG (Solid laser)

Nd → Neodymium

Y - Yttrium

A - Al

G - Garnet.

⇒ Titanium → high T_m

⇒ Tungston → high oxidation forming tendancy

2 Solid/ Liquid state Welding :-

Base Metal - solid

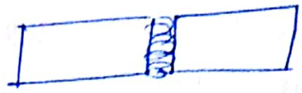
Filler Metal - liquid

(wetting & spreading)

- Brazing >427° ; < M.P. base.
- Soldering < 427°

Why edge prepration

- easier filling of liquid
- more depth of penetration



Solder ↳ (lead + Tin) → Filler Material

at 427° tin start evaporating

* Filler material enter due to capilary action.

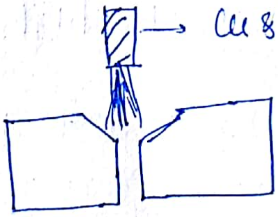
Soldering, solder → lead + tin (soldering) HCl + ZnCl (flux Materials)

speltar → Cu & Zn, Cu & Al, Cu & Ag (Brazing

Flux material - Borax, (Brazing)

→ Cu & tin (Braze

Braze welding

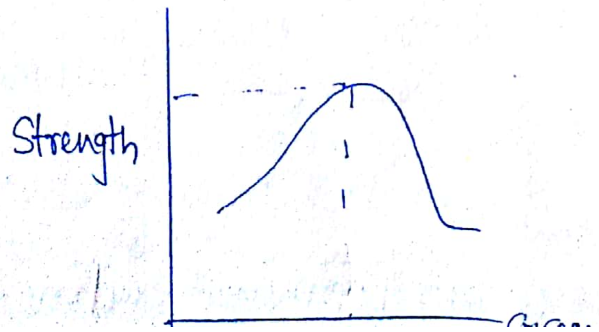


temprature

↘ $T_{welding} > T_{brazewelding} > T_{brazing} > T_{soledering}$

Strength

$\sigma_{welding} > \sigma_{brazewelding} > \sigma_{bracing} > \sigma_{soledering}$



Soldering:- Filler material melting temp is less than 427°c (< 427°C).

→ Filler material is an alloy of lead and Tin known as solder.

→ Filler material enter into the gap between two workpiece by means of capilary action.

→ strength of joint is less.

→ Flux material used is zinc cloride (ZnCl) and HCl

Application! ① Electrical & electronic circuit design
② Febrication of PCB's (Printed circuits board.

Brazing:- Filler material meting temp is greater then 427°c (> 427°c) and less than melting temp of base material.

→ Filler matel is an alloy Cu & Zn, Cu & Al, Cu & Ag it is know as spelter

→ Filler metal is enter into workpiece by means of capilory action

→ strength of joint is more than soledring but less than welding

→ Flux material used is Borax.

Application! ① Joining of hydrollic circuit to minimize leakage
② Febrication of heat exchanger & radiator.

Braze welding :– Filler material melting temp is greater than 427° (> 427°) and less then melting temp. of base material.

→ Filler metal is an alloy of Cu + Tin (Bronze)

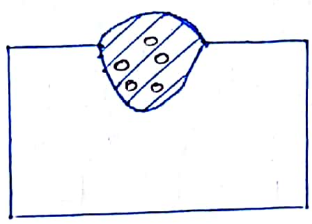
→ Filler metal is enter into the workpiece by means of gravity force.

→ Strength of the joint is more.

Application :– ① Joining of cutting tool tips.

Welding Defects

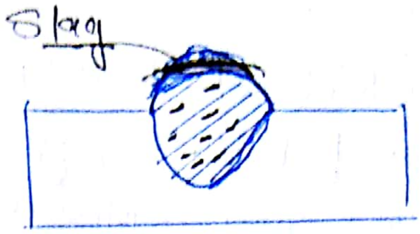
① Gas porosity :–



If the liquid metal is ~~trap~~ absorving gasses from atmosphere and they will trapped inside the weld bead will form gas porosity.

Remedies :– ① Provide sufficient amount of flux & protect liquid metal by providing inert gas atmosphere.

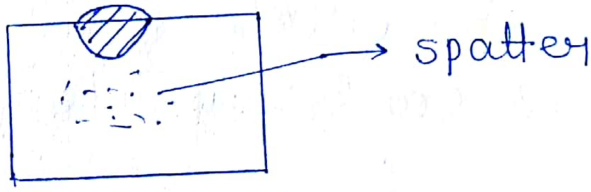
② Slag inclusion:-



Due to lack of heat input and ~~insuff~~ improper possitioning of welding torch with workpiece, if the slag is trapped inside liquid metal will form slag inclusion.

Remedies:- Provide sufficient amount of heat input and position the welding torch properly.

③ Weld spatter:-



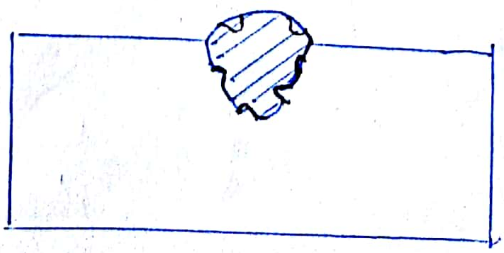
Due to excess amount of heat input liquid metal can be splash off to the base metal will form a rough surface know as weld spatter.

Remedies: ① Provide sufficient amount of heat input

② Reduce arc blow.

③ select optimum welding speed.

④ lack of fusion & Penetration:-

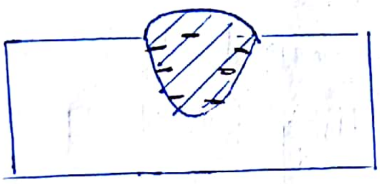


Due to ~~excess~~ leck of heat input and excess amount of welding speed filler metal is not fused properly with base metal and depth of penetration is less

Remedies!– ① Provide sufficient amount of heat input

② Select optimum welding speed.

⑤ Cracks:–



→ Due to non uniform cooling Internal stress will be develope inside the weld weed.

If the stress will be more than the strength of material cracks will be form.

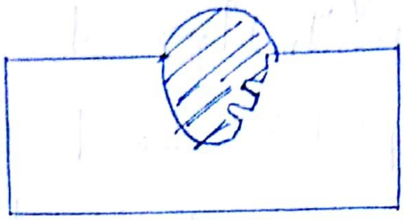
Hydrozen embrittlement!– IF atmosphere gas trapped into the weld ~~weed~~ bead and it will be penetrated into the base metal will form a crack known as hydrozen embrittlement.

Remedies:– Provide uniform cooling using preheating and post heating.

Preheat the electrode before welding

⑥ Weld Decay :-

Only in case of stainless steel. (SS)



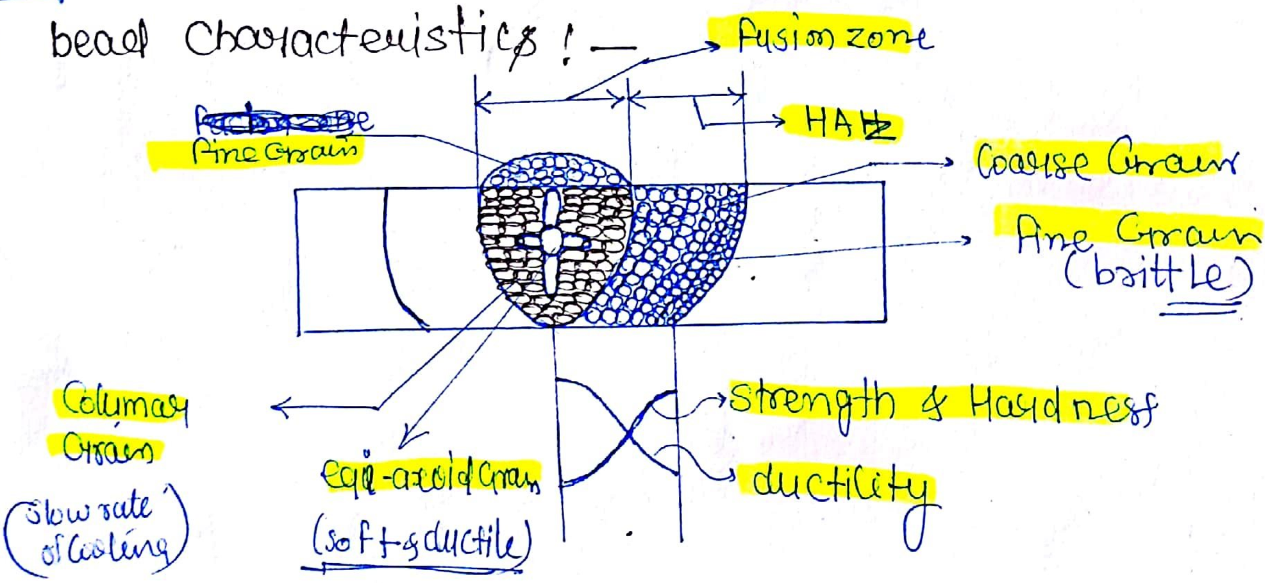
$Cr \xrightarrow{O_2} Cr_2O_3$

In stainless steel due to fast rate of cooling Chromium will be converted in chromium carbide. Due to this in absence of Chromium there is a possibility of Corroson will takes place Due to ~~which~~ this there is possibility of cavities can be form in the weld bead is known as weld decay.

This can be overcome by providing uniform Cooling with preheating and post heating.

* V. Imp

Weld bead Characteristics :-



☆ Weldability

	Weldability
① Melting temp $(T_m)\uparrow \Rightarrow$	$\downarrow$
② thermal conductivity $(K)\uparrow \Rightarrow$	$\downarrow$
③ coeff. thermal expansion $(\alpha)\uparrow \Rightarrow$	$\downarrow$
④ % of carbon $\uparrow \Rightarrow$	$\downarrow$
⑤ oxide formation. tendency $\uparrow \Rightarrow$	$\downarrow$

eg Which is easy to weld → m.s, Al, Cu, C.I.

⇒ order m.s., CI, Cu, Al → oxide formation