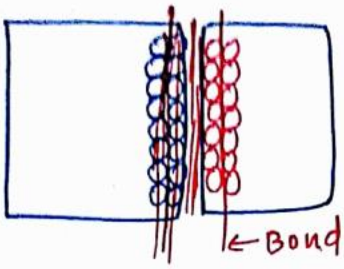
14/9/2016

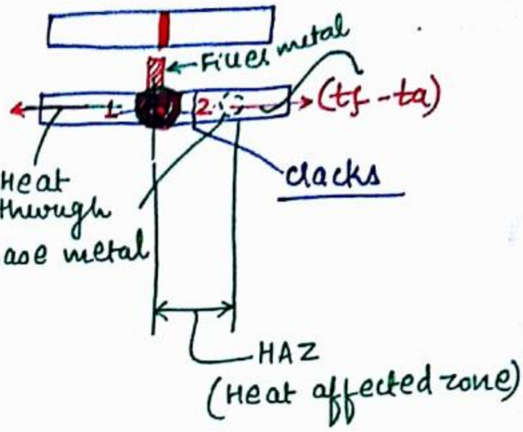
WELDING



fused

① t<5

② t>5



AWS

American welding Society.

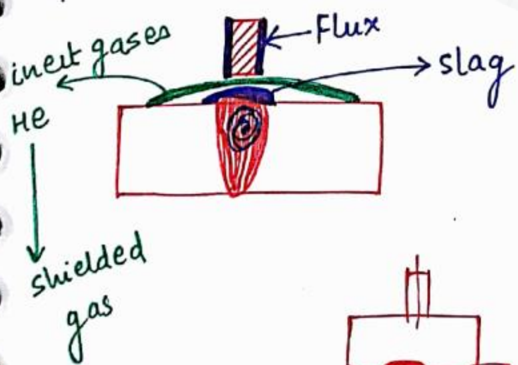
ANNEALING →
(heat treatment process)

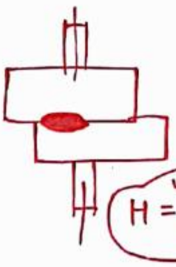
Book → ✓ Ghosh & Malik.
✓ Kalpakjian.
✓ Richard little.

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 materials.

Welding

- Solid state (Autogeneous) ← Two Base metals no filler material.
  - Explosive
  - ultrasonic
  - Friction
  - Forge
  - Diffusion
- (Fusion) Liquid state (Homogeneous)
  - Arc
    - Flux cored
    - shielded Gas
      - TIG
      - MIG
      - PAW
    - submerged
  - Resistance
  - Chemical Reaction
    - Gas
    - Thermit





$H = I^2RT$

Welding

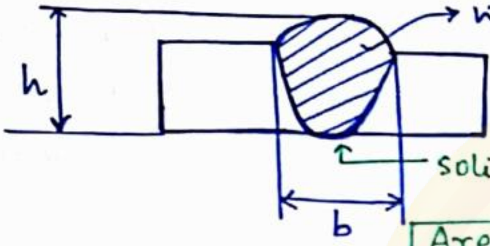
Solid / Liquid (Hetrogeneous)

- Brazing
- Soldering

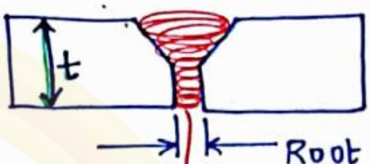
* **WELDING TERMINOLOGY** :-

① **Butt Joint** :-

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

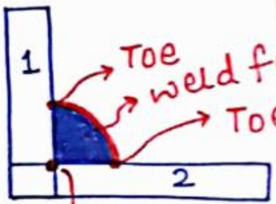


$\boxed{\text{Area} = b \cdot h}$

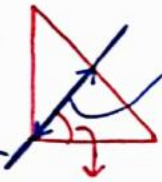


✓ strength also in bottom → hence more strength of joint

Fillet weld :-



✗ 0 strength



Throat → shortest dist. b/w weld face & Root

45° → shear force applied → then shear failure occurs.

* Weld Pool :- Amount of liquid metal between the 2 workpieces before solidification.

* Weld Bead :- Amount of material which is enter into the workpiece in a single pass.

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

* Penetration :- Amount of material which is penetrated into Base material.

* Root gap :- It is a minimum distance between 2 workpieces before joining.

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

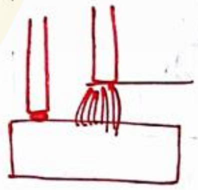
* Root :- It is a point of deepest penetration in a fillet.

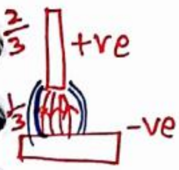
* Throat :- It is a shortest distance b/w Root and weld Face. It is a weakest section in a fillet.

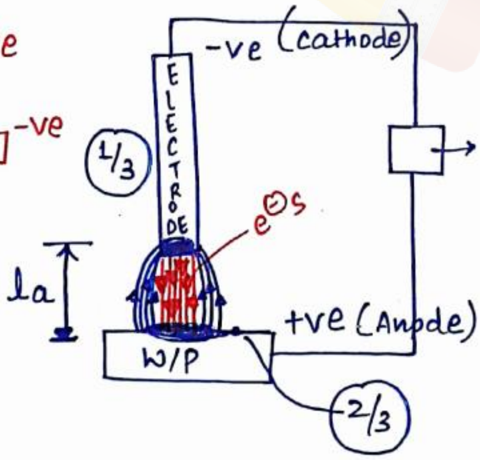
* WELD DEPOSITION RATE :- It is the amount of material which enter into the workpiece per unit time (kg/hr).

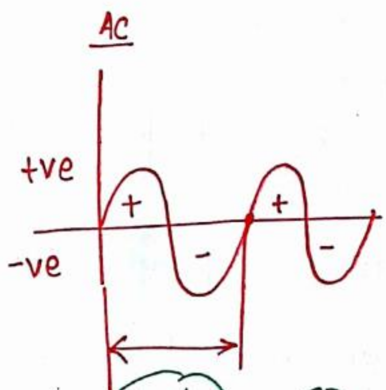
* ARC WELDING PRINCIPLE :-

$KE = \frac{1}{2} m v^2$









$\frac{2}{3} + \frac{1}{3} \rightarrow 1$

(+) (-)

uniform heat transfer or generation

la → Arc Length

(0.5 - 1.5) d → dia of electrode

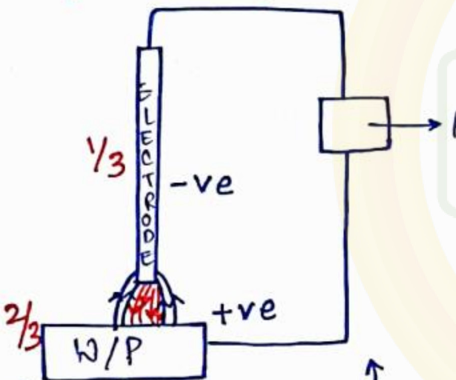
When the electrode is in contact with w/P due to short circuit, electric arc will be generated. To continue the arc further some gap is maintained between electrode and workpiece known as arc length. Due to moment of e⊖s from negative to positive 2/3rd of heat will be generated on Anode. and due to movement of +ve ions from +ve to negative, 1/3rd of heat will be generated on the cathode. Due to continuously changing the polarity, uniform heat will be generated on cathode and anode. To concentrate more heat on the electrode and workpiece, DC arc welding can be used.

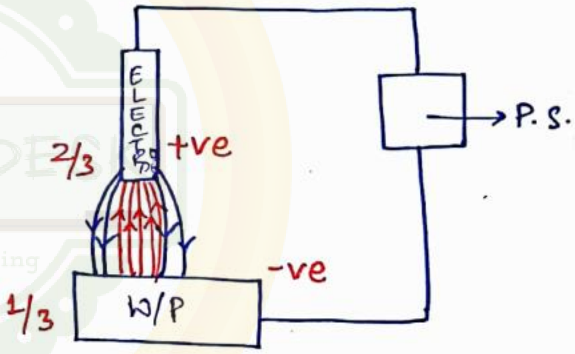
* DC Arc Welding :-

① **Straight Polarity** :- (DCSP, DCEN)

[Direct current straight polarity, Direct current electrode negative]

② **Reverse Polarity** :- (DCRP, DCEP)





①:- ✓ S.P. :- Electrode is negative and workpiece is +ve.

✓ More heat will be generated on the workpiece when compared to electrode.

✓ It is used for welding of high thickness and high M.P. materials.

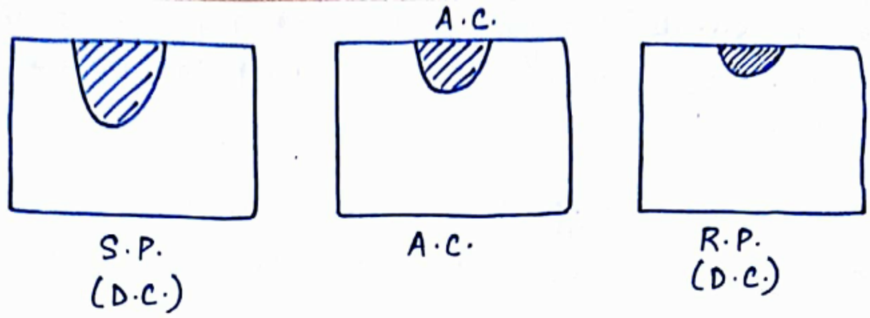
✓ Depth of penetration is more. ✓ weld deposition rate is less.

②:- RP:- ✓ Electrode is +ve and workpiece will be -ve.

✓ More heat will be on the electrode when compared to w/P.

✓ used for welding of less thickness and low M.P. materials.

✓ Depth of penetration is less. ✓ weld deposition rate is high.



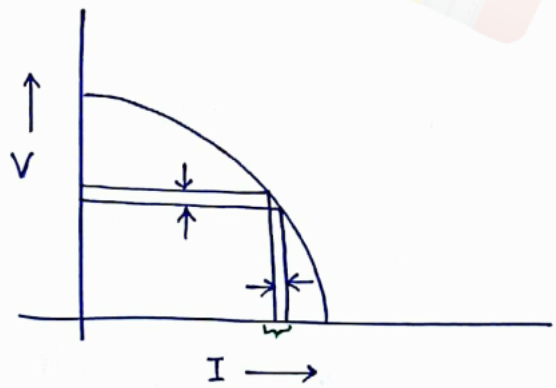
* **WELDING TECHNIQUES** :- There are 2 movements for the electrodes. ① linear movement of the electrode with respect to workpiece is known as linear welding speed.
② Downward movement of the electrode to maintain constant arc length.

If the two movements of the electrode are control manually, then it is called manual arc welding technique.

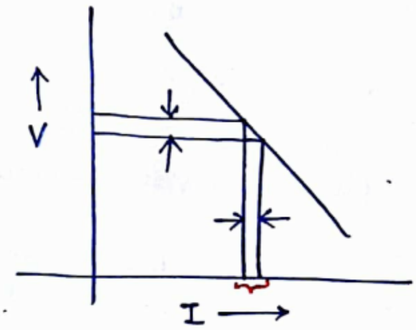
If the 2 movements of the electrode are control by automatic m/c's then it is called Automatic Welding Technique. If one of the movement is controlled manually, one is by machines then it is called semi-automatic welding technique.

* **Types of Welding Machines** :-

① **Constant current type (droop)** :- $\boxed{V_a = A + B I_a}$



② **Constant Voltage Type (linear/Flat)** :-

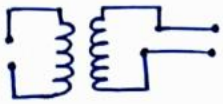


① C.C.T :- For a small change in arc voltage, corresponding changes in the current is very small. These are used in manual arc welding technique.

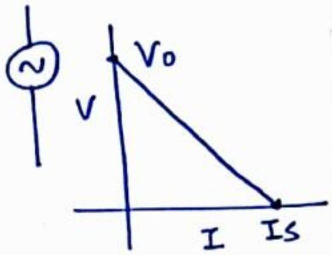
② C.V.T :- For a small change in arc voltage, corresponding changes in the current is very high. These are used in automatic welding technique.

① Open circuit voltage (V_0)

$V_0 = 80V$



$I = 0$



② Short circuit ~~voltage~~ current (I_s)

$V = 0$

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

transformer

$$\frac{I_t}{I_s} + \frac{V_t}{V_0} = 1 \quad ①$$

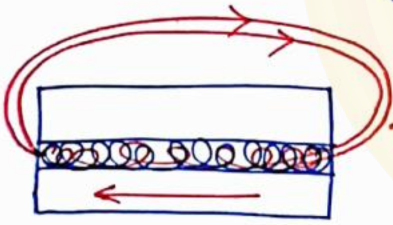
③ Duty Cycle $= \dfrac{\text{Arc on time}}{\text{arc on time} + \text{Idle time}}$

10 min

AWS — american welding society

$$V_a = A + B l_a \quad ②$$

$\frac{6}{6+4}$ 60%



multipass

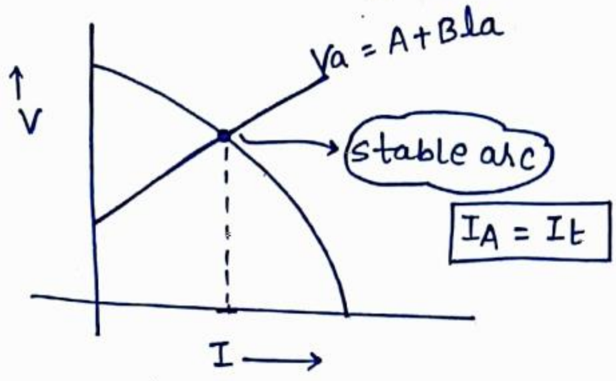
① OCV :- It is the maxm. rated voltage that can be measure across the 2 open terminal under no loading condition.

② SCC :- It is the maxm. rated current that can be allowed through a given circuit.

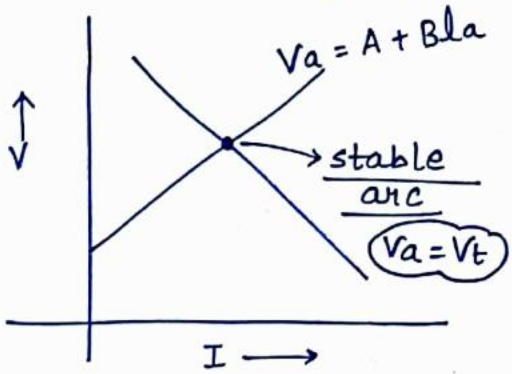
③ DC :- It is the % of time during which arc is "on" without overheating elements in a welding machine.

$V_a \mid V_t$
$I_a \mid I_t$

① **Constant current Type** :-



② **Constant voltage Type** :-



Q Arc length voltage characteristics are given by

$V_a = 24 + 4l_a$

V-I characteristics of the power source can be assumed as a straight line with open ~~vir~~ circuit voltage of 80V and short circuit current of 600A. Determine optimum arc length for maxm. power?

Sol $V_a = 24 + 4l_a$ ← (Given)

V-I $V_0 = 80V$, $I_s = 600A$

$(l_a)_{opt} = ? \rightarrow P = f(l_a)$

$\rightarrow \frac{\partial P}{\partial l_a} = 0 \Rightarrow (l_a)_{optimum} = ?$

from equ. ① $\rightarrow$ $\boxed{\frac{I_t}{I_s} + \frac{V_t}{V_0} = 1}$

$V_t = V_0(1) - \left(\frac{I_t}{I_s}\right)V_0$

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

Stable arc :- (∵ straight line)

$V_a = V_t$

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

$I_t = (420 - 30l_a)$

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

$\frac{\partial P}{\partial l_a} = 0$

$\Rightarrow \boxed{(l_a)_{opti} = 4mm}$

$\Rightarrow \boxed{P_{max} = 12KW}$

Q V-I characteristics of power source is given by

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

arc-characteristics are given by $I_a = 20(V-16)$.

Determine power of a stable arc?

Sol

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

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

RW

$V_a = V_t$

stable arc :-

$$I_a = I_t$$

$$I_a^2 = I_t^2$$

$$[20(V-16)]^2 = -600(V-60)$$

$$400(V^2+256-16V) = -600V+36000$$

$$\frac{102400}{4} + \frac{400V^2}{4} - \frac{6400V}{4} = \frac{-600V}{4} + \frac{36000}{4}$$

$$25600 + 100V^2 - 1600V = -150V + 9000$$

$$\underbrace{100V^2 - 1600V + 150V - 9000 + 25600 = 0}_{\text{solve}}$$

$V = 7.09$ ✗ $\quad 23.4$ ✓

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

$$= 20(7.09-16)$$

$$= -ve$$

$$\boxed{\begin{aligned} V &= 23.4\,V \\ I &= 148\,A \end{aligned}}$$

$$P = 23.4 \times 148$$

$$P = 3.46\,kW$$

Q Gate 2016: arc length voltage characteristics are given by

$$V_a = 20 + 4l_a$$

arc length in welding process changes from 4mm to 6mm and the power source current —"— 450 to 550A.

assuming linear power source characteristics. determine open circuit voltage and short circuit current. (73)

Sol $V_a = 20 + 4l_a$

$l_{a_1} = 4mm$ ↓ $I_{t_1} = 550A$ ↑ $V_0 = ?$

$l_{a_2} = 6mm$ $I_{t_2} = 450A$ $I_s = ?$

$$V_t = V_0 - \left(\frac{I_t}{I_s}\right)V_0$$

$$V_{t_1} = V_0 - \left(\frac{550}{I_s}\right)V_0$$

$$V_{t_2} = V_0 - \left(\frac{450}{I_s}\right)V_0$$

$$\frac{I_t}{I_s} + \frac{V_t}{V_0} = 1 \quad \text{RW}$$

$$\frac{550}{I_s} + \frac{V_t}{V_0} = 1$$

$V_{a_1} = 20 + 4(4) = 36V$

$V_{a_2} = 20 + 4(6) = 44V$

stable arc

$V_a = V_t$

$$36 = V_0 - \left(\frac{550}{I_s}\right)V_0 \quad \text{—(1)}$$

$$44 = V_0 - \left(\frac{450}{I_s}\right)V_0 \quad \text{—(2)}$$

$V_0 = 80V$ $I_s = 1000A$

Q Previous Qn. ⟶ all data are given :-

SIR Q → A D.C. welding machine with a linear power source characteristics provides open circuit voltage of 80V and short circuit current of 800 A. During welding, arc length changes from 5mm to 7mm and current changes from 460 to 500A. What is the linear voltage characteristics of welding arc?

Sol

$I_s = 800A$ $V_0 = 80V$

$l_a \rightarrow$ 5mm to 7mm

$I_{t_1} = 460A$

$I_{t_2} = 500A$

SIR

$V_0 = 80V$

$V_a = A + B l_a$

$I_s = 800A$

$l_{a_1} = 5mm$ $I_{t_2} = 460A$

$l_{a_2} = 7mm$ $I_{t_1} = 500A$

RW

$V_t = V_0 - \left(\frac{I_s}{I_t}\right)^{-1} V_0$

$$V_{t_1} = V_0 - \left(\frac{I_{t_1}}{I_s}\right) V_0$$

$$= 80 - \left(\frac{500}{800}\right) 80 = 30V$$

$$V_{t_2} = 80 - \left(\frac{460}{800}\right) 80 = 34V$$

$$30 = A + B(5) \quad (1)$$

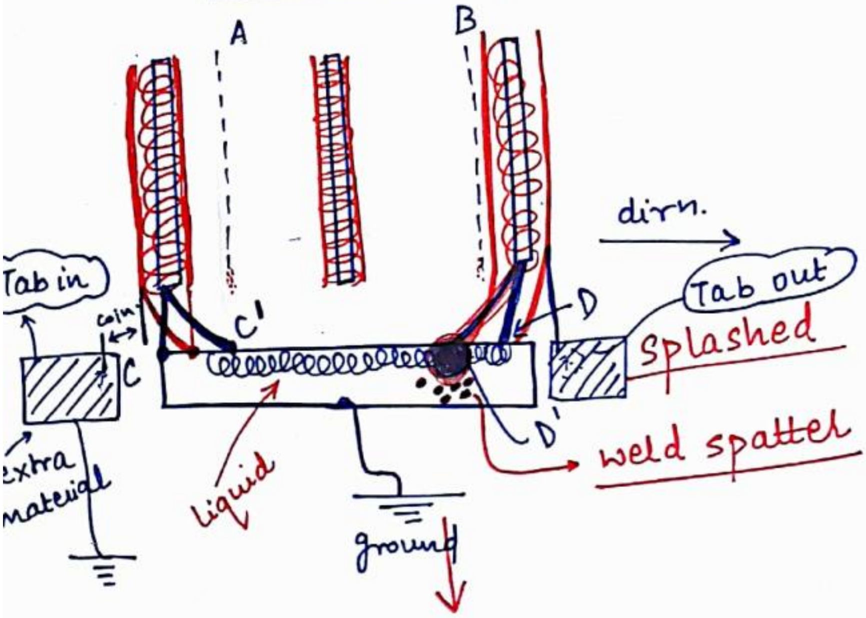
$$34 = A + B(7) \quad (2)$$

$A = 20$ $B = 2$

$$\boxed{V_a = 20 + 2 l_a}$$ Ans

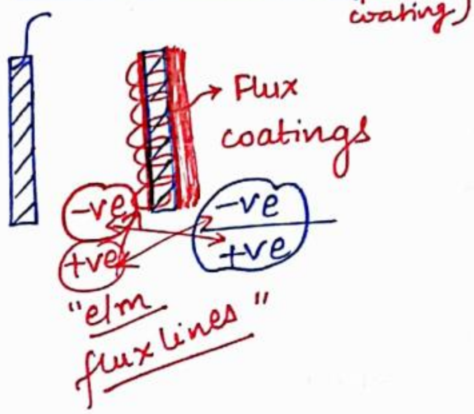
* ARC BLOW :-

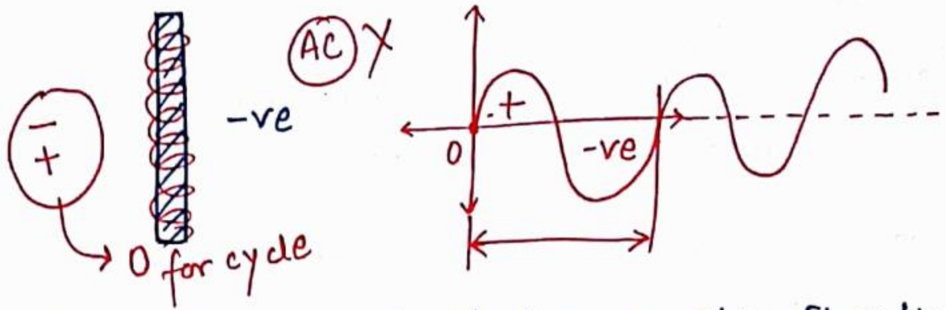
dirn.



✓ Flux coatings

✓ Bare Electrode (without flux coating)





Due to deflection of electromagnetic Flux lines, electric arc will be deflected towards the workpiece is known as arc blow. Due to arc blow, heat concentration on workpiece will be less at the beginning and end of the workpiece. and weld spatter will be formed.

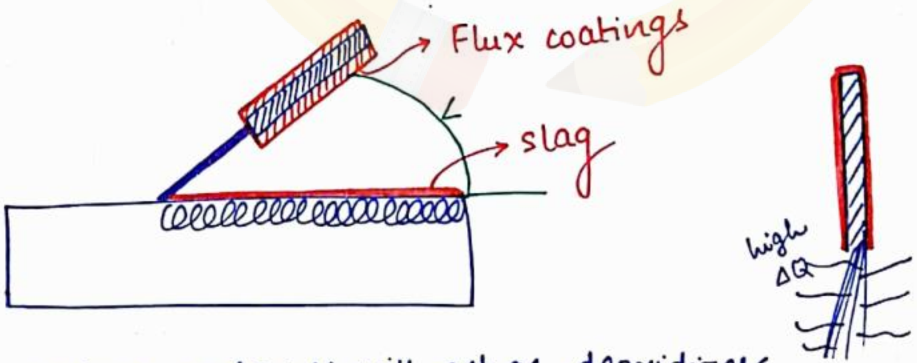
Remedies :- ⓐ provide some extra material in the beginning and end of the workpiece which is known as Tap in and Tab out

ⓑ Reduce the intensity of the welding current at the begining and end of the workpiece.

ⓒ Use small arc length.

ⓓ provides flux coatings on the electrode.

* Functions of Flux Coatings :-



✓ Flux coating materials will act as deoxidizers.
✓ By Forming the slag, they will protect the liquid metal from the atmospheric gases. ✓ slag will control the heat transfer rate of the liquid metal. ✓ By adding alloying elements, strength of the joint can be ↑ed. It will control the viscosity of the liquid metal.
✓ by Reducing the arc Blow, ~~heat~~ stability of the arc will be ↑ed. ✓ By Reducing heat transfer losses from the arc, heat concentration on the W/P will be ↑ed.

* Flux Coating Materials :-

ⓐ **De-oxidizing elements** :- ⟨1⟩ Graphite ⟨2⟩ Alumina ⟨3⟩ Ferro silicon and ⟨4⟩ Ferro manganese.

ⓑ **Slag formation compounds** :- ⟨1⟩ iron oxide ⟨2⟩ Titanium oxide. ⟨3⟩ silicon di-oxide ⟨4⟩ silica flour ⟨5⟩ Calcium Fluoride CaF

ⓒ **Arc stabilisers** :- ⟨1⟩ sodium oxide ⟨2⟩ calcium oxide and ⟨3⟩ potassium silicate.

ⓓ **Alloying elements** :- ⟨1⟩ chromium ⟨2⟩ nickel ⟨3⟩ cobalt and ⟨4⟩ Vanadium.

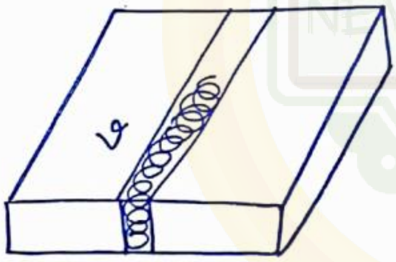
ⓔ **Gas forming materials** :- ⟨1⟩ cellulose ⟨2⟩ calcium carbonate ($CaCO_3$)

\+

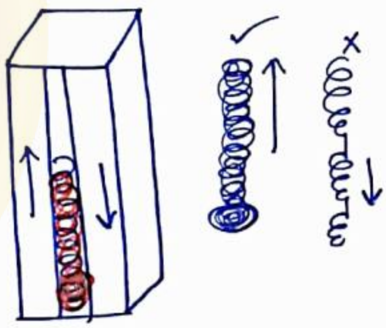
= CO_2 → protects ✓

* Welding Techniques Based on position :-

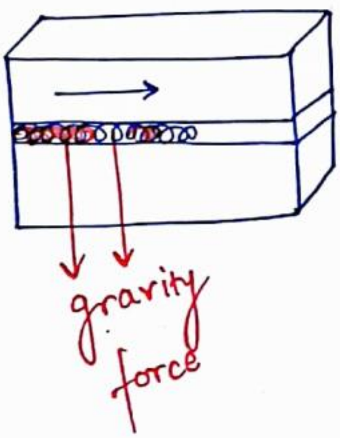
① **Flat welding (F)** :-



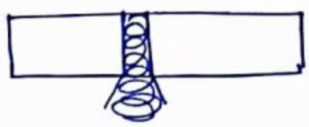
③ **Vertical (V, D)** :-



② **Horizontal welding (H)** :-



④ **Overhead (O)** :-



* Electrode Specification :- (BIS)

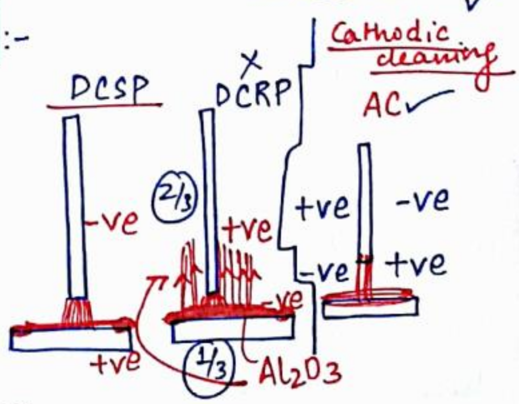
→ Beurae of Indian standards.

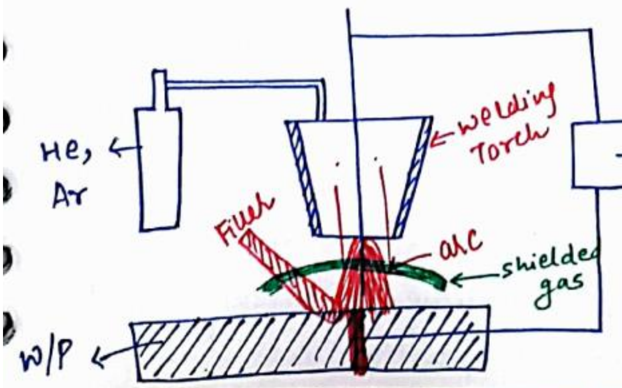
E 1 2 1 322 P

- E → Type of electrode manufacturing (E means Extrusion)
- 1 → Type of flux coating (1 means high cellulose)
  (2 means high Titatinium).
- 2 → Position of electrode
  - 0 → all the positions → F, H, V, D, O
  - 1 → F, H, V, D
  - 2 → F, H
- 1 → Polarity of electrode (1 means ~~deepless~~ DT -direct current electrode positive)
- 322 → strength of the electrode
  - 3 → Tensile strength
  - 2 → yield strength
  - 2 → % of elongation
- P → specific information regarding electrode (P means deep penetration).

* SHIELDED GAS Arc Welding :-

① Tungsten (high M.P.) Inert gas (TIG) (GTAW) :-

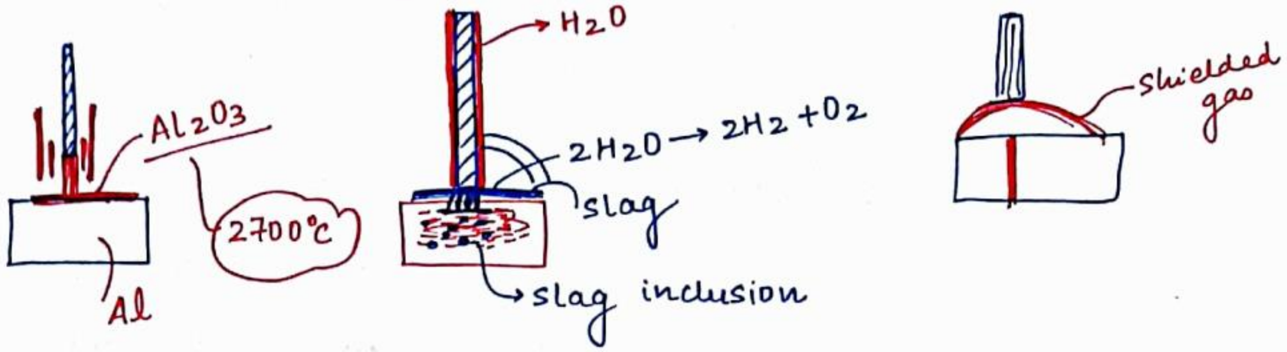




① $t < 5mm$

$t > 5mm$

damped Electrodes



✓ Tungsten Inert gas welding (TIG) / Gas Tungsten arc welding (GTAW)

✓ Arc is generated between a non consumeable tungsten electrode and workpiece.

✓ liquid metal in the weld pool can be protected by providing inert gas atmosphere.

✓ For welding of less than 5mm thickness of the workpiece material without using the filler material, joint can be produced.

✓ For welding of more than 5mm thickness of the w/p material, filler metal is supplied externally. Movement of the filler metal can be controlled manually.

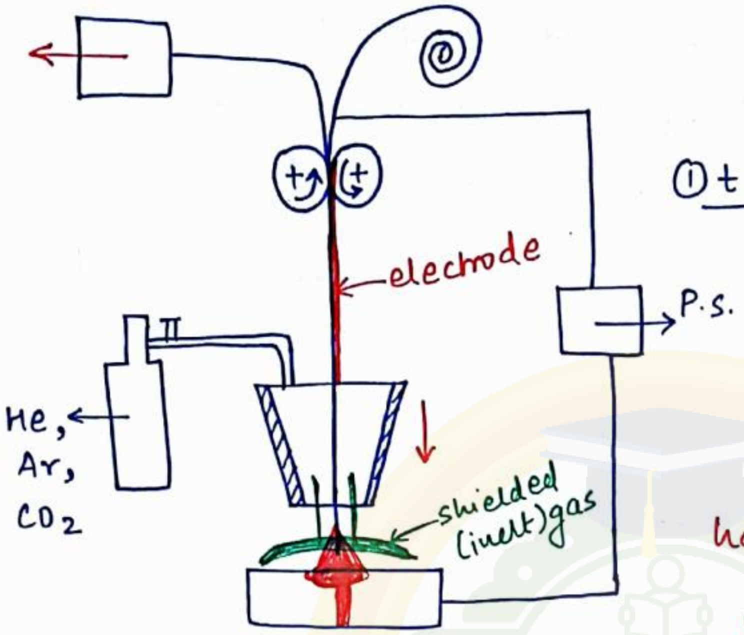
✓ For welding of other materials except Al-Mg alloys, direct current straight polarity can be used.

✓ For welding of Al-Mg alloys, AC power supply can be used in which 1st half of a cycle. due to straight polarity, more heat will be on the workpiece. In the next half of a cycle, due to reverse polarity, oxide layers can be cleaned from the work surface due to movement of e⊖s from workpiece to electrode. This is known as cathodic cleaning. Generally used for less than 5mm thick materials. operating cost is more.

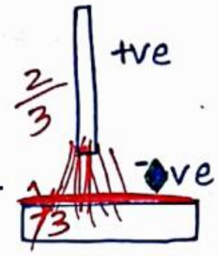
✓ **Applications** :- Welding of Al, Mg and its alloys in aerospace, automobile and chemical industries.

② Metal Inert Gas (MIG, GMAW)

① DCRP ✓ high I → 150-450A



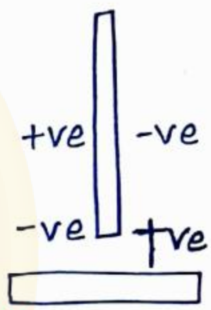
① t > 5mm



② AC

half cycle → S.P. and R.P.

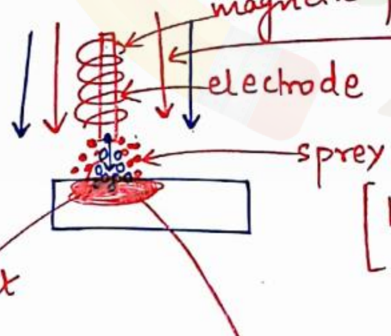
uniform heat generation



electrode
⇩
wire
ϕ 1 - 1.5mm

① Droplet

② Sprey



[hence E/m forces dominating gravity force.]

[sprey (fine droplets)]

high depth of penetration (due to sprey) Hence →

✓ Magnetic Pull Effect.

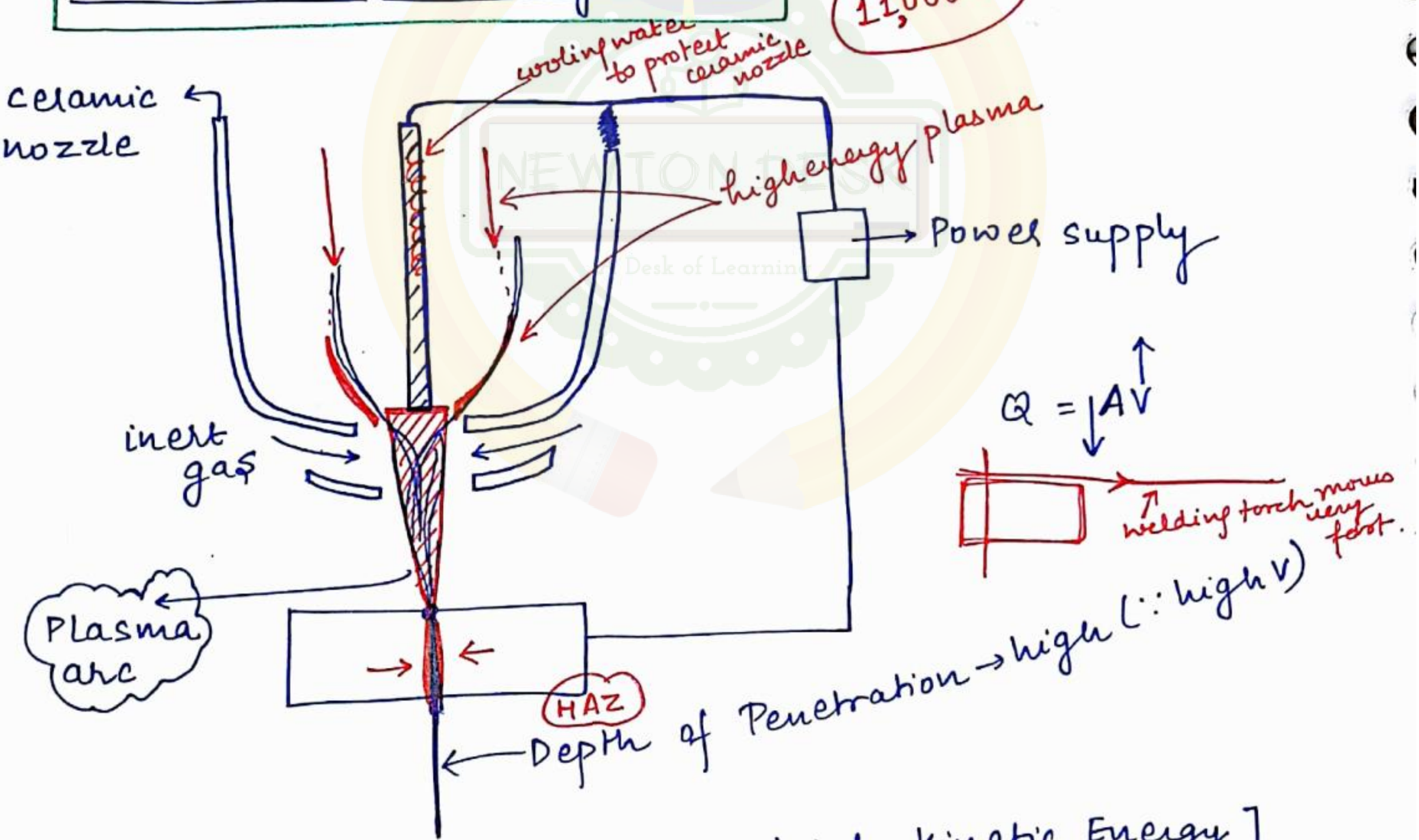
✓ pinch Effect.

✓ Arc is generated between a consumable electrode and workpiece. Electrode is in the form of wire which is continuously supplied to the workpiece through the movement of the rollers. Rollers movement can be controlled by providing servomechanism.

✓ For welding of all the materials including Al, Mg-alloys; direct current reverse polarity are AC power supply with a high rate of current can be used. In general, Metal transfer will takes place from electrode to workpiece is in the form of sprey at high rate of current.

* APPLICATIONS :- (a) Used for welding of Al, Mg, Cu and its alloys in automobile and aerospace industries.

* Plasma Arc Welding (PAW)



[plasma arc + electric arc → high kinetic Energy]
$(KE)_{PA}$ $(KE)_{EA}$

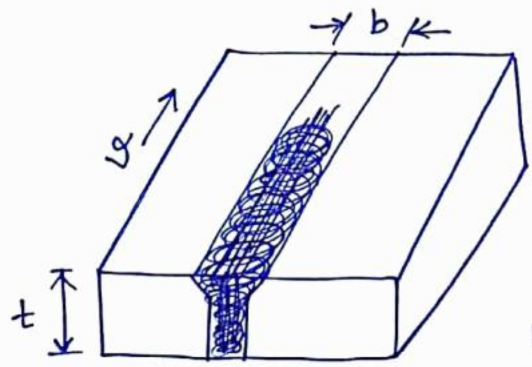
✓ Arc is generated between non-consumable Tungsten electrode and work piece by supplying high energy plasma through the ceramic nozzle, it will be combine with electric arc and produce plasma arc which is having high Kinetic energy and it will be focused on the workpiece at a given point. due to this heat concentration on the w/p will be very high. ✓Depth of penetration and welding speed will be maximum, it can be used for welding of high thickness and high Melting point materials.

✓ weld Bead width and heat affected zone will be minimum. Liquid metal in the weld pool can be protected by providing inert gas atmosphere.

✓ we can use direct current straight polarity.

* **Applications** :- ✓ welding of Titanium, nickel, cobalt and stainless steel in aerospace, jet engines, gas turbine blades, etc.

* **Melting Efficiency** :-



$A_b = b \times t$

$v \rightarrow$

$P = VI$

$\eta_h \rightarrow$ Arc heat transfer efficiency.

$H_m \rightarrow J/mm^3$

$H_s \rightarrow J/mm^3$

$H_m = mC\Delta t + mL$ (J)

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

area (J/mm³)

$$\frac{J/s}{mm^2 \cdot \frac{mm}{s}}$$ (J/mm³)

$$\boxed{H_s = \frac{VI}{v} \times \eta_h \ (J/mm)}$$

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

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

WB
Pg 65
Pb 13

(13) $H_s = \frac{VI}{v} \times \eta_h$

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

$$H_s = 796.87 \ (J/mm)$$

(15) $\eta_m = \frac{H_m}{\frac{VI}{A_b v} \times \eta_h}$

$$0.5 = \frac{10}{\frac{2 \times 10^3}{5 \times v} \times 0.7}$$

$$\boxed{v = 14 \text{ mm/s}}$$

(28) $\eta_m = \frac{H_m}{\frac{VI}{A_b \times v} \times \eta_h}$

$$H_s = 1200 \ J/mm$$

$$0.45 = \frac{15}{\frac{200}{A_b}} \qquad \boxed{A_b = 36 \text{ mm}^2}$$

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

(38)

$$H_s = \frac{\cancel{V_1} I_1}{v_1} = \frac{\cancel{V_2} I_2}{v_2}$$

$$\frac{50}{150} = \frac{I_2}{120}$$

$$\boxed{I_2 = 40A}$$

(41) $$H_s = \frac{VI}{v} \times \eta_h = \frac{20 \times 150}{\frac{300}{60}} \times 0.8 = \underline{480\,J/mm}$$

(43) $\boxed{I^2 D = C}$

Duty cycle

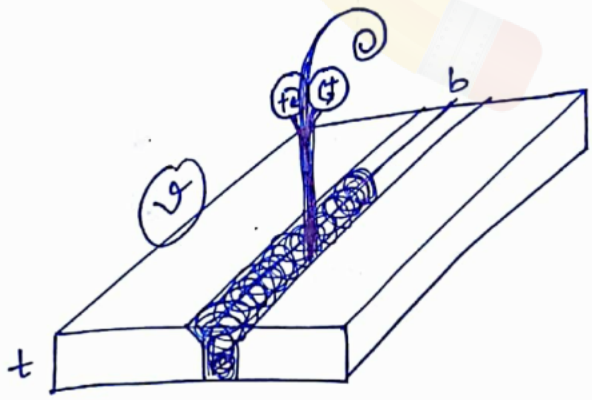
$$I_1^2 . D_1 = I_2^2 . D_2$$

$$(100)^2 . 0.6 = (160)^2 . D_2 \Rightarrow \underline{D_2 = 0.234}$$

$$\%\ \text{change} = \frac{D_1 - D_2}{D_1} = \frac{0.6 - 0.234}{0.6}$$

$$\Rightarrow \underline{60.9\%}$$

(46) $\boxed{\text{correction}}$ → Heat input ------ KJ/mm.



RW

200A, 25V,
18cm/min,
d = 1.2mm,
4m/min

Area = 1mm²

(1) $$H_s = \frac{VI}{v} \times \eta_h = \frac{25 \times 200}{\frac{18 \times 10}{60}} \times \frac{0.65}{1000}$$

$$= 1.08\ KJ/mm$$

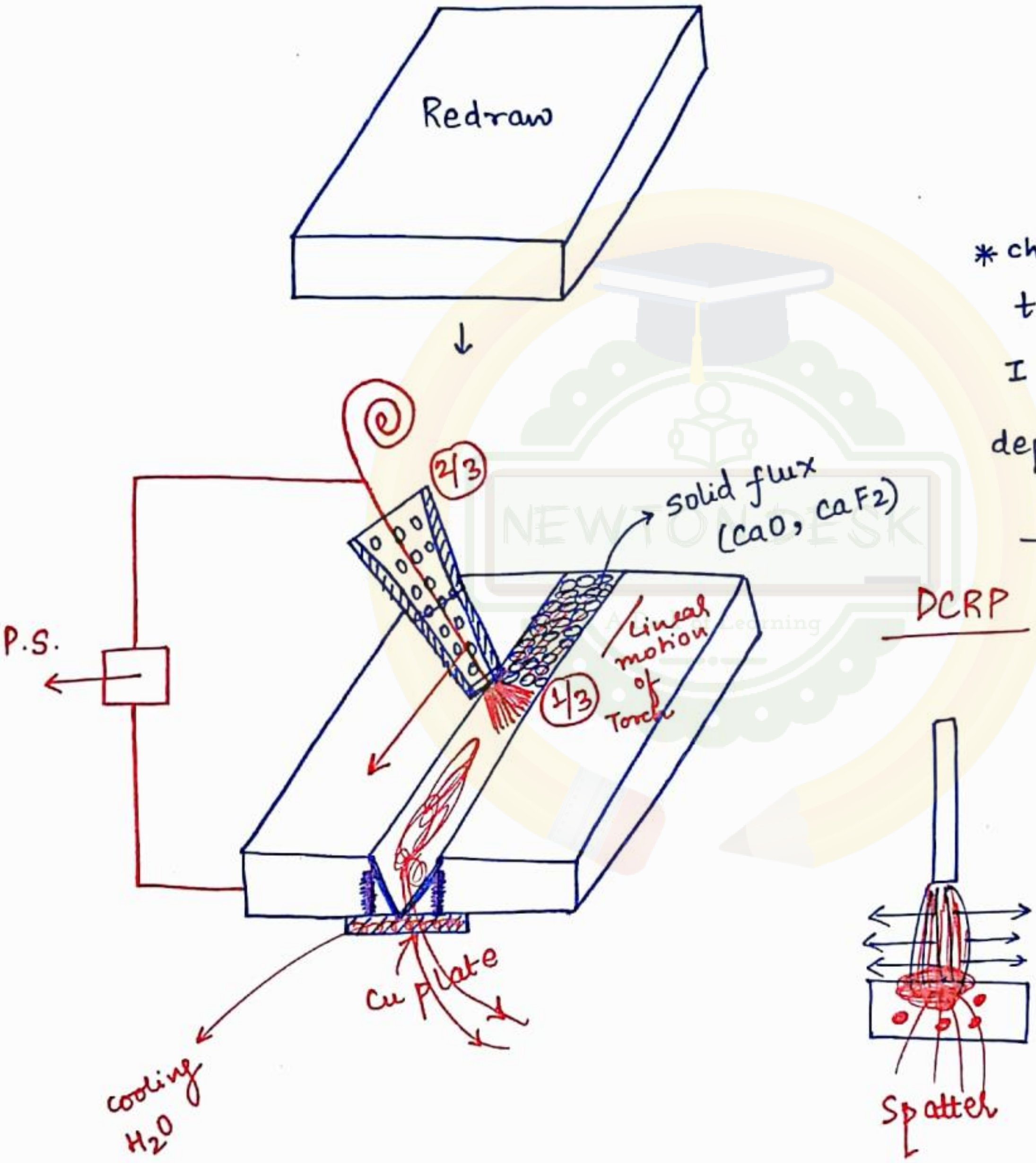
② $A_w \times f_w = A_b \times v$

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

$\boxed{A_b = 25.13 \text{ mm}^2}$

15/9/16

* SUBMERGED ARC WELDING :-



* characteristics :-
  - $t \rightarrow$ 15-50 mm
  - $I \rightarrow$ 200 - 2000 A
  - deposition rate $\rightarrow$ 20 kg/hr
  - $v \rightarrow$ 5 m/min.

Arc is generated between a consumable electrode and workpiece. By supplying solid form of the flux through the welding ~~torque~~ torch, it will be covering on the surface of the arc. such that arc will be submerged under the flusk, due to this :-

ⓐ Heat transfer losses from the arc will be minimum.

ⓑ Heat concentration on the w/p and depth of penetration is more.

ⓒ By reducing the splashing of the liquid metal, weld spatter will be negligible.

ⓓ Slag inclusions will be minimum.

ⓔ Welding speed and weld deposition rate is very high.

ⓕ It can be used in mass production.

ⓖ Welding can be performed in flat position only.

ⓗ Weld bead width and Heat Affected zone is maximum.

Applications :- ⓐ Joining of high thickness plates in ship Building.

ⓑ Fabrication of pressure vessels and LPG cylinders.

ⓒ Structural Application for → Mild steel. → low carbon steel.

WB Pg 68

Q30 V-I DC $V_0 = 80V$, $I_s = 600A$

$\boxed{P = VI}$ $V_a = A + BI_a$

$$\frac{I_t}{I_s} + \frac{V_t}{V_0} = 1 \qquad I_A = I_t$$

SIR $V_0 = 80V$

$I_s = 600A$

$$V_t = V_0 - \left(\frac{I_t}{I_s}\right)V_0 = 80 - \left(\frac{I_t}{600}\right)80$$

$$P = V_t I_t$$

$$P = \left[80 - \left(\frac{I_t}{\cancel{600}_{\cancel{30}\,15}}\right)\cancel{80}^{\cancel{4}\,2}\right] I_t$$

$$P = \left[80 - \left(\frac{I_t}{15}\right)2\right] I_t$$

$$\frac{\partial P}{\partial I_t} = 0 \Rightarrow I_t = 300A$$

$V_t = 40V$

$P = I_t V_t$

$P = 40 \times 300$

$\boxed{P = 12\,000W}$

Shortcut $\xrightarrow{**}$

$$\boxed{\begin{array}{l}\text{Max. Power :-} \\ V_t = \dfrac{V_0}{2} \\ I_t = \dfrac{I_s}{2}\end{array}}$$

Q44 $V_0 = 80V$ $I_s = 300A$

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

Q. Steel plates are to be welded by arc welding process using linear power source characteristics with a open circuit voltage of 80V and short circuit current of 300A. Arc length is 4mm, welding speed is 2.5mm/sec, heat transfer efficiency is 0.85, arc length voltage is given by $V_a = 20 + 1.5 l_a$, heat input to the w/p is given by (J/mm = Hs) ---------

Sol Given :- $V_0 = 80V$ $V_a = 20 + 1.5 l_a$

$I_s = 300A$

$l_a = 4mm$

$v = 2.5 mm/s$

$\eta_h = 0.85$

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

$$= \frac{80 \times 300}{\frac{0.85}{l_a \times 2.5}}$$

$V_a = 20 + 1.5(4) = 26V$

$$V_t = V_0 - \left(\frac{I_t}{I_s}\right) V_0$$

$$= 80 - \left(\frac{I_t}{300}\right) 80$$

Stable arc

$V_t = V_a$

$$80 - \left(\frac{I_t}{\cancel{300}}\right)\cancel{80} = 26$$

$$\underline{I_t = 202.5A}$$

$$H_s = \frac{V_t I_t}{v} \eta_h$$

$$= \frac{26 \times 202.5}{2.5} \times 0.85$$

$$= 1790.1 \, (J/mm)$$

Q7 In MIG welding process, power source characteristics are given by $V_t = 36 - \frac{I_t}{60}$, arc length characteristics are given by $V_a = 27 + 2l_a$. Find the changes in the power of the source if the arc length changes from $\cancel{4}2$ mm to $\cancel{6}4$ mm. (87)

Sol

$V_t = 36 - \frac{I_t}{60}$

$V_a = 27 + 2l_a$

$l_{a_1} = \cancel{4mm}\ 2mm$

$l_{a_2} = \cancel{6mm}\ 4mm$

$V_{a_1} = 27 + 2(2) = 31V$

$V_{a_2} = 27 + 2(4) = 35V$

linear Relation

$V_{a_1} = 27 + 8 = 35V$

$V_{a_2} = 27 + 12 = 39V$

$V_t = V_a$

$36 - \frac{I_{t_1}}{60} = 31$

$I_{t_1} = 300A$

$36 - \frac{I_{t_2}}{60} = 35$

$I_{t_2} = 60A$

$P_1 = V_{t_1} I_{t_1} = 31 \times 300 = 9.3KW$

$P_2 = V_{t_2} I_{t_2} = 35 \times 600 = 2.1KW$

$\boxed{P_1 - P_2 = 7.2KW}$

Q7 During MIG welding process direct current reverse polarity with the welding current of 150A and voltage of 30V and welding speed 6m/min. A metallic wire electrode of 1.2mm diameter is feed at a rate of 12m/min. Density of the w/p material is 7000 kg/m3, specific heat is 500 J/kg-°C and Melting Tempr. is 1530°C, ambient Tempr. is 30°C. Consider 2/3rd's of heat will be available for melting of electrode. Determine melting efficiency.

Sol $I = 150 A$

$V = 30V$

$v = 6 m/min$

$d = 1.2 mm$

$f = 12 m/min$

$\rho = 7000 kg/m^3$

$C = 500 J/kg\text{-}^\circ C$

$t_m = 1530^\circ C$

$t_a = 30^\circ C$

$\dot{V}$ = volume flow rate = $A_w \times f_w$

$$= \frac{\pi}{4}(1.2)^2 \times 10^{-6} \times \frac{12}{60}$$

$$= 2.26 \times 10^{-7} \ m^3/s$$

$\dot{m}$ = mass flow rate = $\dot{V} \times \rho$

$$= 2.26 \times 10^{-7} \times 7000$$

$$= 1.58 \times 10^{-3} \ kg/s$$

$$H_m = mC\Delta t + \cancel{mL}$$

$$= 1.584 \times 10^{-3} \times 500 \times (1530 - 30)$$

$$= 1187.52 \ J/s$$

$$H_s = V \times I \times \eta_h$$

$$= 30 \times 150 \times 2/3$$

$$= 3000 \ J/s$$

$$\eta_m = \frac{H_m}{H_s} = \frac{1187.5}{3000} = 39.58\%$$

Q In arc welding technique with linear power source characteristics with open circuit voltage of 80V and $I_s = 1000A$, arc length characteristics are given by $V_a = 18 + 2.5 l_a$. Find the optimum voltage of the arc.

Sol

$$V_t = V_0 - \left(\frac{I_t}{I_s}\right) V_0$$

$$V_t = 80 - \left(\frac{I_t}{1000}\right) 80$$

$$10^3 V_t = 8 \times 10^4 - I_t \, 80$$

$$\frac{-10^3 V_t + 8 \times 10^4}{80} = I_t$$

$$\boxed{I_t = 1000 - 12.5 V_t} \quad \text{or} \quad I_t = (80 - V_t)\frac{1000}{80}$$

$$P = V_t I_t$$

$$P = V_t (80 - V_t) \frac{1000}{80}$$

$$\frac{\partial P}{\partial V_t} = 0 \Rightarrow (V_t)_{opt} = \underline{40V}$$

other method

$$V_t = V_a$$

$$80 - \left(\frac{I_t}{1000}\right) 80 = 18 + 2.5 l_a$$

$$I_t = (750 - 31.2 l_a)$$

$$P = V_t I_t$$

$$P = (18 + 2.5 l_a)(750 - 31.2 l_a)$$

$$\frac{\partial P}{\partial l_a} = 0 \Rightarrow (l_a) = \underline{8.8 \text{ mm}}$$

$$V_a = 18 + 2.5 l_a$$

$$= 18 + 2.5(8.8)$$

$$= \underline{40V}$$

2016 GATE

Q:> arc length voltage in a welding process is given by

$$V_a = 100 + 40 l_a$$

during welding, arc length changes b/w 1mm to 2mm and welding current is changing from 200 to 250 A. assuming a linear power source characteristics, calculate open circuit voltage and short circuit current.

Sol

$$V_a = 100 + 40 l_a$$

$l_{a_1} = 1\text{mm}$ $\quad I_{t_1} = 250 \text{ A}$

$l_{a_2} = 2\text{mm}$ $\quad I_{t_2} = 200 \text{ A}$

$$V_t = V_0 - \left(\frac{I_t}{I_s}\right) V_0$$

$$V_{t_1} = V_0 - \left(\frac{200}{I_s}\right) V_0$$

$$V_{t_2} = V_0 - \left(\frac{250}{I_s}\right) V_0$$

$$V_{a_1} = 100 + 40(1) = 140 V$$

$$V_{a_2} = 100 + 40(2) = 180 V$$

Stable arc

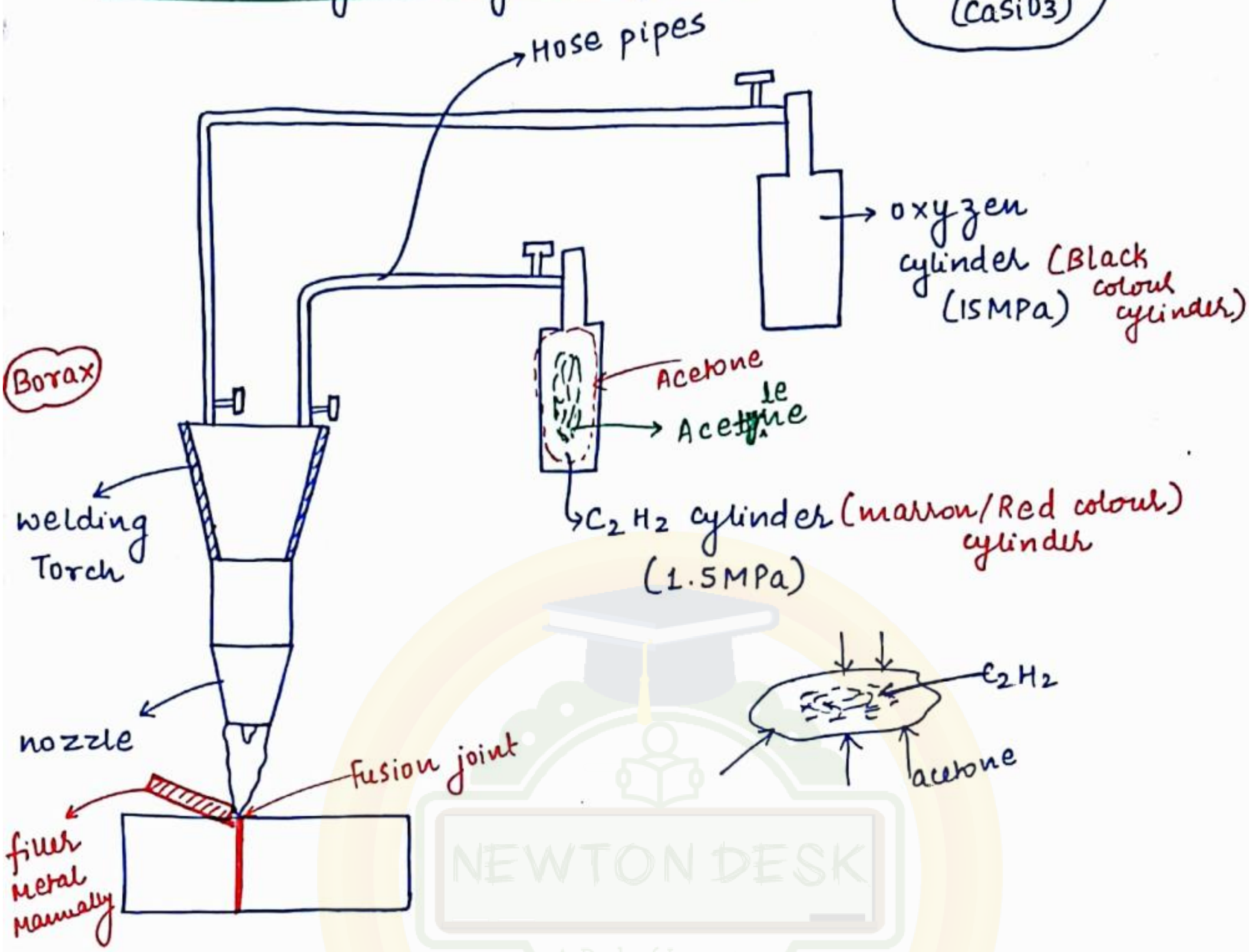
$$V_a = V_t$$

$$140 = V_0 - \frac{200}{I_s} V_0$$

$$180 = V_0 - \frac{250}{I_s} V_0$$

* CHEMICAL REACTION :-

✓ Gas welding :- (oxy - Acetylene)



Primary Reaction :-

$$C_2H_2 + O_2 \longrightarrow 2CO + H_2 + \Delta h_1 \rightarrow 1 \text{ mole } O_2$$

$$\boxed{\Delta h_2 > \Delta h_1}$$

Secondary Reaction :-

$$2CO + H_2 + \frac{3}{2}O_2 \longrightarrow 2CO_2 + H_2O + \Delta h_2 \longrightarrow 1.5 \text{ mole } O_2$$

$$\boxed{C_2H_2 + 5/2\, O_2 \rightarrow 2CO_2 + H_2O + \Delta h}$$

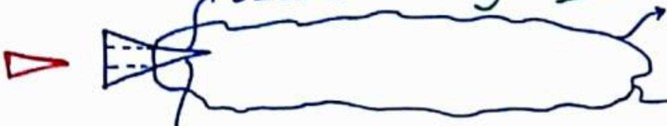
Gas Flames

① Neutral Flame

3200°C

Hissing sound → less due to area ↑/large for heat transfer.

1275°C



outer Flame ← (output of 2nd Rx^n.)

Inner cone

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

② Oxidizing Flame

3300°C

Roaring sound

1275°C

outer flame

Inner cone length small

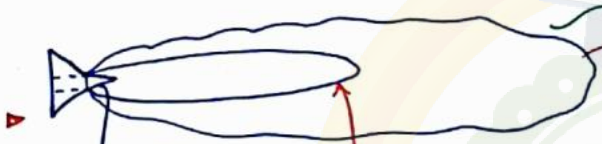
$$\frac{O_2}{C_2H_2} = 1.15 - 1.5$$

$$\frac{O_2}{C_2H_2} = 0.85 - 0.95$$

③ Carburizing Flame → Reducing Flame

No sound

1275°C



2900°C

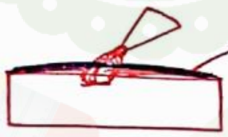
Intermediate flame → length indicate unburned carbon.

↓

Red Colour Flame

↑ volume Ratio's ↑

✓ Oxidizing Flame →



CuO_2

(Cu, Zn & Brass)

This metals can be welded by using oxidizing flames.

✓ Carburizing Flame :-

✓ Nickel Based alloys → (hardness)

✓ High carbon steel (hardness).

✓ Neutral Flame → C.I. (cast Iron)

By burning the acetylene in the presence of O_2 due to exothermic Reaction, heat will be produced. This heat will be utilised for melting of the base material to produce a fusion joint. For complete combustion of 1 mole of Acetylene, 2.5 moles of oxygen is required in which 1 mole is consumed from oxygen cylinder & 1.5 moles are consumed from atmosphere.

By changing the volume flow rates of oxygen and acetylene, different flames can be produced. they will be used for diff. applications.

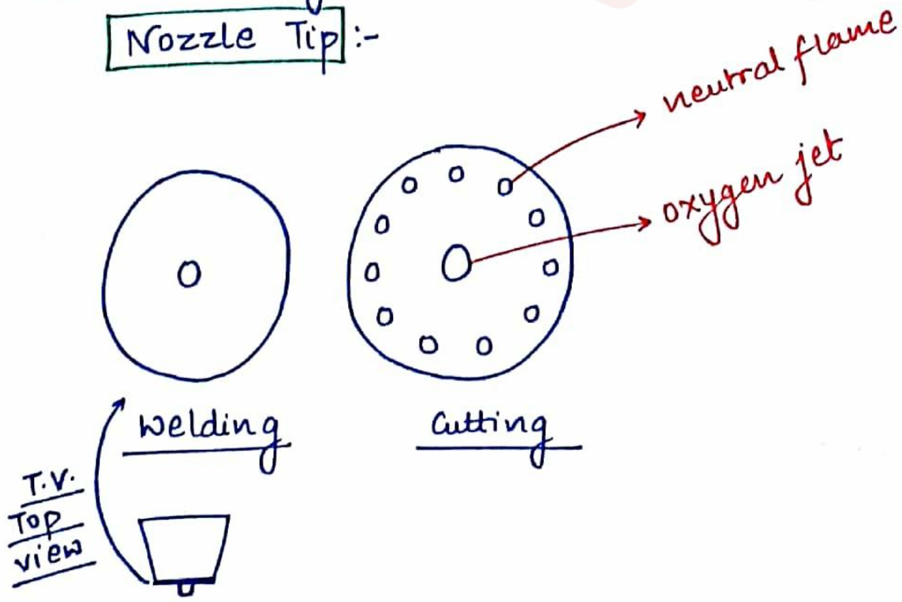
Applications of the flame :- ① Neutral flame :- It is a general purpose flame used for welding of Mild steel, low carbon steels, aluminium alloys, alloyed steel and cast Iron.

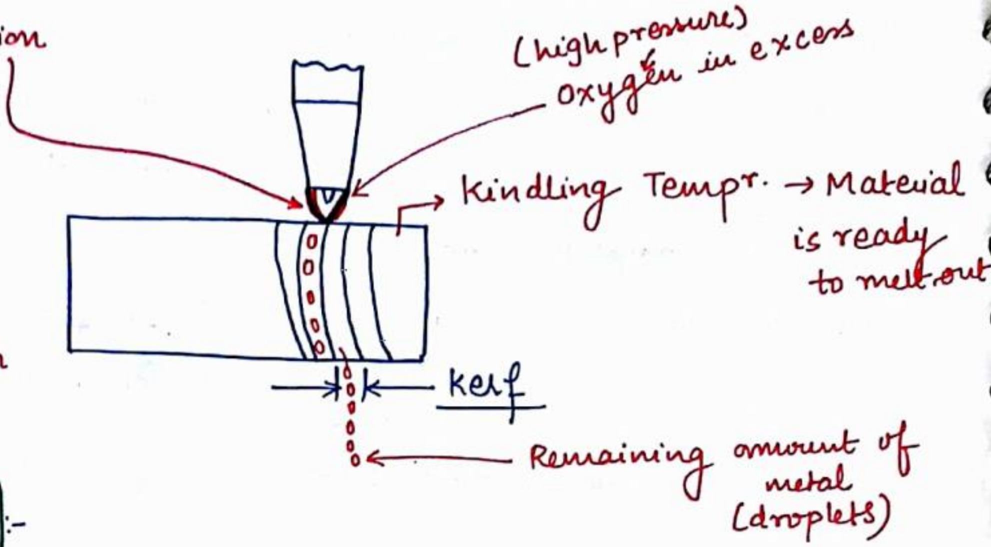
② Oxidizing flame :- used for welding of Cu, Zn and Brass.

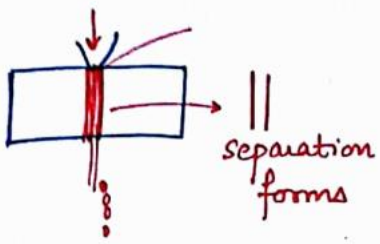
③ Carburizing flame :- used for welding of High carbon steels and Nickel Based alloys.

* Gas Cutting :-

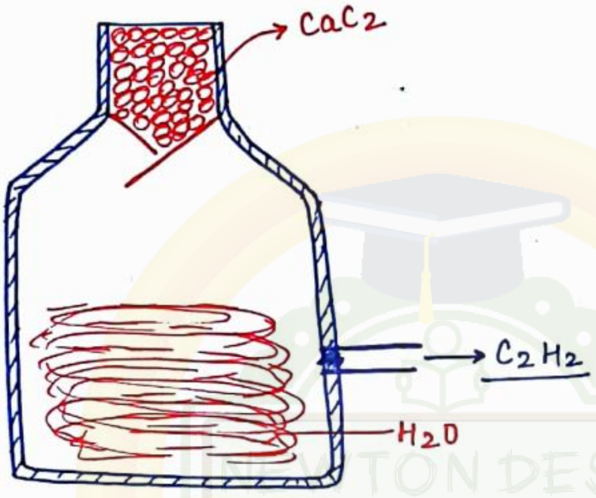
Nozzle Tip :-







C_2H_2 Generator :-



$$CaC_2 + H_2O \longrightarrow C_2H_2 + CaO$$

Ex:- $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

iron sheet ← gas cutting

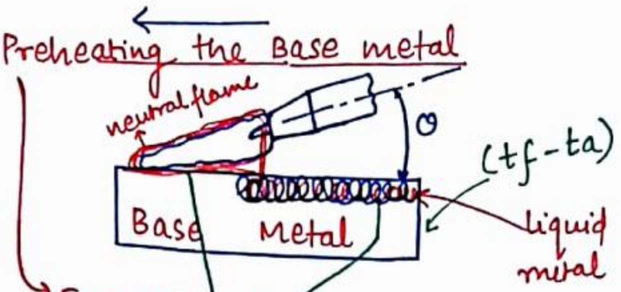
Fe evaporates due to oxidisation

✓ Material having oxides M.P. tempr. very high is difficult to cutting

same setup which is used for welding can be used for gas cutting except in the form of Nozzle tip. Through the circumferential holes, initially neutral flame is coming and it will be used for preheating the Base material upto Kindling tempr. It is a minm. tempr. at which material is readily to get oxidized. After this, through the central hole high pressure oxygen jet is released on to the workpiece. Such that more amount of metal can be evaporated by melting and remaining metal can be blown out in the form of fine droplets.

* Gas Cutting Techniques :-

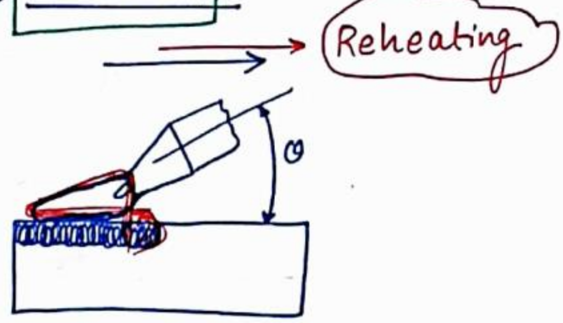
① Forehand :-



✓ Fast Rate of welding.
(Advantage)

Δt ↓ (decreases)
(B.M. & liquid Metal)
↓
slow rate of cooling
↓
coarse grain structure of liquid metal.
↓
internal σ ↓
↓
crack ↓ formⁿ. → more ductile

② Backhand :-



"θ ∝ t" → thickness of the Base metal.

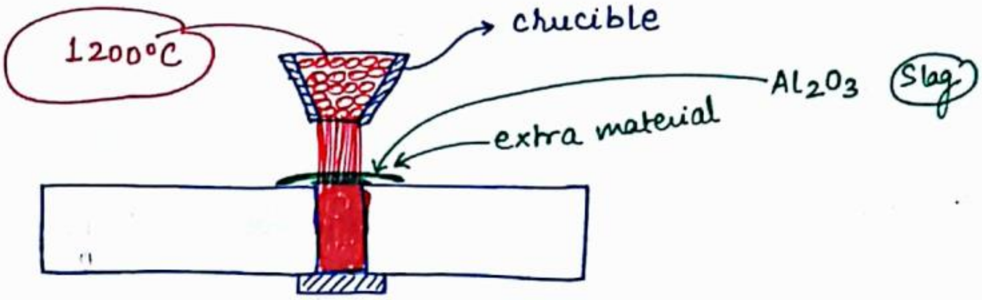
✓ **Forehand welding** :- In this technique, welding torch is moving from Right to left. Inner cone is melting the base material & outer flame is preheating the Base material before welding. By reducing diff. of tempr., slow rate of cooling can takes place. Due to this, ductile structure will be formed and it will minimize the crack formation.

✓ **Backhand Welding** :- In B.H. welding, welding torch is moving from Left to Right. During the process, inner cone is melting the material and outer flame is reheating the already welded portion. Due to this stresses developed in the joint can be releived and crack formⁿ. can be minimized.

✓ In case of Cast Iron, due to fast rate of cooling, free form of the carbon will be converted into carbides. It will become brittle structure and cracks will be formed. To overcome this, it can be easily welded by gas welding technique using preheating.

* THERMIT WELDING :-

Easily movable



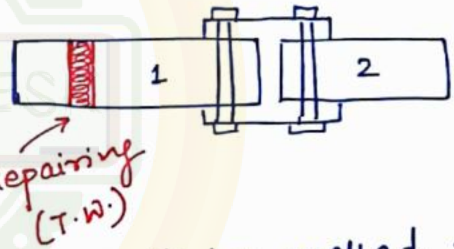
$$3Fe_3O_4 + 8Al \rightarrow 9Fe + 4Al_2O_3 + \Delta h$$

$Fe_3O_4 : Al$ (3:1) (By mass).

$CuO_2 : Al$

for deposition → $Cr_2O_3 : Al$

Thermit mixture can be heated in a crucible upto 1200°C by using magnesium rods at this tempr., due to thermit Reaction, heat will be produced. using this heat, Iron will be melted. It will be enter into the gap b/w 2 workpieces and it will be allowed to solidify. Al_2O_3 will be acting as a slag.



Applications :- ① Repair works of Railway Rails.

② Joining of Broken castings and high thickness plates.

③ कुछ नहीं।

* Atomic Hydrogen Welding :-

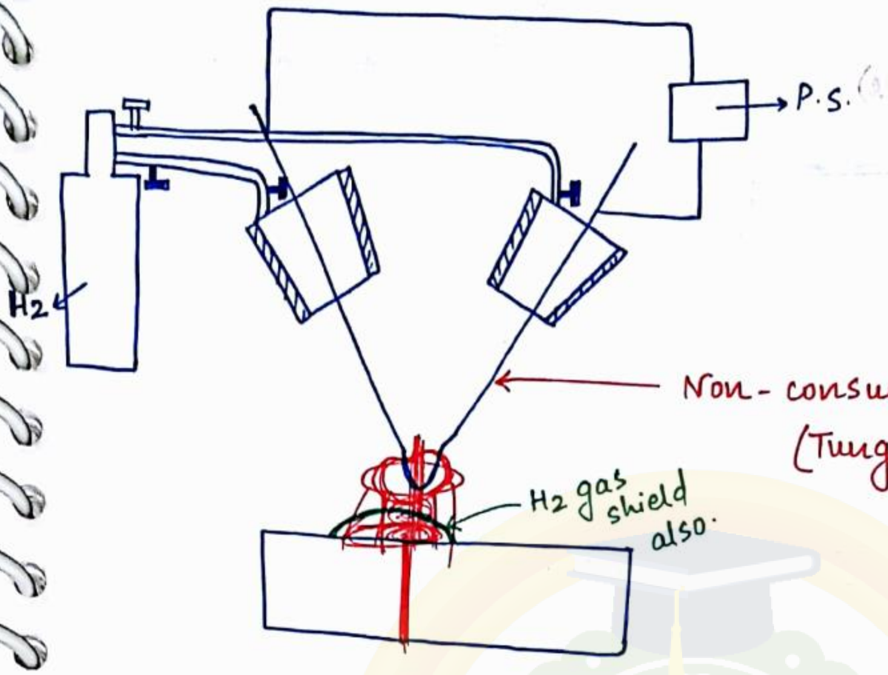
Combination of arc + gas welding.

4000°C

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

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

✓ Heating agent.
✓ Sheilding gas.



High Pressure
↓ H2 gas.
gas defects

Arc is generated between 2 non-consumable Tungsten electrodes. By suppling hydrogen gas, due to heat from the arc, hydrogen molecules will be dissociated into hydrogen atoms by consuming some heat. When they will be in contact with work surface due to unstability, they will recombine as hydrogen molecules. During the process, some heat will be released due to exothermic reaction. This heat will be transfer to the workpiece for melting of Base material to produce the joint, hydrogen gas will be acting as heating agent and also it will act as shielding gas to protect the liquid metal. AC powersupply can be used.

Applications :- ① welding of Tool steel and Die steel.
② Repair works of cutting tools and Dies.

* RESISTANCE WELDING :-

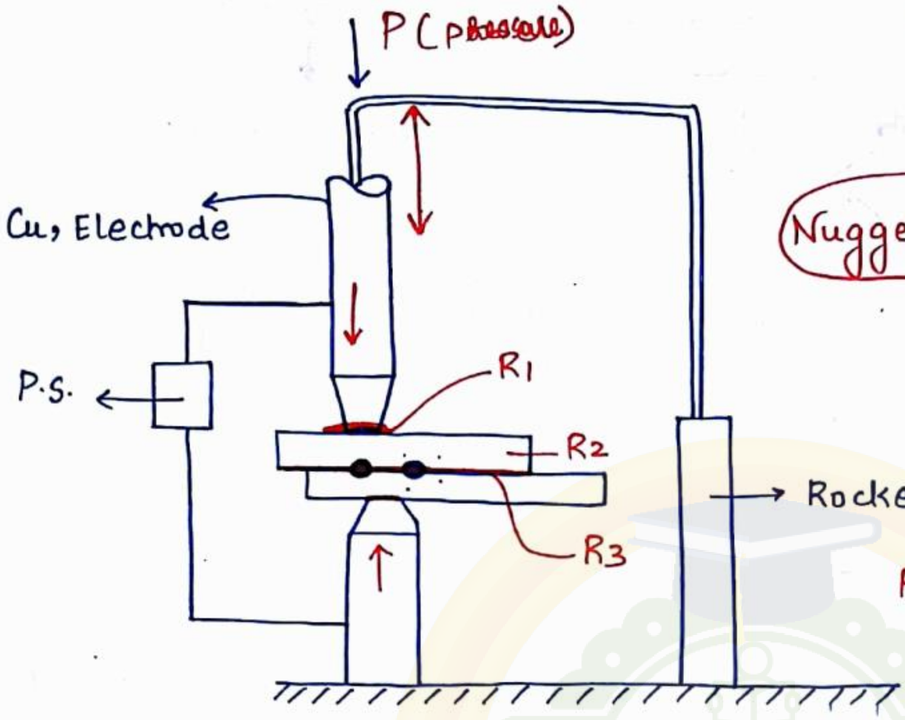
(a) SPOT WELDING :-

Thickness < 1 - 3 mm

$I \rightarrow 10{,}000\,A - 50{,}000\,A$

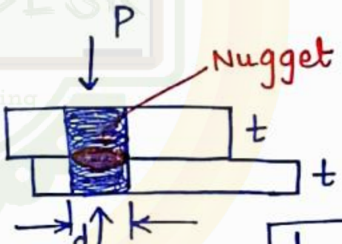
$t \rightarrow 0.01 \rightarrow 0.5\,sec$

Step down transformer



Nugget joint

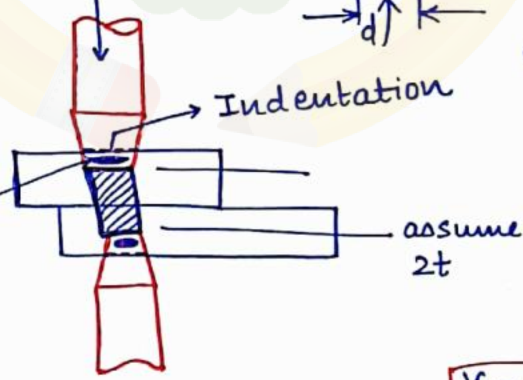
$R_3 >> R_1 \; \& \; R_2$



$\boxed{d = 6\sqrt{t}}$ → thickness

$\boxed{h = 2t}$

But



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

This has to be added hence to remove.

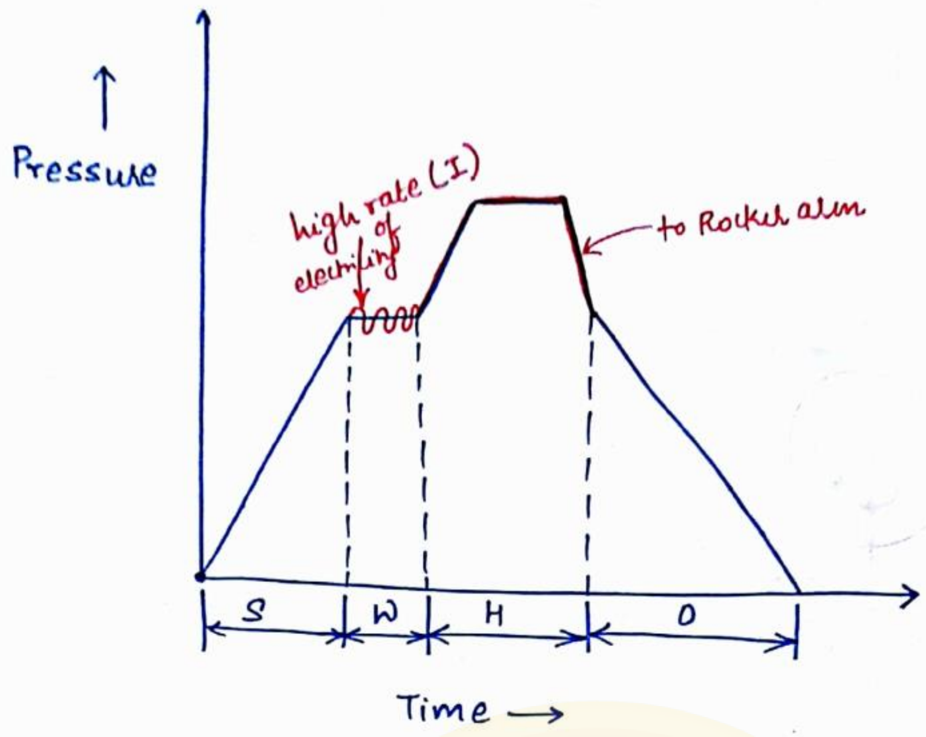
$\boxed{V = \frac{\pi}{4} d^2 h}$

$\boxed{m = V \times \rho}$

$\boxed{H_m = mc\Delta t + mL}$

$\boxed{H_s = I^2 R T}$

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



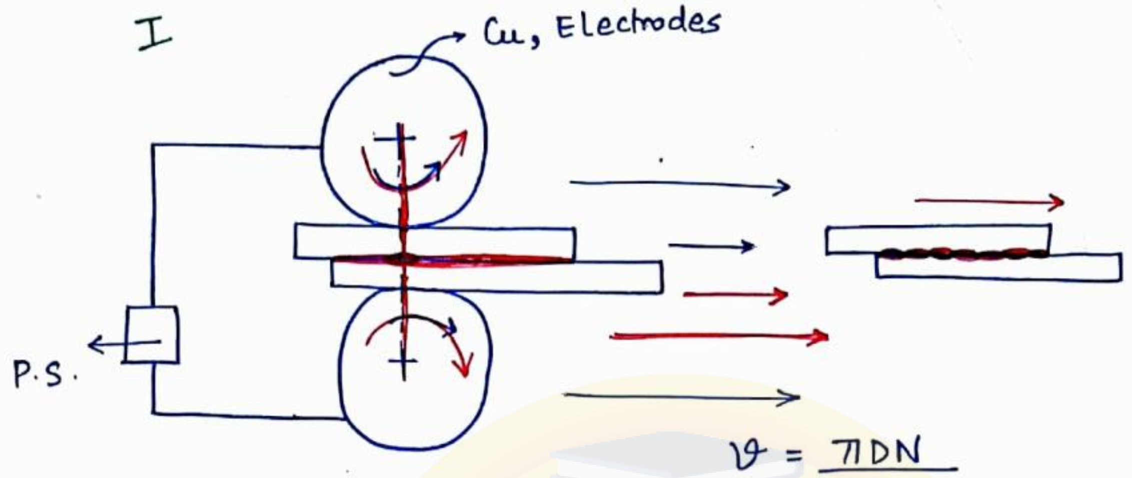
S → squeeze time
W → weld Time
H → Hold Time
O → off Time

} cycle Time

For joining of sheet materials, this technique can be used, two sheets which are to be welded will be provided b/w 2 Cu electrodes. By supplying high rate of current for a small fraction of time. heat will be generated at the contact of 2 workpieces due to contact resistance. after getting sufficient amount of heat by switch off the power supply, external pressure can be applied to produce joint between 2 surfaces below the electrodes. Leak proof joint is not possible. There is a possibility of indentation at the contact of electrode and workpiece.

Applications :- (a) lap joining of sheet materials in automobile bodies and refrigerator bodies.

(b) SEAM WELDING :-



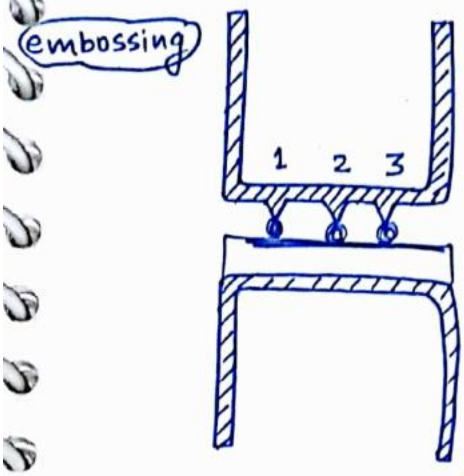
$$v = \frac{\pi D N}{60}$$

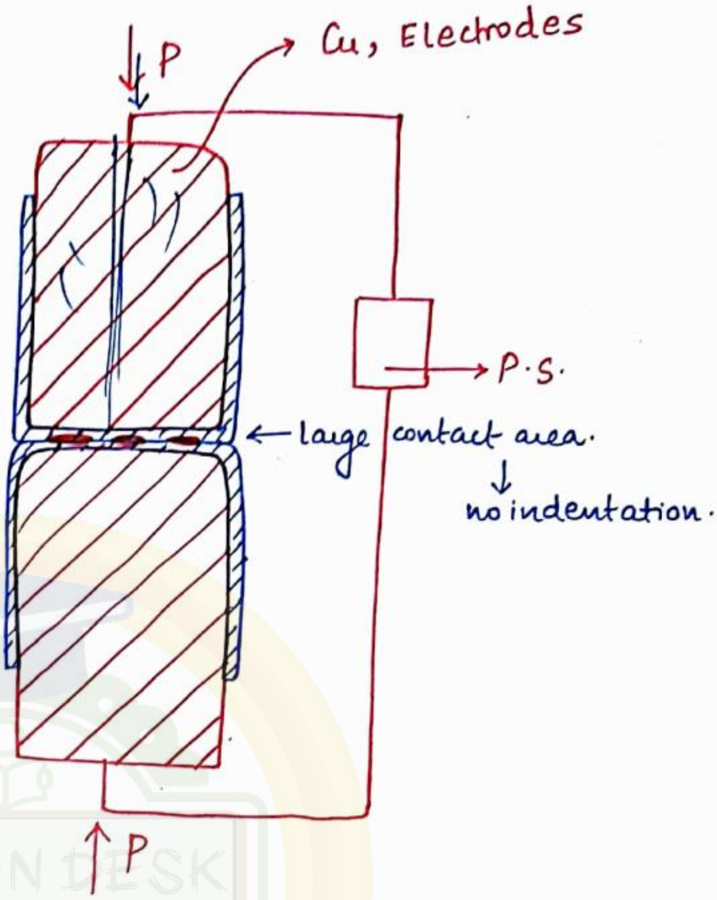
5m/min

Two sheets which are to be welded will be provided between 2 Cu electrodes which are in the form of Rollers or wheels. By supplying high rate of current through the electrodes to the workpiece, heat will be generated at the contact of 2 workpieces due to contact resistance. after getting sufficient amount of heat by rotating the rollers, external pressure can be applied. Due to this, nugget can be formed. Due to continuous rotation of the rollers and continuous application of power supply, nuggets can be overlapped due to this leak proof joint can be produced. welding speed is very high It can be used in mass production.

Applications :- (a) Fabrication of fuel tanks, gasoline pipes. (b) muffler used in exhaust pipe. (c) Radiator bodies.

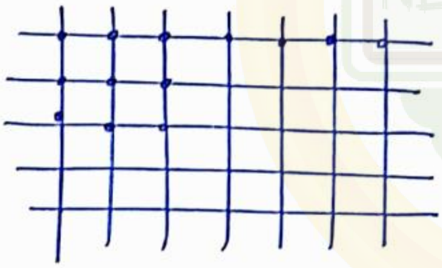
(c) PROJECTION WELDING :-



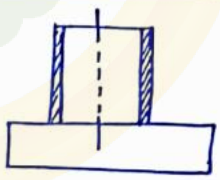


Applications :-

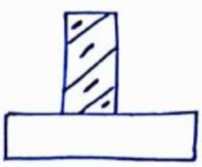
Wire Mesh



Threaded Nut



Threaded screw



On one of the sheet which is to be joined produce projections by embossing technique. 2 sheets are provided between 2 large size copper electrodes. By supplying high rate of current through the electrodes, heat will be generated at the projections. After getting sufficient amount of heat by switch off the power supply, external pressure can be applied through the electrodes, such that no. of nuggets can be produced at the projections in a single cycle.

Indentation between electrode and sheet will be Negligible. Leak proof joint is not possible. it can be used in mass-production only.

$\boxed{\text{Applications}}$:- (a) Fabrication of wire mesh.

(b) joining of threaded screws and nuts to the sheet material.

Q> Two sheets of 1.5mm thickness are to be spot welded by supplying a welding current of 10,000A for 0.1 sec's. Maximum Indentation allowed on the sheet material is 10% of sheet thickness. Density of the nugget material is $8\, gm/cm^3$. Heat Required for melting of the metal is 1.38 KJ/gm. Calculate the melting efficiency? Take contact Resistance as $R = 200\, \mu\Omega$.

Sol> $I = 10,000A$

Thick = 1.5mm

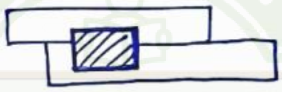
$t = 0.1$ sec

10%

$\rho = 8\, gm/cm^3$

$H_m = 1.38\, KJ/gm$

$R = 200\, \mu\Omega$.



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

$h = 2\left(1.5 - 1.5 \times \frac{10}{100}\right)$

$h = 2.7\, mm$

$d = 6\sqrt{t}$

$d = 6\sqrt{1.5}$

$d = 7.348\, mm$

$V = \frac{\pi}{4} d^2 \cdot h = \frac{\pi}{4}(7.348)^2(2.7)$

$= 114.49\, mm^3$.

$m = V \times \rho = 114.49 \times 10^{-3} \times 8$

$= 0.915\, gm$

$H_m = 1.38 \times 0.915$

$= 1.26\, KJ$

$H_s = I^2Rt$

$= (10,000)^2 (200 \times 10^{-6}) \times 0.1$

$= \underline{2000 J}$

$\eta_m = \frac{H_m}{H_s} = \frac{1.26}{2} = \underline{63.16\%}$

Q:> For a spot welding of 2 sheets of 3 mm thickness with a welding current of 10,000 A for 0.2 sec's. Heat dissipated to the base metal is 10,00 J. assuming Heat Req. for melting is 20 J/mm³, contact Resistance is 200 μ ohm (Ω). what is the volume of weld Nugget?

Sol:> $I = 10,000 A$

$t = 0.2 s$

$H_d = 1000 J$

$H_m = 20 J/mm^3$

$R = 200 \mu \Omega$

$V_n = ?$

$H_d = H_s - H_m$

$H_s = I^2Rt$

$= (10,000)^2 \cdot (200 \times 10^{-6}) \times 0.2$

$= \underline{4000 J}$

$H_d = 4000 - H_m$

$(H_d = 1000 J)$

$\boxed{H_m = 3000 J}$

$H_s = I^2Rt$

$H_s = 5000$

$vol. = \frac{H_m}{H_m/V} = \frac{3000}{20}$

$= 150 mm^3$

Pg.65
Q(14) Sol>

$t = 2mm$

$I = 6000A$

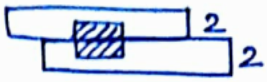
$t = 0.15 sec$

$H_m = 2.9 J/mm^3$

$D = 5mm$

$t_n = 2.5mm$

$R = 75 \mu\Omega$



$h = 2.5mm$

$d = 5mm$

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

$\boxed{V = 49.08 mm^3}$

$H_m = 2.9 \times 49.08$

$= \underline{142.35 J}$

$H_s = I^2 R t$

$= (6000)^2 (75 \times 10^{-6}) (0.15)$

$= \underline{405 J}$

$\eta_m = \frac{H_m}{H_s} = \frac{142.35}{405} = 35.14\%$

(16)

$t = 2mm$

$I = 10 kA = 10,000 A$

$time = 0.1 sec$

$H_s = mc\Delta t + mL$

$t_a = 293K$

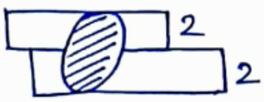
$t_f = 1793K$

$\rho = 7000 kg/m^3$

$mL = 300 kJ/kg$

$c = 800 J/kg K$

SIR



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

$V = 4/3 \pi (2)^3$

$\boxed{V = 33.51 mm^3}$

$m = v \times \rho$

$= 33.51 \times 10^{-9} \times 7000$

$= \underline{2.345 \times 10^{-4}\ Kg}$

$H_m = mc\Delta t + mL$

$= 2.345 \times 10^{-4} \left[800(1500) + 300 \times 10^{3}\right]$

$= \underline{351.75 J}$

$H_s = I^2 R t$

$= (10{,}000)^2 \times 500 \times 10^{-6} \times (10 \times 10^{-3})$

$= \underline{500 J}$

$\eta_m = \dfrac{351.75}{500} = 70.37\%$

(31) $t = 1.5mm$

$I = 10{,}000\ A$

$t = 0.2 sec$

$R = 100 \mu\Omega$

$d = 5mm$

$H_m = 1200\ KJ/Kg$

$\rho = 800\ kg/m^3$

$\% = 1 - \eta_m$

RW
2000
1.5mm 29.mm3
235.619

$h = 2 \times 1.5$

$= 3mm$

$d = 5mm$

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

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

$= \underline{58.9 mm^3}$

$m = V \times \rho$

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

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

$H_m = \cancel{mc\Delta t} + mL$

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

$= 565.4 J$

$H_s = I^2 R t = (10{,}000)^2 \times (100 \times 10^{-6}) \times 0.2$

$= 2000 J$

$\%$ of Heat lost $= \dfrac{H_s - H_m}{H_s}$

$= \dfrac{2000 - 565.4}{2000} = \underline{71.7\%}$

(32) $t = 2mm$

$I = 2500A$

$t = 0.005 sec$

SIR

$H_m = H_s$

$H_m/V \times Vol. = H_s$ 144 =

$100 \times \frac{\pi}{4}(6)^2 \times 4 = (25,000)^2 R \times 0.005$

$R = 3.62 \times 10^{-4} \Omega$

$R = 362 \mu\Omega$

(45) $H_m = H_s$

$mc\Delta t + mL = H_s$

$m[c\Delta t + L] = H_s$

$V \times \rho [c\Delta t + L] = H_s$

$0.05 \times depth \times 10^{-9} \times 2700 [896(630) + 398 \times 10^3] = 0.5 J$

$\boxed{depth = 3.84 mm}$

Q. 2016 gate spot welding of 2 sheets of 2mm thickness is carried out by supplying a welding current of 4000A for 0.2 sec's. a weld nugget formed between 2 sheet metal is 5mm diameter. assuming cylindrical shape for Nugget. what is a thickness of the weld nugget in mm. Take latent heat = 1400 KJ/kg, $R = 200 \mu\Omega$, $\rho = 8000 Kg/m^3$.

Sol

$I = 4000A$

$t = 0.2s$

$d = 5mm$

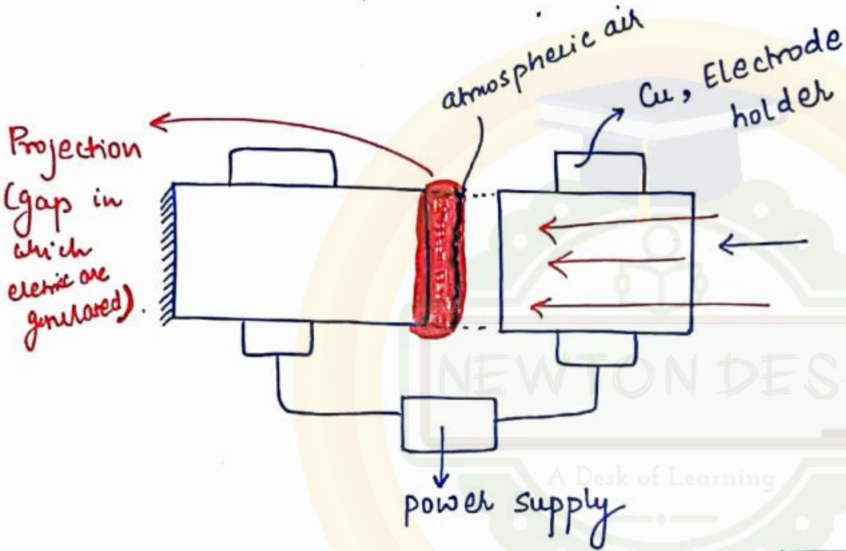
$L = 1400 KJ/Kg$

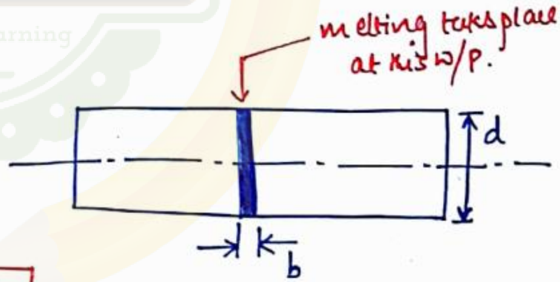
$R = 200 \mu\Omega$

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

16/9/2016

* **FLASH BUTT WELDING** :-





$V = \pi/4 \, d^2 . b$

$m = V \times \rho$

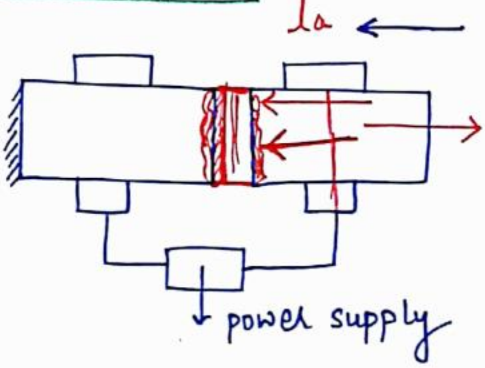
$H_m = mc\Delta t + mL$

$H_S = I^2RT$

$$\boxed{\eta_m = \frac{H_m}{H_S}}$$

New (fresh)

* **FLASH WELDING** :-



FBW :→ for joining of the objects end to end to produce a Butt joint between the 2 sulfaces, this technique can be used. 2 workpieces which ale to be welded will be held in 2 Cu electrode holdels. one will be fix and other is movable. when the 2 workpieces ale come to closel by supplying high rate of cullent at the contact of 2 w/p, due to lesistance to ail, heat will be generated. after getting sufficient amount of heat by switch off the powel supply, extemal pressule can be applied to produce joint b/w the 2 objects.

Heat generation is due to electrical Resistance.

b = amount of material which is melted from both ends of the object.

Flash welding :→ Two workpieces which ale to be welded will be provided b/w 2 copper electrode holdels. By ~~gaining~~ giving the power supply, 2 w/p's will be made in contact at the 2 ends. Due to short circuit, electric alc will be genelated. To continue the electric alc some gap is maintain between two workpieces. Heat will be generated at the two ends of the object due to electric alc. after getting sufficient amount of heat by switch off the powel cycle, extelnal plessule can be applied to produce the joint b/w the 2 ends of the object. Heat generation is due to electric alc.

Application :- Joining of the objects end to end which ale made up of Mild steel, Aluminium, Alloyed steels etc. (ϕ 0.1 - 25 mm)

Q> Two pipes of 110 mm outside diameter and 100 mm inside diameter are joined by Flash Butt welding technique using 30 V power supply. At the interface, 1 mm of metal is melted from each pipe which has internal resistance of 42.4 Ω. Energy req. for melting of the metal is 64.4 MJ/m3. Time taken for welding is :- ?

Sol> $V = \frac{\pi}{4}(D_o^2 - D_i^2)b = \frac{\pi}{4}((110)^2 - (100)^2)\,2$

$= 3298.67\ mm^3$

SIR

$D_o = 110\ mm$

$D_i = 100\ mm$

$V = 30V$

$R = 42.4\ \Omega$

$H_m = 64.4\ MJ/m^3$

$H_m = 3298.67 \times 10^{-9} \times 64.4 \times 10^6$

$H_m = 212.43\ J$

$\boxed{H_m = H_s}$

$H_s = I^2Rt = \frac{V^2}{R} \cdot t$ $\boxed{V = IR}$

$\Rightarrow 212.43 = \frac{(30)^2}{42.4} \cdot t$

$\Rightarrow \boxed{t = 10\ sec}$

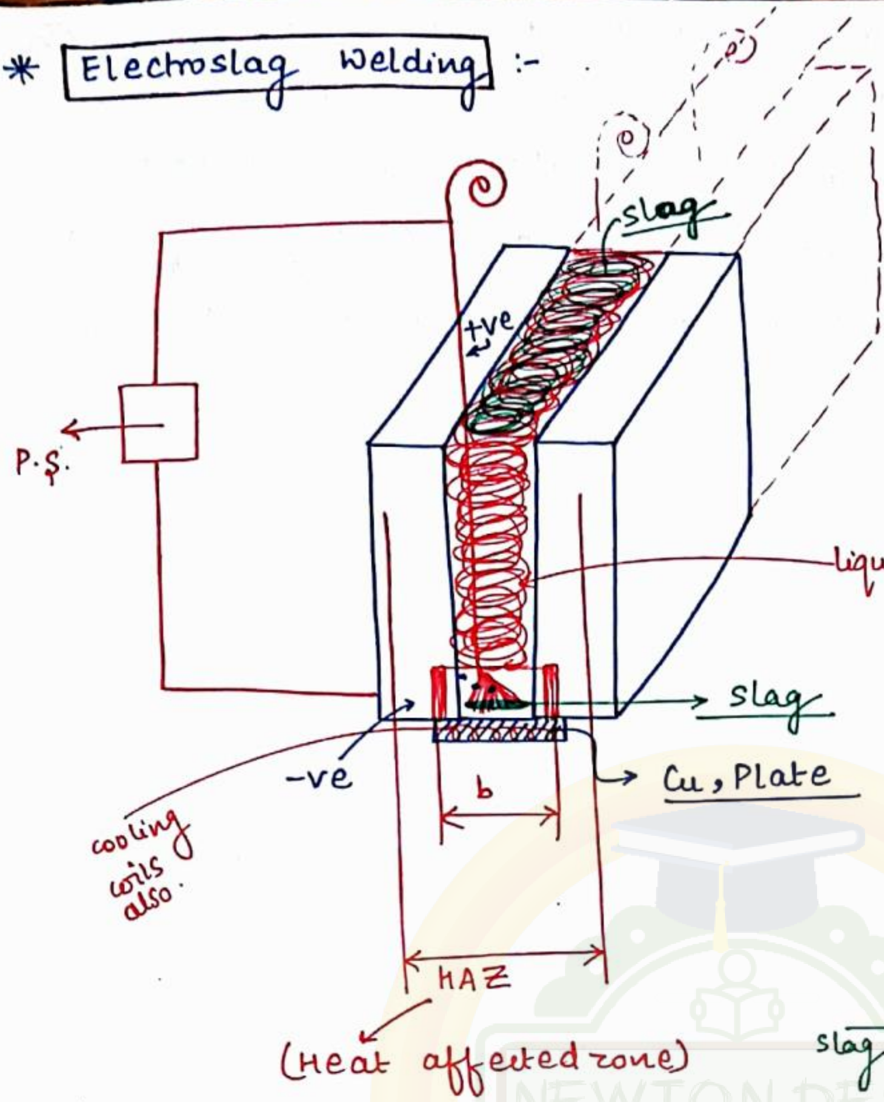
Q> Two sheets of 1 mm thick are welded by Resistance welding technique with a welding current of 30,000 A for 0.005 seconds. Resistance of the joint ~~can be~~ is taken as 100 μΩ. The joint can be assumed as cylindrical shape with 5 mm dia. & 1.5 mm height. Heat req. for melting the steel is 10 J/mm3. Calc. the melting η.

$450 = I^2Rt$

$H_s \uparrow$

Sol 65.4%

* Electroslag Welding :-

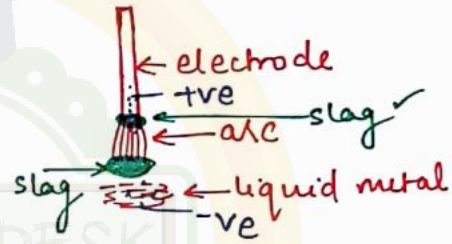


$I \to 1000A$

Thickness → 50-200 mm

DCRP

Direct current Reverse polarity.



press frames

For joining of high thickness objects vertically edge to edge. This technique can be used.

Arc is generated between a consumable electrode and workpiece. due to this, by melting the electrode material, liquid metal can be produced b/w the 2 surfaces. By adding sufficient amount of the flux, slag will ~~can~~ be produced. when the height of the liquid metal is increased. It is in contact with electrode, due to short circuit, electric arc will be extinguished. By supplying high rate of current, heat generation will be continued due to resistance of slag.

✓ Welding will takes place vertically in upward dirⁿ.

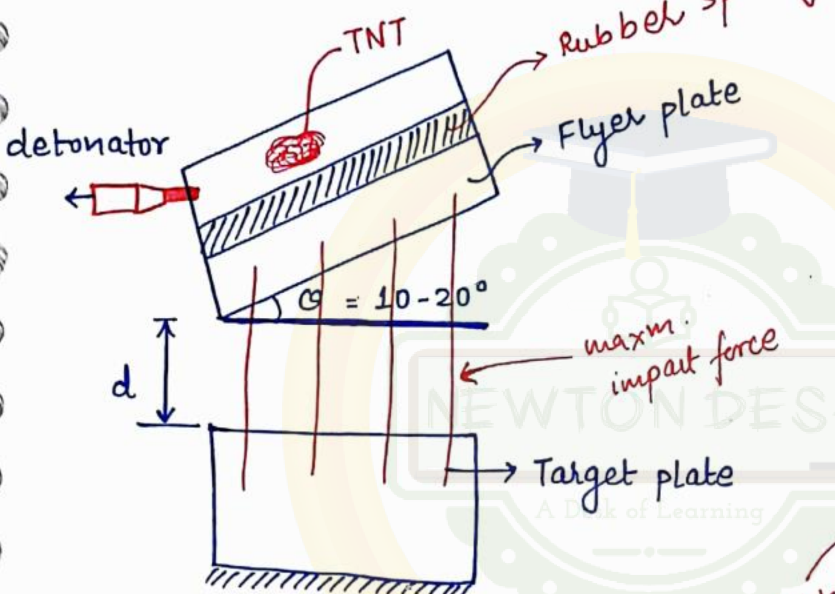
* **Applications** :- ① ~~Solid~~ Joining of high thickness plates vertically in ship building process.

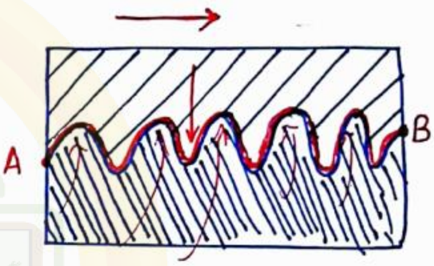
② Fabrication of press frame and Rolling stand mill.

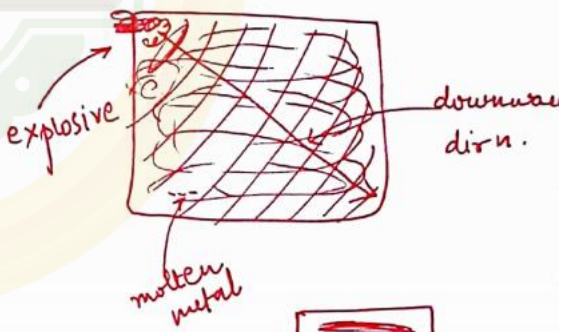
* SOLID STATE WELDING :-

① Explosive welding :-

TNT
Dynamites
Ammonium Nitrite

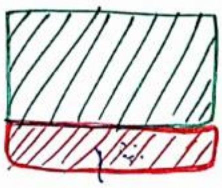


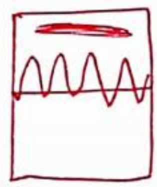




d → stand off distance.

Cladding





For joining of high thickness objects, surface to surface; this technique can be used. Two objects which are to be welded, one will be fixed (Target plate) and other is movable. It is flyer plate. by exploding low velocity, explosive material, energy will be released. using this, flyer plate will be forced on to target plate. Due to impact force, joint can be formed b/w the two workpieces due to plastic or permanent deformation. strength of the joint will depends on amount of impact force. Flyer plate is provided some distance from target plate to gain the momentum. Flyer plate is provided some inclination with horizontal surface to ~~gain the~~ provide direction for welding.

* **APPLICATIONS** :- ⓐ Joining of the objects in solid state to ↑ the corrosive resistance (cladding).

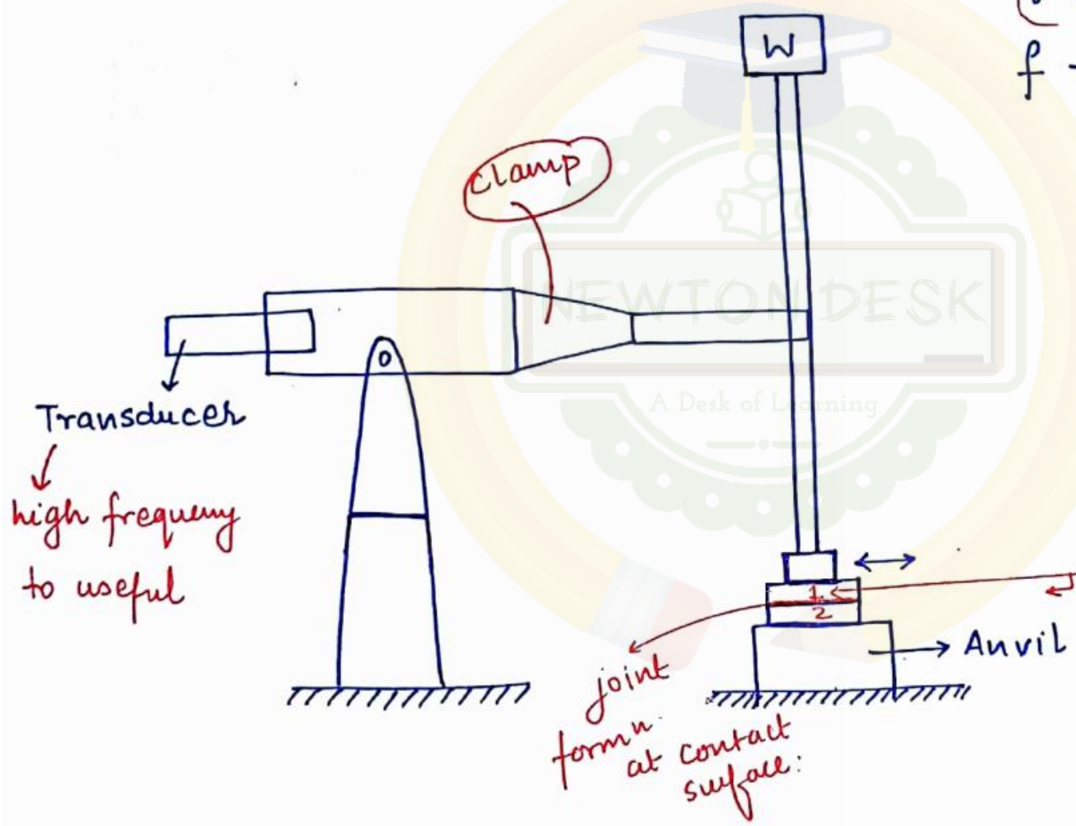
ⓑ Joining of dissimilar materials like Al to Ti and Al to steel.

② ULTRASONIC WELDING :-

Less thickness material.

$t < 1-2\,mm$

$f \rightarrow 20-60\,KHz$



✓ SIM card chip + plastic

✓ bike वाली metal + plastic

✓ Al foils

For joining of less thickness materials like Foils. This technique canbe used. High frequency power supply will be given to transducer. It will produce high frequency ultrasonic vibrations. This will be transfer to the workpiece by providing clamp. Due to the vibrations, initially rubbing action will takes place & heat will be generated because of friction. After reaching 40-50% of melting tempr. by releasing the static load, joint can be formed at the contact of two surfaces. Accuracy of the joint is very high.

Applications → (a) Fabrication of di-oxides and Tri-odes in electronic industry.

(b) Fabrication of keys, etc.

③ FRICTION WELDING :-

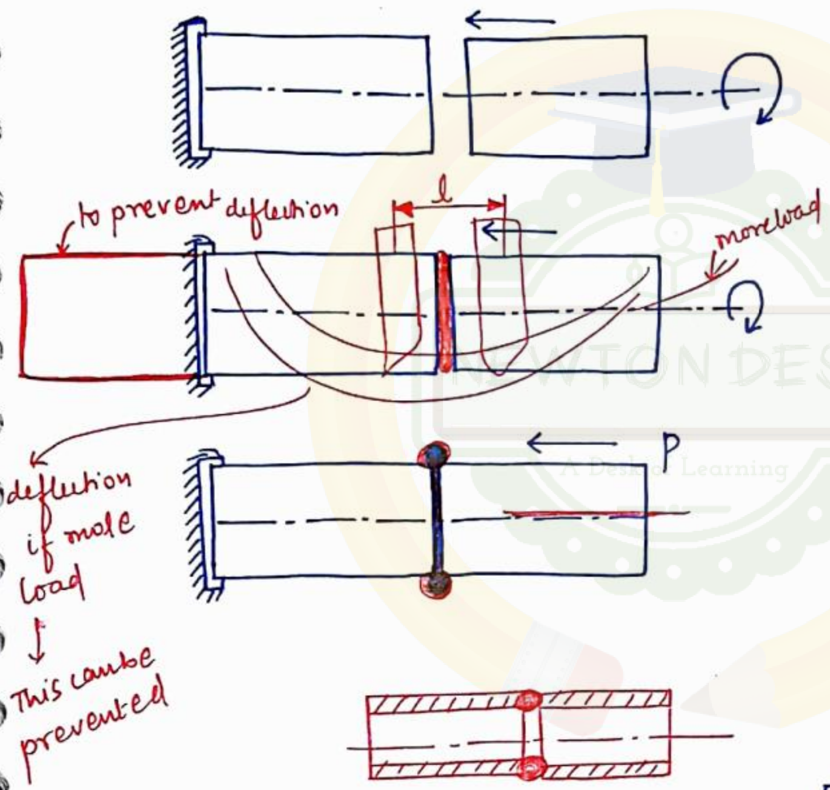
$N \rightarrow 4000 - 6000$ rpm.

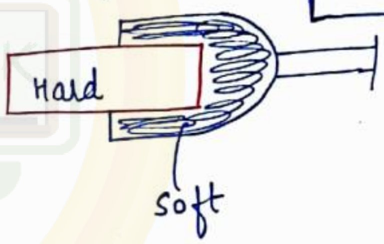
$p \rightarrow 40 - 400$ MPa

$F_f = p \times A \times \mu$ ← frictional force

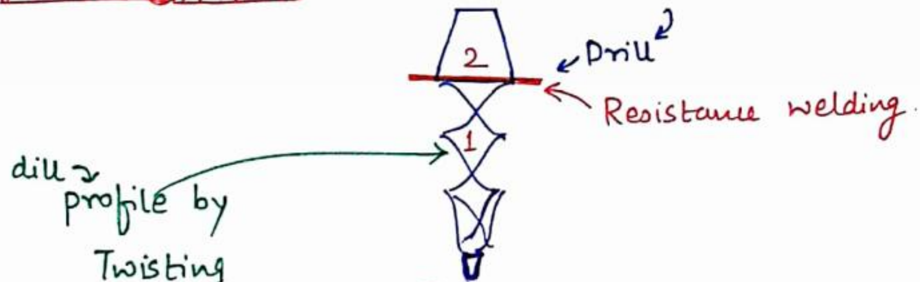
$T = F_f \times r$ ← Torque

$$\boxed{P = \frac{2\pi NT}{60}}$$





Axle & hub
pipes & valves
Drill bit & shank.



Friction Welding

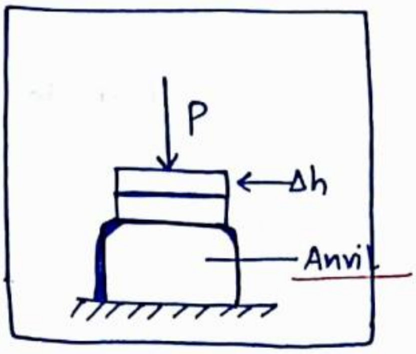
for joining of axis symmetric objects, end to end, this technique can be used. Two objects which are to be welded, one will be fixed and other is having rotational and linear movement by making the contact of 2 objects at the end. due to rubbing action, heat will be generated. After getting sufficient amount of heat (Recrystallization tempr.) by stopping the rotation, external pressure can be applied to produce a forged joint. strength of the joint is very high. similar and dissimilar metals can be welded.

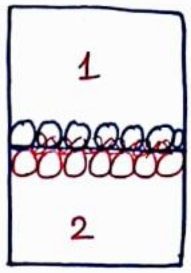
Applications :- ✓ Axle & hub.
- ✓ Pipes & valves.
- ✓ Drill bit & shank.

* FORGE WELDING :-

It is similar to blacksmithy forging operation. workpiece will be heated by providing inside forge, by applying external hamering force, It will be deformed into required shape and size and at the ends of the object by applying hamering force, joint will be formed. There is a possibility of oxide formation. To overcome this flux metal can be added. Accuracy and strength of the joint will be less. It can be used for village level agriculture applications.

* DIFFUSION WELDING :-





for joining of dissimilar materials, this technique can be used. Two workpieces which are to be welded will be provided in intimate contact. By applying pressure and heat at a slow rate at a contact of two surfaces, grains will be diffused at each other by means of pure diffusion process. To minimise oxide formation, this process will be carried out under vacuum or inert gases will be supplied. Strength of the joint is more.

Applications :- (a) Fabrication of composite laminates.

(b) Joining of metals to Non-metals like Al to ceramic

* ELECTRON BEAM WELDING :-

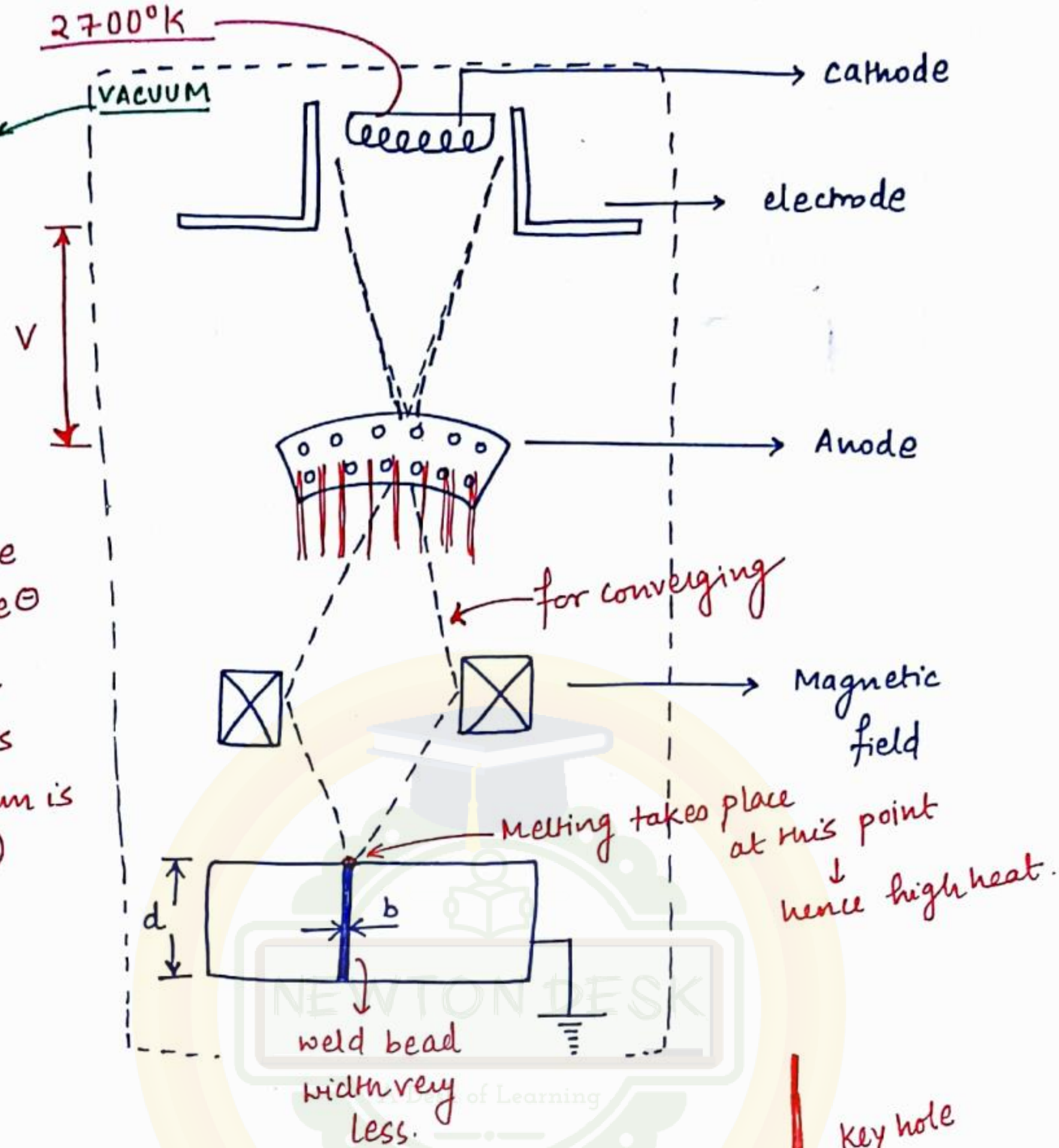
(EBW)

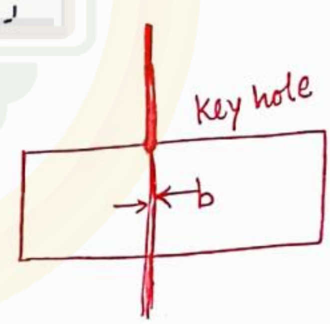
[N.P.]

no chances of oxide formation

A single ray of e⊖ beam

(KE of this electronic beam is very high)





$V \rightarrow \underline{20} - \underline{120}$ KV

$v \rightarrow 50,000 - 2,00,000$ km/s

(2×108 m/s)

d : b

10 : 1 $\longrightarrow$ 30 : 1

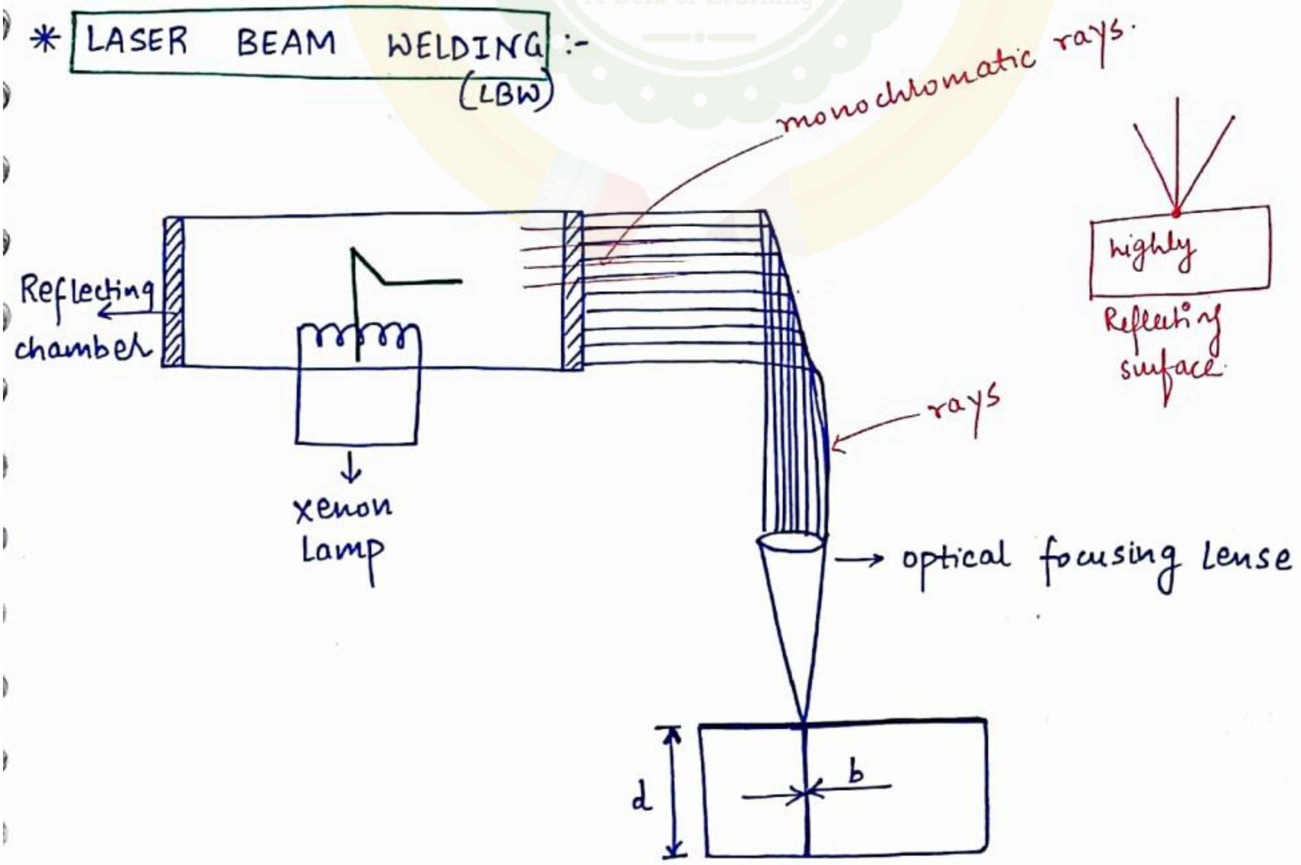
$v \rightarrow$ 10m/min

Missiles → high MP metals are going to weld using e⊖ beam welding

High Precision Technique → ISRO not cost e⊖s will be emitted from the cathode at high temperatures due to thermionic emission. They will be directed towards the W/P by providing electrodes. By creating more potential difference between cathode and anode, e⊖s will be accelerated towards anode. By creating magnetic field, e⊖s coming from different directions will be merged as a single ray of Electron beam and it will be focused 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 max^m. weld bead width and heat affected zone is minimum. This process will be carried out under vacuum. highly oxidizing materials can be welded. Operating & maintanence cost is more

* **Applications** - ⓐ welding of titanium, stainless steel and Barium (super alloys), tungsten, etc. in aerospace, jet engines, turbine blades, missiles and Nuclear Power plants.

* **LASER BEAM WELDING** :- (LBW)



d : b

4:1 → 10:1

$v \rightarrow 10 m/min$

1> CO_2 laser

2> Nd : YAG

↳ Neodymium

Y → Yttrium

A → Al

G → Garnet

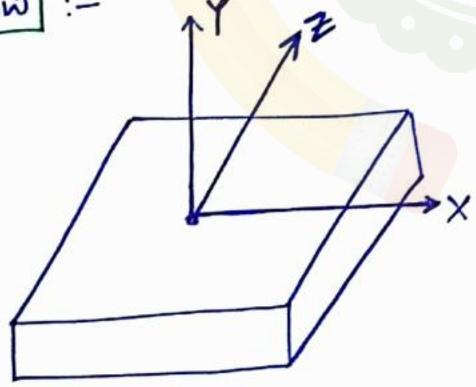
atoms can be pumped into high energy levels and atoms will release energy in the form of photons. from the Reflecting chamber, monochromatic and coherent light rays will be coming and they will be converged as a single ray of beam using optical Focussing lense. This will be focused on the workpiece at a given point, due to this heat concn. will be maxm, heat igh thickness and high M.P. metals can be welded/melted. Heat affected zone is minm. There is no need of vacuum.

* **Applications** :- welding of Al, Cu, Titanium and super alloys in aerospace and electronic industries.

* **HEAT FLOW CHARACTERISTICS** :-

$$\theta_m = (T_m - T_a)$$

① **3-D Flow** :-



Rate of heat input

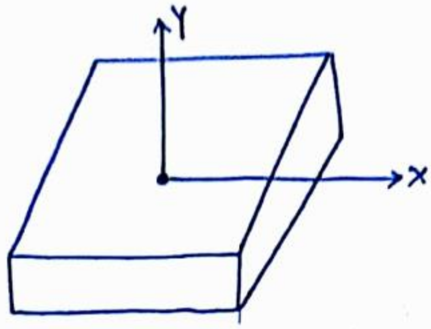
$$Q = \frac{5}{4} \pi b K \theta_m \left[\frac{2}{5} + \frac{v b}{4 \alpha} \right]$$

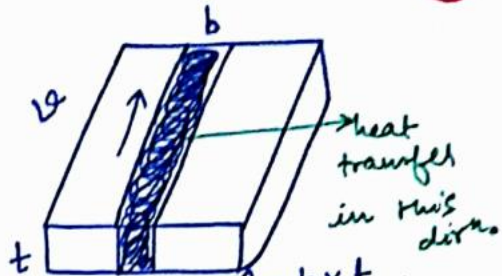
$H = f(x, y, z)$

point source, ← heat source

Ex:- Spot welding

② $\boxed{\text{2 - D Flow}}$:-





$A = b \times t$

$v =$ ______ .

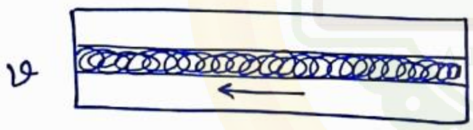
$$\boxed{Q = 8 K \theta_m t \left[\frac{1}{5} + \frac{v b}{4\alpha} \right]}$$

$H = f(x, y)$

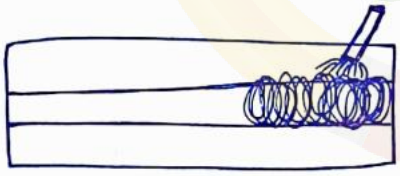
Line source

Ex:- Butt joint

* Q is rate of heat input.
* k → thermal conductivity.
* b is weld bead width.
* θ_m → difference of melting & ambient tempr.
* v → linear welding speed
*



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

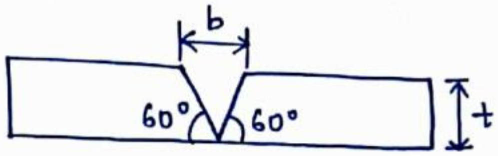


Q In a Butt welding operation, heat input is given by

$Q = 8 K \theta_m t \left[\frac{1}{5} + \frac{v b}{4\alpha} \right]$. Two plates are to be joined with a power source of 2.5 KW and heat transfer η as 85%. Take thermal conductivity will be equal to 45 W/m-°C. Difference of tempr. is 1450°C. $\alpha = 1.2 \times 10^{-5}\ m^2/s$. Determine maxm. welding speed for the joint which is shown in figure.

Diagram

↓



$Q = 2.5\,KW$

$\eta_h = 85\%$

$k = 45\,W/m^\circ C$

$\theta_m = 1450^\circ C$

$\alpha = 1.2 \times 10^{-5}\,m^2/s$

$\tan 30^\circ = \dfrac{b/2}{3}$

$\boxed{b = 3.464\,mm}$

$$2.5 \times 10^3 \times 0.85 = 8 \times 45\,(1450) \times 3 \times 10^{-3}\left[\frac{1}{5} + \frac{v \times 3.46 \times 10^{-3}}{4 \times 1.2 \times 10^{-5}}\right]$$

$\boxed{v = 16.05\,mm/s}$

* **SOLID / LIQUID STATE** :-

Brazing

① $> 427^\circ C$

$<$ M.P.B.

Cu & Zn
Cu & Ag
Cu & Al

Flux → Borax

Spelter

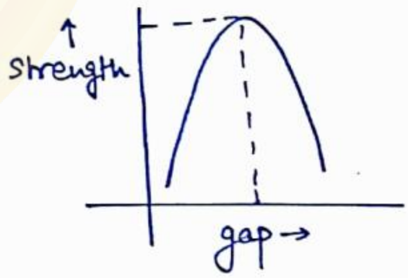
good capillary action

Soldering

① $< 427^\circ C$

Lead & Tin (solder)

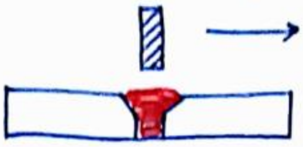
$ZnCl_2$ & NH_4Cl



Spreading & wetting

lead + Tin → $427^\circ C$

Braze welding



Gate Qn → * $T_W > T_B > T_S$

$\sigma_W > \sigma_{BW} > \sigma_B > \sigma_S$

✓ **Brazing** :- Filler material melting tempr. is greater than 427°C and less than melting tempr. of Base material. It is an alloy of Cu and zinc, Cu and Ag (silver), Cu and Aluminium. It is known as spelter. Flux material used is Borax. Filler metal is entered into the w/P by means of capillary action.

✓✓ **Applications** :- (a) producing of hydraulic circuit with a leak proof joint.

(b) Plumbing applications.

✓ **Soldering** :- Filler material melting tempr. is less than 427°C. It is an alloy of lead and Tin known as solder. It is enter into the w/P by capillary action. Flux metal used is $ZnCl_2$ and NH_4Cl (ammonium chloride)

✓✓ **Applications** :- (a) Design of electric and electronic circuit.

(b) Fabrication of PCB's (printed circuit boards).

✓ **Braze welding** :- Filler metal is an alloy of Cu and Tin known as Bronze. It is enter into the w/p by means of gravity force. strength of the joint is more.

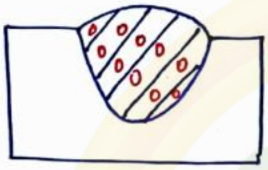
✓✓ **Applications** :- (a) Joining of cutting tool tips.

* **TYPES OF SOLDER** :-

	Pb	Sn
(a) Soft solder.	40%	60%
(b) Medium —"—	40 + 10 50%	50%
(c) Electrician's solder.	60%	40%

* **Welding Defects** :-

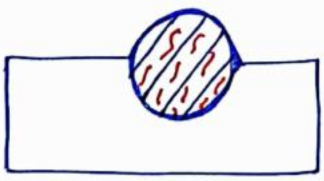
① **Gas Porosity** :-



By absorbing atmospheric gases in the liquid metal during the solidification process will form Gas porosity.

Remedies :- ✓ provide sufficient amount of the flux and protect the liquid metal by providing shielding gas.

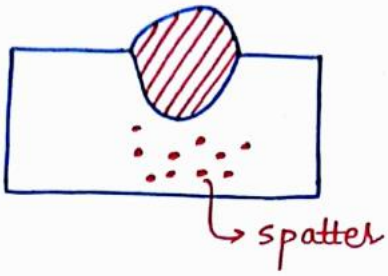
② **Slag Inclusions** :-



Due to lack of heat input and improper positioning of welding Torch, slag can be included in the weld joint.

Remedies :- ✓ provide Sufficient amount of heat input and protect the liquid metal by using inert gas.

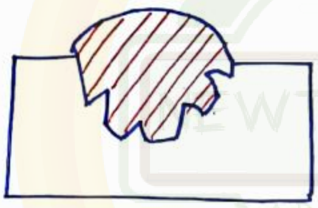
③ Weld spatter :-



Due to splashing of the liquid metal, after solidification on the base material, rough surfaces can be produced known as spatter.

R :- provide sufficient amount of heat input and reduce arc blow

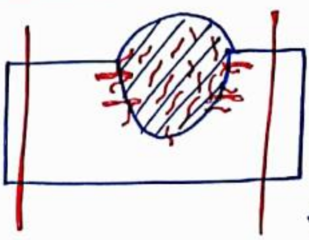
④ Lack of fusion and penetration :-



Due to lack of heat input, filler material (metal) is not penetrated with base material properly.

R :- provide sufficient amount of heat input. Select optimum welding speed.

⑤ Weld cracks :- Due to non-uniform cooling internal stresses can be developed in the weld joint. If the stresses will be more than the strength of the Base material, cracks will be found.

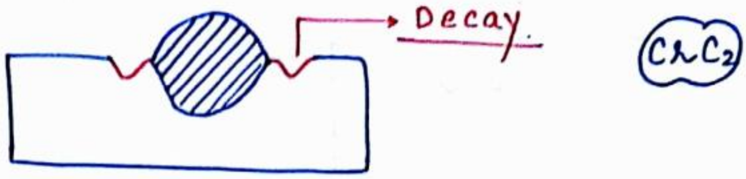


R :- provide preheating & post heating.

If the Hydrogen gas will be trapped inside the liquid metal during solidification process, it will be penetrated into HAZ will form a crack

Known as "HYDROGEN Embrittlement"

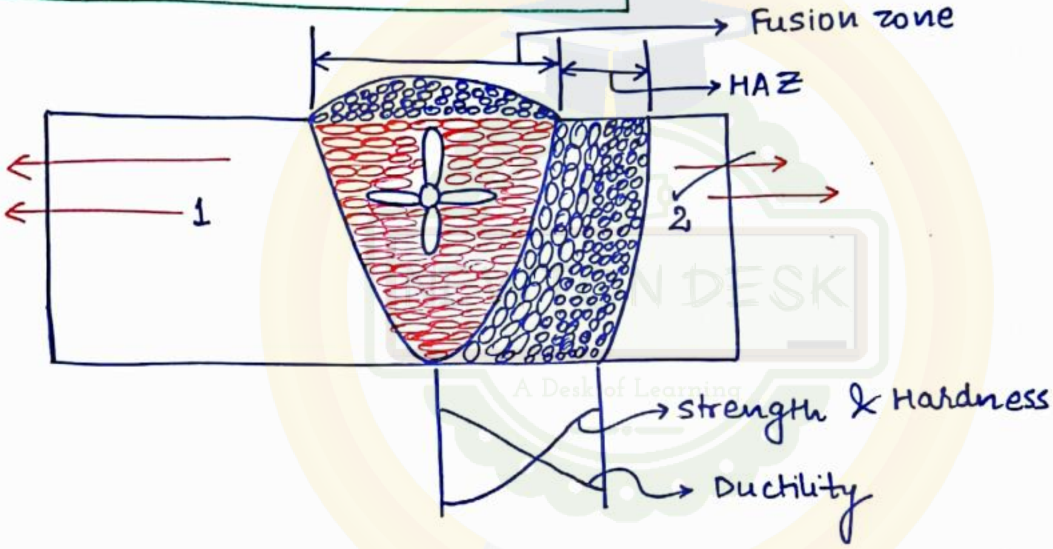
⑥ Weld Decay :-



In case of stainless steel, due to fast rate of cooling, chromium present in the HAZ will be converted into Chromium carbide. due to absence of Cr, there is a possibility of corrosion. due to this, a cavity is formed known as weld decay.

R :- provide preheating and post heating

* Weld-Bead characteristics :-



* Weldability :-

① Tm i.e. Tm ↑, ↓ weldability. ✓ Al, M.S., Cu, C.I.

② K ↑, ↓ —"— ✓ M.S., C.I., Cu, Al.

③ α (coefficient of linear expansion) ↑, ↓ —"—.

④ % of Carbon ↑, ↓ —"—
↳ material hard & brittle ← difficult to weld.

⑤ oxide formation ↑, ↓ —"—

Answers :-

CH → 19

1 → D
2 → C
3 → B
4 C
5 B
6 D
7 D
8 C
9 D
10 A
11 D
12 D
13 B
14 B
15 B
16 C
17 D
18 B
19 B
20 B
21 A
22 B
23 A
24 A
25 D
26 A
27 C
28 C
29 D
30 A
31 C
32 B
33 C
34 C
35 A
36 D
37 A
38 A
39 C
40 C

Routile → Titanium oxide.

CH → 20

1 A
2 A
3 C
4 A
5 D
6 D
7 C
8 A
9 B
10 D
11 A
12 B
13 C
14 D
15 D
16 B
17 B
18 B
19 C
20 A
21 C
22 C
23 A
24 A
25 B
26 B

CH → 21

1 D
2 C
3 C
4 B
5 C
6 A
7 A
8 C
9 D
10 A
11 A
12 D
13 A
14 A
15 C
16 A
17 A
18 B
19 A