Engineering Materials

Material :- A substance which is used in the field of engineering is called engineering material.

Classification of Engineering materials

Engineering Materials
- Metals
- Polymers
- Ceramics
- Composites

(a) Metals
- Ferrous
  - Main element is iron, steel
  - Cast Iron
- Non-Ferrous
  - Al
  - Cu
  - Pb
  - Ni

(b) Polymers
- Thermoplast (can be deformed into other form)
  - Polystyrene
  - PVC
  - Polyurethane
- Thermoset (can't be deformed into other form)
  - Bakelite
  - Epoxy

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(c) Ceramics
- Glass
- Silica
- Alumina

(d) Composites
(Less weight but high strength)
- Carbon fibre
- Glass Reinforced Plastic
- MMC [Metal Matrix Composites]
- PMC [Polymer Matrix Composites]

Engineering materials can be selected on the basis of following considerations

(i) Properties of ~~most~~ materials
(a) Mechanical properties
(b) Chemical properties
- Oxid^n
- Red^n

(c) Physical Properties
- Melting Point
- Specific heat
- Density

(ii) Cost of materials
(iii) Availability of materials

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★ Mechanical Properties

1. Ductility :- The ability of a material to deform longitudinally under tensile force is known as ductility.

2. Brittleness :- The ability of a material to break under compressive force is known as brittleness.

3. Elasticity :- The ability of a material to deform on applying load and return to its original shape on the removal of load.

4. Plasticity :- The ability of a material to deform on applying load ~~and~~ but not return to its original shape after removal of load, means permanent deformⁿ.

5. Hardness :- The ability of a material to resist the indentation.

$$B = \frac{P}{\frac{\pi D}{2}\left[D - \sqrt{D^2 - d^2}\right]}$$

D... Diameter of load
d... Diameter of indentation
P... Load

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6. Toughness :- The capacity of a material to absorb energy before fracture is known as toughness of material.

7. Stiffness :- The ability of a material to ~~deform the~~ resist (under) the elastic deformation is called stiffness.

8. Malleability :- The ability of a material to deform into flat thin sheets without any crack under cold working condition.

9. Damping :- Damping is the shock absorbing capacity of a material. Grey Cast Iron.

Stress	~~Strain~~ Pressure
Force is applied on particular cross section of material.	Force is applied on the surface of material.

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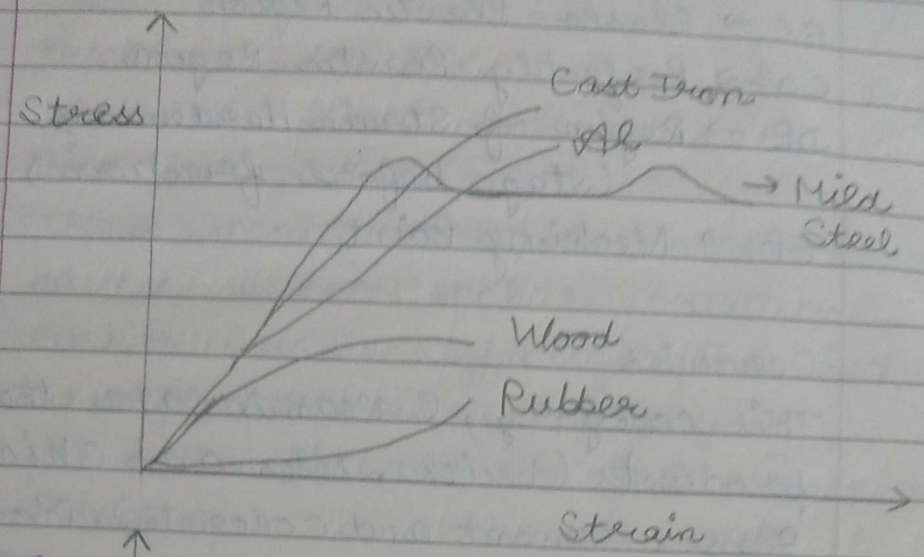
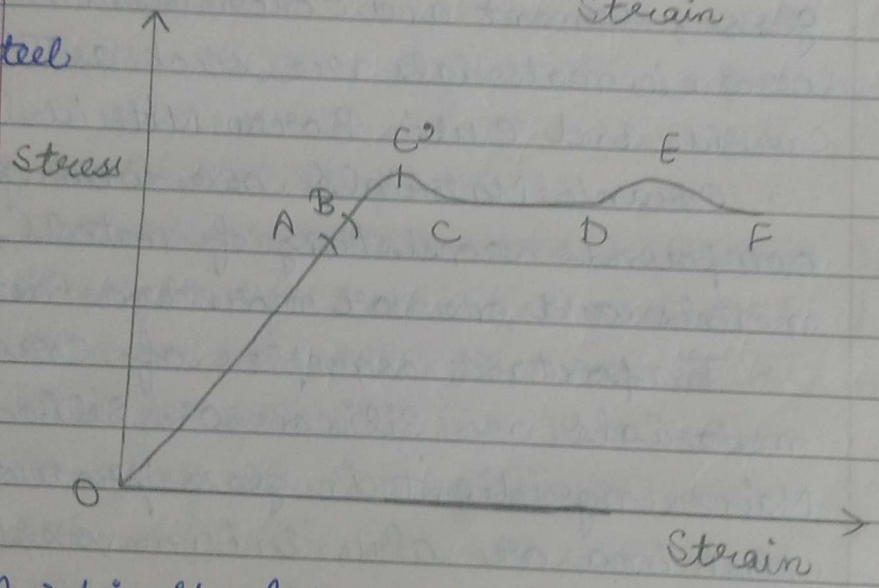
★ Stress-Strain Curve



Mild Steel



A → Limit of proportionality
B → Elastic limit
C' → Upper yield point
C → Lower yield point
D → Strain ~~Harden~~ hardening point
(Strain ~~Strats~~ Starts)
E → Ultimate Stress Point (Max. Stress)
F → Point of fracture

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OA → Region of proportionality
BC → Elasto-Elastic Region
CD → Perfectly Elastic Region
DE → Region of Strain Hardening
(Stage before fracture)
EF → Necking Point

★ Ceramics

This category, Ceramics are the clay products (bricks, tiles and China ware, glass, cement and concrete). Modern ceramic materials are such as Tungsten Carbide and Cubic Boron Nitride [CBN].

Ceramic Materials are inorganic compounds consisting of metals, semi-metals and one or more non-metals.

Important examples of Ceramics materials are Silicon or Silicon dioxide. Main ingredient in glass products is alumina or aluminium oxides which are used ranging from ~~abber~~ abrassives to artificial bones.

★ Applications :-

(i) Used as a abrassive.
(ii) Used in computer memories, light bulbs, in clay piping and building tiles, artificial teeths and bones.

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In general, Ceramic Materials can be of three types :-

(i) Traditional Ceramics

Silicates, bricks and cements.

(ii) New Ceramics

More recently developed ceramics based on non-silicates such as oxides and carbides. Such types of ceramics have superior mechanical and physical properties than traditional ceramics.

(iii) Glasses :-

Based on non-crystalline structure.

★ Mechanical Properties

(i) Ceramic Materials are rigid and brittle.

(ii) Strength of Ceramic Materials is higher than metals due to atomic bonding (In general)

(iii) Bonding in ceramics is more rigid which doesn't permit slip under stress.

(iv) Tensile Strength and toughness are relatively low.

★ Physical Properties

(i) Lighter than metals but heavier than polymers.

(ii) Melting temp. are higher than metals.

(iii) Electrical and thermal conductivities of most of the ceramics are lower than

metals (So, they are insulators)

★ Polymers

Polymers are the compound consisting long chain molecules, each molecule is made up of repeating units connected together.

There may be thousands, even million of units in a single polymer molecule. Polymer can be separated as plastic and rubber.

(i) Thermoplast Polymers :- They are oftenly called solid materials at room temp. (25°C) but they become viscous liquid when heated upto few hundred degrees. This characteristic allow them to be easily and economically shaped into products. They can be subjected under heating and cooling cycle repeatedly without significant degradation of polymer.

Example → Polystyrene, PVC, polyurethane, polypropylene, Nylon, ~~etc~~ polyethylene, poly tetra ~~fluo~~ ~~fluro~~ fluoro ethylene (PTFE) etc.

(ii) Thermoset Polymers :- They can't tolerate repeated heating cycles as was in case of thermoplast. Thermosets when initially heated, they soften but at a particular

elevated temperature also produce a chemical reaⁿ that hardens the material into an infusible solid. If re-heated, then thermosets will degerade.
Example → Bakelite, Epoxy, Melamine, ~~etc.~~ ureas, etc.

* Elastomers :- These are the rubbers and have extreme elasticity, when subjected to relatively low mechanical stress (by a factor of 10 - can be elongated ten times).

* Mechanical Properties of ~~a~~ Thermoplast Polymers :-
(i) much lower stiffness and much lower hardness.
(ii) greater ductility, lower tensile strength (In general 10% of metals)
~~(iii)~~

* Physical Properties of Thermoplast
(i) lower density than metals and ceramics
(ii) lower melting temp..
(iii) high co-efficient of thermal expansion [5 times of metals and 10 times of ceramics]
(iv) higher insulating properties.

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★ Mechanical properties of Thermosets :-

(i) more rigid.
(ii) brittle in nature.
(iii) less soluble.
(iv) capable at higher service temp..

★ Composites

Composite Material is a ~~symmetr~~ material system which composes two or more physically distinct phases whose combination as a whole produces aggregate properties that are different from its constituents.

Properties :-

(i) Fatigue properties are generally better.
(ii) Toughness is also high.
(iii) ~~don~~ don't corrode as steel.
(iv) better appearance and smooth surface.

Disadvantages :-

(i) Many polymer based composites are subjected under attack of chemicals.
(ii) Manufacturing methods for shaping the composites ~~are~~ may very slow and costly.

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Phases in composite materials :-

In general, composite materials consist of two ~~physical~~ phases namely as primary phase and secondary phase.

The primary phase forms the matrix within which secondary phase is embedded.

Embedded phase sometimes referred as reinforcing agents. Reinforcing phases may be in the form of fibres, particles or may be in other geometries. In general, these phases are insoluble in each other but strong adhesion must exist at their interface.

Classification of composite materials :-

(a) Metal Matrix Composite (MCC) :- These materials include mixture of ceramics and metals such as cementoid carbides.

→ lower co-efficient of thermal expansion as compared to metals.

→ high stiffness capacity and strength

→ greater heat resistance

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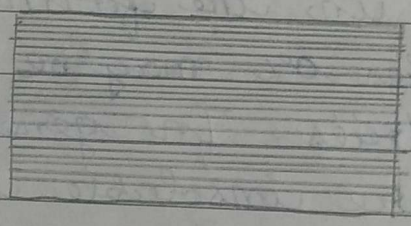
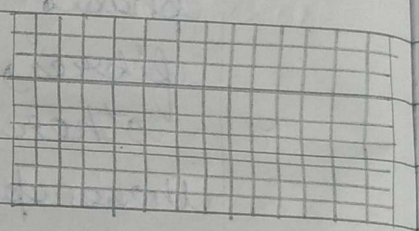
(b) Ceramic Matrix Composite (CMC):- This is a least common composite material. Aluminium Oxide (Al_2O_3) and Silicon Carbide (SiC) are materials those are embedded with fibres.

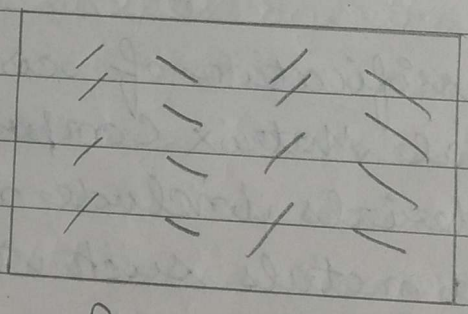
(c) Polymer Matrix Composite (PMC):- Thermosetting Raisins are the most ~~use~~ widely used polymers in PMC.



1D on the basis of fibres



2D on the basis of fibres



Random

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Manufacturing Process

Manufacturing Processes

Primary	Secondary	Tertiary	Joining Process
- Forging	- Turning	- Finishing / Super Finishing	- Welding
- Extrusion	- Drilling	- Coating	- Bridging
- Drawing	- Milling	- Polishing	- Soldering
- Rolling			
- Casting			

★ Advantages of cold working :-

(i) No heating is required. [Sometimes, in general]

(ii) Better surface finishing is obtained.

(iii) Better dimensional control.

(iv) Better strength, fatigue and wear properties.

Fatigue → cyclic failure constant

Creep → Failure under loading

★ Disadvantages :-

(i) Higher forces are required for deformation.

(ii) Undesirable (residual) stresses may be produced.

(iii) Strain-hardening occurs.

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★ Advantages of hot working :-

(i) No strain hardening occur.

(ii) Lesser forces are required for deformation.

(iii) No residual stresses are introduced in materials.

★ Disadvantages of hot working :-

(i) Poor accuracy and dimensional control of parts.

(ii) Handling of hot metal is difficult

(iii) Heat energy is required.

(iv) Lower tool life.

Imp ★ Forging

Forging is a process in which a material is shaped by the application of compressive forces exerted either manually or by power hammer. This process may be carried on materials either in their hot state or in cold state.

Rivets, bolts, ~~hoo~~ crane hook, connecting rods, gears, turbine shafts, etc.

Forged parts have good strength & toughness. Some common types of forging processes :-

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(a) Open die Forging:- It is the simplest and slowest forging process.
It is not suitable for large scale production.

(b) Closed die Forging:- [hot iron is kept in cavity and then shapened through hammering]
This process is used at a particular shaped die to control flow of metal. Heated metal is adjusted in lower cavity accordingly. Excess metal is squeezed out around the periphery of the cavity.

(c) Press Forging:- [Thick part is shaped]
This process is used for large cross-section of metals. Hydraulic press is used to obtain the slow & squeeze action instead of series of ~~cycle~~ ~~cycling~~ cyclic hammering like in the case of closed die forging.
Example→ Full injection nozzles, gears, turbines.

(d) Upset Forging:- [bolt head]
Upset Forging is the process which involves increasing the cross-section of material along its length.
Example→ Bolt head and coupling (joining two shafts).

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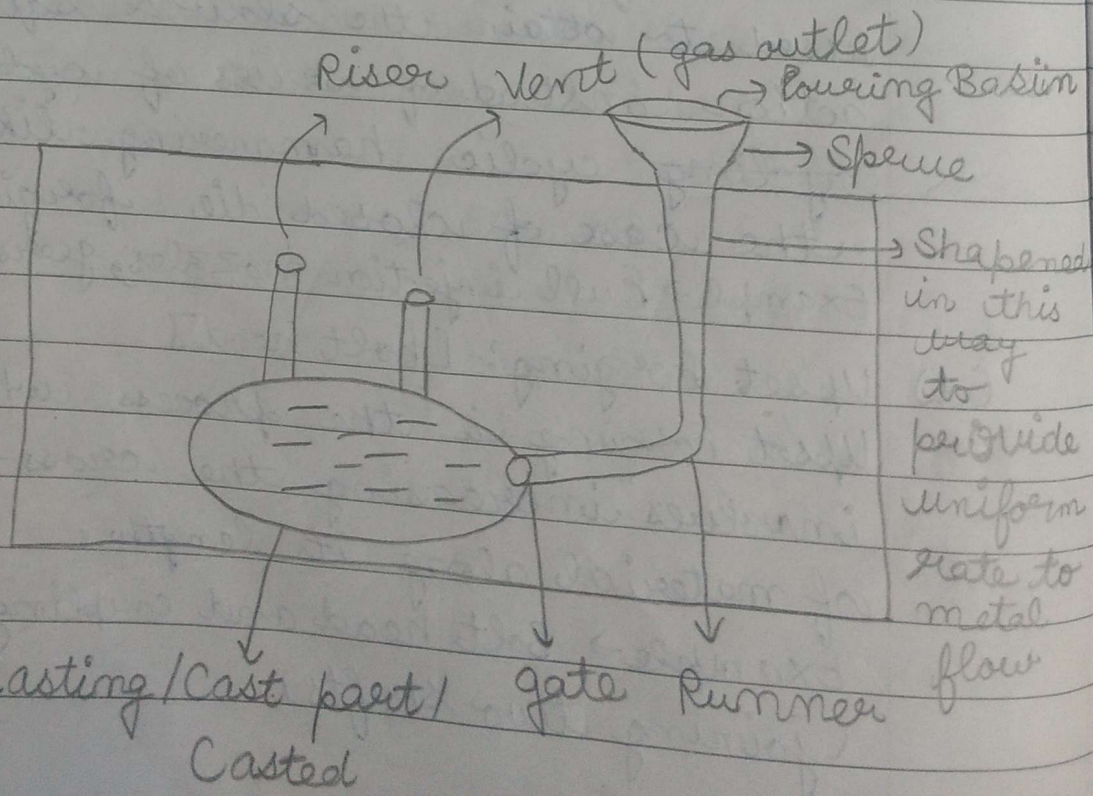
particular portion of rod is flatened equal in upper and lower side.

(e) Swaging Forging
In this process, diameter of a rod is reduced by forcing it into a confining die.
Example → Screw driver.

(f) Roll Forging [Red hot iron passed through the small gap between two rollers]
This process is used to reduce the thickness of round or flat bar with the corresponding increase in length.
Example → Leaf Spring, Axle.

☆ Casting



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Casting means pouring molten metal into the mould cavity and allowing it to solidify. When solidified, desired metal is taken out either by breaking the mould or by taking the mould apart. Solidified object is called casted / casting / cast part.

★ Advantages :-

(i) Molten metal can flow into very thin sections, therefore, complex shapes can be easily created.

(ii) It is possible to cast any material. ~~(iii)~~ (Ferrous and non-ferrous)

(iii) Size and weight of product is not a limitation.

Limitations :-

(i) Metal casting process is labour intensive.

(ii) Poor dimensional accuracy and surface finish.

★ Casting Terms

(i) Pouring Basin
(ii) Sprue
(iii) Cope - Upper part
(iv) Drag - Lower part
(v) Riser
(vi) Gate
(vii) Vent
(viii) Runner

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Imp.

☆ Pattern allowances

+ve allowance

(i) Shrinkage allowance → Liquid Shrinkage
→ Solid Shrinkage

(ii) Taper allowance

(iii) Machining or finishing allowance

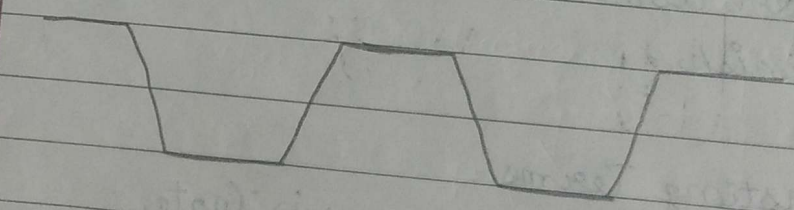
(iv) Distortion allowance

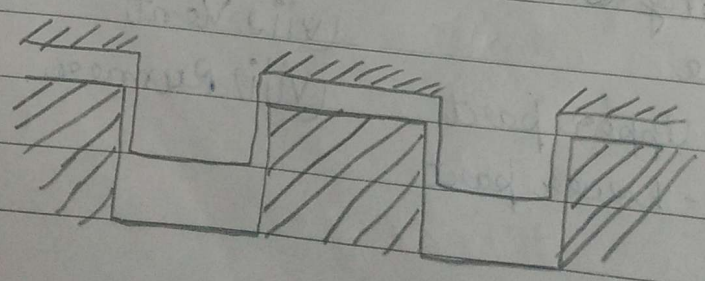
(v) Rapping allowance

-ve allowance

(i) Liquid Shrinkage :- To account this shrinkage, riser is used.
Solid Shrinkage :- To account this shrinkage, Shrinkage allowance is provided on the patterns.
Rate of contraction with temperature depends upon type of material.

(ii) Taper Allowance





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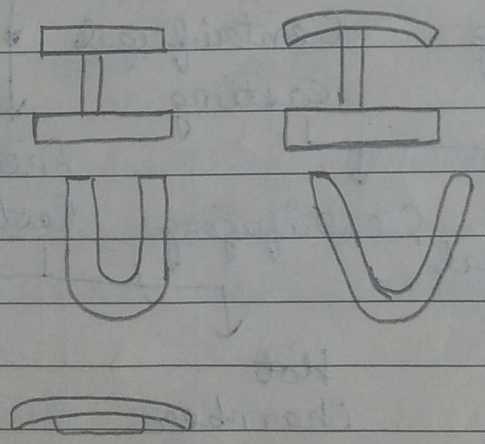
In taper allowance, tapering provided by the pattern maker on all vertical surfaces of the pattern so that it can be removed from sand without tearing of sides of sand mould and without excessive rapping by the moulder.

(iii) Machining & Finishing Allowance :- As we know, finishing & ~~machining~~ accuracy in the sand casting is poor, therefore, it is essential to provide machining or finishing allowance in order to achieve the exact dimension of the product / part with proper finishing.

(iv) Distortion Allowance :-



Sometimes casting may distort during solidification due to their typical shapes.

For example as if I-section, T-section, U-section, etc.

(v) Rapping Allowance :- Before withdrawing from the sand mould, pattern is ~~w~~rapped all around the vertical faces to enlarge the mould cavity ~~to enlarge the~~ slightly which helps in easy removal which enlarge the final casting. Hence, it is desirable that the original pattern dimensi~~on~~on should be reduced to account this increase.

Classification of Casting

- Expendable mould
  - Sand Casting
  - Shell Casting
  - Investment Casting
- Permanent Casting (mould cavity)
  - Centrifugal casting
    - True centrifugal Casting
    - Semi Centrifugal Casting
    - Centrifuging
  - Die Casting
    - Hot chamber die casting
    - Cold chamber die casting

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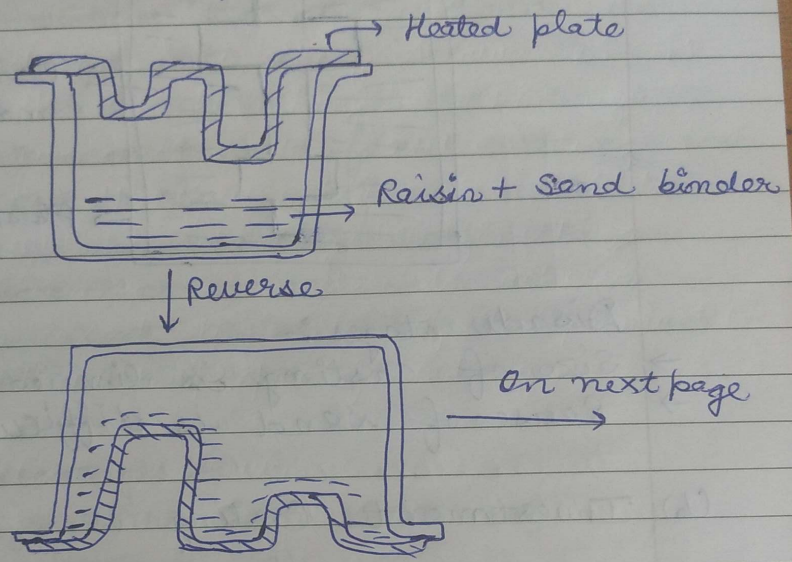
★ Casting

(a) Shell Casting

It is a process in which sand is mixed with thermosetting raisin and is allowed to come in contact with heated pattern plate (100°C – 500°C)



→ Cope and drag cells are kept in a flask with necessary backup material and finally molten metal

Advantages:-

→ Better surface finishing.

→ Thin sections can be easily casted.

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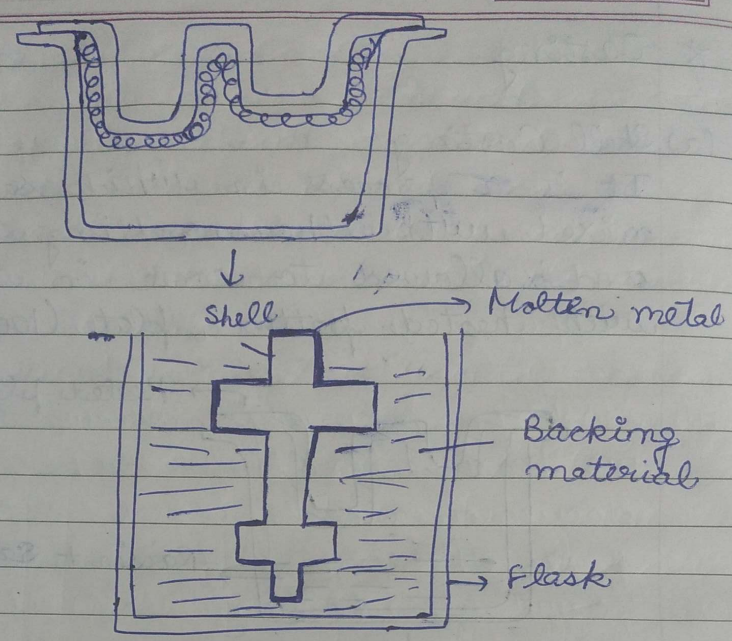
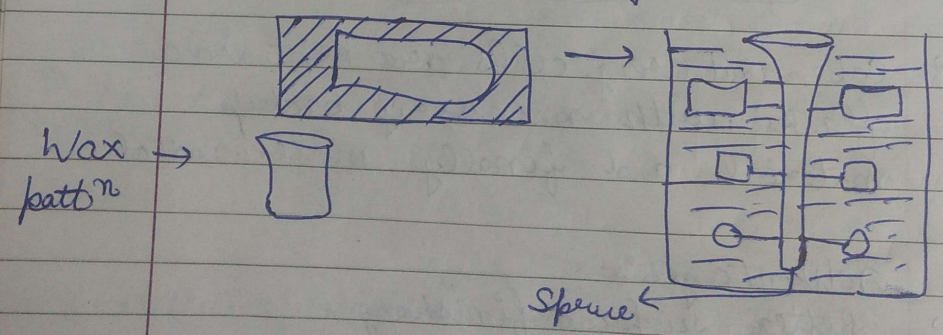


Disadvantages :-

→ Size of casting is limited

→ Reuse of sand is difficult

(b) Investment Casting



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In this process, patt^{n}s are prepared by injecting / pouring wax into metal dies. A no. of patterns can be attached to central wax sprue (in form of assembly). Mould ~~refractory slurry and~~ is prepared by surrounding the pattern with ~~refracting~~ refractory slurry and then set at a temp. After that mould is heated so that pattern melts and flows out ~~and~~ and leave a clean metal behind. Then pour the molten metal through main sprue. Molten metal enters the cavity. After solidify, desired patt^n is obtained.

Advantages :-

→ high dimensional accuracy
→ no parting line
→ very thin sections can be easily casted
→ complex shapes can also be easily casted.

Disadvantages :-

→ process is suitable ~~for~~ only for small size
→ process is relatively slow.

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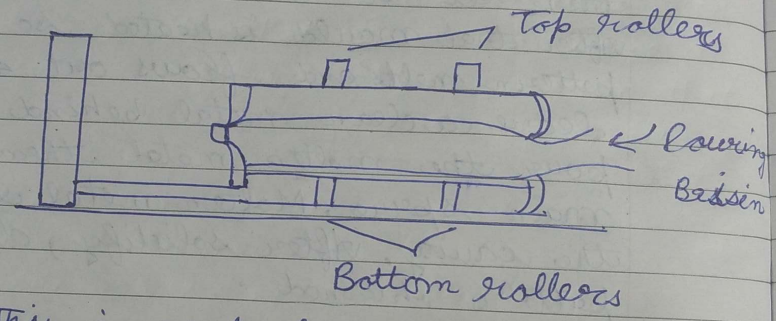
* Centrifugal Casting

In this process, mould is rotated rapidly about its central axis and metal is poured accordingly. Due to centrifugal force, metal is under pressure at its solidifies.

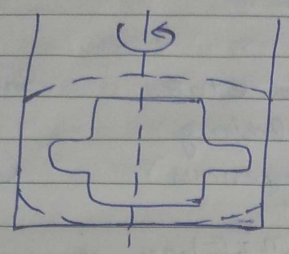
(i) True Centrifugal Casting / Horizontal casting



This is used for making hollow tubes, pipes which are axis symm. with concentric holes. Due to to centrifugal force, metal is always pushed outward. Due to conti. pressure, metal ~~sol~~ solidifies. In the true centrifugal casting, we can cast large hollow pipes easily.

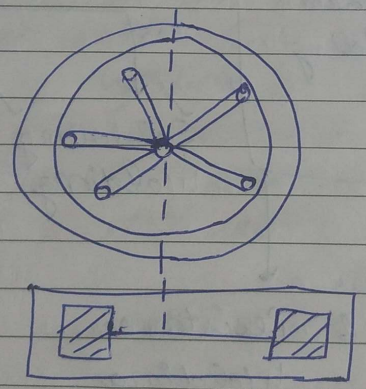
(In general, axis of rot^n in true centrifugal casting is horizontal but may be verti. or any angle b/w them).

(ii) Semi-Centrifugal Casting



In this casting process, mould is rotated vertically about its central axis. (axis symm. with concentric holes)

(iii) Centrifuging



→ not axis symm.

→ possible only in vertical condition.

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Welding
(Joining Process)

- **Solid State Welding (Autonomous) (No filler metal)**
  - Cold Welding
  - Friction Welding
  - Diffusion Welding
- **Liquid State Welding (Homogenous)**
  - Comp.^{n} of parent metal is same as that of filler metal
  - Arc Welding
  - Chemical reaⁿ welding
  - Resistance Welding
    - Spot Welding
    - Projection Welding
    - Seam Welding
- **Solid / Liquid Welding (Heterogeneous)**
  - Comp.^{n} of filler metal can be diff. from that of ~~f~~ parent metal.
  - Soldering Welding
  - Brazing Welding
  - Adhesive Welding

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Chemical sea^n Welding

- Gas Welding ✓
- Thermitt Welding

Arc Welding

- Shielded metal Arc welding
  - TIG
    Tungsten Inert gas welding
    (non-Consumable electrode is used)
  - MIG
    Metal Inert gas Welding
    (Consumable electrode is used)
- Submerged arc welding ✓

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1. What do you understand from resistance welding?
2. Explain with its types.
2. Enlist and explain welding defects. (Any five)

Welding is a process of joining two metallic components (similar or dissimilar) by fusion with or without appⁿ of pressure and with or without use of filler metal. Fusion of metal takes place by means of heat.

Advantages :-

(i) A good weld is strong as the base metal. (welding is done properly)

(ii) Large no. of metals and alloys can be joined by welding

(iii) Repair and maintenance is easy.

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Disadvantages:-

(i) Welding produces harmful radⁿs.
(ii) A very skilled welder is required.
(iii) Cost of equipment is high.
(iv) Welding heat may produce metallurgical changes.

Applications:-
(i) In automobile sector
(ii) In building consⁿ
(iii) In piping and pipelines
(iv) In household furnitures.
piping (single pipe)
pipelines (series of pipes)

★ ~~Bridging~~ Brazing and Soldering
In brazing and soldering, parent metal doesn't ~~metal~~ melt but only filler metal melts which fill the joints by capillary action.
If the filler metal having mt. temp. more than 450°C but lower than mt. temp. of components, then it is called brazing or hard soldering.

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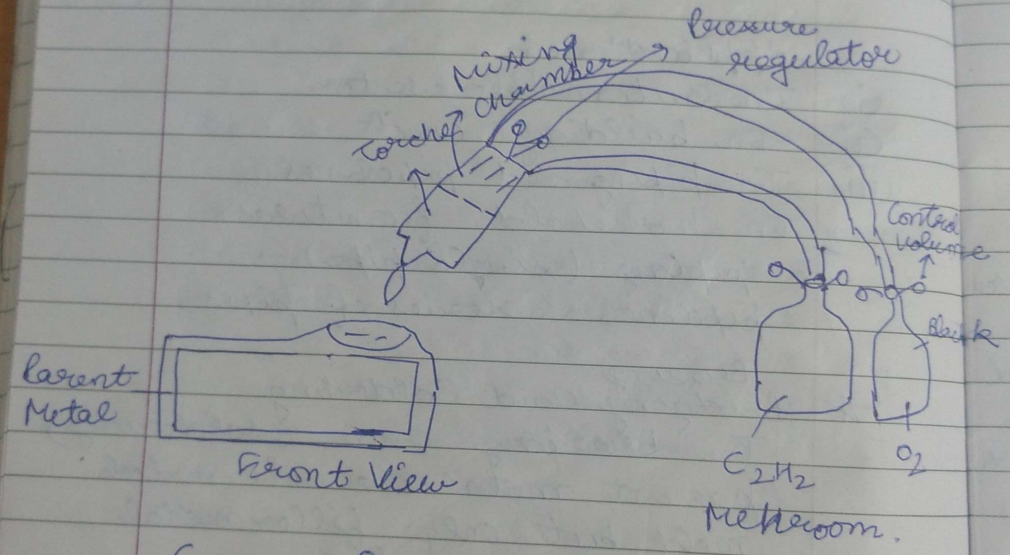
If melting temp. of filler metal is lower than 450°C and also lower than melting point of components, then is called soldering or soft soldering.

* Gas Welding
Oxy-acetylene welding



Gas welding is also called oxy acetylene gas welding. This process is a fusion welding process where joint is completely melted to obtain the fusion. Fuel ~~is~~ gas generally used is acetylene because

of its high temp. generated in the flame. When acetylene is mixed with oxygen in a correct prop^n inside the welding torche, ignition, in order to create the flame which is sufficient to melt the joining area of parent metal. Temp. of base metal is around 3100°C.

Types of flames :-

(a) Neutral – prop^n of C_2H_2 and O_2 is same

(b) Oxidising and carbonising

Oxidising	Carbonising
prop^n of O_2 is more	prop^n of acetylene is more.

Advantages :-

(a) No electric current is reqd.

(b) Equipment setup is simple.

(c) It can be applied to a ~~var~~ wide variety of manufacturing process.

Sheet of silencer is not thick, so gas welding is used.

Disadvantages :-

(a) Flame temp. is less than the temp. of arc.

(b) More skilled operator is reqd.

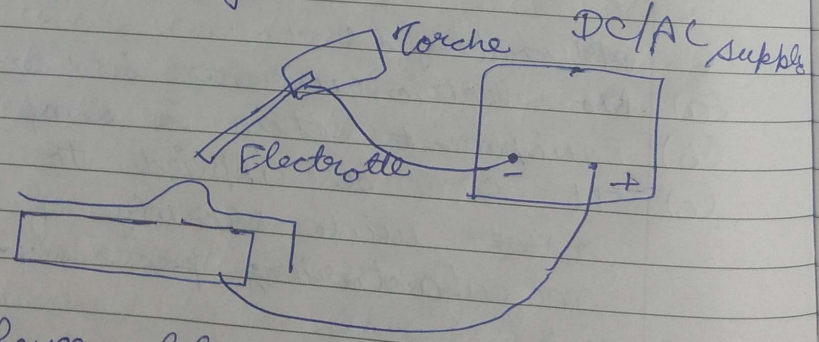
(c) Gas flame takes a long time to heat up as compared to arc flame.

Applications :-

(a) Generally welding of mild steel ~~or~~ & stainless steel.

(b) In automotive and air craft industries.

Straight Polarity :- Work piece connected to +ve terminal whereas electrode connected to -ve terminal of battery.



Reverse Polarity :-

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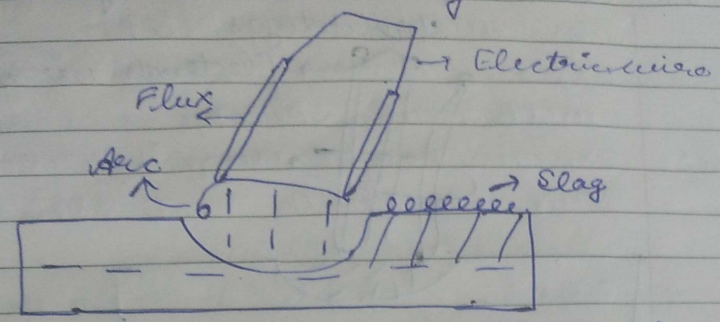
Shielded Metal arc welding :-



→ Here shielding of electrode is done by flux

→ diameter for electrode (2.5–6.35 mm)

Steps in the procession of welding :-

(i) Electrode is melt.
(ii) Flux is also melt.
(iii) Arc is produced.
(iv) Slag " "
(v) Impurities are removed.

Job of any thickness can be welded by this process in general but very small thickness below 3 mm may create a difficulty in welding. Similarly, welding may be tedious/difficult for thickness greater than 20 mm.

Adv. / Disadv. (Same as that of welding)

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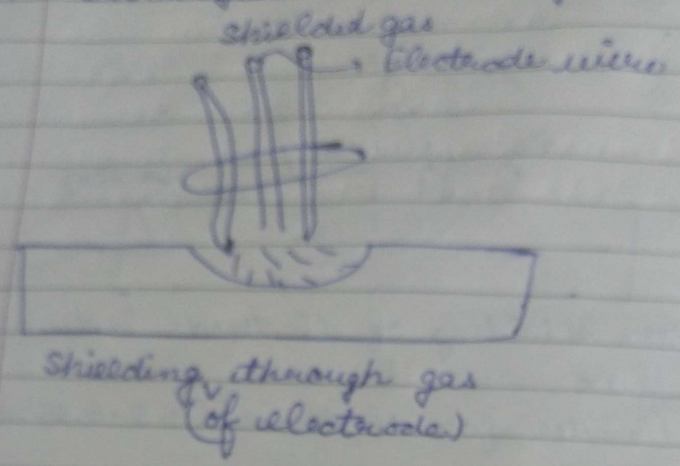
★ Submerged arc welding



This is a semi-automatic process which can produce long weld seam. In this type of welding process, electrode will be in the form of spool of Cu coated wire. It is mainly used in downhand (leftward position) welding. It is extensively used in joining of thick plates. It can't be used for plates having thickness less than 5 mm.

Advantages:-

(i) High deposition rate.

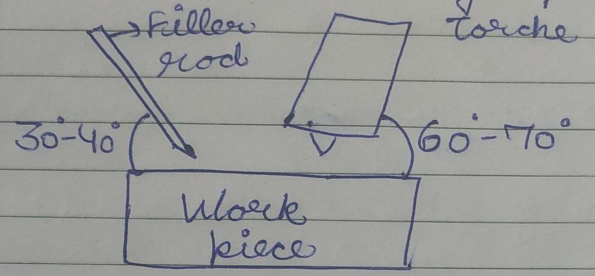
(ii) Weld bead is very clean and smooth because of nozzle (special) arrangement.

(iii)

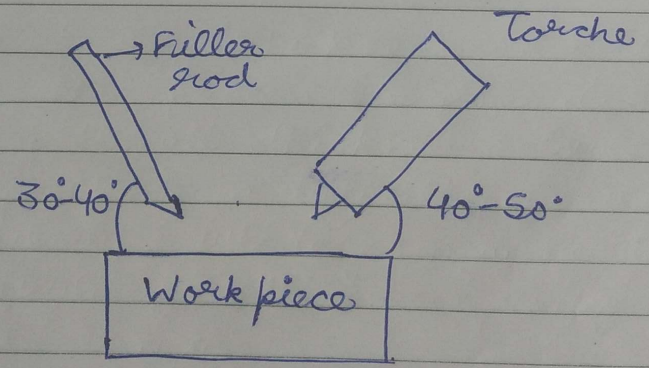
App. :-

(i) in fabrications of pipe.
(ii) Ship building.
(iii) pressure vessel industry.
(iv) L.P.G. cylinder.

Downward / left ward Welding position



Upward or right ward welding posi^n



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Assignment Ques:

(a) Explain working principle of Vernier Cal. with neat sketch.

(b) Explain working principle of micrometer with neat sketch.

(c) Explain height gauge's working principle with neat sketch.

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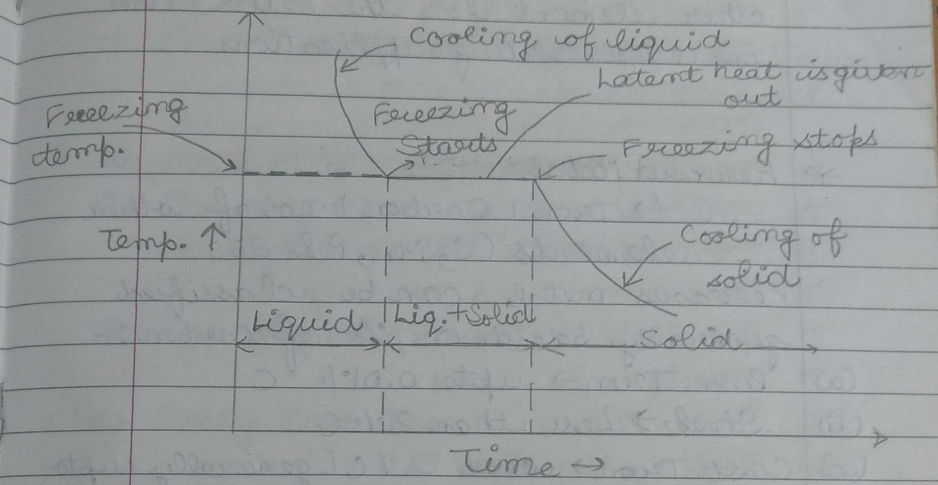
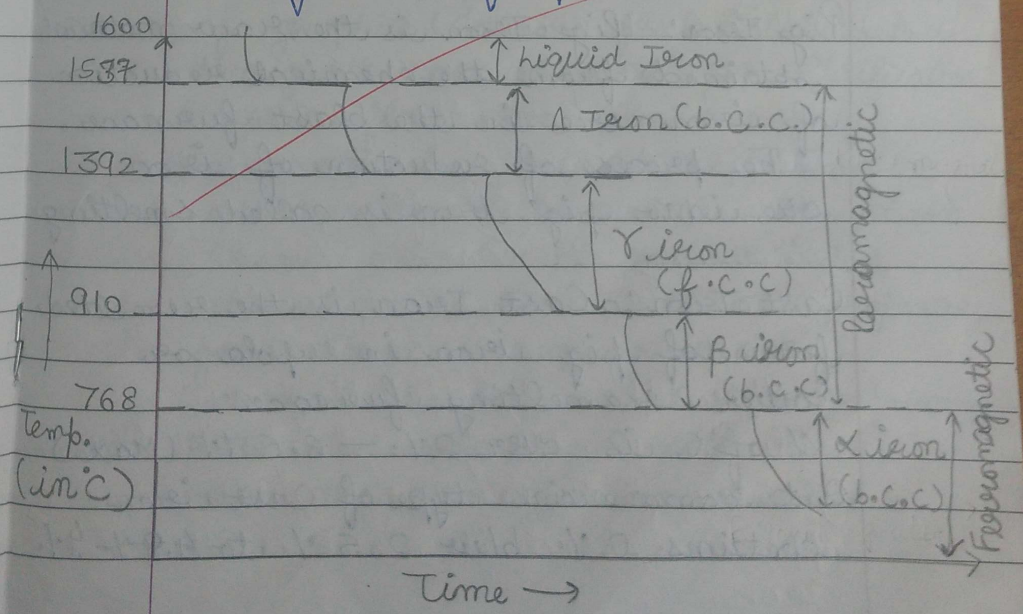
Assignment-1
Engineering Materials

1. Cooling Curve for a pure metal :-



2. Cooling Curve for pure ~~metal~~ iron :-



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Pure iron is very difficult to obtain & have not much use in engineering. However if it can be alloyed with other element for the better use in engineering applications.

* Ferrous Metal
  ↳ Iron + Carbon + no. of other elements (S, Mn, P & Si)

Ferrous metal can be classified generally based on % of carbon:-

(a) Pure Iron → upto 0.01% C
(b) Steel → Less than 2% C
(c) Cast Iron → over 2% C [generally upto 5% C, maximum 6.67% C]

Pig Iron:- Pig Iron is the raw material obtained from the chemical reduction of iron ore in the blast furnace. The process of reduction of iron ore into pig iron is called smelting.

Cast Iron:- Cast Iron is the remelted form of pig iron in cupola or other remelting furnace.
% of C is over 2% — 6.67% (Max.)
But commercial type of Cast iron contains C% b/w 2.5% to ~~4.9%~~ 4%.

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→ Brittle in nature.
→ can't be cold worked.
→ easily casted into intricate shapes.
→ cheapest
→ Cast Iron without addition of alloying elements, it is weak in tension & shear.
→ Strong in Compression
→ Damping Capacity of cast iron is much greater than steel.

* Types of Cast Iron:-

(a) Grey Cast Iron

C → 2.5% to 4%.

Si → 1% to 3%.

This chemistry results in the formation of graphite (Carbon) flakes distributed throughout cast product upon solidification. Graphite flakes ~~the~~ give the grey appearance in the Cast Iron, when fractured, hence the name is Grey Cast Iron. Dispersion of graphite flakes accounts for two attractive properties

(i) good vibration damping - which is desirable in engine and other machinery.

(ii) Internal lubricating Qualities - which makes the cast metal machinable.

→ Ductility of grey Cast iron is very low.
→ compressive strength of grey Cast Iron is significantly less than its tensile strength.

Applications :-
→ Automotive engine blocks & heads
→ Motor housing
→ Machine tool bases
→ Gear and pump housing
→ Gas and water pipes for under ground purposes.
→ Brake drums
→ Sliding Surface of machines
→ Piston Rings, gearings.

(b) White Cast Iron

C → upto 2.5%.
Si → less than 1.5%.

It is formed by more rapid cooling of molten metal after pouring thus causing the carbon to remain chemically combined with iron in the form of cementite (Fe_3C) rather than precipitating out of solution in the form of flakes. When fractured surface has a white crystalline appearance, hence its name is White Cast Iron.

→ very hard and brittle

→ Due (to) this ~~white cross section~~ entire cross section is white means unmachinable except by grinding. So, it has limited applications.

→ wear resistance is excellent.

→ strength is good.

Applications :-

(a) Railway brake-shoes

(b) Extrusion dies

(c) Crinding balls

(c) Malleable Cast Iron :-

When casting ~~who~~ of white cast iron are head treated to separate the carbon out of solution and form graphite aggregates, resulting metal is called malleable cast iron. The new microstructure can possess ~~fo~~ substantial ductility (upto 20% elongation)

In Grey Cast Iron, free carbon is in the form of flat or plate like particles whereas in malleable cast iron, graphite is in the form of irregular shaped spherical particles which are much more desirable from strength point of view ~~or~~ (then) flakes.

→ Malleable Cast Iron is stronger and tougher.
→ Ductile.
→ Easily Machinable [due to presence of graphite]

Applications :-
(i) Pipe fitings and flangy
(ii) Certain machine components
(iii) Wheel hubs
(iv) Hinges
(v) Spanners
(vi) Cranks
(vii) Brake pedals in cars
(viii) Spring hangers

(d) Ductile Cast Iron :-
To produce the ductile Cast molten metal is first completely desulphorised. Thus small amount of alloy containing magnesium or cerium are added to molten iron to precipitate graphite as small spherical nodules.
Ductile Cast Iron is also called 'Nodular Cast Iron'.
→ have high fluidity.
→ stronger, more ductile, tougher.
→ Less porous than grey Cast Iron

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Applications :-

(i) ~~Moto~~ Machinery components requiring high strength and good wear resistance.

(ii) hydraulic cylinders

(iii) cylinder heads of compressors & ~~direct~~ diesel engine

(iv) → Rolls of rolling mills.

(v) In general parts subjected to impact loading or requiring a high elastic modulus.

(e) Chilled Cast Iron :-

Produced on quick cooling/chilling by replacing the 'metal chills' inside the mould but near its surface.

→ can only be machined by grinding.

Applications :-

→ Stamping dies.

→ Mill & crushing rolls.

→ Railway wheels

→ Car wheels

→ Cam followers

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☆ Some involved impurities → Mn, P, S & Si.

Effect of impurities on iron

1. Sulphur (S):- Generally harmful in Cast Iron. In Grey Cast Iron, it counteracts the graphitising effect of Si, lower fluidity. During pouring, decrease strength & make metal more brittle. So it should be kept as low as possible (below 0.1%)

2. Manganese (Mn):- It enhances the formation of carbides, means white and hardens C.I. But help to control the ~~hardness~~ harmful effect of Sulphur (Try to kept below 0.75%)

3. Phosphorus (P):- Increase the flow ability of grey Cast Iron. It induces brittleness in Cast Iron and not kept above 1%.
Phosphorus Irons are useful for casting of intricate designs when cheapness is essential.

4. Silicon (Si):- It is important graphitiser for cast irons, which makes the Cast Iron soft & easily

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machinable.

✱ Effect of alloying element on Cast Iron

1. Nickle (Ni) :-
→ to refine the grain structure.
→ increase strength ~~of~~ and toughness.
→ increase resistance to corrosion.
→ promotes machinability of CI.
→ It has no effect on ductility.
(Amount 0.25 to 5.0%.)

2. Chromium (Cr) :-
→ Increase strength, hardness
→ resistance to corrosion
→ Increase wear resistance & heat resistance properties of CI
→ ~~Flame~~ Have tendency to prevent graphitisation
[Amount 8% – 30% generally]

3. Copper (Cu) :-
→ increase fluidity
→ improves mechanical properties mainly (Hardness or toughness)
→ promotes formation of graphite, hence, will slightly improve the machinability of CI.
[Amount upto 1%]

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4. Molybedenum :-
→ increase the strength and toughness.
→ improves high temp strength of C.I
[Amount 0.25 to 1.25 %]
[Generally used with combination of Nickel & chromium]

5. Vanadium :-
→ promotes grain refinement.
→ ↑se strength
→ ↑se resistance to fatigue stresses.
→ ↑se wear resistance.
→ Reduce graphitisation.

★ Steel :-
Iron + Carbon [0.02 % to 2.11 %]
Steel is grouped into the four main categories :-
(i) Plain Carbon Steels
(ii) Low Alloys Steels
(iii) Stainless Steels
(iv) Tool Steels

(i) Plain Carbon Steel :-
Carbon as a principal alloying element with only small amounts of other elements [about 0.5 % Manganese]
→ Four digit number system 10XX → 10 indicates plain carbon steel, 1050 → it

means 0.30% carbon

Based on the carbon content, plain carbon steel can be classified into three ways:-

(a) Low Carbon Steel :- Carbon less than 0.20%

Applications :-

→ Most widely used.

→ Automobile sheet metal parts

[This have many popular applications where high strength is not required]

(b) Medium Carbon Steel :- Carbon [0.2% to 0.50%]

Applications :-

→ Machinery components

→ Engine parts, crank shaft, connecting roads.

(c) High Carbon Steel :- Carbon > 0.50%

Applications :-

→ For high strength,

→ When stiffness and hardness are needed

→ springs, cutting tool blades, etc.

(ii) Low Alloy Steels :- are ~~low~~ iron carbon alloys that contain additional alloying elements in amounts less than 5% by weight.

Other elements [Cr, Mn, Mo, Ni, V]

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(iii) Stainless Steels :- A group of highly alloyed steels designed to provide high corrosion resistance. Principal alloying element in stainless steel is chromium usually above 15%. & other main element is Nickle.

(iv) Tool Steels :- A class of highly alloyed steels designed for use industerial cutting tools, dies and molds.
They must have → high strength, hardness, wear resistance, toughness under impact load.
For this purpose, tool steels are heat treated.

☆ ~~Superall~~

☆ Super Alloys

A superalloy, or high-performance alloy, is an alloy that exhibits several key characteristics: excellent mechanical ~~strength~~ strength, resistance to thermal creep deformation, good surface stability and resistance to corrosion or oxidation. The crystal structure is typically face-centred cubic

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austenitic. Examples of such alloys are Hastealloy, Inconel, Waspalloy, Rene alloys, Haynes alloys, Incoloy.

Super alloy is a metallic alloy with high mechanical strength & resistance to surface degradation at high temp. (above 650°C). Typically having a matrix with an austenitic, FCC crystal structure. Stable alloy with resistance to deformation & high temp. strength. In Superalloys, oxid^n & corrosion resistance is provided by formation of protective oxide layer which is formed when the metal get exposed to oxygen & encapsulates the material & thus protecting the rest of component.

Most important strengthening mechanism is through the formation of secondary phase precipitates such as gamma prime and carbides through precipitation strengthening.

The 3 major classes of super alloys are:-

* Nickel based super alloys
* Iron based super alloys
* Cobalt based super alloys

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→ Superalloys are ~~the~~ heat-resisting alloys based on nickel, nickel-iron, or cobalt that exhibit a combination of mechanical strength and resistance to surface degradation.

→ Superalloys are primarily used in gas turbines, coal conversion plants, and chemical process industries, and for other specialized applications requiring heat and / or corrosion resistance.

→ A noteworthy feature of nickel-base alloys is their use in load-bearing applications at temperature in excess of 80% of their incipient melting temperatures, a fraction that is higher than for any other class of engineering alloys.

→ Applications of superalloys are categorized below; the bulk of tonnage is used in gas turbines:

Applications :-

→ Aircraft gas turbines : disks, combustion chambers, bolts, casings, shafts, exhaust systems, cases, blades, vanes, burner cans, afterburners, thrust reversers.

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→ Steam turbine power plants :- bolts, blades, stack gas re-heaters.

→ Reciprocating engines :- turbo chargers, exhaust values, hot plugs, value seat inserts.

→ Metal Processing :- hot-work tools and dies, casting dies.

→ Medical applications :- dentistry uses, prosthetic devices.

→ Space Vehicles :- aerodynamically heated skins, rocket engine parts.

→ Heat-treating equipment :- trays, fixtures, conveyor belts, baskets, fans, furnace mufflers.

→ Nuclear power systems :- control rod drive mechanisms, valve stems, springs, ducting.

→ Chemical and petrochemical industries :- bolts, fans, valves, reaction vessels, piping, pumps.

→ Pollution control equipment :- scrubbers.

→ Metal Processing Mills :- ovens, afterburners, exhaust fans

→ Coal gasification and liquefaction systems : heat exchangers, re-heaters.

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Assignment-2

1. Explain the terms used in casting.

Sol

Ans→

(i) Pouring Basin :- A reservoir at the top of the sprue that receives the stream of molten metal poured from ladle. It may be made from Cast Iron for non-ferrous alloys, if chilling is not a problem.

(ii) Sprue :- It is a (vertical) channel connecting the pouring basin with current and gates. Sprues are made tapered downward to prevent aspiration of gases through surrounding moulding sand.

(iii) Cope :- The upper part of the chamber in which casting is done. The (upper) metallic container in the assembled position.

(iv) Drag :- The lower part of the chamber. The lower metallic container in the assembled container.

(v) Riser :- These are reservoirs of molten metal that feed molten metal to the casting properly as it solidifies, to prevent shrinkage cavities in

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the casting.

(vi) Gate :- The channel through which the incoming metal enters the mould cavity directly.

(vii) Vent :- These are holes made or pierced in the sand ~~to prevent~~ for the gases to escape through.

2. Give brief explaination about steps in making sand casting.

Ans.→ (i) Make the pattern and with the help of pattern prepare the mould and the necessary cores.

(ii) Clamp the mould properly in the mould cavity with the help of the cores.

(iii) Melt the metal or alloy to be casted.

(iv) Pour the molten metal into the mould cavity.

(v) Allow the metal to cool down and solidify. Remove the casting from the mould. This operation is called Shake Out.

(vi) Clean and finish the casting. The operation is called as fettling.

(vii) Remove the defects if any.

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3. What are the types of pattern? Explain each of them.

Ans → (a) Loose Pattern :- This pattern is basically a replica of the desired casting. It is kept slightly larger than the casting. They can be made up of wood and metal depending upon the volume of production.

Loose patterns are of two types :-

(i) One piece or solid pattern.

(ii) Split or Parted pattern.

~~(b) Loose Piece Pattern :-~~

(b) Gated Pattern :- A gated pattern is simply one or more loose pattern having attached gates and runners. They reduce the moulding time since gates and runners are not to be cut by hand.

(c) Match Plate Pattern :- A kind of split pattern having the cope and drag mounted on opposite sides on a plate, called match plate. This type of pattern is used for large number of castings.

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(d) Cope and drag pattern :- A kind of split pattern having the cope and drag mounted on seperated plate. These patterns are used in large production of castings when ~~in th~~ the complete moulds are too heavy to be handled by one worker.

(e) Skeleton patterns :- These patterns are used for large castings having simple geometrical shapes. These are simple wooden frames that outline the shape of the part to be cast. These are also used in pit or floor moulding process.

4. Give the details about ~~making~~ moulding materials and their properties.

Ans →

(a) Sand

Sand are of three types :-

(i) Natural Sand

(ii) Synthetic Sand

(iii) Chemically Coated Sand

Silica sand is the most widely used moulding material. It forms the bulk of moulding sand. It is cheap, plentiful and easily available. It is characterised by a high softening

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temperature and thermal stability.

(b) Binders :-
Binders used in a foundary are :
Inorganic and Organic binders.
Organic binders are mainly used for core making.
Clay binders are the most important inorganic binders. The common types of clay used in moulding sands are :- Fireclay, Kaolinite, Bentonite.
Bentonite is the most commonly used clay. It needs smaller amount of water to obtain a given degree of plasticity.

(c) Additives :- These are the materials added in small quantities in moulding sand in order to ~~ent~~ enhance its existing properties and import its special kind of properties. These are necessary to give good surface finishing to the casting and eliminate the casting defects.

(d) Facing Materials :- The materials are added to moulding sand to make the casting surface smooth and clean.

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It helps in easy peeling of sand from casting surface during the shake out.

(e) Cushion Materials :- These materials are added to burn and form gases when molten metal is poured into the moulding cavity. This give rise to space for ~~so~~ accomodation of the molten metal at the mould cavity surface.

5. Explain the sand mould~~ing~~ ~~process~~ making procedure.

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6. What is green sand moulding? Also enlist the advantages and disadvantages.

Sol⇒ Green Sand Moulding is composed of a mixture of sand (Silica sand, SiO_2), clay (which acts as a binder) and water. The word 'green' is associated with condition of wetness and freshness and because the mould is left in the damp condition.

☆ Advantages :-

(a) Least expensive.

(b) Less distortion than in dry ~~sand~~ sand moulds because no baking is needed.

(c) Flasks are ready to reuse in minimum time.

(d) Less danger of hot tearing of Casting than in other types of castings.

☆ Disadvantages :-

(a) Sand control is more critical than in dry sand moulds.

(b) Erosion of mould is more common in the production of large casting.

(c) As the weight of casting increases, surface finish and dimensional accuracy deteriorates.

7. What are the sand casting defect? Enlist and explain each of them.

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Ans → (a) Blow holes:- These defects occur when excessive evolved gas is not able to flow through the mould. So, it ~~gets~~ is collected in form of bubbles and preventing the molten metal ~~to~~ from filling the space.

(b) Misrun or Short run:- This defects occurs when mould cavity is ~~a~~ incompletely filled. The reasons for this can be inadequate metal supply, too low mould or melt temperature, improper designing of gates.

(c) Cold Shut :- An interface within the casting that is formed when two metal streams meet without complete fusion.

(d) Mismatch:- A shift ~~th~~ of the individual parts of the casting w.r.t. each other. This may occur due to mould shift or core shift.

(e) ~~Mismatch:-~~ Drop:- This defect may arise by breaking away of a part of mould sand as a result of weak packing of the mould, low strength of the moulding sand.

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Assignment - 3

1. What do you Understand from resistance welding? Explain with its types.

Ans:- Resistance Welding is a group of welding process in which the coalescence is produced by the heat obtained from resistance of the work due to electric current supply in the electric circuit, of which the work is a part, and by applying pressure and without use of any filler metal.

The voltage can be low but the currents are very hight (thousands of amperes). Materials of high heat conductivity and specific heat (Al, Cu) call for very high currents ~~without~~ to prevent dissipation of heat.

A special feature of resistance welding is that there is rapid heating of welding surface due to application of currents of high amperage.

Advantages:-

* Heat is localised.
* Action is rapid.
* No filler metal is needed.
* operation requires little skill.

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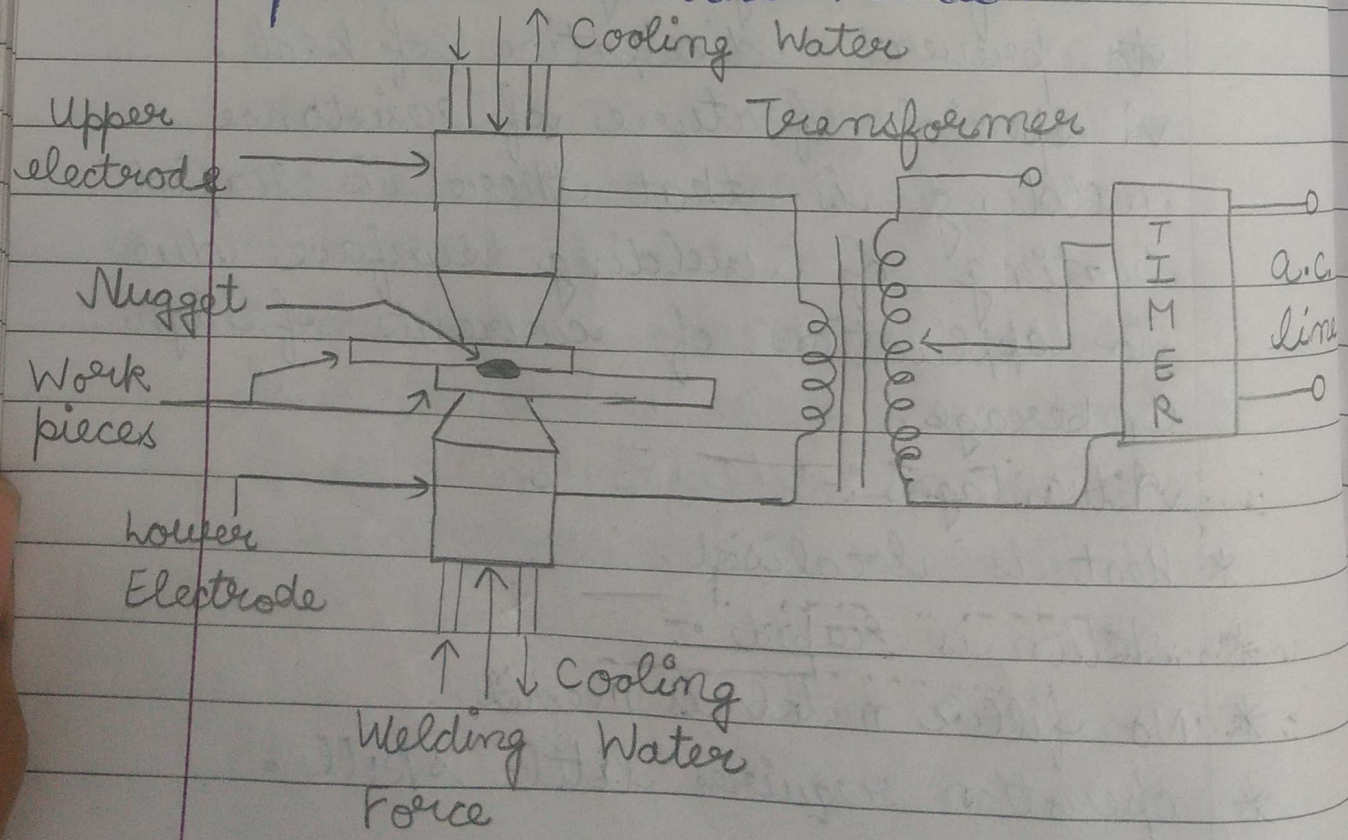
Disadvantages :-

* High cost of equipment.
* Limitations to the types of joints made.

This welding process finds extensive application in construction and engineering industries.

There are six types of (resistance) welding process:

(a) Resistance Spot Welding :- In resistance spot welding process, the metal parts to be overlapped are held between two bar type metal electrodes and then electric current is switched on. The electrodes apply pressure on the metal.



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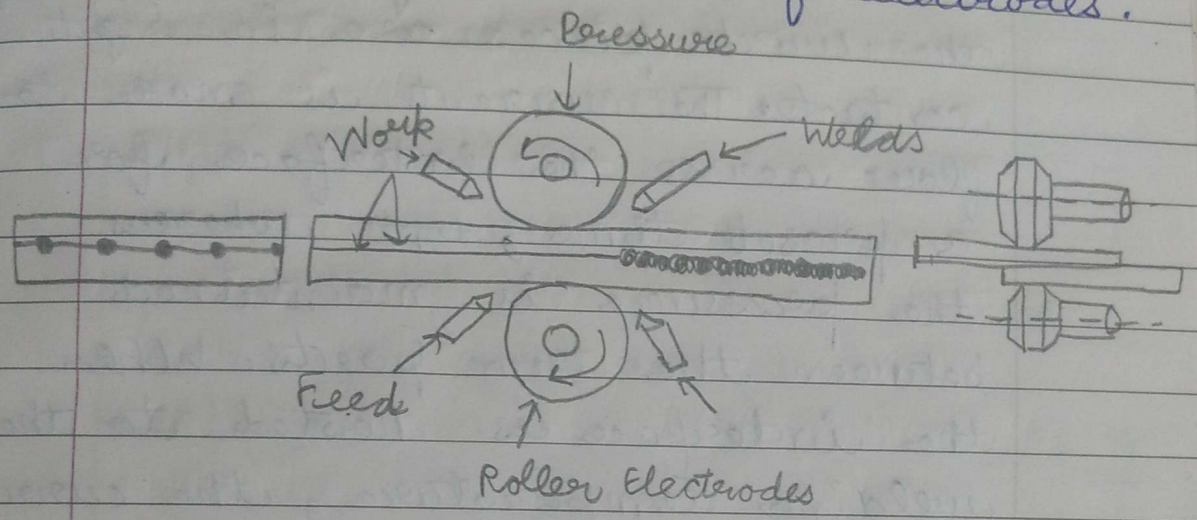
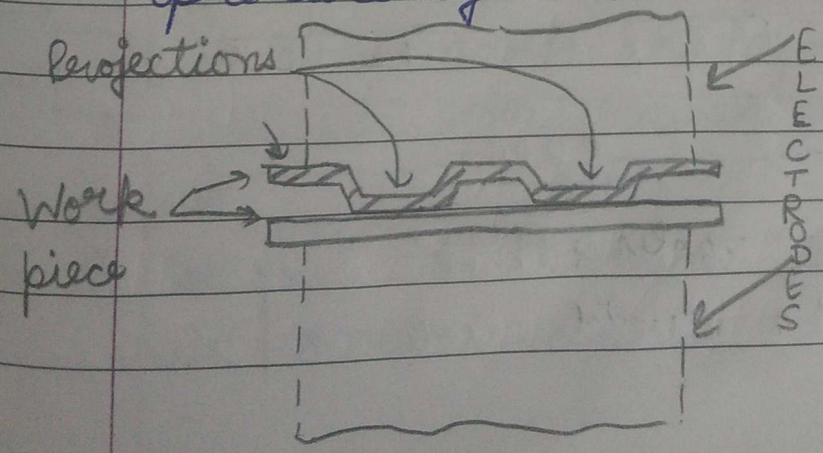
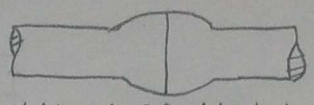
(b) Resistance Seam Welding :- In this process, the series of spot welds along a line can be obtained more conveniently. The electrodes are in the form of rotating disc where welding is done by the continuous movement of electrodes.



(c) Resistance Projection Welding :- In this process, the currents are concentrated only at the spots to be welded. There are projections made on one of the sheets. When the current is switched on, the projections acquire their ~~there~~ respective place by applying pressure by electrodes.





Upset Butt Weld

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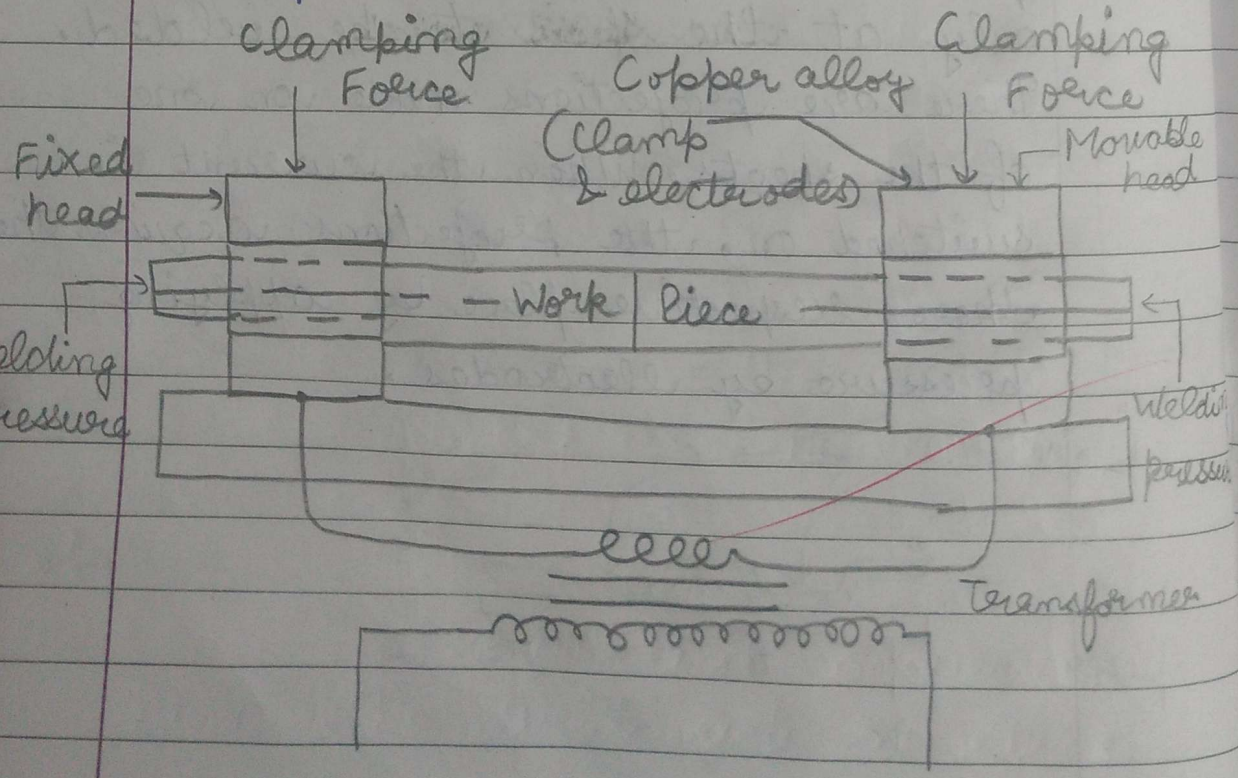
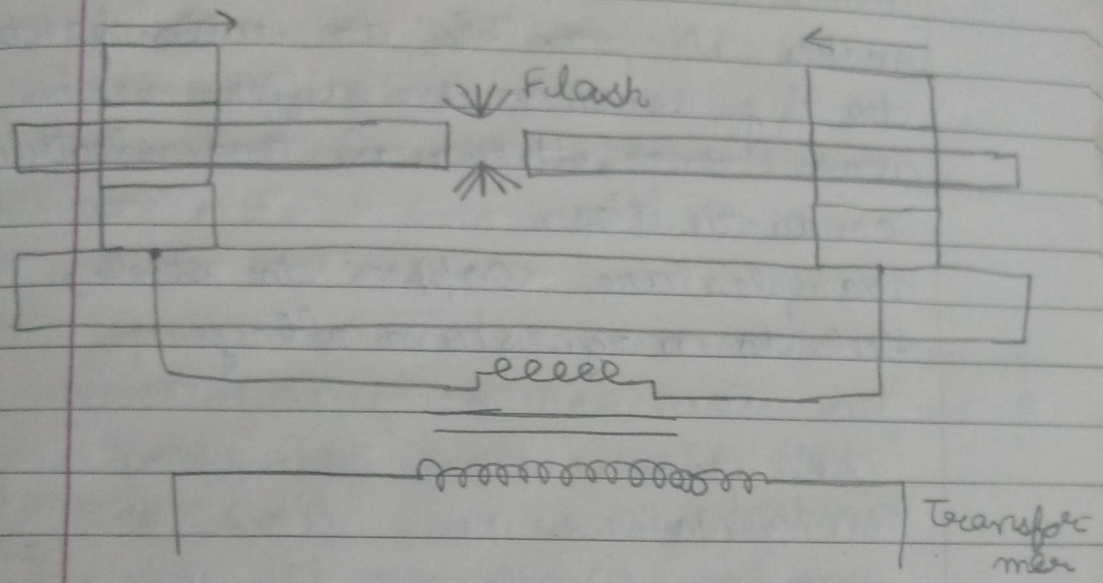
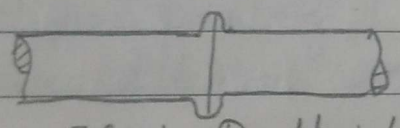
(d) Upset Welding :- In this process, the two ends of the ~~wo~~ work pieces are clamped in the position of electrodes. The movable head is moved towards the fixed ~~surfa~~ head until the abutting surfaces of the work pieces are in light contact. The current is made to flow across the interface for a preset time, ~~unt~~ whereas the pressure is maintained between the two parts. When the interface is heated to the welding temperature, the current is switched off and the welding pressure is increased to form an 'upset'.



(e) Flash Butt Welding :- In this process, the parts to be welded approach each other and come into contact when current is switched on.





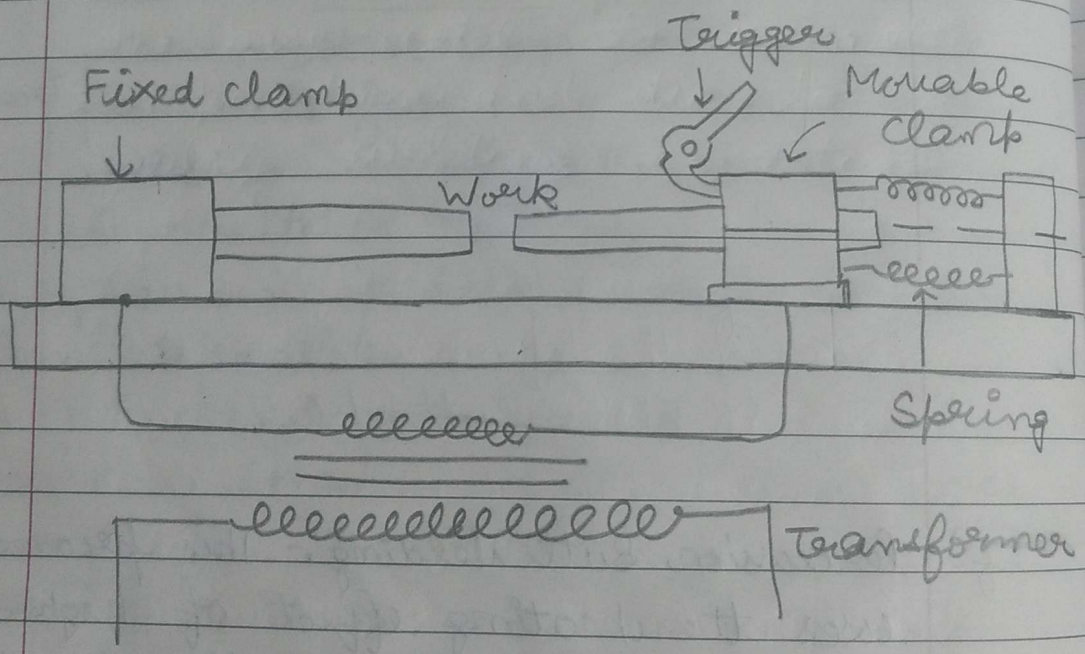
Flash Butt Weld

(f) Percussion Butt Welding :- This process uses the heating effect of high intensity electric arc produced by discharge of electric energy, in combination with the percussion blow to forge (weld) metal pieces together.

When the movable clamp is released, it moves rapidly alongwith one of

the workpiece. When the workpieces are 1.6 mm apart, there is discharge of electric energy and thus production of arc along their surfaces. This welding makes it possible to weld parts having considerable difference in mass ~~and~~, thermal and electrical conductivities.

Examples are copper to steel, steel to magnesium alloys.



2. Enlist and explain the welding defects.

Ans :-

(a) Cracks :- Cracks that occur in or near the weld act as stress

raisers which make the service life of the weldment very ~~three~~ unreliable. Cracks that occur in the base metal at low temperatures (around 200°C) are called cold cracks. Cracks that occur in the weld metal zone even when the metal is still hot are called hot cracks.

(b) Undercut :- An undercut is a groove melted in the base metal adjacent to the toe of the weld. The reasons for occurence of this welding defects are :- improper feeding of filler rod, improper ~~pro~~ position of electrode or torche tip and excessive heating.

(c) Porosity or Voids :- Blowholes and gas pockets weaken the weld appreciably and act as stress raisers which may cause defects in the weld.

(d) Inclusions :- Inclusions ~~suffer~~ refer to the slag or dirt deposited in the weld during the welding. The inclusions are due to

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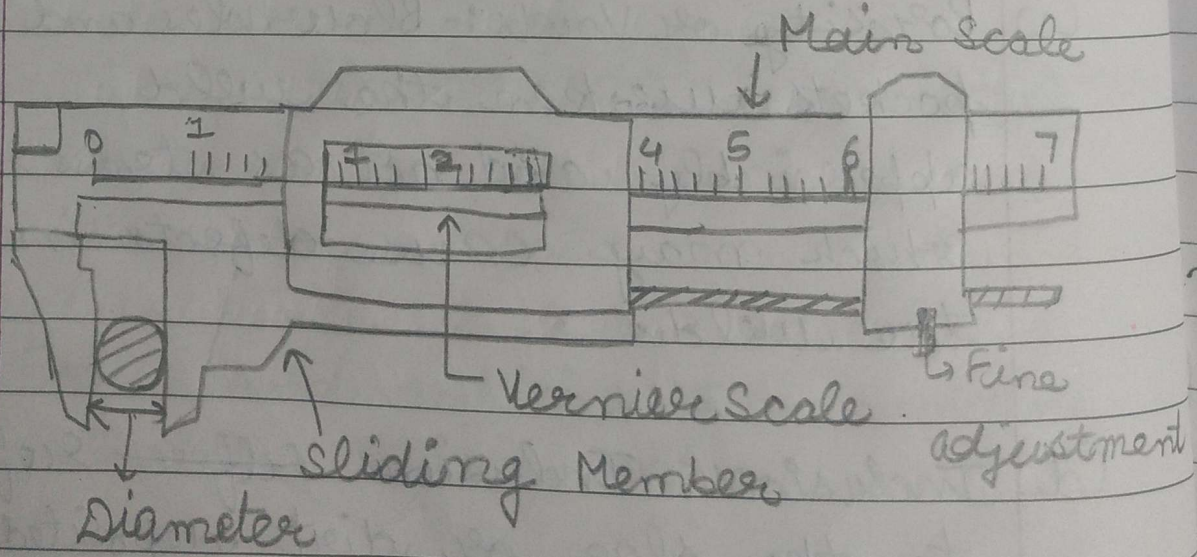
contamination of base metal, deposited metal by oxides, non-uniform melting of the electrode coating, high melting point and high viscosity of slag.

(f) Lack of Fusion :- It is lack of coalescence between the deposited and the base metal or incomplete penetration of weld metal into the base metal. This may occur due to inability to raise the base metal to its melting temperature and due to faulty welding conditions.

3. Explain the working principle of vernier caliper with neat sketch.

Ans →



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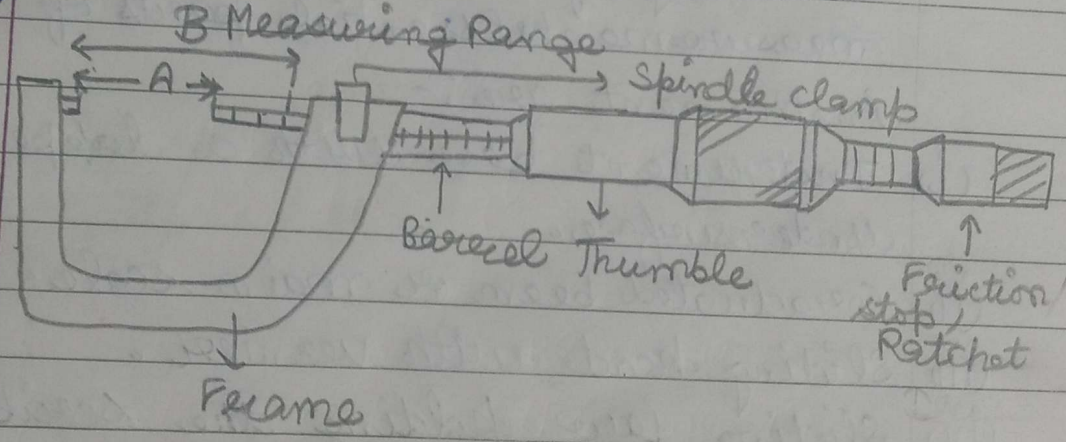
Vernier Caliper is used to measure inside and outside diameter of shafts, thickness of parts etc. accurate to 0.02mm by vernier scale attached to caliper. It consists of main scale which carries the fixed graduations, two measuring jaws, and movable vernier scale.

4. Explain working principle of micrometer with neat sketch.

Ans→



Micrometer is used to measure dimensions like diameter and thickness to an accuracy of 0.01mm. The essential parts are :-

(a) Frame :- Made of steel or light alloy

(b) Thumble :- Tabular cover fastened with spindle and moves with the spindle.

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(c) Barrel :- It has datum or fiducial line and fixed graduations.

(d) Friction Stop / Ratchet :- Ratchet slips when the pressure on the screw exceeds a certain amount.

(e) Spindle Clamp :- This is used to lock the instrument at any desired setting.

5. Explain working principle of height gauge with neat sketch.

Ans → The vernier height gauge is used to measure height of parts to an accuracy of 0.02 mm in metric measurements. Essential parts of instrument are :-

(i) Instrument base with a lapped undersurface.

(ii) Graduated beam or main scale.

(iii) Sliding head with vernier.

(iv) Sliding jaw holding the scribe.

(v) Vernier clamp which moves with the sliding head.

(vi) Fine adjustment screw in vernier clamp

~~(vii)~~

Scrib
clamp
screw
Scrib
clamp
Jaw
Scrib

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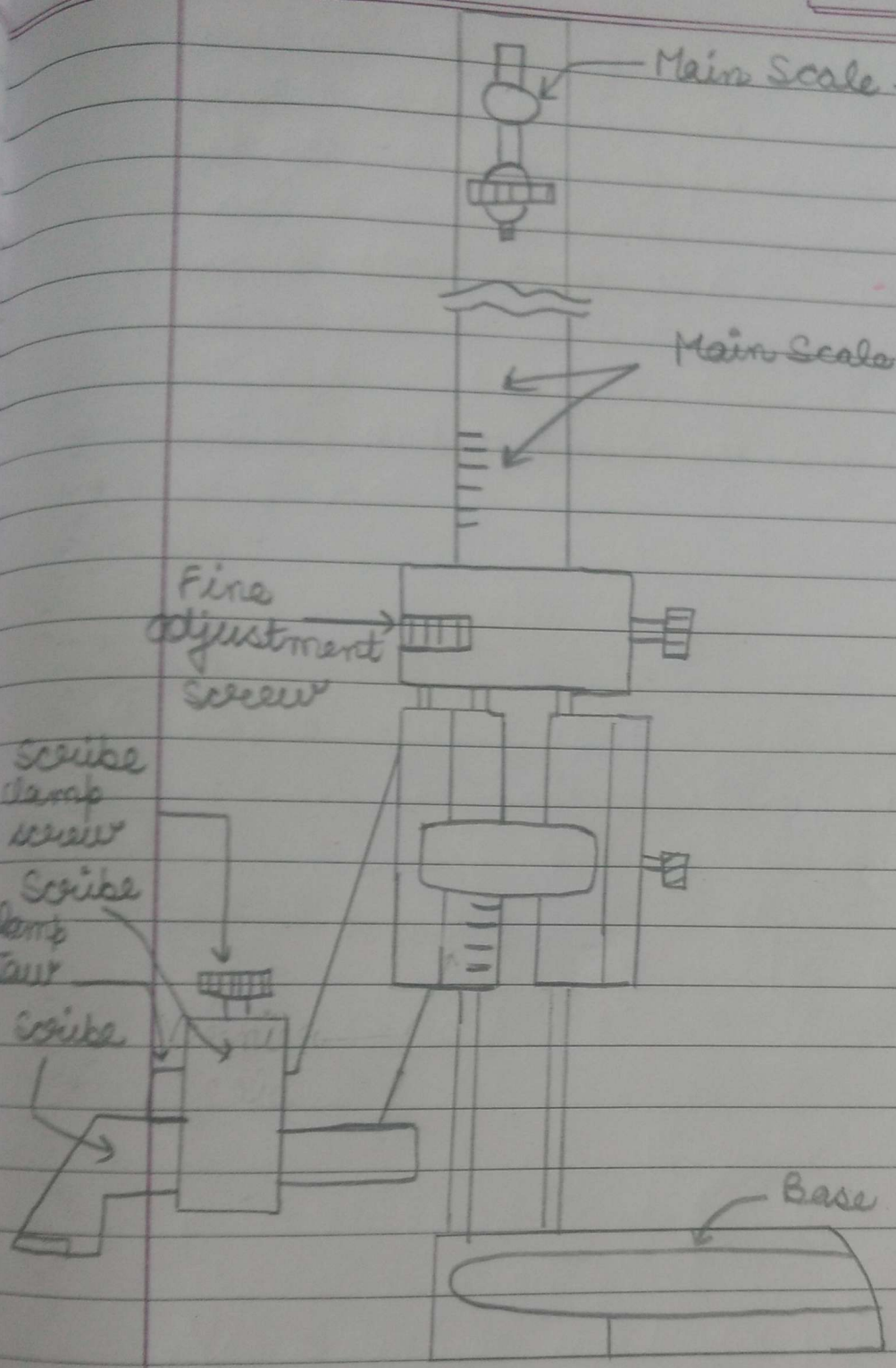

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