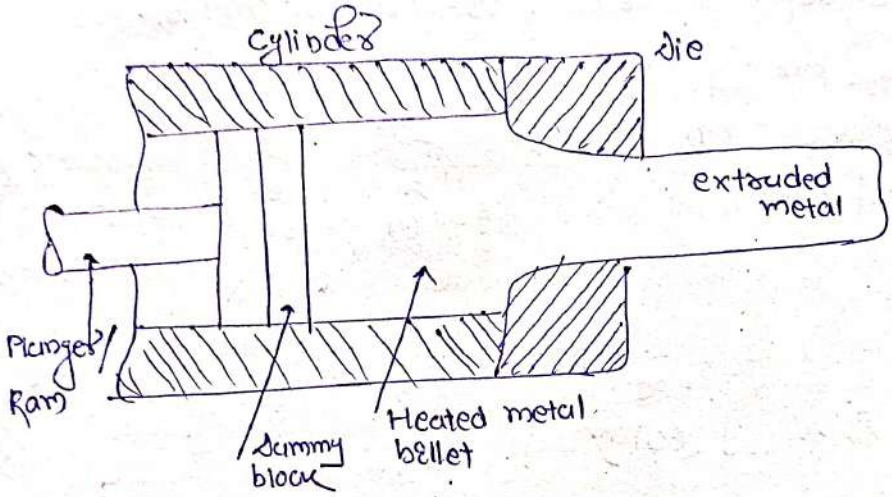
Metal forming processes :-

EXTRUSION :-

→ Process which is commonly used to make collapsible tubes such as toothpaste tubes, cans, usually using soft materials such as Aluminium, lead, tin. Usually a small shot of solid material is placed in the die and is compacted by a ram, which causes cold flow in the material.



Note

→ Process by which long straight metal parts can be produced.

→ Cross-sections that can be produced vary from solid round, rectangular, to L shapes, I shape, tubes and many other different types.

→ Done by squeezing metal in a closed cavity through a die using either a mechanical or by hydraulic press.

→ Extrusion produces compressive and shear forces in the stock.

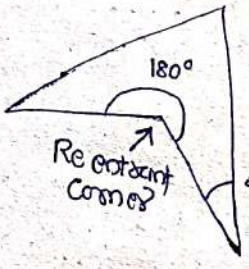
→ No tension is produced, which makes high deformation possible without tearing the metal.

→ Can be done Hot or cold.

→ A dummy block which is a steel disc of <10 mm (0.50 to 0.75 of diameter) thick with a diameter slightly less than the container is kept between the hot billet and the ram to protect it from the heat and pressure.

Advantages -

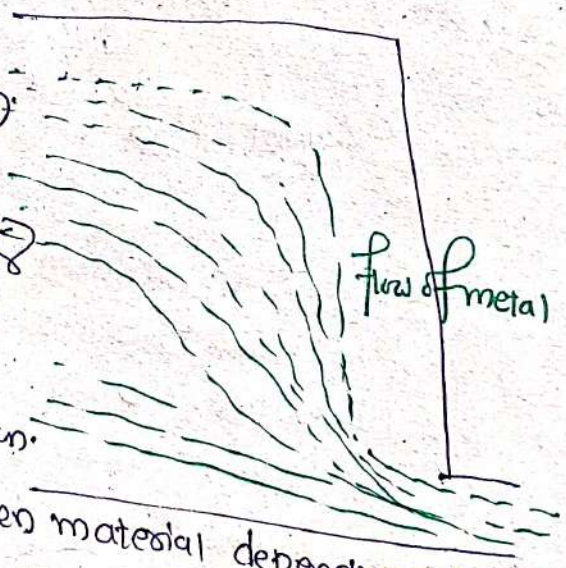
→ possible to make components which have a constant cross-section any length as can be had by the rolling process.
→ complexity of the part is more good as compare to rolling.
→ Single pass process.
→ amount of reduction that is possible in extrusion is large.
→ brittle material easily extruded.
→ Easy to produce sharp corners and re-entrant angles.
→ large diameters, thin walled tubular products with excellent concentricity and tolerance.



An irregular polygon an interior angle that greater than 18

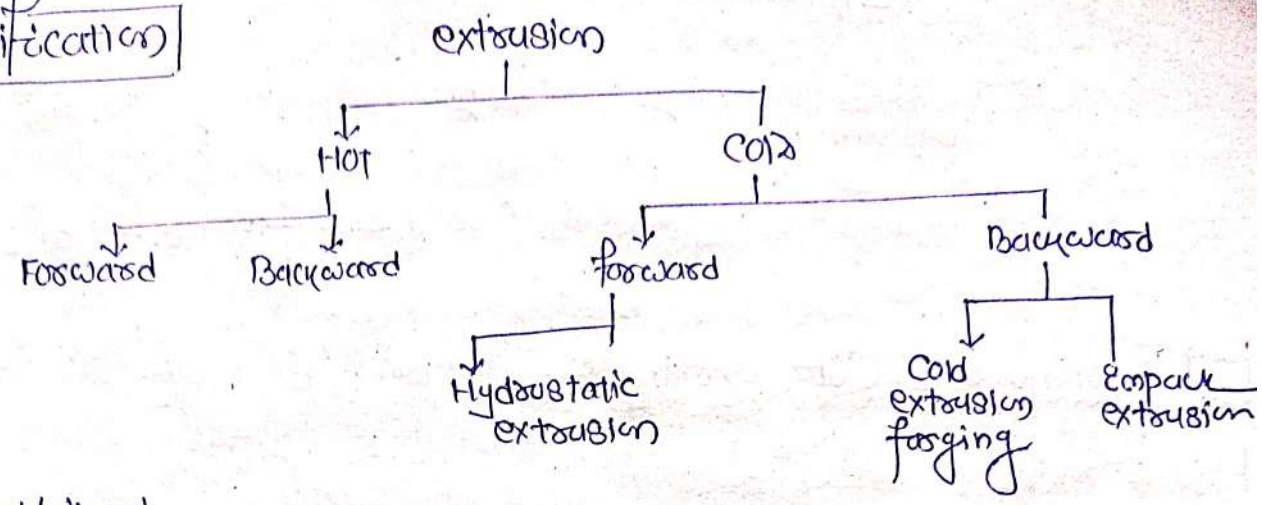
extrusion ratio

ratio of cross-sectional area of the billet to that of the extruded section.
→ 20 to 50.
→ low extrusion ratios are used for intermediate operation when the billets are extruded to a given diameter before the final extrusion.



→ The extrusion pressure for a given material depends on the extrusion temp., the reduction in area and extrusion speed.
→ extrusion speed depends on the work material.
too high extrusion speed could cause excessive heat generation in the extruded metal causing lateral cracks.

Classification



Hot

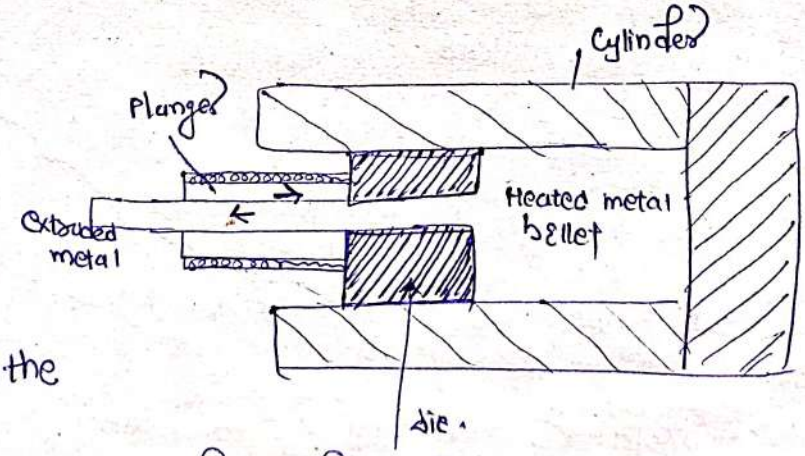
① Forward/direct extrusion process → Same as fig ①

→ lubricants are used — at low temp — mixture of oil and graphite.

→ molten glass is generally used for extruding steels.
- liquid form at the operating temp
- provid necessary heat insulation.

→ To reduce the damage to equipments, extrusion is finised quicly and the cylinder is cooled before further extrusion.

② Backward/indirect extrusion process →



→ overcome the friction.

→ opposite direction of the flow of metal to that of ram movement, thus, the billet & the container remain stationary and hence no friction.

→ extrusion pressure not affected by the length of the billet in the extrusion press since friction is not involved.

→ Surface quality good & no heat reacting due to the friction betn billet and the extrusion cylinder.

disadvantage →

↳ problem of handling extruding metal coming out through the moving ram.

↳ Surface defects of the billet would end up in the final stage.

HOT working and COLD working :-

Hot working

→ working above the recrystallisation temp. are termed as hot-working process.

COLD working

→ below cold working

Recrystallisation →

under the action of heat and force when the atoms reach a certain higher energy level, the new crystals start forming which is termed as recrystalisation.

⇒ recrystalisation destroy the old grain structure deformed by mechanical working and entirely new strain free crystals are formed.

⇒ recrystalisation temp. generally varies betw one third to half the melting point of most of the metals.

HOT working ① Advantages → as the material is above the recrystallisation temp. any amount of working can be imparted since there is no strain hardening taking place.

→ At high temp, the material would have higher amount of ductility and therefore there is no limit on the amount of hot working that can be done on a material.

→ Shear stress gets reduced at higher temp. less force requirement to achieve the necessary deformation.

(ii) Disadvantages :-

→ Due to brittleness some metals can't be hot worked.
→ Surface finishing is poor.
→ difficult to achieve dimensional accuracy.
→ Handling and maintaining of hot metal is difficult and troublesome.

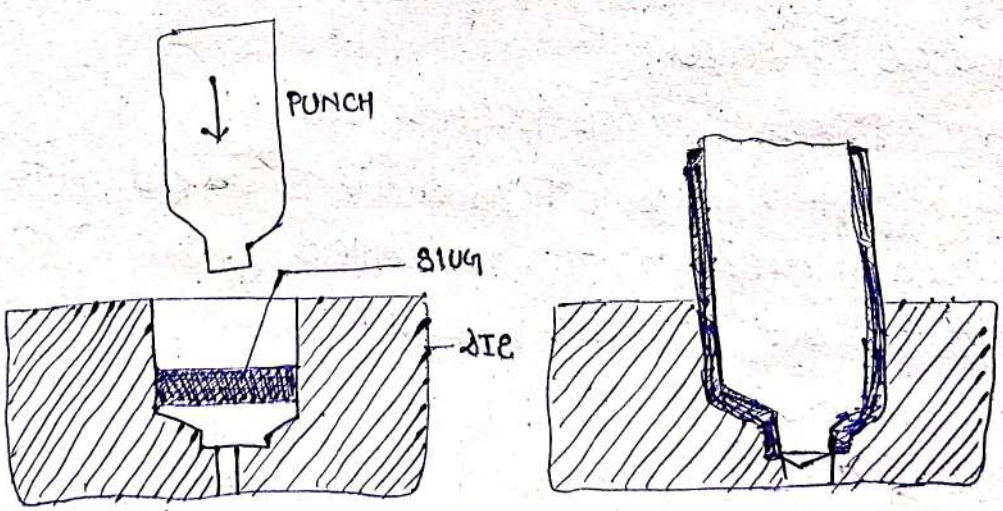
COLD WORKING

① Advantages → Increase the strength and hardness of material.
→ better dimensional accuracy is achieved.
→ for easier to handle cold part and also economical for smaller sizes.

② disadvantages → as higher yield strength at lower temp. the amount of deformation that can be given to is limited by the capability of the presses or hammers used.
→ maximum amount of deformation limited.
→ some brittle material can't be cold worked.

Impact extrusion →

Actually backward extrusion process.



In this process, which is shown in fig below the punch descends with higher velocity and strikes in the centre of the blank which is placed in die. The material deforms and fills up the annual space between the die and the punch flowing upward.

eg - laminated plastic for mfg of tooth paste.
Shaving cream tubes, collapsible tube containing paste

Cold extrusion - forward cold extrusion.

Similar to forward hot extrusion process except extrusion ratios possible are lower and extrusion pressures are higher.

Eg. cans, shock absorber cylinders, rocket motors, various aluminium brackets.

Hydrostatic extrusion

This is a direct extrusion process but the pressure is applied to the metal blank on all sides through fluid medium. The fluid is commonly used are glycerine, ethyl glycol, mineral oils, castor oil mixed with alcoholate.

Very high pressures are used 1000 to 3000 MPa.

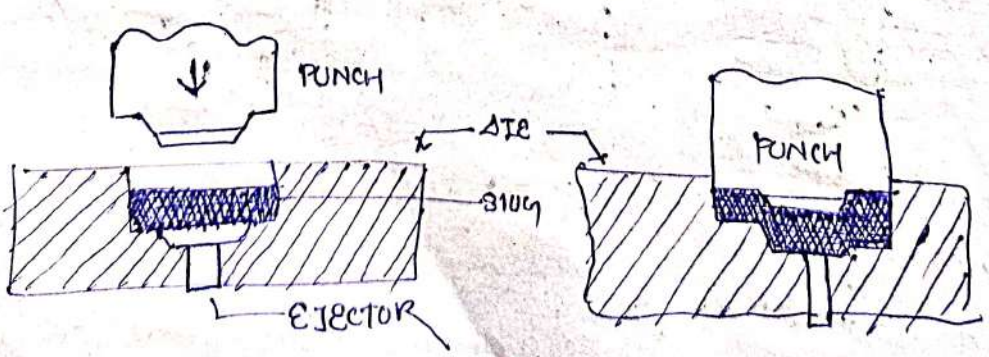
Brittle materials can also be successfully extruded by this method.

Cold extrusion forging

This process is depicted in fig.

This is generally similar to the impact extrusion process, but there are two differences.

1. In this process the punch descends slowly.
2. The height of extruded product is short and side walls are much thicker than the thin walled products produced by the impact extrusion process.

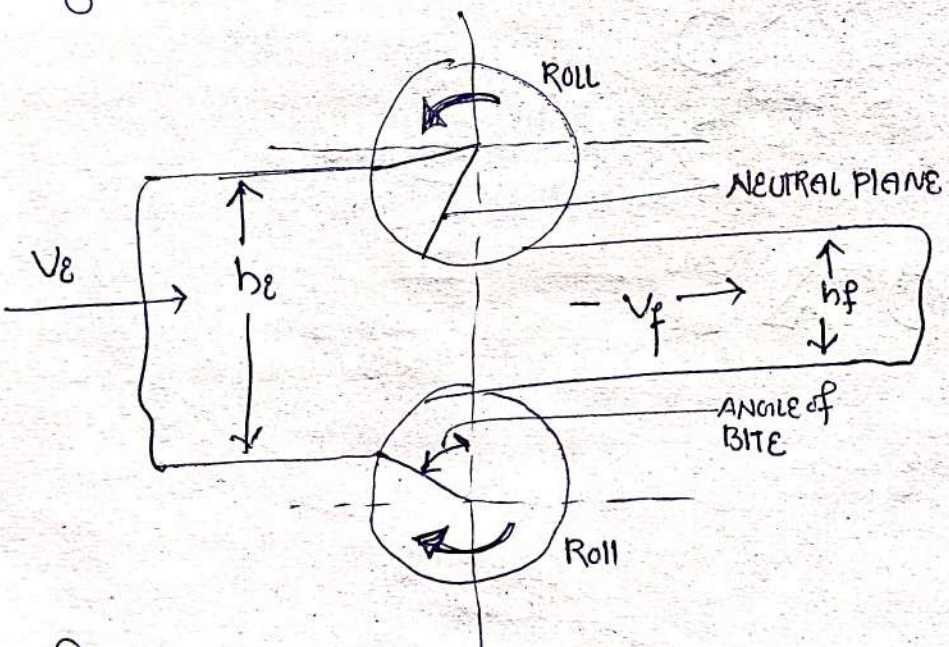


ROLLING

→ Rolling is a very economical process for producing large volume of material with constant cross section. also most important industrial metal forming operations.

→ Rolling is the plastic deformation of materials caused by compressive force applied through a set of rolls, the cross section of the o/p is reduced by the process; material get squeezed betwn a pair of rolls, as a result of which the thickness gets reduced and length gets increased.

→ Rolling is done most on high temp.

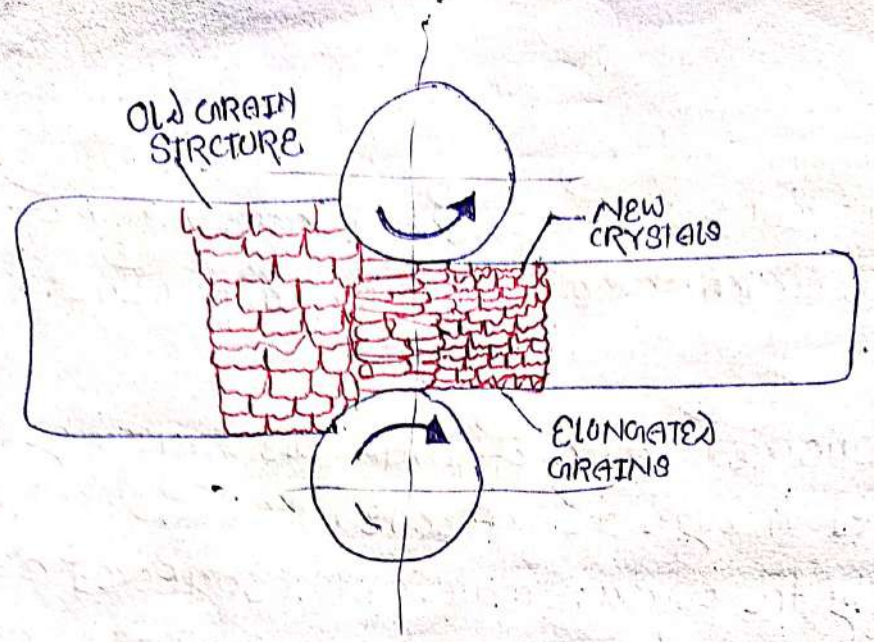


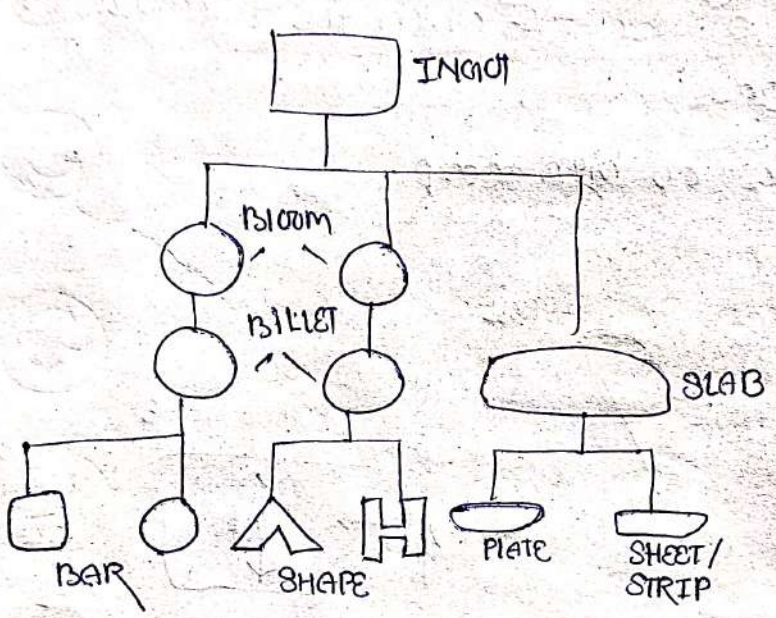
angle of bete — the reduction that could be achieved with a given set of rolls is designated as angle of bete.

→ The metal leaving the rolls could be at a higher velocity than when it entered as the area of cross section decreased.

neutral plane → Initially when the metal enters the rolls the surface speed of rolls is higher than that of the incoming metal, where as the metal velocity at the exit is higher than that of the surface speed of the rolls.

Betwn the entrance and exit the velocity of the metal is continuously changing, whereas the roll velocity remains constant. Somewhere the contact length, the velocities of the metal and rolls are same.





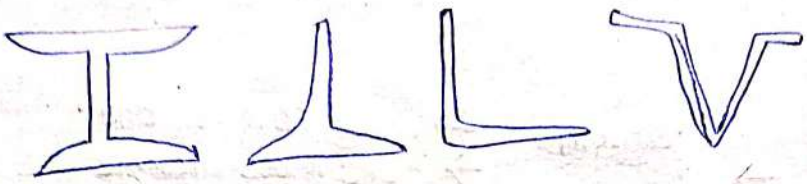
Difference betw HOT and COLD ROLLING :-

HOT rolling	COLD rolling
(i) Metal is fed to the rolls after being heated above the recrystallization temp.	(i) metal is fed into the rolls when it's temp is below the recrystallization temp.
(ii) Hot rolled metal doesn't shows a work hardening effect.	(ii) work hardening effect shows metal
(iii) Coefficient of friction betw rolls and stock is higher	(iii) relatively lower.
(iv) heavy reduction in cross sectional area is possible	(iv) not possible.
(v) poor surface finish	(v) smooth and oxide free surface finish.
(vi) Roll radius is larger	(vi) roll radius is small

→ **Rolling advantages** ⊢

higher productivity with low cost.

Produce components having constant cross section throughout it's length many shapes such as I, T, L and Channel section are possible.



Type of rolling	maximum angle of bet (in degree)
Cold rolling with lubrication and smooth surface finish	3 to 4
Hot rolling of tubes	12 to 14
Hot rolling of sheets	15 to 22
Hot rolling of rough rolls	27 to 34

→ pressure on rolls gradually builds up from the entry to the neutral point where is highest and then decrease till it reaches the exit.

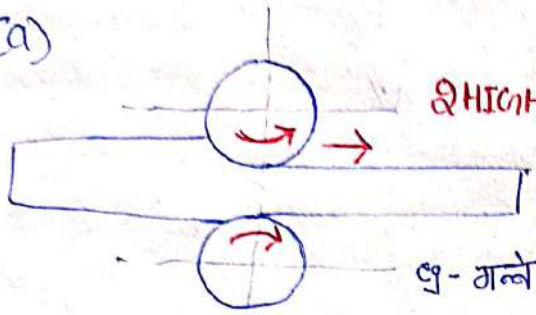
Roll separating force → separates the two rolls apart can be determined obtained by multiplying the average roll pressure with the total contact area.

→ The average roll pressure can be decreased by the reducing the maximum pressure.

Different types of rolling mills or Rolling stand arrangement :-

→ rolling stand arrangements are given by the nos of roll employed.

(a)



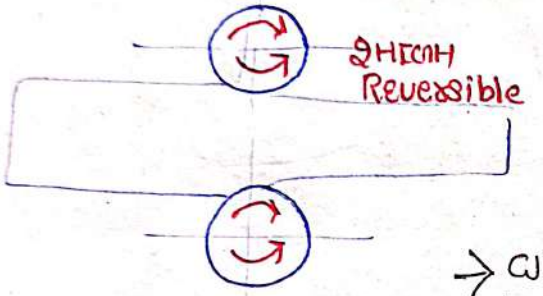
2HIGH

→ most common one.
→ rolls move always one direction.

→ 2 rollers moving in opposite direction

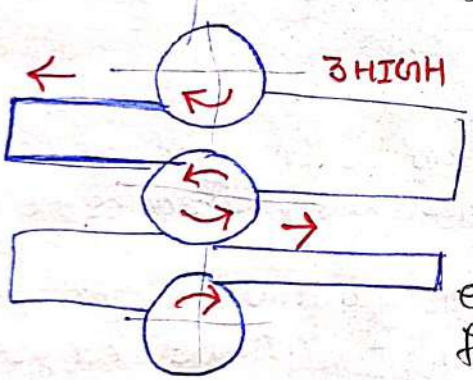
दु - गन्ने की मशीन

→ major disadvantage - To reduce a big ingot into sheet several passes needed.



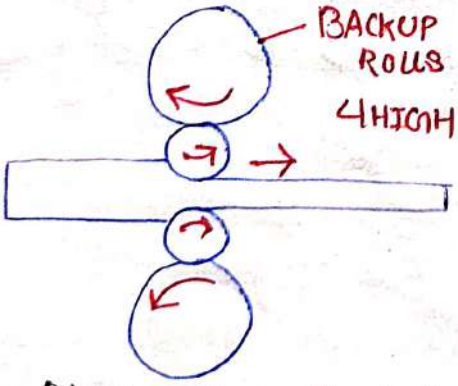
2HIGH Reversible

→ rolls rotation may be reverse.
→ Particularly used in reducing the handling of hot metal in between rolling passes.
→ when metal reached right side direction of roll reversed and metal allowed to enter the next pass. expensive



3HIGH

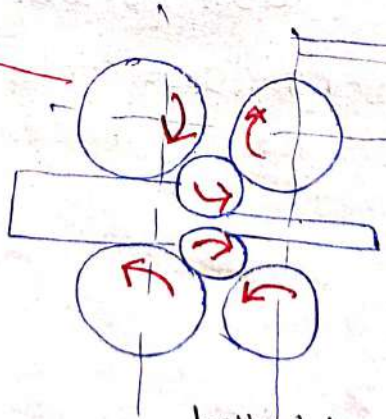
→ two continuous passes in a rolling sequence without reversing the direction.
→ All metal passed through bottom roll set the end of the metal is entered into other set of rol for next pass. table tilting arrangement



BACKUP ROLLS

4HIGH

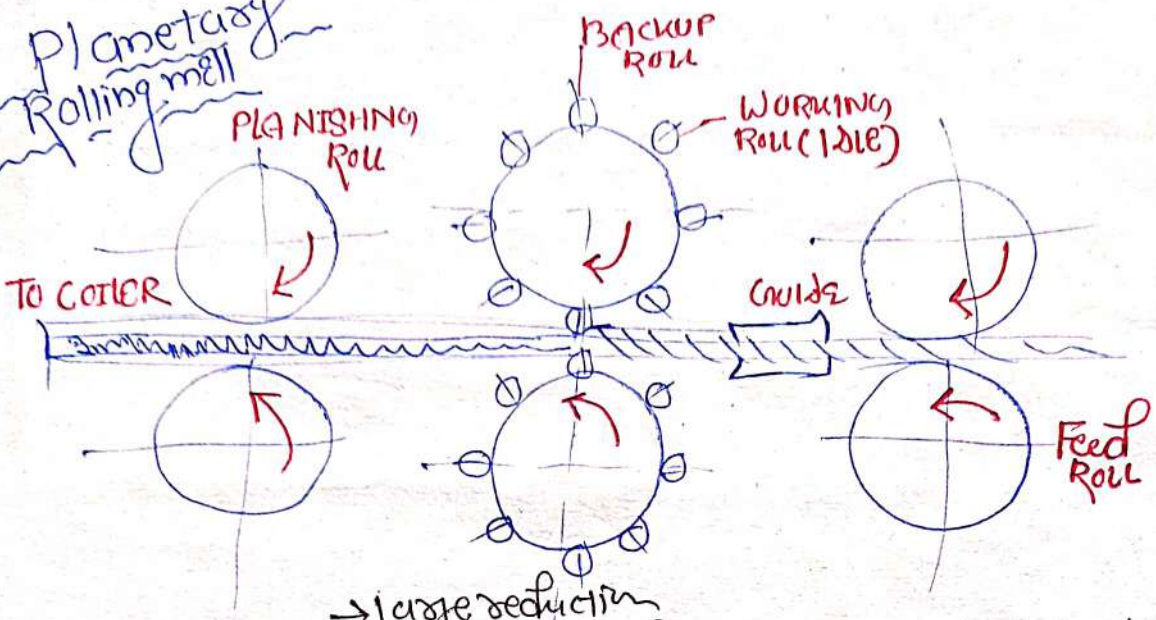
2 high rolling mill, but with the small sized rolls. The other two rolls are backup rolls for providing the necessary rigidity to the small rolls.



CLUSTER

better backup can be provided to the small role with a cluster.
- large reduction
- no of free rotation wheel in the of a small roll.

Planetary Rolling mill



→ large reduction
→ a number of free rotating wheel on steed of a single small roll are fixed to large backup roll in the planetary rolling mill arrangement.

upper and lower direction - same
middle one - opposite.
→ ~~sequasie~~ requires less costly motive power. It has hegher output.

4HIGH

When large quantities of similar size w/p needed then effeciency is good.

4-backup
Cold rolling
extra pressure

WELDING

Brazing

Brazing is a coalescence of a joint with the help of a filler metal whose liquids temp. is above 450° and is below the solidus temp. of the base metal.

→ In brazing the base metal is not melted. dissimilar metals can be joined. eg. Al and mg.

→ Brazed joints is not useful for high temp welding because of the low melting temp. of the filler metal.

→ The filler metal reaches the joint by capillary action. it's necessary to control the clearance betw two parts. The temp. at which filler metal is entering the joint is also important.

→ Too much clearance doesn't allow capillary force to draw the filler metal into joint and also insufficient clearance may be too small to allow the filler metal to give rise to an effective strength.

SOLDERING

→ Soldering is the method of joining similar or dissimilar metal by means of a filler metal whose liquidus temp. is below 450°C.

→ filler metal enters the joints by capillary action.

→ needs to solvent cleaning. acid pickling and mechanical cleaning of the joint surface.

→ To remove the oxides from the joint. surface for avoiding filler metal from oxidizing fluxes are generally used in soldering.

⇒ Tensile strength of butt joint depend upon the contact area in case of lap joint depending upon the strength requirements. The bonding area chosen. But the limitation of lap joints is that the thickness of joint increases for overlapping of the parts.

→ For small thickness, straight edge joints are done and for the edges is prepared in such a way that heat of welding can penetrate the entire depth. To facilitate the process the joint is widened.

→ for very thick plates, the welding needs to be done from both sides

→ The V joint is easier to make and the amount of extra metal to be filled in the joint increases greatly with an increase in the thickness.

→ A U joint is preferable when the amount of extra metal to b added to fill the joint is less beyond a certain thickness.

Necessary consideration of during fusing →

It's essential to clean the interface to remove any oil, dirt, pain or grease. These would interfere during proper fusing of meta and weaken the joints.

→ To remove the oily substances from the surface organic solvent such as acetone and carbon tetra chlorides are used.

→ foreign substances are removed by means of cleaning with a rag soaked in the solvent.

→ Heavier oxide films are removed by acid pickling wire brush or emery. Also the oxides presence on the surfaces can be removed by the use of fluxes. The types of flux used depends upon the operations and parent metal that is being welded.

"Flux is a material that is expected to react with oxides present and form low density slag which would float on the top of molten metal pool protecting it form further oxidation."

→ flux is a material used to prevent, dissolve, or facilitate remov of oxides and other undesirable surface substance. as defined by AWS (American Welding Society)

→ filler metal used all the welding process. except resestance welding.

flux used in welding proces — Ammonium chloride
zinc chloride
Hydrochloric acid
Borane

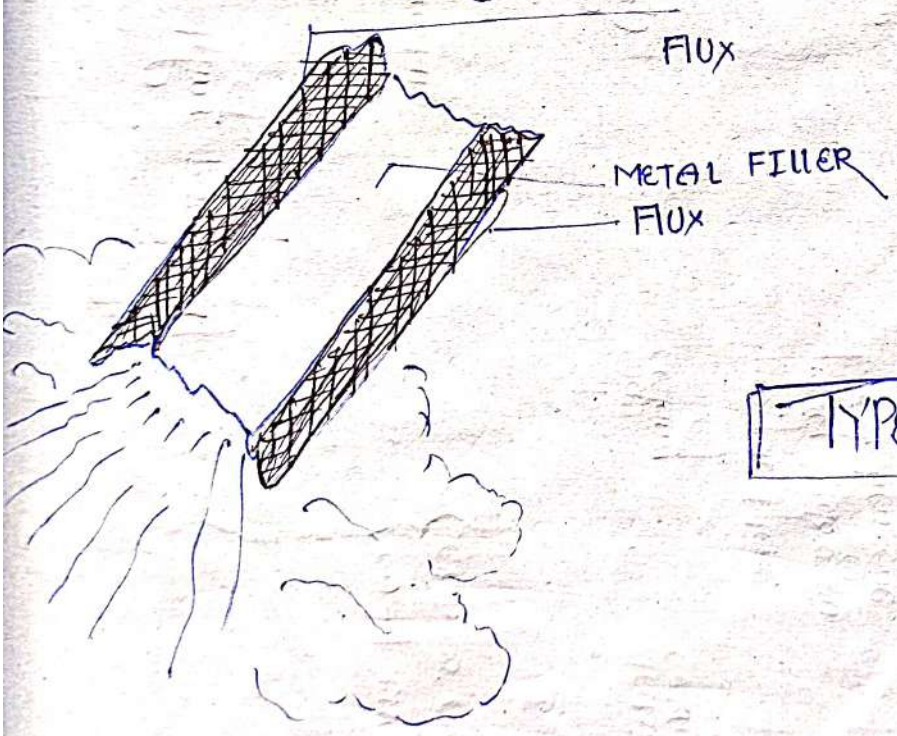
→ flux can be a paste, powder or granula incase of soldering / Brazing and gas welding pastes are used.

SMAW (ordinary electrode) has a coating of flux on bare wire.

Fluxcored GMAW (MIG) wires have flux inside the hollow wire

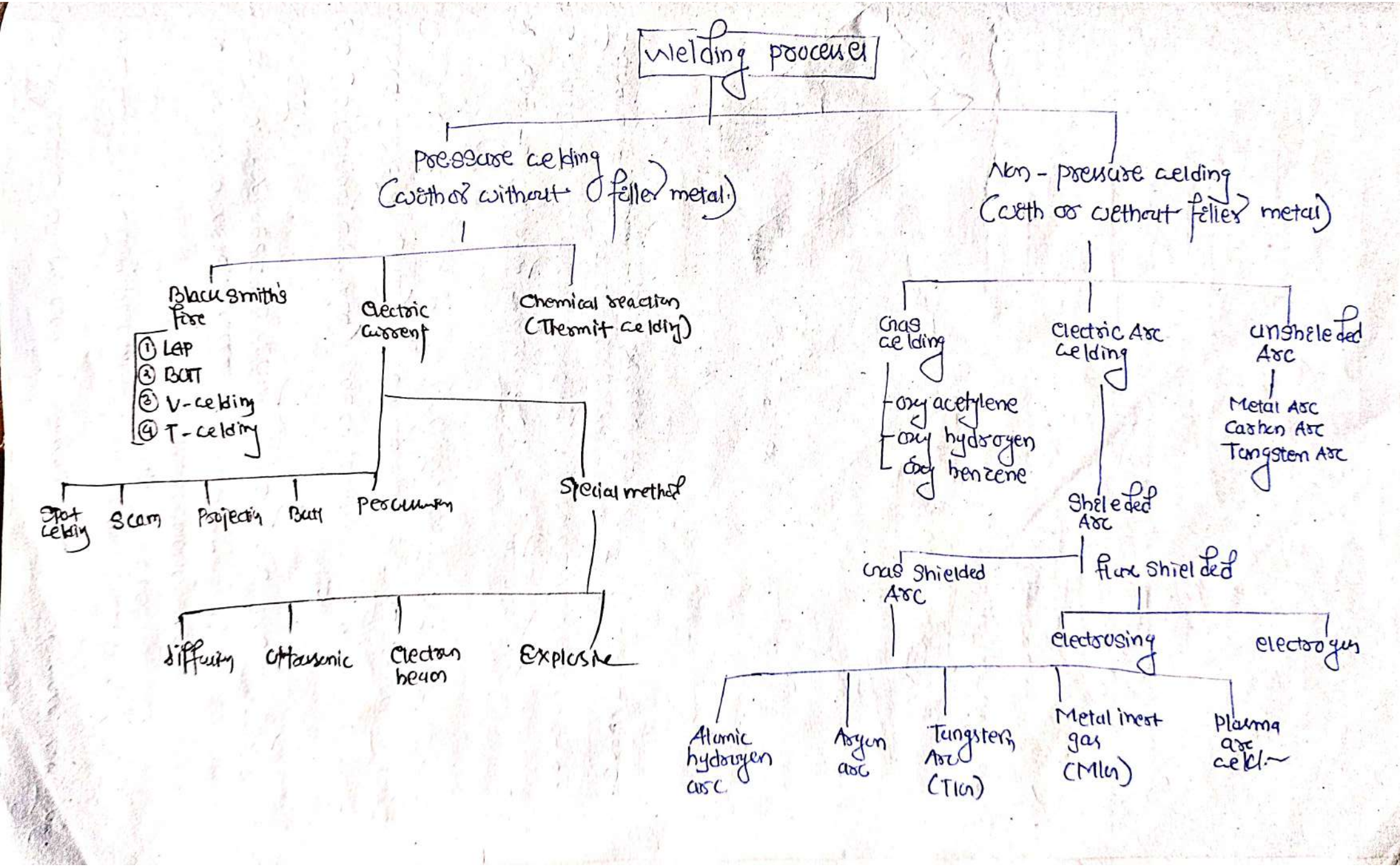
SAW (Submerged Arc welding) — flux powder in form of granules.

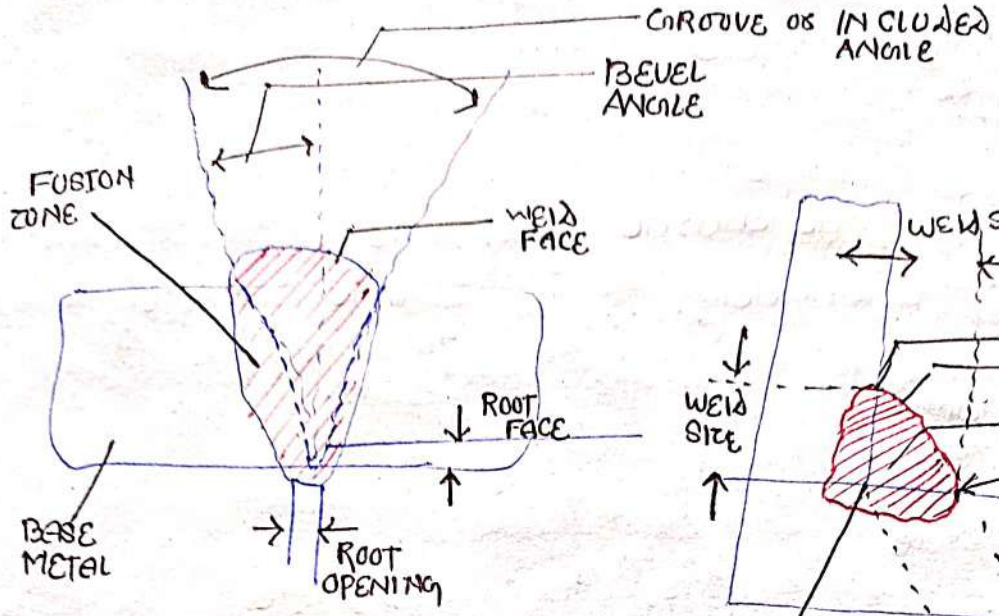
→ flux helps to cleaning the surface; Adding alloying elements; Arc stability; positional ceding (vertecal/overhead); increase deposition rate; producing gas/slag that protects weldpool from atmosphere.



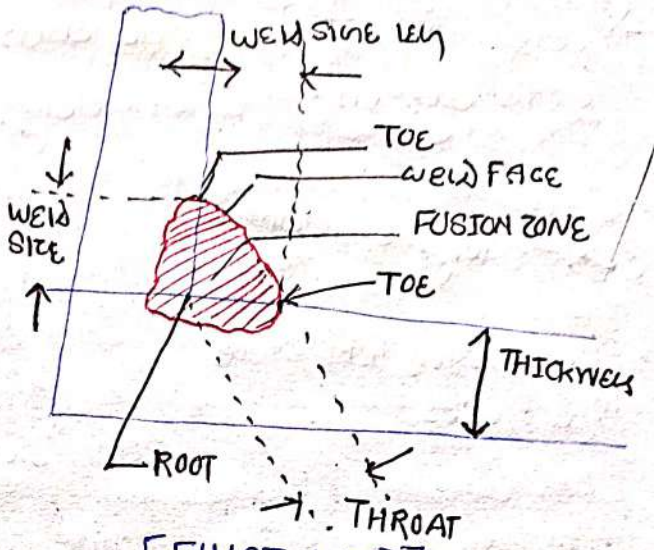
TYPES OF WELDING

- electric arc welding
- gas welding
- Thermit welding
- Resistance welding
- friction welding


Welding processes
Pressure welding (with or without filler metal)
Non-pressure welding (with or without filler metal)
Blacksmith's fire
1. Lap
2. Butt
3. V-welding
4. T-welding
Electric current
Chemical reaction (Thermit welding)
Spot welding
Seam
Projection
Butt
Percussion
Special method
Diffusion
Ultrasonic
Electron beam
Explosive
Gas welding
Electric Arc welding
Unshielded Arc
oxy acetylene
oxy hydrogen
oxy benzene
Metal Arc
Carbon Arc
Tungsten Arc
Shielded Arc
Gas shielded Arc
flux shielded
electrosing
electrogas
Atomic hydrogen arc
Argon arc
Tungsten Arc (TIG)
Metal inert gas (MIG)
plasma arc welding



[BUTT WELD]



[FILLET WELD]

Shape of welding surface

flat

convex

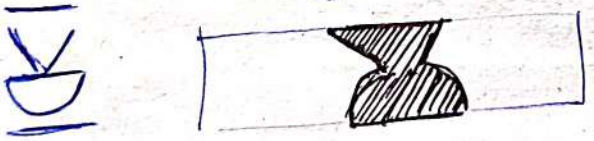
concave

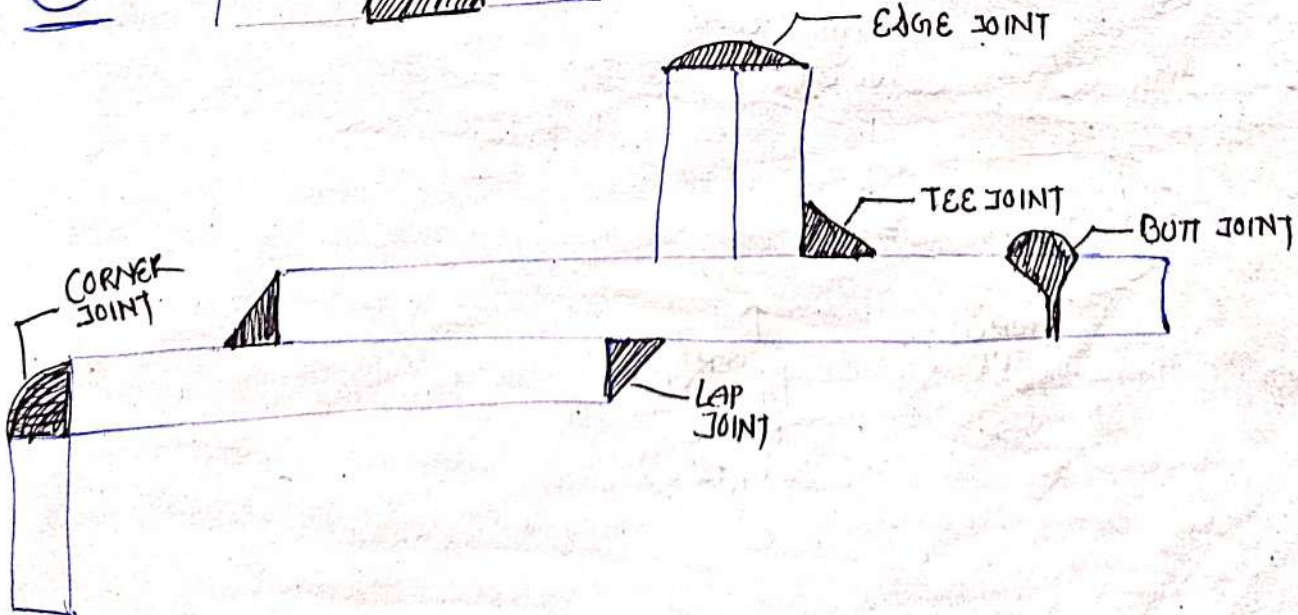
Flat (Flush) single V butt weld

Convex double-V-butt weld.

Concave fillet weld

Flat (flush) single V butt weld with flat (flush) backing run





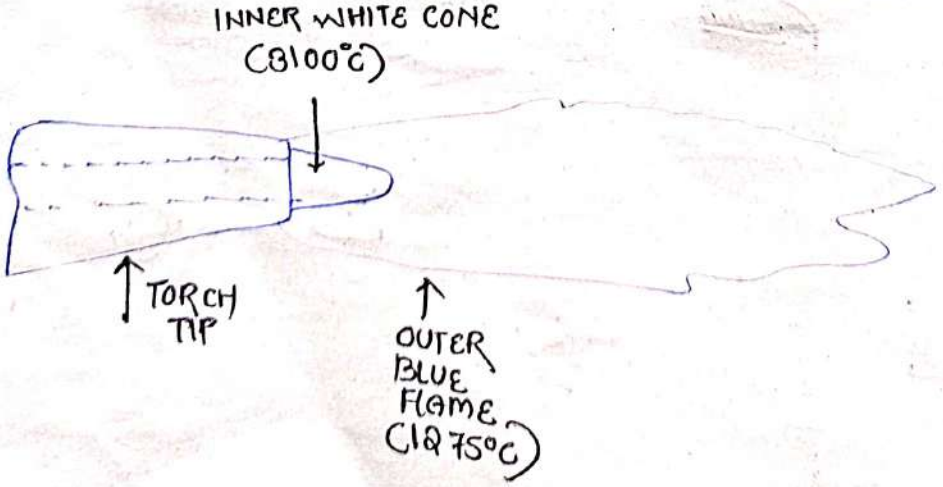
OXY ACETYLENE or GAS WELDING :-

→ Combustion of fuel gas such as acetylene in combination with oxygen — fusion welding. — Joint is completely melted to obtain the fusion.

OFW
Oxy-fuel gas welding

Combustion take place in 2 stages — fuel gas suchas acetylene and oxygen mixture burn releasing intense heat.
— white cone.

Gases	Chemical formula	Heat content MJ/m³			Flame Temp, °C
		Primary	Secondary	Total	
Acetylene	C_2H_2	18.97	36.03	55	3100
Propylene	C_3H_6	16.38	71.62	88	2500
Propane	C_2H_8	9.38	83.62	93	2450
Methyl acetylene Propadiene	C_3H_4	21.00	70.00	91	2927
Hydrogen	H_2	-	-	10	2390
Natural Gas	$CH_4 + H_4$	0.41	36.59	37	2350



2 Stages →

(1st) — reaction for oxy acetylene welding

$C_2H_2 + O_2 \longrightarrow 2CO + H_2 + 448\,\frac{KJ}{mol}$ ($18.75\,\frac{MJ}{m^3}$ of acetylene)

The inner white cone temp. — 3100°C.

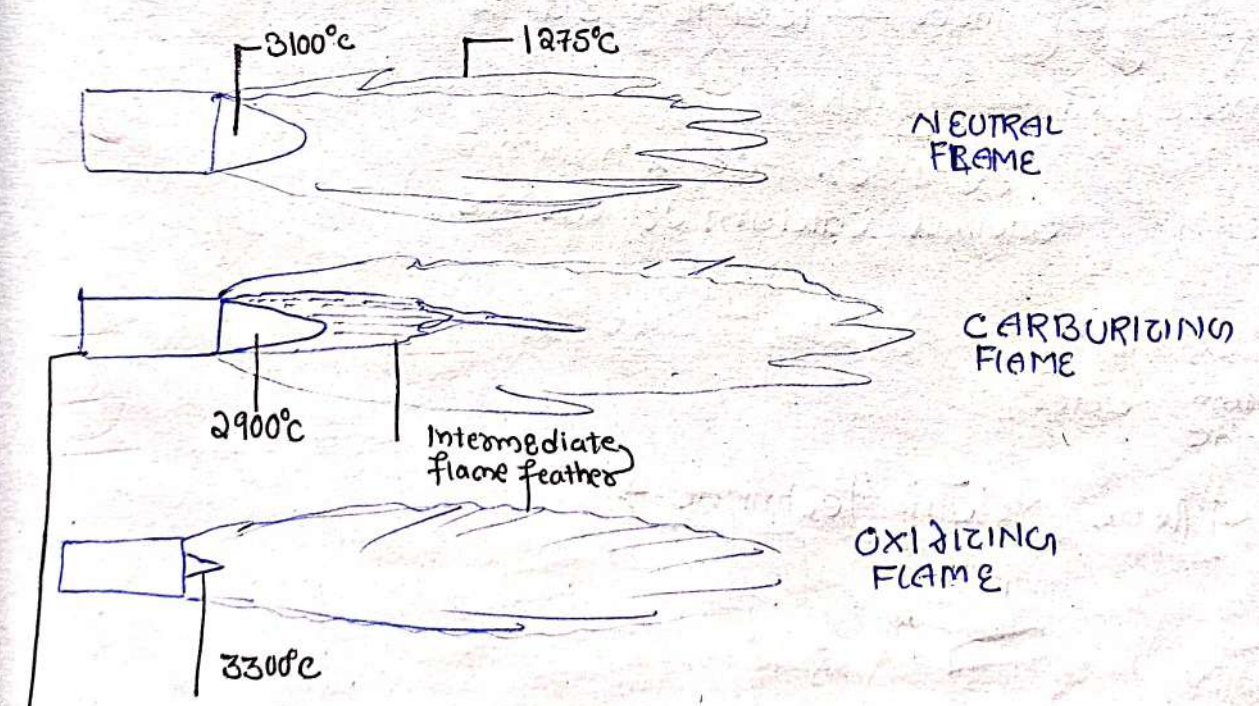
(2nd) The carbon monoxide [CO] and Hydrogen produced in the first stage further combine with the atmospheric O_2 and give rise to the outer bluish flame.

$4CO + 2H_2 + 3O_2 \longrightarrow 4CO_2 + 2H_2O + 812\ KJ/mol$ ($35.77\ MJ/m^3$)

temp of bluish flame — (1200 to 2000°C) — Preheating steel distributed large area

inner (3100°C) —— directly melting.

VARIOUS TYPES OF FLAMES →



→ intermediate flame feather — reddish in colour.

length of this flame feather indicates excess acetylene present.

Since the unburned carbon present goes into the weld metal pool, the metal appears to boil, This excess carbon causes steel to become extremely hard and

→ Flame provides a strong reducing atmosphere in the welding zone. readily oxidised.

eg - oxygen free copper alloys.
high carbon steel.
cast irons;
hard surfacing with high speed steel and cemented carbid

→ Oxygen excess — oxidizing flame

excess O_2 badly oxidises the weld metal. because of burning of me the weld pool foams and sparks.
- Produce loud noise.
- non ferrous alloys such as copper base alloys.
  zinc base alloys.
- cast iron and manganese steels.
- create oxide film to protective cover over the metal pool.

EQUIPMENT →

oxygen storage cylinder — 13.8MPa to 18.2MPa.

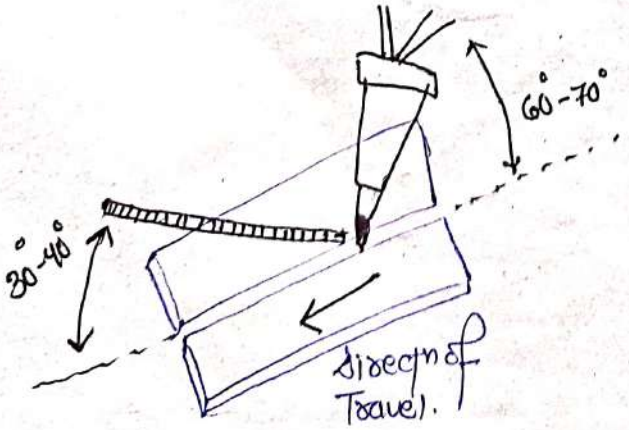
acetylene stored — 200kPa

80 to 85% porous material such as calcium silicate and

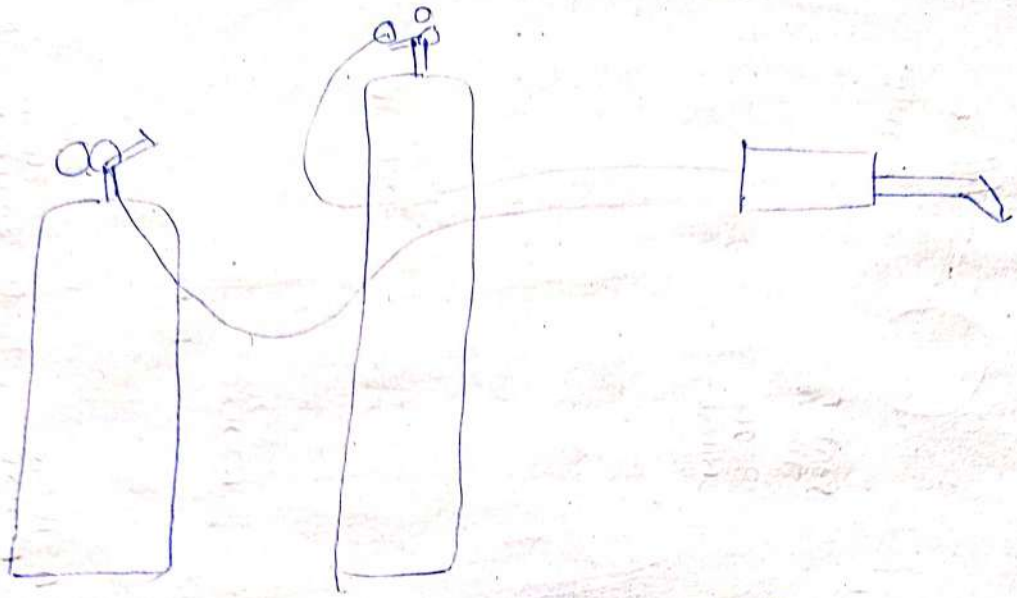
$$CaC_2 + 2H_2O \longrightarrow C_2H_2 + Ca(OH)_2$$

calcium carbide — water

OXY-Acetylene Welding Technique →



[LEFTWARD]



→ Feller rod not use — mild steel —— copper coated to prevent rusting
not coated with flux
Cast iron rods —— square shaped.
Brazing rods —— brass and bronze.

Feller rod - 1m. long. —— Size increases as the metal thickness to be joined increases.

1-5mm. diameter feller rod —— 18 SWG sheet.
2-3mm. " " " —— 3mm thick sheet.

→ B Oxy powder - flux — gas welding of mild steel

Advantages

(i) wide variety of mfg processes and repairs.

(ii) As the source of heat and feller metal are different, the welder can have control over feller metal deposition rates.

Disadvantages

(i) Not economical to join heavy sections.

(ii) flame temp is less than the temp of arc welding.

(iii) fluxes used, produce fumes, that are irritating in nature.