SSP Notes

JANUARY 2018

Wednesday
1st Week • 003-362

03

08:00
09:00
10:00
11:00
12:00
Lunch
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
Eve.

INTRODUCTION TO MANUFACTURING PROCESS

FEB 2018

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
18	19	20	21	22	23	24	25	26	27	28	•	•	•	•	•	•	•	•	•	•

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SSP Notes

WELDING

→ Welding is a process for joining two similar or dissimilar metals by fusion, with or without application of pressure; with or without the use of filler metal.

→ Welding generally affects the metallurgy of the components, it is therefore usually accompanied by post-weld heat treatment for most of the critical components.

→ Weldability is defined as property of a metal which indicates the ease with which it can be welded with other similar or dissimilar metals.

It depends on:

a) metallurgical changes that occur due to welding
b) changes in hardness in and around the weld
c) gas evolution and absorption
d) extent of oxidation
e) effect of cracking tendency of the joint.

→ $\text{Castability} \propto \frac{1}{\text{Weldability}}$ — (*)

→ Plain low carbon steel (C - 0.12%) = best weldability amongst metals.

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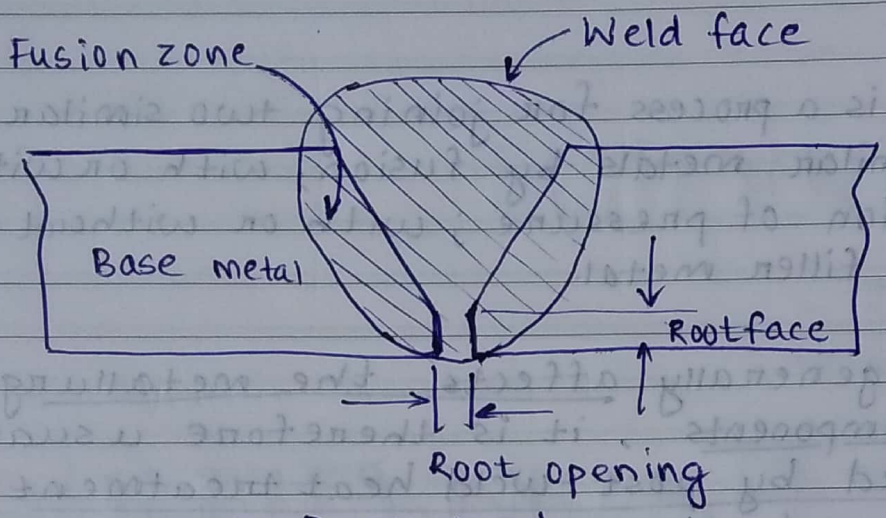
SSP Notes

08:00



09:00

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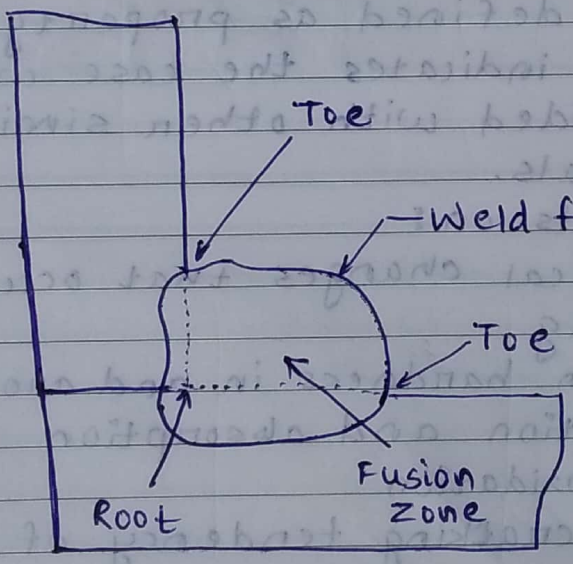
12:00

Lunch

(a) Butt weld

13:00



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18:00

Sunday 07

(b) Fillet weld

19:00

20:00

Eve.

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SSP Notes

- Butt - welding joints edge preparations -
  a) straight
  b) single - U
  c) single - V
  d) Double - U
  e) Double - V
  f) single - J
  g) single bevel
  h) Double - J
  i) Double - bevel

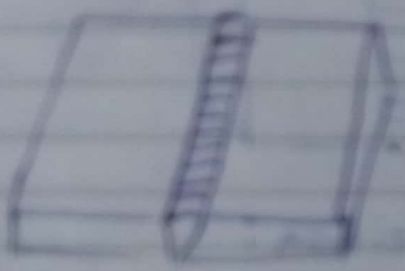
Welding joints

Lap - weld joint
i) Single lap
ii) Double lap
iii) Tee fillet weld

Butt - weld joint
i) Single - Vee Butt weld
ii) Double - Vee Butt weld

- Welding positions

1. Flat or down - hand position:
   → Most simple and most convenient



2. Horizontal welding position:
   → Plane of workpiece - vertical
   → Deposited weld - horizontal
   → Welding rounds the corners

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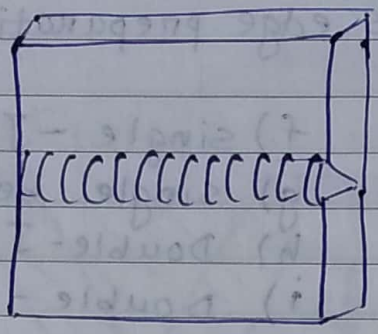
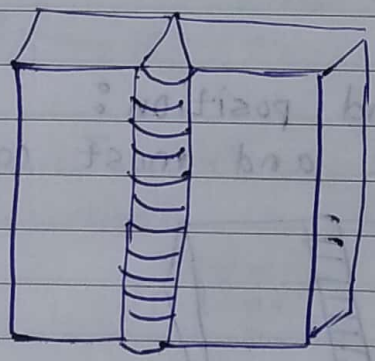


3. Vertical Welding Position:
12:00
→ Plane of workpiece = vertical
→ Weld on vertical surface

Lunch

→ Vertical-up welding - when strength is the major consideration
13:00
→ Vertical-down welding - sealing operation and for welding sheet metal.
14:00
15:00



16:00
17:00
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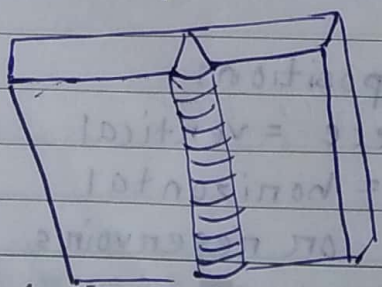
4. over head position:



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SSP Notes

→ Most difficult
→ The force of the flame against the weld serves to counteract the pull of gravity
→ The electrode is held with its welding end upward. very
✓ → short arc + basic coated electrodes.

GAS WELDING

→ Using heat of combustion of oxygen / air and fuel gas. The intense heat produced melts and fuses together the edges of the parts to be welded, generally with the addition of filler metal.
(Oxy-acetylene is most widely used)

● Oxy-acetylene Welding

→ Welding torch = $O_2 + C_2H_2$ mixture
→ Filler metal = welding rod
→ used to build up seam slightly for greater strength.

■ Flames

① Neutral welding Flame

→ Approx. equal volumes of O_2 and C_2H_2.

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SSP Notes

are mixed in the welding torch and burnt at the torch tip.

→ Temperature : 3260°C (5900°F)

→ Clear, well-defined inner cone, indicating complete combustion.

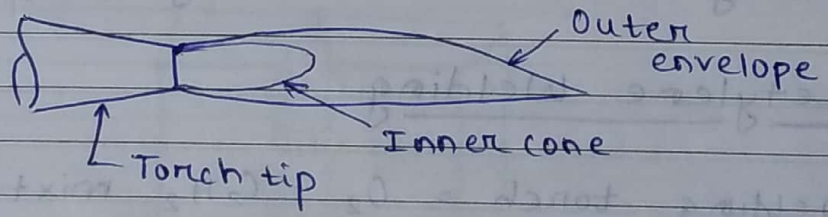
→ Inner cone = light blue

Outer flame envelope = O_2 (in air) + superheated CO + H_2 (from inner cone)

→ This envelope is much darker blue than inner cone.

→ Doesn't affects no chemical change on molten metal.

→ Uses - i) Welding of mild steel
ii) stainless steel
iii) cast iron, copper and aluminium



(2) Carburising (OR) and Reducing -

→ Excess acetylene, can be recognized by acetylene feather, which exists between the inner cone and outer envelope.

→ Longer and brighter in color

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SSP Notes

08:00 → With iron and steel, carburizing flame produces very hard, brittle substance known as iron carbide (Fe_3C)

10:00 → C_2H_2 (Carburising flame) > C_2H_2 (Reducing flame)

11:00 → 3038°C = temperature

12:00 → Carburizing - flame :
* welding of lead
* carburizing (surface-hardening) purpose

Lunch → Reducing flame :
* ensures absence of oxidizing conditions.
* welding with low alloy steel rods
* welding those metals which don't absorb carbon (non-ferrous)
* (* welding high carbon steel)

13:00

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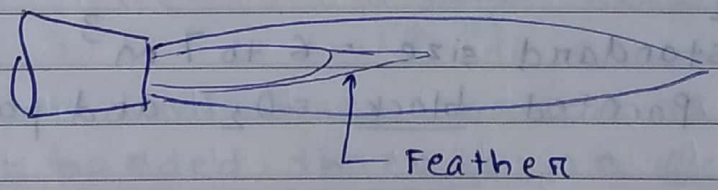
16:00



17:00

18:00

(3) Oxidising welding flame

19:00 (Loud-roaring sound)

→ Excess oxygen than acetylene

20:00 → shorter length, much bluer in colour, more pointed than neutral flame.

Eve. → Outer flame envelope is much shorter and tends to fan out at the end.

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SSP Notes

→ Hottest flame (3500°C or 6300°F)

→ Disadvantages :

a) Forms hard, brittle, low strength oxides with many metals.

b) Weld bead has scummy or dirty appearances.

→ Uses :

a) Not welding steel

b) Welding –

(i) Cu-base metals

(ii) Zn-base metals

(iii) Few ferrous metals – Mn steel (Manganese) – cast iron

The oxides here create a protective that protects base metal.

■ Equipments

(1) Cylinders

Sunday 14

→ standard size = 6 to 7 m^3

→ Painted black = O_2 and painted maroon = C_2H_2

→ C_2H_2 cylinder fitted with absorptive material like acetone, which can absorb a large volume of C_2H_2 and release it when pressure falls.

→ C_2H_2 is generated by carbide reaction.

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O_2 cylinders - equipped with about 40 L of O_2 at a pressure of 154 kgf/cm² at 21°C.

→ To protect from dangers :
a) every valve has a safety device to release O_2 before there is any danger of rupturing cylinder
b) Fragile discs and fusible plugs are provided in cylinders valves in case it is subjected to danger.

(2) Gas pressure regulators

→ Regulate supply of O_2 and C_2H_2, connected between the cylinder and hose leading to welding torch.
→ Two fitted gauges → i) to know gas pressure in cylinder
ii) reduced pressure at which gas goes out
→ cylinder and hose connections have left-handed threads on acetylene regulator while right-handed on O_2 regulator.

(3) Welding Torch

→ Tool for mixing O_2 and C_2H_2 in correct ratio and burning the mixture at tip end.
→ Gas flow to torch is controlled by two needle valves.

SSP Notes
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SSP Notes

08:00 Types -

i) Positive pressure (medium or equal pressure)
09:00 = more common $O_2 - C_2H_2$ torches

ii) Low pressure or injector type.

10:00 (4) Torch tips

11:00 → Gases pass through here just prior to their ignition and burning.

12:00 → Tips are identified by the diameter of the opening which further depends on type of metal to be welded.

Lunch

13:00 (5) Hose pipes

14:00 → For supply of gases from pressure regulators (generally rubber hose pipes)

15:00 → standard : i) Green = O_2
ii) Red = C_2H_2
16:00 iii) Black : other industrially available welding gas.

17:00

18:00 (6) Goggles

→ Fitted with colored lenses, protect eye from harmful heat, UV, infrared rays

19:00

20:00 (7) Gloves

→ Protect hands from heat.

Eve.

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SSP Notes

08:00 (8) Spark-lighter

09:00 → Frequent ignition of welding torch.

10:00 (9) Filler rods

11:00 → Generally held 90° to the welding tip.

→ These have nearly same composition as the base metal.

12:00

→ Metallurgical properties of weld deposit can be controlled by optimum choice of filler rod.

Lunch

→ Most of them contain deoxidizers to control the O_2 content of weld pool.

13:00

14:00 (10) Fluxes

15:00 → Used to remove the oxide film and to maintain a clean surface.

16:00

→ Generally in Gas welding of Al, Stainless steel, cast iron, brass, silicon bronze.

17:00

18:00

19:00

20:00

Eve.

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Eve.

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SSP Notes

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18:00

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SSP Notes

ARC WELDING

→ The process in which an electric arc between an electrode and a workpiece or between two electrodes is utilized to weld base metal is called arc welding process.

→ To prevent weld pool from atmosphere →
i) Use shielding gas
ii) Use coatings or fluxes

■ Equipments

(1) Power source

(Read the printed material)

Reverse polarity

→ For thin base metals
i) Workpiece or tables = ⊖ ve
ii) Electrode = ⊕ ve ← $e^{\ominus}$ movt.
iii) Higher rate of deposition
iv) Lower depth of penetration

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SSP Notes

08:00 **Straight polarity**

09:00 → For thick base metals
i) Work piece = ⊕ve
ii) Electrode = ⊖ve
$e^{\ominus}$ movt.
10:00 iii) Lower rate of deposition
iv) Higher depth of penetration.
11:00

12:00 **(2) Welding cables**

Lunch → Insulated Cu or Al cables.
→ Required for conduction of current from the power sources through electrode holder → arc → workpiece
13:00 ↓
power source.
14:00

15:00 **(3) Electrode Holder** (150 - 500 A)

16:00 → for Holding electrode manually and conducting current, usually matched to the size of the lead, which in turn matched to the amperage output of the arc welder.
17:00
18:00

19:00 **(4) Welding Electrodes**
→ Piece of wire or a rod of metal or alloy
20:00 • Types -
(1) Consumable Electrodes
Eve. (a) Bare electrodes
(b) Coated electrodes

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SSP Notes

08:00 (2) Non - consumable Electrodes
(a) Carbon or Graphite Electrodes
09:00 (b) Tungsten electrodes

10:00 • Consumable electrode

11:00 → The end of this electrode starts melting when arc is struck between electrode and workpiece.

12:00

Lunch

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15:00

16:00 Sunday 21

17:00

18:00

19:00

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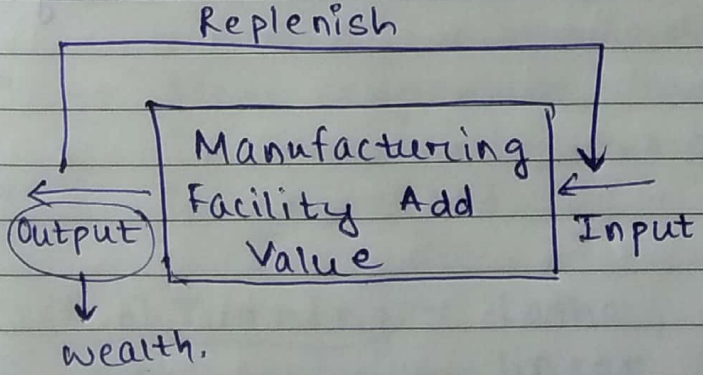
SSP Notes

INTRODUCTION

- Manufacturing system approaches.
- Basic manufacturing processes
  - → Casting
  - → Forming process
  - → Fabrication process
  - → Material removal process.
- Advanced machining process
  - → ECM → LBM
  - → EDM → AJM
  - → EBM → USM processes.
- Micro - manufacturing process.

* Manufacturing System Approaches

→ Manufacturing technology provides the tools that enable production of all manufactured goods.



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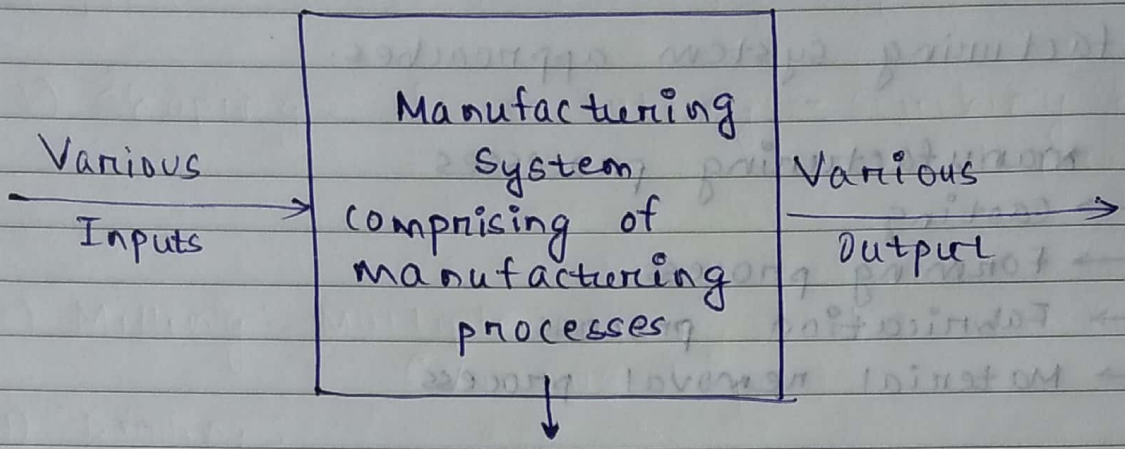

Man. pro. is the key to wealth generation.

* Primary processes (casting) – Overall shape and size is changed
  – Converts raw material into standard stock.

* Secondary processes – Making products that are more likely to be consumed by individuals.
  – Joining (joining) metals etc.
  Ex: Automobile manufacturing

Sunday 04

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SSP Notes

08:00 * Casting

09:00 → Only process where liquid metal is used.

10:00 i) Mould preparation
→ negative of the final shape
(cavity is negative of spherical shape)

11:00 Pattern
→ replica of the final shape

12:00 Refractory material
→ heat-resistant material i.e. minerals resistant to decomposition by heat, pressure or chemical attack.

Lunch

13:00 → It requires preparation of a cavity usually in a refractory material to resemble closely to the object to be realized.

14:00 → Molten metal is poured into this refractory mould cavity and allowed to solidify.

15:00

16:00 * Machining process (material removal)

17:00 → secondary man. pro., where additional unwanted material is removed in form of chips (scribing)

18:00 → Most expensive man. pro. because more energy is consumed, and also a lot of waste material is generated.

19:00

20:00

Eve. a) Turning - Lathe, w/p rotated, tool moves linear manner w.r.t w/p; radially
(Circular shapes)

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SSP Notes

08:00 on parallel to axes of rotating w/p.

09:00 b) Shaping: Form cutting - scribing back and forth to produce a form

10:00

11:00 c) Milling: Multiple cutting tool - material removal (various shapes)

12:00 d) Drilling:

Lunch e) Grinding

13:00 f) Sawing

14:00 → Non-conventional: to improve efficacies than conventional

15:00

16:00

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18:00

19:00

20:00

Eve.

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SSP Notes

Module - 13

(Introduction to casting Process)

→ Induction - base furnace : Homogeneous heating
→ wall - base heating : Temp. gradient is there

- In this process, the material is first liquefied by properly heating it in a suitable furnace and is then poured into a previously prepared mould cavity where it is allowed to solidify. Finally the product is taken off, trimmed, and cleaned to shape.

Important aspects :

1) The melting temperature of the job and the mould materials
2) The solubility of and the chemical reaction blw the job and the mould materials
3) The solubility of the atmosphere in the material at different temperatures to be encountered in the casting operation (like H_2 solubility)
4) The thermal properties - conductivity and coefficient of linear expansion of mould & job material. (As the metal poured is at very high temp.; it is bound to solidify; there would be shrinkage; so there must be enough allowances)
   → through use of risers

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SSP Notes

* Pattern and Mold

→ A pattern is a replica of the part to be cast and is used to prepare mould cavity.

→ Pattern are either made of wood or metal

→ A mould is an assembly of two or more metal blocks, or bonded refractory particles consisting of a primary cavity.

→ The mould cavity holds the liquid metal and acts as a negative of the desired product.

→ The mould also has secondary cavities for pouring and channeling the liquid material into the primary cavity and to act as a reservoir.

→ A four sided frame in which a sand mould is made is referred to as a flask.

→ The top portion is called cope, and the bottom portion is called drag.

→ For producing hollow sections, the entry of liquid metal is prevented by core, whose projections on pattern for locating the core in the mould are core prints.

* Pattern Allowances

→ A pattern is always made somewhat larger than the final job to be produced.

→ The excess in dimensions is referred to as pattern allowance. — a) shrinkage allowance
b) machining allowance
(for ex: to fit a shaft into the hole of wheel, some machining operations are to be done).

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SSP Notes

- Shrinkage allowance —

a) Liquid-phase contraction : pouring temp. ↓ to freezing temp.

b) Phase-transition contraction : Liquid phase ↓ to solid phase

c) Solid-phase contraction : Freezing temp. ↓ to Room temp.

ⓒ >> ⓐ, ⓑ

↳ depends on material

linear coefficient of thermal expansion α_1 of

For dimension l of casting, the shrinkage value $= \Delta l = \alpha_1 l (\theta_{freez.} - \theta_{room})$

→ Usually a cast surface is too rough, to be used as final product, as a result, machining operations are required to produce finished surfaces.

→ There is another deviation from job dimensions. Called draft ; which refers to a taper put on a surface parallel to the direction of withdrawal of pattern from mould cavity which facilitates easy withdrawal of pattern ($\frac{1}{2}^\circ - 2^\circ$)

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Pattern And Mold De

SSP Notes

08:00 * Types of Patterns (watch the videos for better understanding)

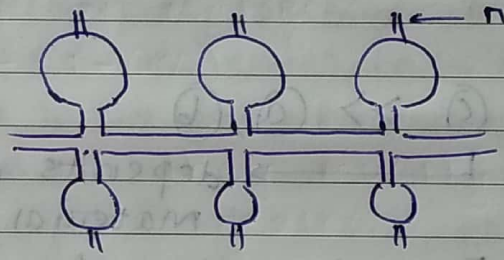
09:00 (1) Loose pattern :→ Retrieving the pattern may cause a mold damage.

10:00 Made of one piece of castings of large no.) soln: → Bolt the pattern to the main pattern and then do the job.

11:00 → First remove main pattern and simultaneously unbolt the loose piece pattern and then the loose pattern

12:00

Lunch (2) Gated pattern :



13:00 → Complete drag first.

→ Single pouring sprue

14:00

15:00 (3) Match-plate pattern :

→ For small castings, several patterns can be mounted on same match-plate

16:00 Sunday11

→ Single match-plate used.

17:00 (4) Cope and drag pattern :

18:00 → Two match-plate used

19:00 (5) Sweep pattern : Used to generate surfaces by revolution.

20:00

(6) Skeleton pattern : Best for hand shaping and for large castings with simple geometries.

Eve.

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SSP Notes

08:00

→ While designing a pattern, the parting line should be chosen so as to have the smallest portion of the pattern in the cope.
(Lest due to high buoyancy force, the mould would be damaged)

12:00 → Molding sand has greater strength in compression than in tension, the heavier sections of pattern should be in drag.

Lunch

13:00 * Types of Molds

14:00 1) Basis of material - a) Green sand mould
b) Plastic mould
15:00 c) Metal mould
2) Method of making them - a) shell mould
16:00 b) investment mould

17:00 → Metal moulds are permanent - large no. of castings can be made from a single mould.

18:00

→ Moulds of refractory materials can be used only once.

19:00

20:00

Eve.

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SSP Notes

* Green sand Mould

→ Constituents :

i) sand — Refractory material, (70-85%)

ii) clay — Binder material (10-20%)

iii) Water — (3-6%) ; Adhesive properties are activated by water

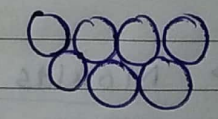
iv) Additives — (1-6%)

v) Organic material — They mostly vaporise - creates a good porosity - allowing expansion of sand (molding) particles to spaces - mould not broken due to sand expansion.

(Percentages may change with ferrous, non-ferrous or casting)

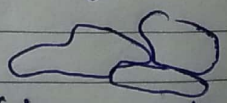
→ Grain-size distribution

→ When sand of equal size; there are large amount of void, high porosity, bulk density is low.



✓ (large amount of void) (high porosity)

→ Reverse is for sand particles having corners and varied sizes.



(low voids, ✗ low porosity)

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SSP Notes

- **Screening test**

→ Accomplished by shaking of sieves, amount of sand collected in different sieves is plotted, the average grain sizes are calculated.

→ clay + water = bonding agent

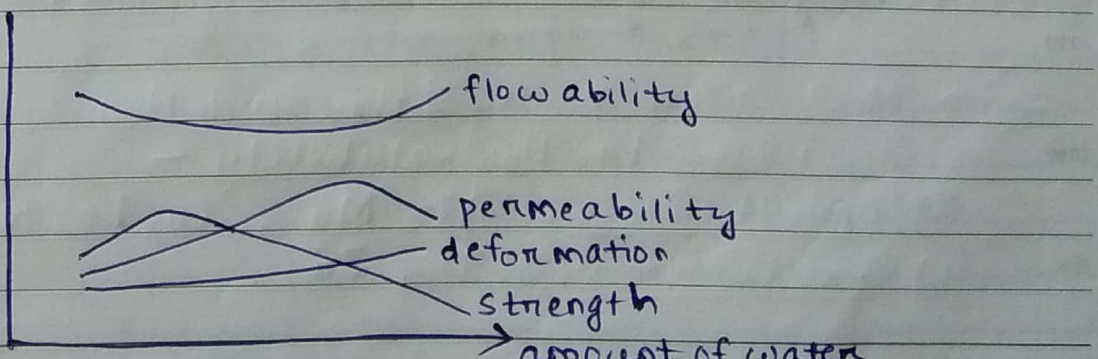
→ (1) Strength (High) : compressive strength

(2) Deformation (More) : Indicates change in length of a standard specimen at the point of failure.

(3) Permeability (More) : Gas flow rate through the specimen under a specified pressure difference across it.

(4) Flowability (More) : Ability of the sand to flow around and over the pattern when the mold is rammed.

(5) Refractoriness (Good) : Ability of sand to remain solid as a function of temperature



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SSP Notes

08:00

Permeability

09:00

a) Low water content - dry clay powder - fill up the void - lowers permeability.

10:00

b) Adequate water content - moist clay forms coating around sand particles - enhancing permeability - as large void numbers.

11:00

12:00

c) High water content - water itself fills the void - reduces permeability.

Lunch

13:00

14:00

15:00

16:00

17:00

18:00

19:00

20:00

Eve.

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Mold - Making Procedures

Friday

7th Week • 047-318

FEBRUARY 2018

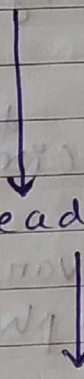
→ Parting compound i.e., non-wetting talc, is dusted for easy removal of pattern.

→ Fine grain facing sand - obtain a good surface on the casting

→ Dead weight placed on cope flask - prevent from floating due to hydrodynamic forces of liquid metal.

→ Gaggers (within cope) - to prevent the sand falling from cope flask when it is lifted from pattern.

→ Re-entrant surfaces - preventing metal from flowing out to obtain desired cross-section.



leads to 3-parts

a) Cope
b) Cheek (part blw cope & drag)
c) Drag

→ Vent holes - easy escape of gases.

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SSP Notes

a) Jolt Ramming - Mold is lifted through a height about 5cm and dropped 50-100 times at a rate of 200/minute
(See video) for better understanding
- There is uneven ramming, but is quite suitable for horizontal surfaces.

b) Squeezing - satisfactory for shallow flasks

c) Sand slinging - very fast & uniform ramming
- sand is thrown at a high speed via a wheel

Melting

→ Gases in metal lead to faulty castings.

Gases -
a) may be mechanically trapped (improper venting due to)
b) may be generated due to variation in the solubility at diff. temp. and phases (in alloys)
c) may be due to chemical reactions.

→ Most common are H_2 and N_2.
According to H_2 solubility -
a) endothermic: Al, Mg, Cu, Fe, Ni
b) exothermic: Ti, Zr

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$$S = C e^{-E_s/K\theta}$$ (S: solubility) in solid metal.

E_s = heat of solution of 1 mol. of H_2
= ⊕ ve for endothermic
= ⊖ ve for exothermic

C, K = constants

θ = absolute temp.

→ Endothermic metals
→ θ decreases from $\theta_{freez.}$ to θ_{room}.
⇒ H_2 solubility decreases in solid
⇒ it has to come out
⇒ through vent holes
⇒ H_2 dissolves in lattice defects and produces no distortions.

→ Exothermic metals
→ θ decreases from $\theta_{freez.}$ to θ_{room}.
⇒ H_2 solubility increases in solid
⇒ forms gas pockets and doesn't escapes out
⇒ produces lattice distortions.

* Sievert's Law

$$\% H \text{ present} = K(P'_{H_2})^{1/2}$$

↑ partial pressure of H in atmosphere over the melt

K can be calculated, taking pH_2 = 1 atm from table 2.2.

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SSP Notes

08:00 → Sources of H - in melt : furnace dampness, air, oil and grease

09:00

→ No simple dehydrogenation addition can be used to eliminate H_2.

10:00

11:00 → Now-a-days; vacuum melting is increasingly used, but expensive and small furnaces are used.

12:00

Lunch → p_{H_2} can be reduced :

a) bubbling some other dry insoluble gases - Cl_2, He, Ar, N_2

13:00

14:00 b) N_2 can't be used for Fe or Ni alloys, since it is soluble in these and may form nitrides which affect grain size.

15:00

16:00

17:00

18:00

19:00

20:00

Eve.

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Solidification of Pure Metals And Alloys

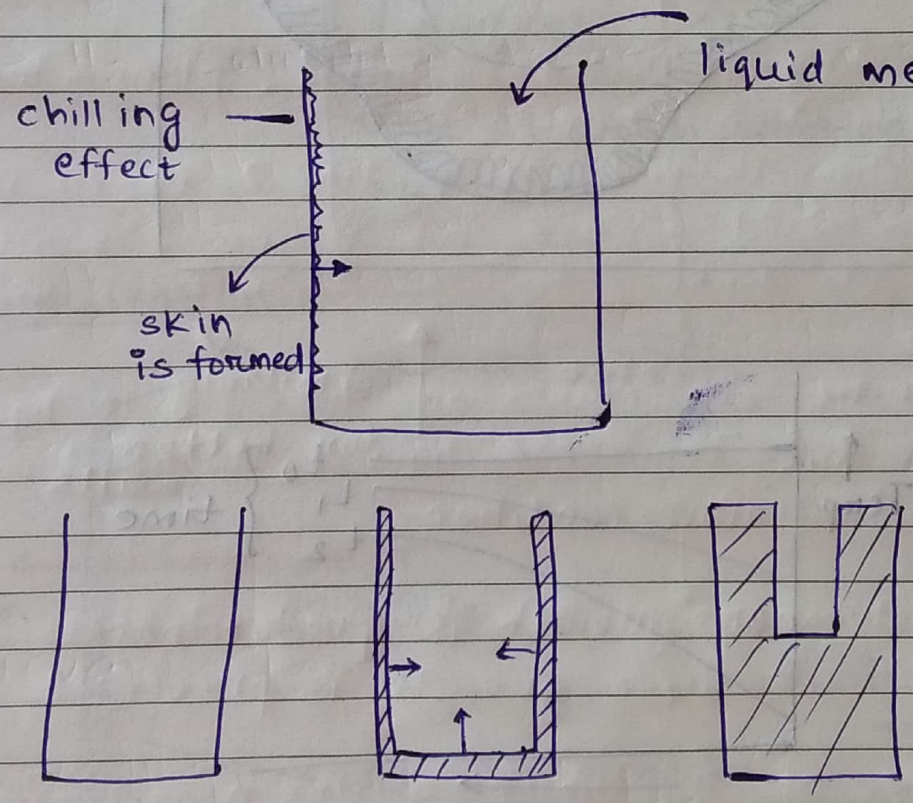
$D = k\sqrt{t} - C$

D = thickness of skin

C, K = constant

→ Magnitude of K is determined by size of casting & how fast heat is extracted from mold.

→ Magnitude of C is determined by degree of superheat.



(Plain-front solidification)

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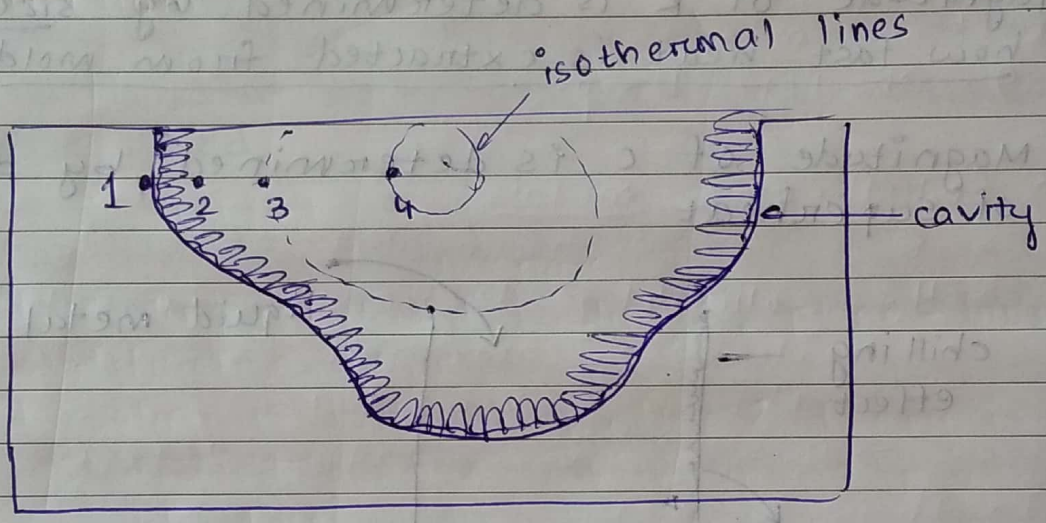
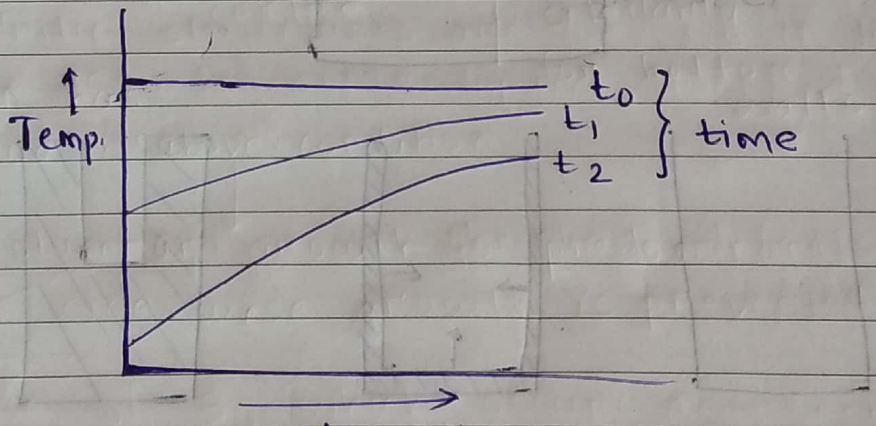
SSP Notes

→ In case of heterogeneous nucleation, presence of foreign particles alter the liquid - solid interface energy enough to assist in nucleation, thereby reducing the amount of supercooling required to effect nucleation.





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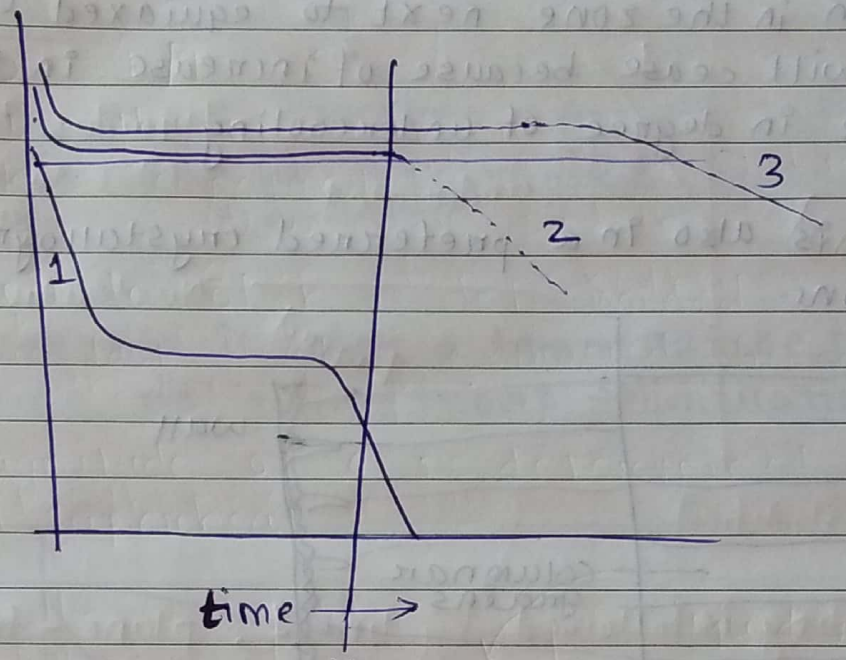
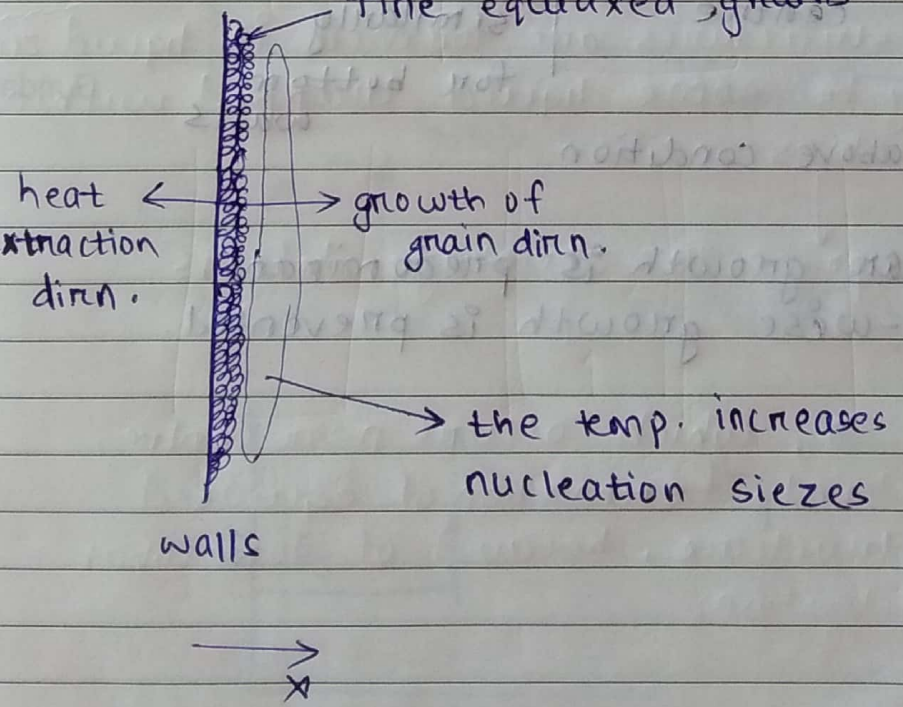


time at which casting is sectioned.

* Nucleation



→ Heat extracted in $-x$ dirn.

→ Crystal losing latent heat (upon solidification) increases the temperature in nearby area.

→ Growth occurs in a direction opposite to heat flow. i.e. $\oplus x$ dirn.

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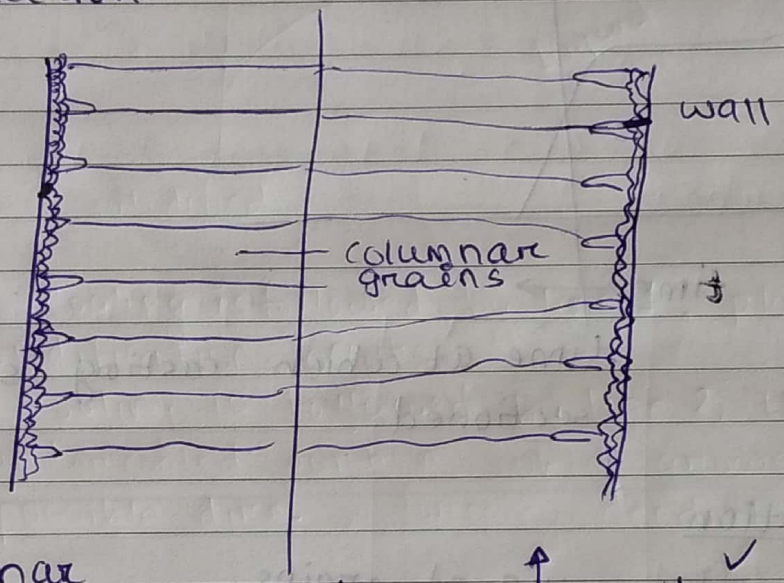
SSP Notes

08:00 * Nucleation in the zone next to equiaxed (fine) grains will cease because of increase in temp./ decrease in degree of undercooling

09:00

10:00 * Growth is also in a preferred crystallographic directions.

11:00



12:00

Lunch

13:00

14:00

15:00 → columnar because nucleation has stopped due to above condition

similarly for bottom walls

16:00

Sunday 25

17:00

→ the columnar growth is predominant, thus side-wise growth is prevented.

18:00

19:00

20:00

Eve.

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18 19 20 21 22 23 24 25 26 27 28 • • • • • • • • • •

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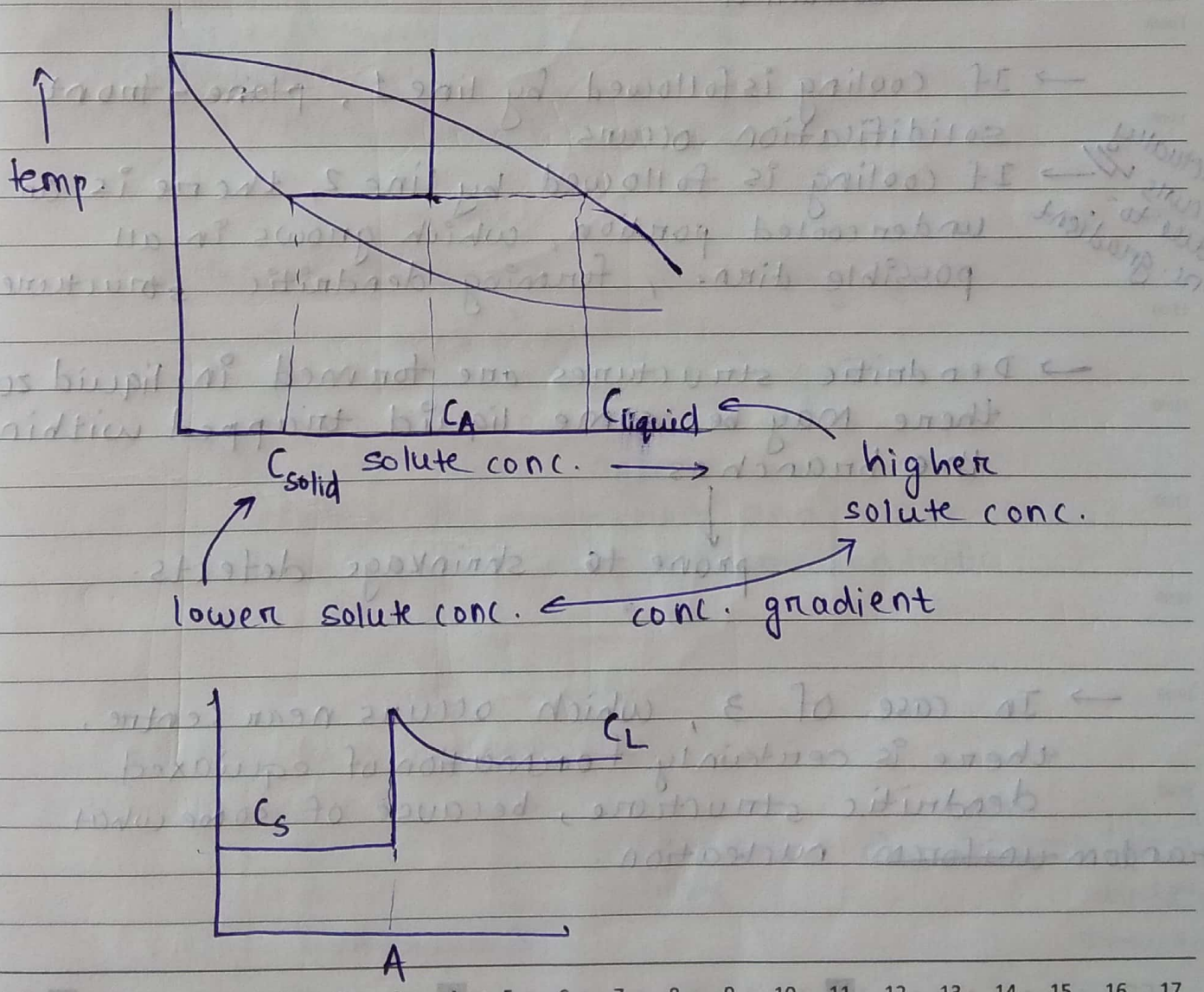
SSP Notes

Alloys

→ In alloys, however, growth of the columnar grain may be interrupted by an equi-axed grain growth.

→ Freezing is over a temperature range; hence no plain-front solidification.



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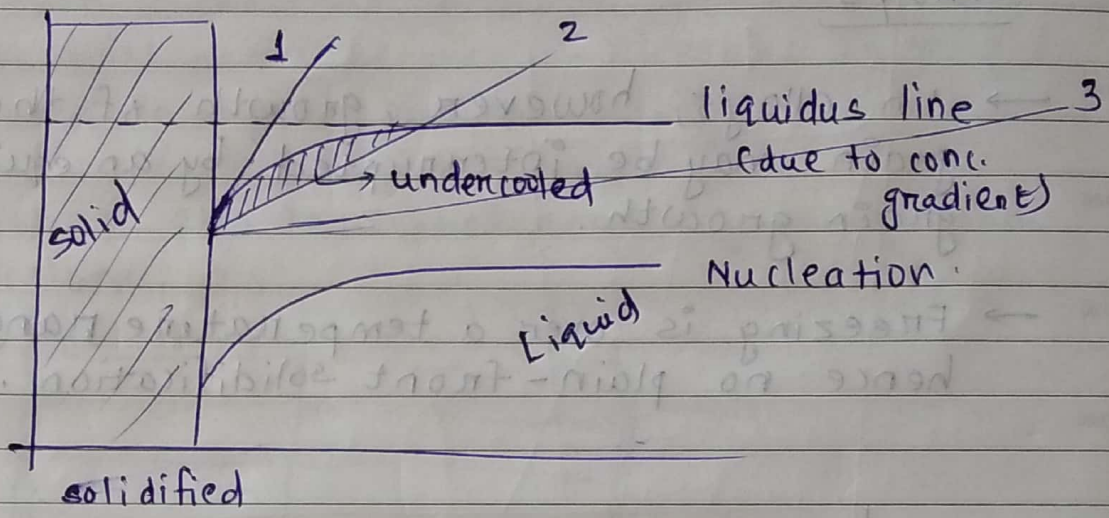
SSP Notes

08:00



09:00

10:00

11:00

12:00

Lunch

13:00

→ If cooling is followed by line 1, plane-front solidification occurs.

14:00

→ If cooling is followed by line 2, there is an undercooled portion, which grows in all possible dirn., forming dendritic structure.

actually occurs due to conc. gradient

15:00

→ Dendritic structures are formed in liquid zone, there may be some liquid trapped within the branches.

↓

prone to shrinkage defects.

16:00

17:00

18:00

19:00

→ In case of 3, which occurs near centre, there is certainly formation of equiaxed dendritic structure, because of somewhat random ~~uniform~~ nucleation.

20:00

Eve.

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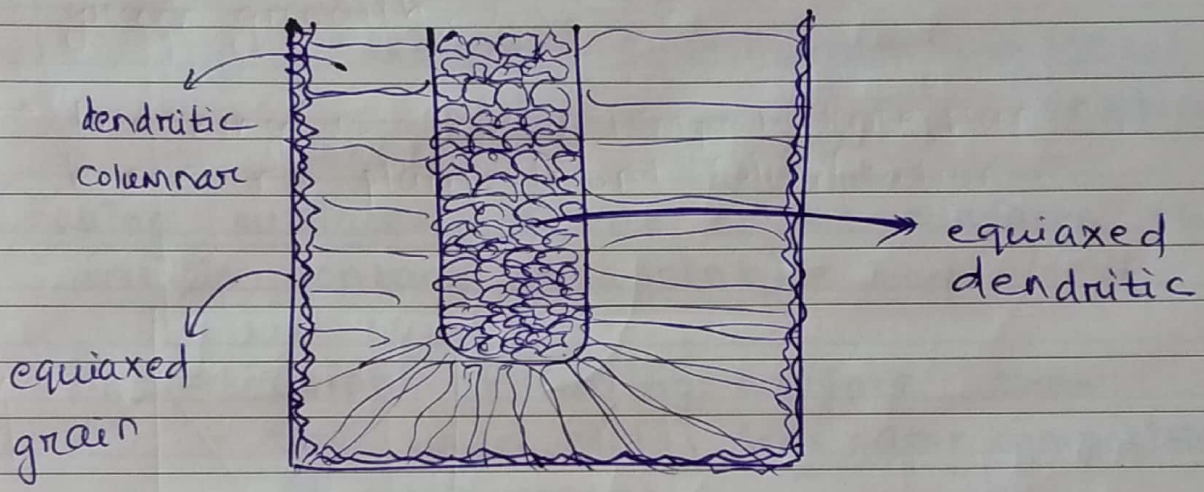
SSP Notes

→ If cooling is followed by line 3, undercooling is low enough to produce random nucleation and equiaxed dendritic structure.



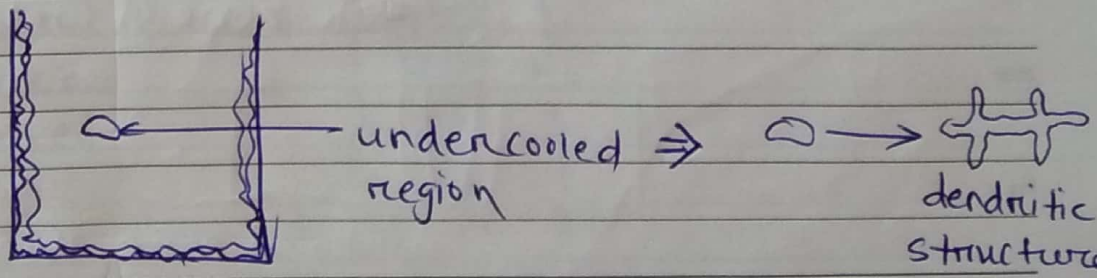
→ Use of heterogeneous nucleating agents.

↓

gives whole equiaxed grains

(because these agents serve as centre for nucleation and hence being large in no. prevent dendritic growth)
of grains.

Note :



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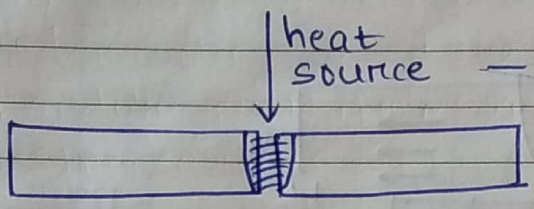
SSP Notes

GAS WELDING

(PRINCIPLE OF FUSION WELDING)



heat source — Arc / Gas Flame / Laser / $e^{\ominus}$ Beam

Fusion ⟶ solidification ⟶ Metal continuity

(Faying surface is one of the surfaces that are in contact at a joint)

⟶ Fusion of faying surface, then the weld metal has same composition as of base metal

⟶ No nucleation, direct growth of partially melt grains.

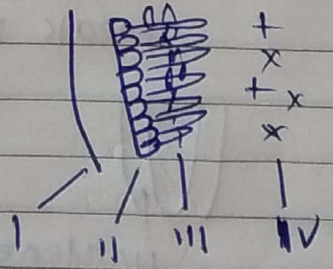
≡ epitaxial solidification

(weld and base metal = same composition)

⟶ When diff. composition ⟶ both nucleation and growth of metal.

Four types of grain structures –

I) Planar
II) Cellular
III) Dendritic
IV) Equiaxed



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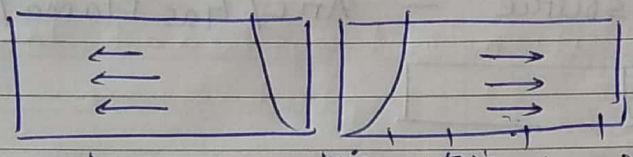
SSP Notes

08:00

09:00



10:00

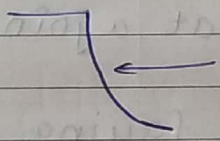
heat flow due to thermal conductivity

temp. increases.

11:00

12:00

Metal is pure ⇒

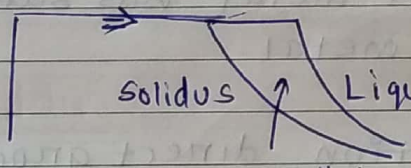


fusion ~~temp~~. boundary

Lunch

13:00

Alloy



fus. bound.

14:00

partial melting zone

15:00

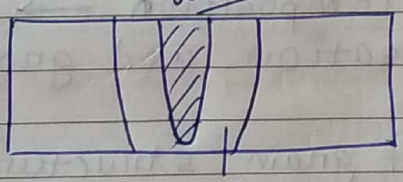
16:00

Sunday 04

(HAZ) heat affected zone (to be reduced)

17:00

weld → can be controlled by filler / electrode composition



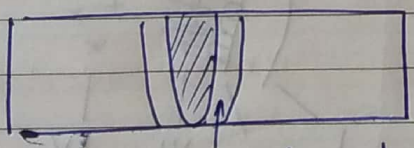
(AL)

18:00

19:00

softened, thick weak zone of weld (HAZ)

20:00



Eve.

(Steel)

Hardened zone, thin (HAZ)

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Brittle

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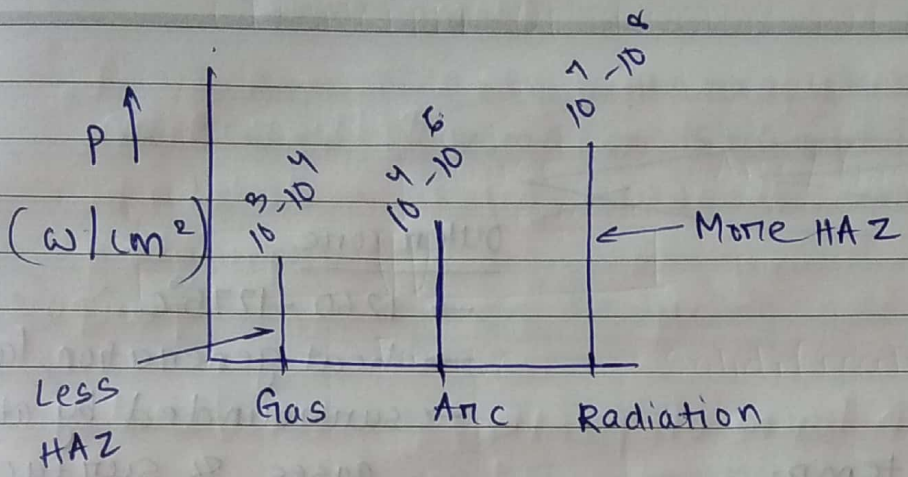
SSP Notes

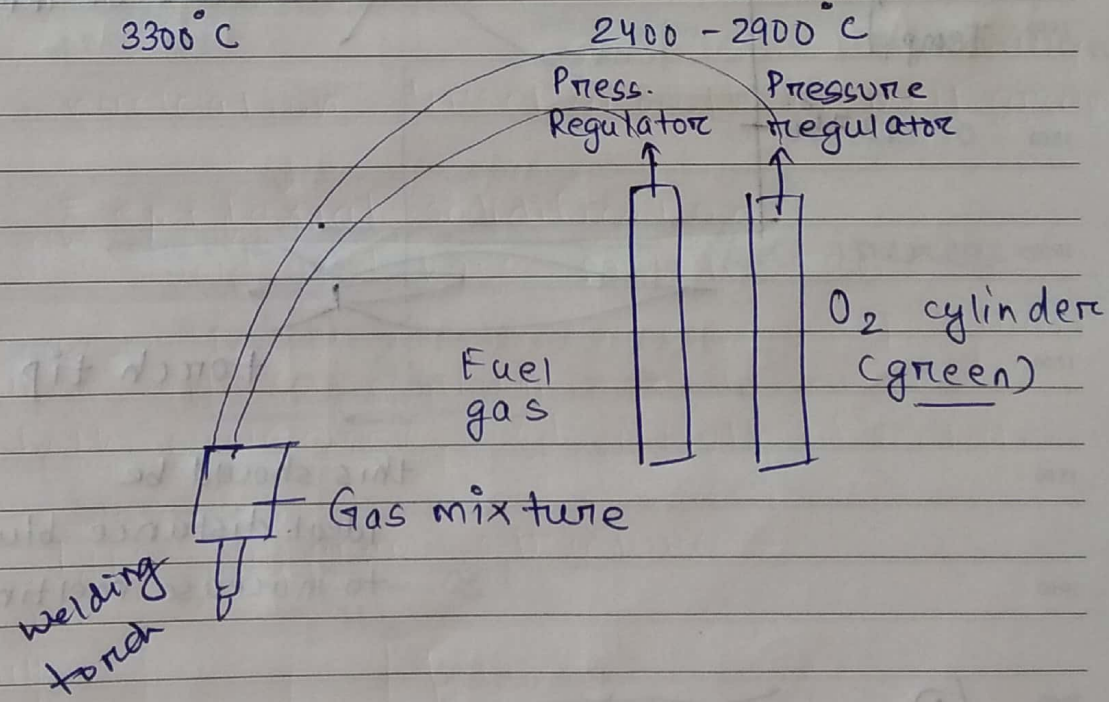


(*) Gas Welding

Fuel Gas : C_2H_2, Propylynine, Propane, H_2, Natural gas

3300°C

2400 - 2900°C



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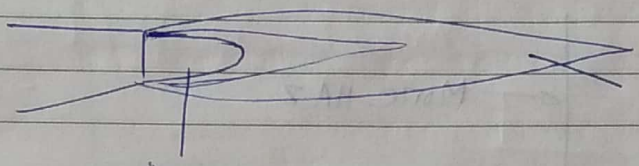
SSP Notes

08:00
09:00
10:00
11:00
12:00
Lunch
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
Eve.



inner cone

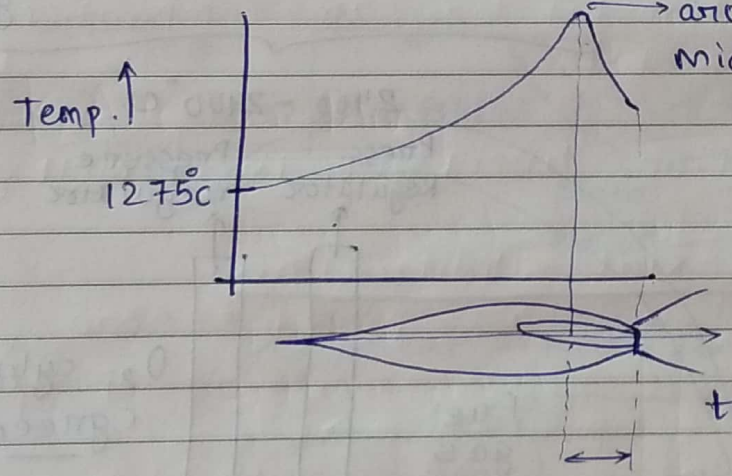
→ highest temp.
→ heat generation, less
→ 3300° C

Outer cone

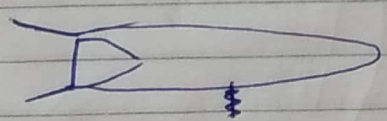
→ 1260 - 1275°C
→ heat generation, large
→ surrounded by atm. gases & surface area is large

⇓

temp. rise in outer flame is limited



this should be ideal distance blw w/p and torch. to increase melting capability

(1) 

→ Oxidising Flame
→ $\frac{O_2}{C_2H_2} > 1$ (~1.1)

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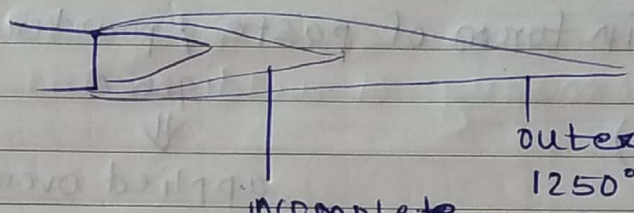
SSP Notes

→ Outer flame - narrow & short
→ Inner flame - sharp / short

(2) Carburising or Reducing



$\frac{O_2}{C_2H_2} < 1$ (~0.9)

→ carbon production → (transfer to) weld (steel, cast iron)

↓ leads to

% C increase → more strength & hardening (low C - steel)

(3) Neutral flame

$\frac{O_2}{C_2H_2} \approx 1$

[*] Flame velocity ∝ Fuel / O_2 ratio
- Press. of gas mixture
- Nozzle design
- effectiveness of combustion

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SSP Notes

Flame types

* 10 - 15 m/sec = quite
* few hundred m/sec = Deflagration
* greater thousand m/sec = detonation (spraying purpose)

→ Fluxes - in form of paste / powder / solid coating / liquid
⇓
applied over faying surfaces

(Borax)

to take care / to protect from O_2 or N_2 ~~are~~ present ~~from~~ in weld metal

O_2 → oxide
N_2 → nitrides

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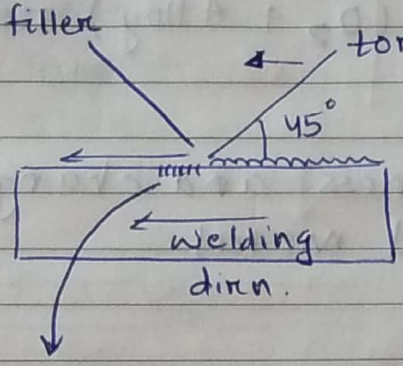
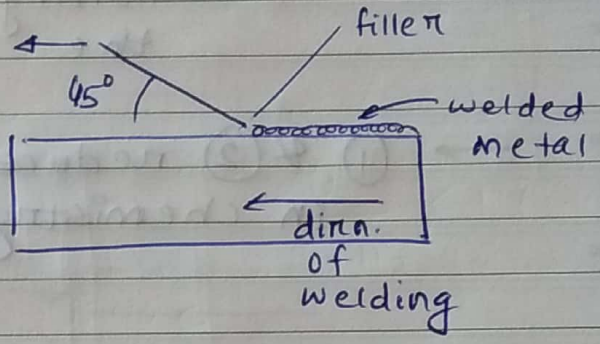
FUNDAMENTALS OF WELDING

→ Gas welding → Forward Welding
→ Backward welding





preheated metal
(reduces cooling rate)
→ especially in case of hardenable steel
→ decreases tendency for cracking
→ melting of metal fastened, faster welding (forward)

→ Flame is pointed or directed towards the already welded metal
→ Flame causes heating of weld metal (post weld ⇓ heat treatment)
Reduces cracking tendency & residual stress.
(Backward)

→ Low power density involved :
a) flame spread over larger area
b) temperature involved is lowered (~3300°C) compared to arc / plasma welding.

→ High heat input to Gas welded joint : ↓ CRate of weld metal, Large HAZ } poor mechanical properties

(1)

APR 2018 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

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SSP Notes

08:00 ② → Protection of gas welded joint is not good; all the gases (air / flame $(O_2 / (O)$ will react with molten metal.
- Oxidizing flame (O_2 + Alloy) reducing the w/p

09:00

10:00

11:00 → ① & ② reduce soundness and change in chemistry of weld metal

12:00

Lunch **Thus Arc Welding is Preferred**

13:00

14:00 * **Arc Welding**

15:00 Welding_position

16:00 ① Flat

② Horizontal

17:00

18:00 ③ Vertical

19:00

④ Overhead

20:00

Eve.

Sunday 11

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SSP Notes

08:00

Types of Weld

09:00

1. Groove
2. Fillet
3. Plug
4. slot
5. Bead weld (surfacing applications)

10:00

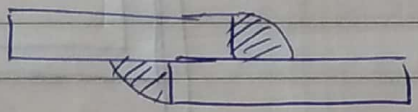
11:00

12:00

(1)

Groove

(2)

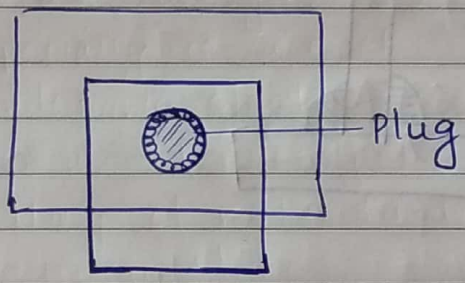


Double Fillet (T-shaped) and Lap

Lunch

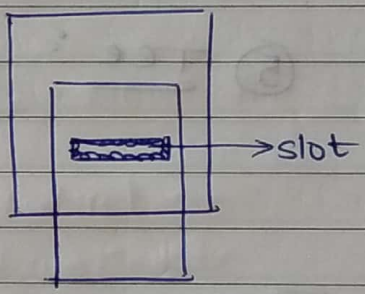
13:00

(3)



14:00

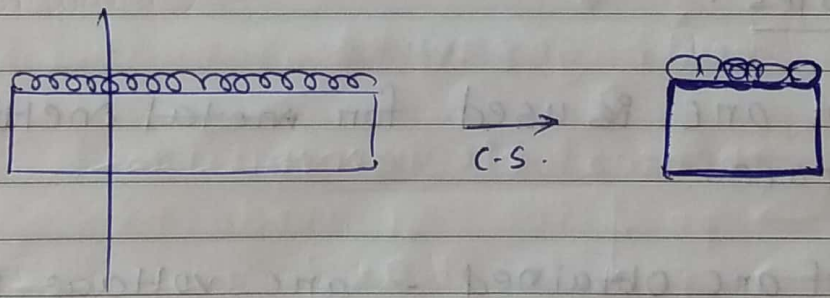
(4)



15:00

16:00

(5)



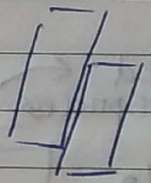
17:00

18:00

Welding joints

19:00

(1) Butt - End to end touching posn.



20:00

(2) Lap - One above other

Eve.

APR 2018

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
22	23	24	25	26	27	28	29	30	•	•	•	•	•	•	•	•	•	•	•	•

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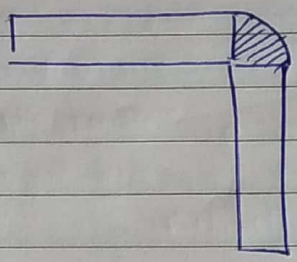
SSP Notes

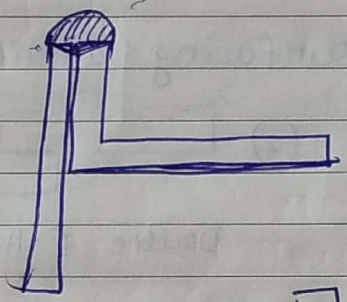
08:00 ③ Corner :



09:00

10:00

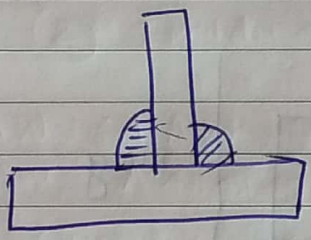
11:00 ④ Edge :



12:00

Lunch

13:00 ⑤ Tee :



14:00

15:00

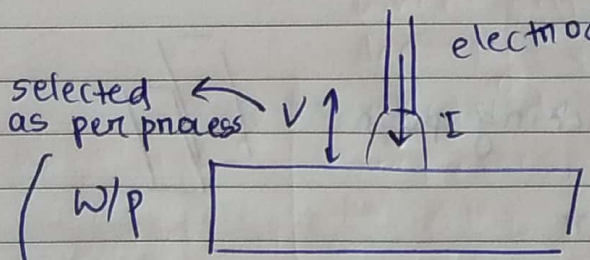
16:00 [*] Principles :

→ Heat of arc is used for ~~metal~~ melting faying surface.

17:00

18:00 → Heat of arc obtained - arc voltage x welding current

19:00



20:00

Power = VI

Net heat supplied = $\frac{VI}{S(\text{welding speed})}$ = J/mm

Eve.

MAR 2018 • • • • 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
18 19 20 21 22 23 24 25 26 27 28 29 30 31 • • • • • • •

GTAW : 10 - 20 V
PAW :

SMAW : 50 - 70V
GMAW : 20 - 40M

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SSP Notes

→ Current is used as main parameter, which is adjusted

SMAW : 60V 100A 200A

Ex

60 x 150 = 9 kJ/s
3 mm/s
3 kJ/mm

60 x 200 J/s 12000 J/s
2 mm/s
6000 J/mm
6 kJ/mm

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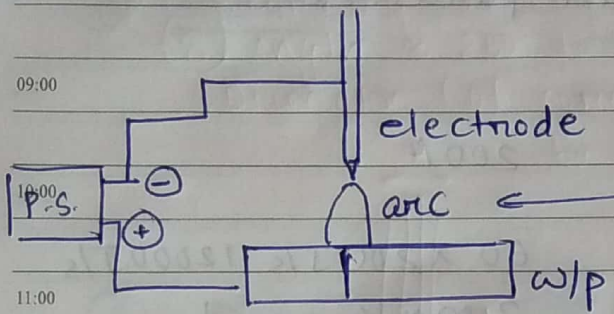
SSP Notes

15 Thursday
11th Week • 074-291

PHYSICS OF WELDING

MARCH 2018

08:00
09:00
10:00
11:00
12:00
Lunch
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
Eve.



initially here was atmosphere

↓

so we require arc initiation method –

① Touch-start method
② Field-start method

① Touch-start (SMAW, GTAW)
GMAW, SAW, Electro-slag W

→ Partial melting, evaporation
→ Touching electrode and w/p

⇓
heat generated
⇓
thermoionic emmission
↓
when sufficient charges ($e^{\ominus}$) density occurs in atmosphere b/w electrode and w/p, the air region becomes conducting, current flows.

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SSP Notes

② Field-start → used when impurities are transferred (contamination) or touch-contact is not suit

(GTAW → tungsten gets transferred to weld pool, so better field-start)

(PAW)

High stregth EM field b/w w/p & electrode

↓

helps emission of $e^{\ominus}$ from cathode

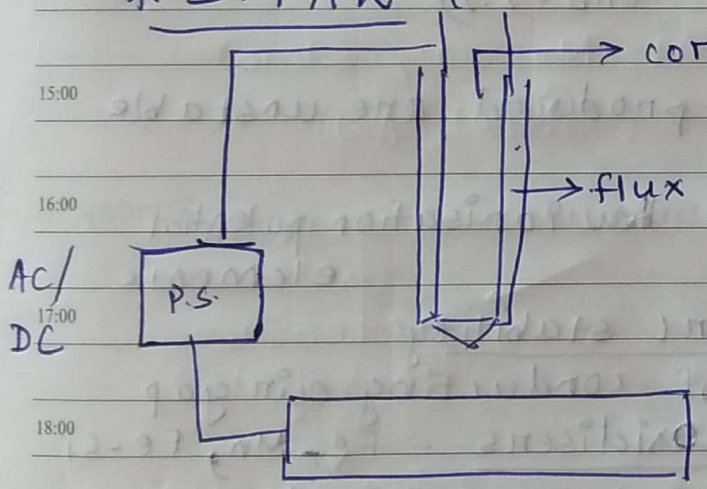
↓

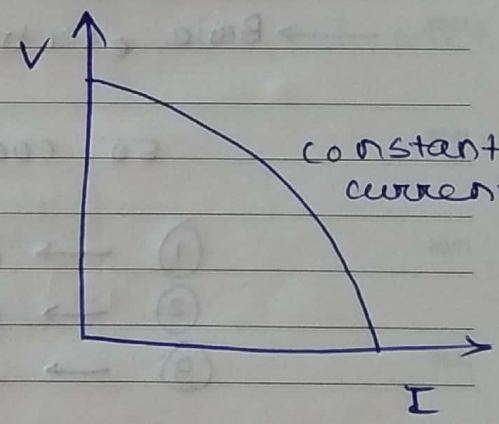
produces charge in air region (gap)

→ Decrease in charge density - extinction of arc

Power of arc = I × V

* SMAW (As manual, sp constant-current supplied)





* AC -

Imp. Low ionisation potential metal (Na, K, Ca)

↓

facilitates the easy emission of $e^{\ominus}$

* DC is common, as can be used with all types of electrode Rutile, cellulosic etc.

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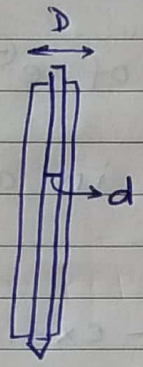
SSP Notes

Length ≈ 250 to 400 mm
Diameter (of core wire in mm) – 1.6, 2, 2.5, 3.15, 4, 6.3, 8, 10 mm based on



→ Ratio of $\frac{D}{d}$ = coating factor ≈ 1.2 – 2.2

thin layer of coating
i) Light coated electrodes (1.2 – 1.35)
ii) Medium coated " (1.4 – 1.7)
iii) Heavily " " (1.8 – 2.2)

→ Bare electrode : Arc produced are unstable
↓
so coating with low ionisation potential elements

① → ensures arc stability
② → provision of conducting air gap
③ → provide deoxidisers – Fe-Mn, Fe-Si (separate out metal got oxidised ; and provide flux for removing impurities)
④ → Removing impurities as slag
⑤ → Also for controlled alloying (The 'Cr' or other metal added in coating – they will be transferred to weld pool)

Weight slag < Weight weld metal

Sunday 18

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SSP Notes

08:00 → Increase deposition efficiency / rate

(6) • Fe powder (in coating) incase of steel

09:00 ↓

more weight

10:00 ↓

so higher amount of coating transferred to weld pool increase rate.

11:00 → vertical / Overhead

12:00 (7) - molten metal falling down.

Lunch - viscosity of weld metal is high (desired)

- the slag formed is dense and prevents falling of slag

13:00 - coating to adjust the viscosity / surface tension of slag & molten-metal, falling tendency of weld met reduced.

14:00

15:00

16:00

* Constituent of flux (Check photo)

17:00 → Low ionisation potential - Na, K, Ca

18:00 → Charcoal

→ Sawdust

19:00 → Hydrocarbon

→ Bonding agent - $NaSiO_3$.

20:00

Eve.

APR 2018 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

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SSP Notes

08:00 → Burning of coating (8) releases → inactive gases CO_2, CO etc. around arc ↓ protecting from contamination of atmosphere

09:00

10:00

11:00

12:00 → Less protective environment, ⇒ O_2, N_2 found in weldmet 0.1% — 0.8%

Lunch

13:00 → Non-critical application - general purpose - SMAW

14:00

→ SMAW not used for Al, Mg, Cr, Stainless steel (GMAW, PAW)

15:00 ↓

16:00 Oxide formation

17:00 ↙ inclusion formed in weldmet ↘ their oxides are refractory material ↓ inhibit the process of arc welding (as don't melt easily ⇓ prevent easy melting of basemetal)

18:00

19:00

20:00

Eve.

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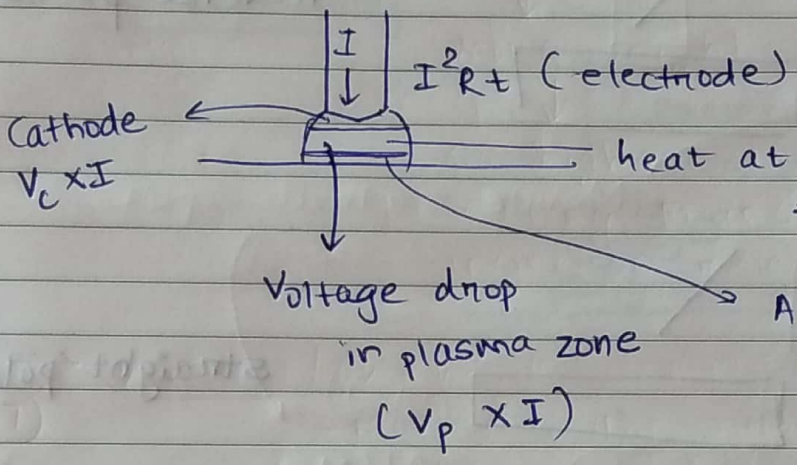
SSP Notes

Shielded-Metal Arc Welding

→ Melting Rate (MR) = $aI + bl I^2$

↑ electrical resistance



$V = V_c + V_a + V_p$

aI → Anode / cathode drop zone heat

a → accounts for V_c

I → welding ct

b → coeff. for resistance related factor

low conducting metal → b value high

l → electrode extension. (ee)

↳ diameter of core

b↑ ⇐ d↓ →

ee ↑ →

I ↑ → } leads to dominance of blI^2 factor

SMAW – $I_{max.}$ at which thermal decomposition of coating occurs / electrode

→

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SSP Notes

08:00 * Polarity

09:00 DC

10:00 DCEP DC Electrode Positive

11:00

12:00 DC Electrode negative

Lunch DCEN

reverse polarity

straight polarity

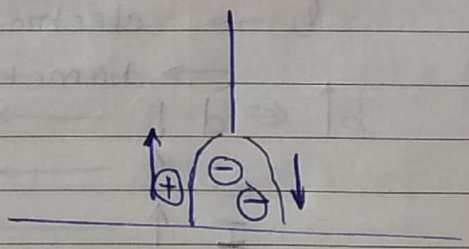
13:00 Effect of polarity
→ Heat generation / distribution in arc
14:00 → stability of arc
→ Cleaning action of welding arc.

15:00

• Heat generation aspect

16:00 → straight polarity

17:00



18:00 GTAW
MUCH better life of electrode ← low melting rate of electrode

Large amount of heat ≈ 2/3 rd of heat in anode

19:00 ↑ cations strike electrodes ← ↓ W/p would be heated more

20:00

Eve.

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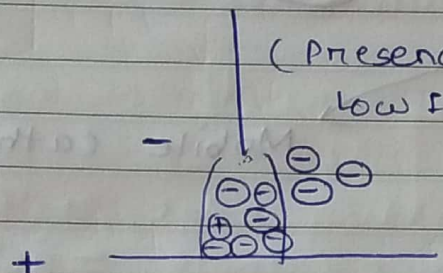
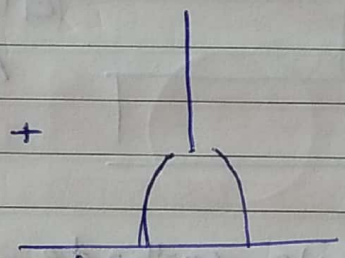
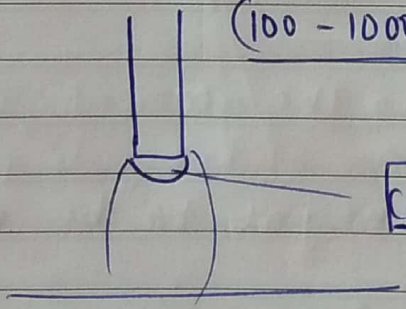
→ SAW / GMAW : DC reverse polarity

- Arc stability





- Cleaning section (GMAW, GTAW)



Cathode spots

1) Mobile - keep on moving over surface of electrode (5 - 10 m/s) ~~on w/p~~

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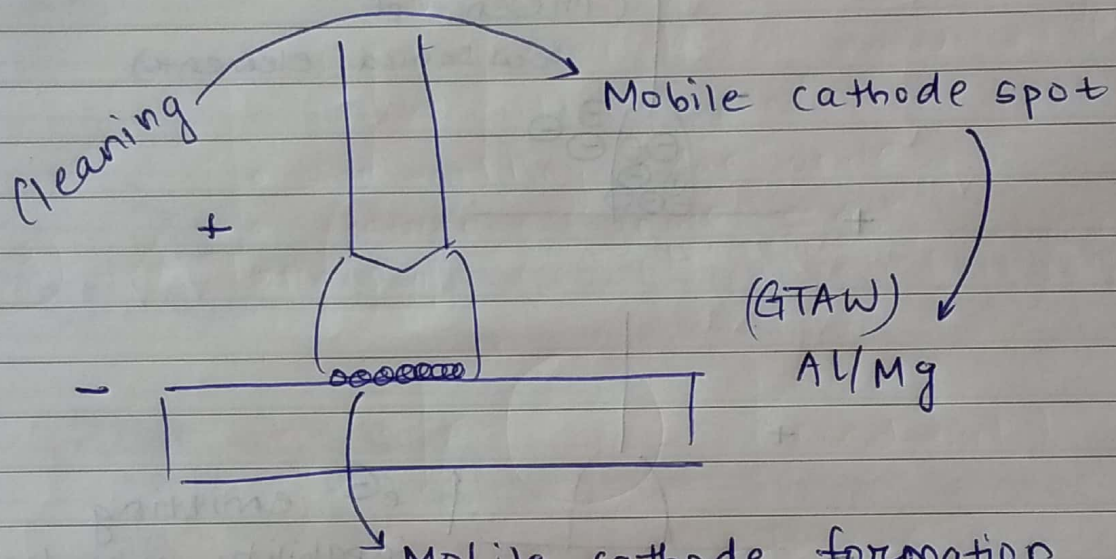
SSP Notes

08:00 2) Pointed

09:00 3) Normal

10:00



11:00

12:00

Lunch

13:00

14:00 Mobile cathode formation

⇓

15:00 Loosening of oxide

⇓

16:00 Floating on weld pool

Sunday 25

17:00

18:00

19:00

20:00

Eve.

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18 19 20 21 22 23 24 25 26 27 28 29 30 31 • • • • • • •

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SSP Notes

LATHE

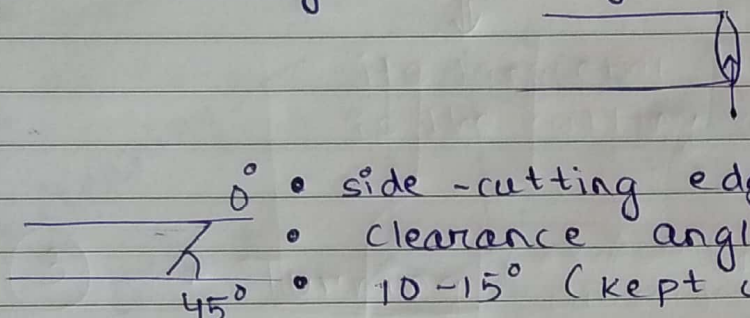
08:00

① → Truing (placing w/p in chuck of head stock)

09:00

② → Facing (clearing the face) → smoothening uneven surface of w/p

10:00



11:00

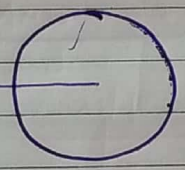
- side-cutting edge angle ≈ 0°
- clearance angle ≅ 45°
- 10-15° (kept unchanged at lab)

12:00

Lunch

13:00

better technique ←



(Feed out)

14:00

$$RPM = \frac{4 \times \text{cutting speed}}{\text{Diameter}}$$

15:00

16:00

in metric - $\frac{100 \times \text{cutting speed (ft/min)}}{\text{Diameter (mm)}}$

17:00

(*) Feed (mm/rev.) (Feed for lathe, feed rate (mm/min.) for milling)

18:00

→ It refers to the amount of tool advancement per revolution of the job parallel to the surface of the job to be machined

19:00

20:00

a) Longitudinal feed = parallel with axis of rotation (turning)

Eve.

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18 19 20 21 22 23 24 25 26 27 28 29 30 31 • • • • • • •

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SSP Notes

$FR = RPM \times T \times CL$ (T ← no. of teeth o; CL ← chip load)

↑ calculated speed for cutter

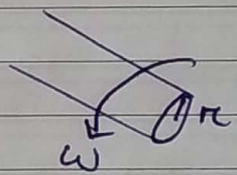
b) Cross feed = right angle to axis of rotation (facing)

c) Angular feed = feed directed at an angle to the axis of rotation (taper turning)

(*) **Cutting speed** (or surface speed)

The cutting speed is the velocity of the tool over the surface of the job and is expressed in feet or meter per minute

$$C.S. = \frac{\pi DN}{1000} \text{ m/min.} = \omega r$$



ω = spindle speed

D = dia. of w/p (mm)

N = no. of revolutions (per min.)

(*) **Depth of cut**

It is the advancement (penetration) of the tool in the job in the direction perpendicular to the surface being machined or the thickness of the chip of material removed by the tool in one cut.

$$\text{Depth of cut (t)} = \frac{D_{final} - d_{initial}}{2}$$

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SSP Notes

08:00 (*) **Spindle speed**

09:00 The angular velocity of the w/p (rev/min.) is called spindle speed.

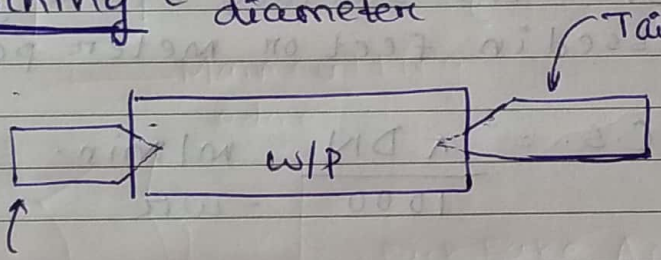
10:00 ⇓

its tangential linear equivalent is the cutting speed.

11:00

12:00 (3) → **Turning** (excess material removed to reduce diameter)

Lunch

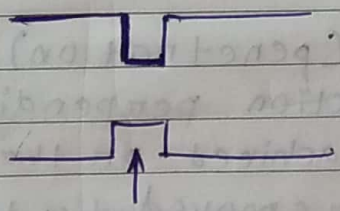


13:00

14:00

15:00

16:00 (4) → **Grooving**



17:00

18:00

19:00

20:00

Eve.

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18 19 20 21 22 23 24 25 26 27 28 29 30 31 • • • • • • •

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SSP Notes

300 - 1500 Lathe

→ Maxm. diameter of w/p that can be machined = Swing (= 300 mm)

→ Maxm. length of w/p that can be held b/w two centers (= 1500 mm)

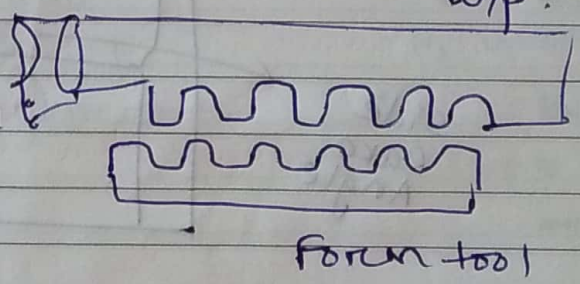
→ Equippment used to hold
a) w/p = fixtures
b) ~~tool~~ = jigs
~~c) wo~~

(Dog & Mandrels)

→ Material removal rate (MRR):
Volume of material removed in one revolution
$= \pi D d f N \ mm^3/min$
$= 1000 \ v \ d \ f \ mm^3/min$

→ Feed Rod RPM / Pinion RPM = Apron constant

→ Cutting with forcm tool



APR 2018: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 / 22 23 24 25 26 27 28 29 30

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SSP Notes

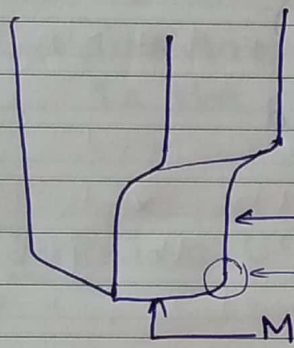
08:00

* SINGLE POINT CUTTING TOOL

09:00

→ Cutting along two surfaces.

10:00



11:00

← Auxillary cutting edge

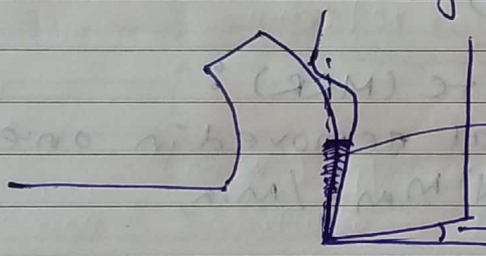
12:00

← Nose (Nose radius ↑ ⇒ Surface finish & Tool strength ↑)

Lunch

Main cutting edge

13:00



14:00

→ Back Rake Angle

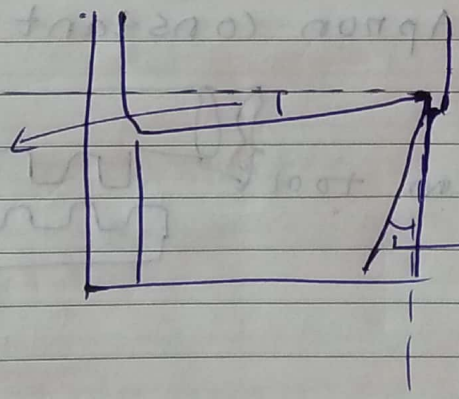
15:00

→ Relief Angle (reduces Tool Wear)

16:00

Sunday 01

17:00



18:00

Side Rake Angle

19:00

→ side Relief Angle

~~Cutting~~

20:00

Eve.

MAR 2018

•	•	•	•	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
18	19	20	21	22	23	24	25	26	27	28	29	30	31	•	•	•	•	•	•	•

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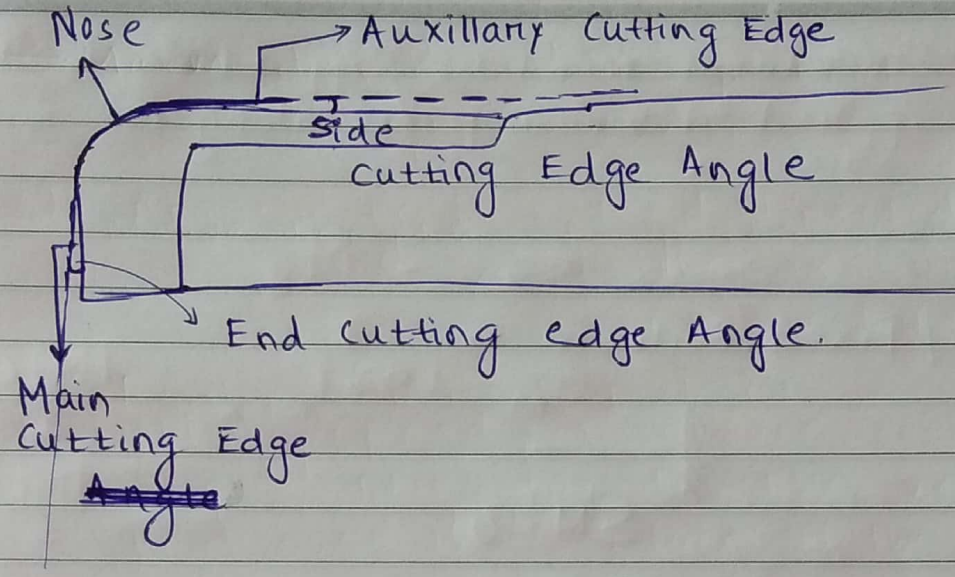

Lunch

* NAMING OF ELECTRODE

Metal recovery
L > K > J
(150%) (130%) (110%)

Numbers/Letters

F X X X X X X X X → Radiographic Quality.

- F → Coated electrodes
- X → Type of covering
  - A: Acid
  - B: Basic
  - C: Cellulosic
  - R: Rutile
  - RR: Rutile - heavy coated
- X → Strength characteristics
- X → Welding posn.
- X → % Elongation and Impact properties
- X → Current condition
- X → Diffusible H_2
  - H_1: upto 15 ml
  - H_2: upto 10 ml
  - H_3: upto 5 ml

Eve.

APR 2018 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

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SSP Notes

08:00

→ **Principle of transmissibility** –

09:00

which states that a force may be applied at any point on its given line of action without altering the resultant effects of the force external to the rigid body on which it acts.

10:00

11:00

→ **Varignon's theorem** –

12:00

which states that the moment of a force about any point is equal to the sum of the moments of the components of the force about the same point.

Lunch

13:00

14:00

15:00

16:00

17:00

18:00

19:00

20:00

Eve.

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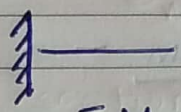
SSP Notes

→ Beams : Structural members supporting loads applied at various points along the member

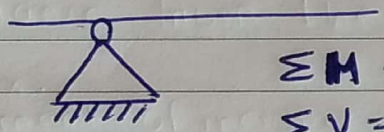
→ Support :

① Encasted / Fixed / Built-in –



$\Sigma M = 0$
$\Sigma V = 0$
$\Sigma H = 0$

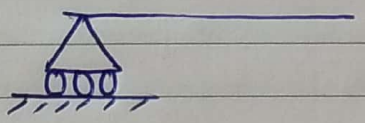
② Hinged –



$\Sigma M = 0$
$\Sigma V = 0$

③ Simply support / Roller support –

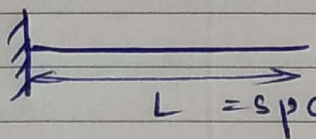
Sunday 08



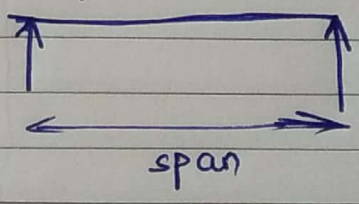
$\Sigma V = 0$

→ Type of Beam : (Statically determinate)

① Cantilever :



② Simply supported :



APR 2018 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

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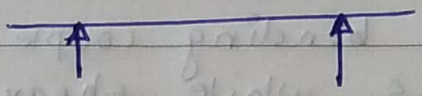
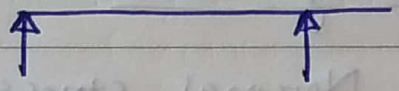
SSP Notes

08:00

③ Overhanging :



OR



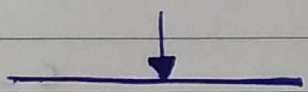
09:00

10:00

→ Loads :

11:00

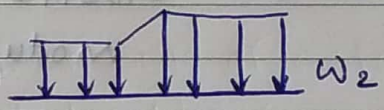
① Point load / concentrated load –



12:00

Lunch

② Distributed load –

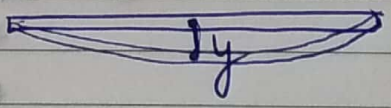


13:00

(*) y = deflection

14:00

$\frac{dy}{dx}$ = slope θ



15:00

M = bending moment = $\frac{d^2y}{dx^2}$

16:00

V = Shear force = $\frac{d^3y}{dx^3}$

17:00

ω = rate of loading = $\frac{d^4y}{dx^4}$

18:00

$$\frac{dM}{dx} = V \quad ; \quad \frac{dV}{dx} = \omega$$

19:00

20:00

Eve.

MAY 2018

•	•	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
20	21	22	23	24	25	26	27	28	29	30	31	•	•	•	•	•	•	•	•	•

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SSP Notes

08:00 → The bending couple M creates normal stresses in c.s., while shear force V creates shearing stress.

09:00

10:00 Normal stress, $\sigma_x = -\frac{My}{I}$

11:00 $\sigma_M = |\sigma_x|_{max} = \frac{|M|c}{I}$

12:00 S = elastic section modulus $= \frac{|M|}{S}$

Lunch

$S = \frac{1}{6} bh^2$ (rectangular shape)

13:00

y = distance from the neutral surface

14:00 $c = y_{max}$.

I = Moment of inertia of the c.s. wrt to a centroidal axis 1^{r} to the plane of the couple

15:00

16:00

17:00

18:00

19:00

20:00

Eve.

APR 2018 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

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