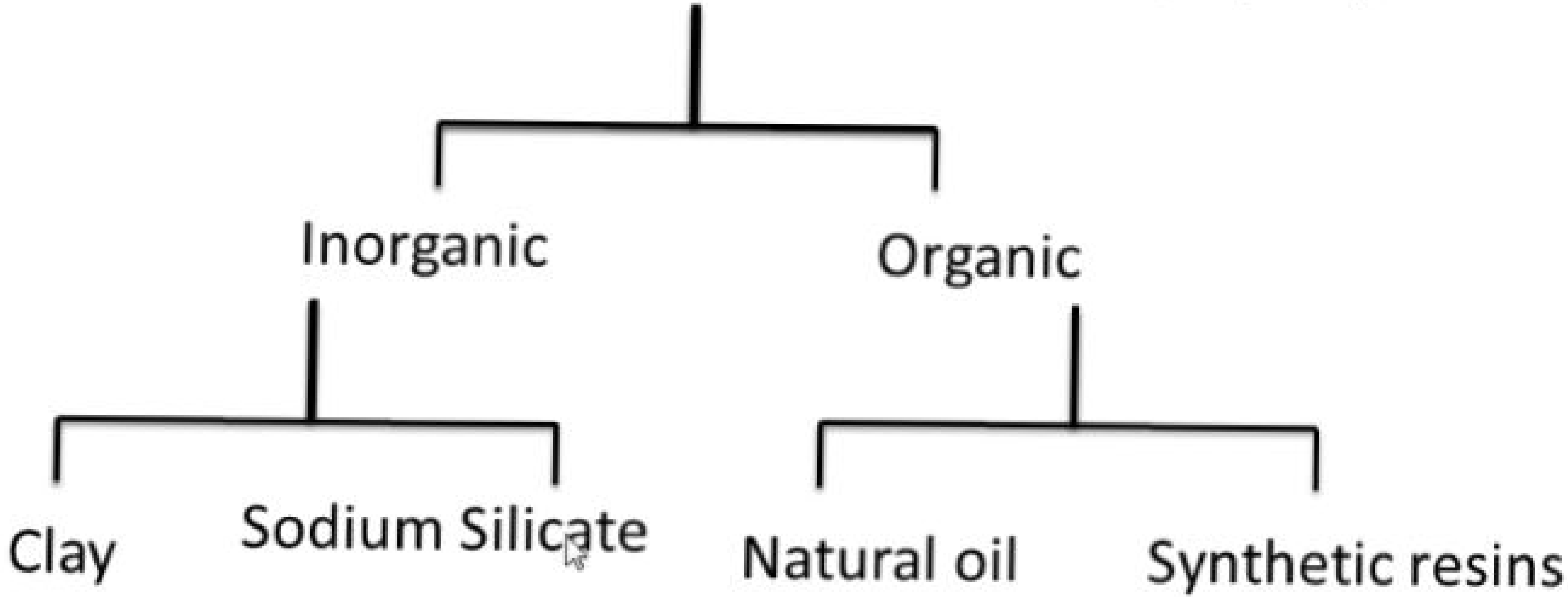
Binder:

1.Ingredient which hold the sand each other by making bond
2. It should retain it property till the solidification is complete
3. When the solidification complete its losses its property



Sodium silicate: SiO_2, Na_2O, H_2O

Weight Ratio	**Typical analysis %weight**			**Sp gr at 20°C**	**Viscosity at 20°C (Centipoise)**
SiO_2/Na_2O	Na_2O	SiO_2	H_2O		
2	17.8	35.7	46.6	1.7	90000
2	16.6	33.2	50.2	1.625	4500
2	15.2	30.4	54.4	1.56	850
2	14.0	28.1	57.9	1.5	200
2.2	13.2	29.2	57.6	1.5	220
2.4	12.7	30.8	56.5	1.5	310
2.9	9.2	26.8	64.0	1.375	100

For foundry use: Ratio: 2-2.4 and water content around 50%

Important facts about sodium silicate

(a) Higher the SiO_2/Na_2O ratio for a given solids content the greater of the viscosity. The rise being very rapid with higher percent of solid.

(b) Higher the viscosity lower the coating ability and hence higher ratio silicates content lower solid percent and higher H_2O percent than lower silicate

(c) Solution below 2.8 ratio are alkaline and above this the solution neutral.

(d) Silicate with ratio less than ‘2’ don’t harden quickly enough to be of foundry use.

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Mechanism of hardening in CO_2 Process

- In CO_2 process the over all hardening is effected by three things:

(a) Chemical gelation

(b) Physical dehydration during gassing

(c) Physical dehydration during storage due to loss of water molecules.

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Chemical gelation:

$$SiO_2 + H_2O + Na_2O + CO_2 \longrightarrow H_2CO_3 + Na_2O + SiO_2$$

$$SiO_2 + H_2O + Na_2O + H_2CO_3 \longrightarrow Na_2CO_3 + SiO_2,2H_2O$$

Slica hydrogel
(Bonding Material)

Physical dehyration: SiO_2 Na_2O H_2O

This bond is stronger than the silica hydrogel. This is because the drying up of silica hydrogel.will result in formation of micro cracks. Aim should be to get minimum of silica gel bond and

High flow rate : Physical dehydration
Low flow rate: Chemical gelation

Over gassing:

This is the result of very low gas flow rates over a particular period of time producing high quantity of silica hydrogel as these conditions give sufficient time for CO_2 to dissolve in water of sodium silicate. The weak silica hydrogel bond will then dry out due to prolong gassing of on standing giving a friable surface. Sodium carbonate produce the weakness

(b) For use in period upto one week after making gassing should be at low flow rates for short time to give low as gas strength with very little or no silicate glass bond, which on storing will develop high strength, due to physical dehydration on drying producing silicate glass bond.

Silica hydrogel is formed which is sufficient to strip the pattern from the mould.

Ingredient of CO_2 Process;

Sand- Clay free dry silica sand

SiO_2/Na_2O ratio – 2: 1

Sodium silicate-3-5%

Mixing -3 min

Normal 1 kg of sodium silicate will required about 0.5 - 0.75 kg of CO_2 gas will passed

Advantage of CO_2 Process:

(a) Much more rigid and stronger moulds and core can be made
(b) High flowability so give better compaction of moulds and cores
(c) Casting produce have better dimensional accuracy
(d) Less friable hence lesser sand inclusion
(e) Lesser gas defect
(f) Faster production
(g) Suitable for jobbing and mass production
(h) Lesser in skill required
(i) process can be automatic

Disadvantage of CO_2 Process:

(a) Poor breakdown (Collapsibility)
(b) Shorter bench life
(c) Higher cost of sand reclamation
(d) Special patterns required

★ Cold Box Process :-

→ **Ingredients -**

(i) **Resin:-**

Phenolic Resin (dissolved in organic solvent) to give low viscosity resin solution to facilitate coating of sand and building with the 2nd Component.

(ii) **Hardner :-**

Polymeric Isocynate

Blended with organic solvent to form a Low viscosity solution.

(iii) **Catalyst :-**

Dimethyl Ethyl Amine, or,

Trimethyl Ethyl Amine.

$\underbrace{(50\% \text{ Resin} + 50\% \text{ Hardner})}_{\text{Total Binder}} \rightarrow 1.5 \text{ to } 2\% \text{ of total Sand}$

→ Its addition depends on Casting.

for Steel → 2% and,

for Cast iron → 1.5 %

→ 0.2 to 0.5 % Amine in a mixture is used at 30 pounds per square inch pressure.

→ CO_2 or NO_2 or Ar are used as Carrier gases.

papergrid

Date: / /

⇒ Mechanism of Hardening:-

Phenolic Resin + Poly isocynate $\xrightarrow[\text{Amine}]{\text{Vapour of}}$ Urethane (Polymeric Bond)

So, water or any other by-products is not formed in this reaction and 3 to 4 % Nitrogen comes from the 2nd component.

- Zr sand, Cr sand or Olivin sand can be used.

This system contains high Carbon which contribute the formation of lusturous Carbon and reducing mould atmosphere during pouring.

- Benchlife of Mixture (Component 1 and 2)
  → 2 to 3 hours.
- Compressive strength - 2000 kg/m^2
- Strip time - 10 to 30 seconds.
- Mixture should be free of water since the Isocynate reacts with H_2O in preference resin.
- Additives - 1 to 2 % Clay Sugar, or,
  1 to 3 % Iron Oxide
- High temperature defect is Venning.
  To reduce this defect, additives are used.
  (In steel Casting, Iron oxide 1 to 3 % used for Venning defect improvement)

papergrid

Date: / /

⇒ Advantages :-

(i) High dimensional accuracy and Surface finish
(ii) Low gas evolution
(iii) High density and good abrasion resistance.
(iv) Excellent Shockout and Collapsibility.
(v) Cold blower and cold shooter can be used for good curing even in thick section of mould or course.
(vi) Sand metal ratio can be reduced to 1:1 due to high sand strength.

⇒ Limitations :-

(i) Amine vapoure is highly inflamable and poisonous.
(ii) Prone to venning.
(iii) Low pouring temperature metals and alloy, moulds and core, may not show good breakdown properties.
(iv) Thickness greater than 10 mm may show surface roughness.

Hot Box Process — Ingredients for Hot Box

05 Friday
339-026 Wk 49
DEC '14

(1) BINDER

Resin → 1.5–2% of sand weight

~~Binder used~~ i) Urea formaldehyde
where N_2 can be tolerated furfuryl alcohol content
used for light alloys

(ii) Phenol formaldehyde – nitrogen free
used for ~~st~~ steel casting.

iii) Urea phenol formaldehyde – ~~no~~ low nitrogen
Used for gray iron casting.

~~(iv) Urea formaldehyde – good breakdown~~

06 Saturday
340-025 Wk 49
DEC '14

(2) CATALYST – (0.5% of sand wt / 25% resin wt)

(i) Chloride type – used in ~~summer~~ winter
ii) Nitride type – used in summer

Mechanism: liq resin + catalyst + heat → solid resin + water + heat.

Selection of catalyst depends on acid demand value and other chemical properties of sand. Sand temperature change in the order of 11°C ± 5 must variation in acid

07 Sunday

demand value required catalyst adjustment to maintain optimum performance.
Core box and pattern temperature 220–225°C.

December 2014	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W
	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

Too high ~~surf~~ core box temp may cause
and this may give friable surface
particularly in thin ~~surface~~ section core.
~~Too high~~ and the surface colour indication
for good curing slightly yellow to very
light brown.
but dark ~~d~~ brown to black indication for
bad curing.

<u>Sand</u> — High silica sand with low acid demand
value sand are used.

Viscosity increases with
storage of resin. They should
be stored in dark place out of sunlight.

Phenolic and furyl resin are extensily
used for producing intricate core and
mold. They require good tensile strength
~~for~~
For low cost gray iron casting -

Hot Box Process

Advantages —

- Core drying is not required.
- Lesser resin required.
- Binder cost is less.
- Low resin addition gives lower gas problems.
- Conventional equipments can be used.
- Cycle time is fast.

Limitations

- Production of hollow cores require costly

tooling.
- Core shooting or core blowing machine has to be cleaned ~~and~~ at shift ends.
- Larger core are costlier than self processed and equipment is costly.

Mechanism of Curing -

In the first stage, when the three components are mixed with sand, part C quickly begins to cross link with part A and the rate of cross linking or polymerisation is governed by urathene catalyst component of part B. These action produces a urathane coating on sand with enough bonded sand strength to strip the pattern & core box & handle the mold or core second stage of curing rxn is similar to bent drying mechanism in which

oxygen combine with alkyd oil resin component and nearly polymerize fully at room temp to form a tough urathane bond. The metallic dryers present in part B catalyst accelerate the oxygenation or drying. This process of drying could be slow at room temp but faster at 150 -250°c. As the full curing is dependent on oxygen, section size and shape of the mold & core along with temp determine how long it takes to attain a complete

01 Monday * Three part process for core Making (ABC process) DEC '14
335-030 Wk 49

Part A - Alkyd oil type resin - 1-2% sand wt.

Part B - Liquid amine (i.e. metallic catalyst) Pre-blended with Part A or added separately. 2-10% wt of part A.

Part C - Polymeric methyl diisocynate 18-20% wt of part A.

Mechanism

Alkyd + NCO (amine) + urathane catalyst → alkyd urathane.

02 Tuesday DEC '14
336-029 Wk 49

isocynide group of MDI

(ii) Alkyd + O_2 + metallic dryers → rigid cross linked urathane

Effect of
The naphthanates or oxides of cobalt, V, Pb, Mn & Zirconium accelerate the activation by oxygen & increase the rate ~~poto~~ of polymerization or cross-linking

December M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W core for max curing & high properties mold or core should be heated at 150°C with forced air even for about 1 hr.

Advantages -
- Good for heavy mold & cores.
- Max work time to streak time ratio giving high productivity.
- Uniform curing throughout the section in the shortest time
- High mechanical strength

- Good
- Excellent collapsability
- Low gas evolution.
- Good holding life for mould & core
- Less reinforcement is required.

Limitation
Relatively higher cost of binder
Bench life is critical.

Advantages (Continued)

- Good stripping characteristics
- Good flowability of sand mixture
- Sand metal ratio as low as 2:1
- By ~~varion~~ varying catalyst amt & ~~a~~ type, curing type can be selected.
- Casting poured within 3-4 hrs
- Good shakeout properties.

Limitations

- Sensitive to sand temp.
- ~~Ura~~ Urea ~~limited~~ modified resin have ~~are~~ limited self life
- Some furan resin content cause pollution problem on disposable.
- Low cost fural binder with high N_2 & H_2O content cause ~~to~~ veining & porosity of the casting.

~~Part A~~ -

NO BAKE PROCESS.

No ~~back~~ bake Process - is based on room temp curing of two or more binder components after they are mixed with sand. Curing of the binder system begins immediately after all components are combined

For a period of time, after initial mixing, the sand mixture is workable and flowable to allow the filling of the core box or the mould. After an ~~initial~~ additional time period, sand mix cures to pt where it can be removed from the box. The time diff bet^n filling & stripping of box can range from a few minutes or hrs depending on the binding system used, curing agent its & amount, sand type & temp.

Binder - Furan resin binder - 0.9% - 2% of sand weight.

Types
Low furfuryl ~~alkyl~~ alcohol content - 40-60% alcohol
Medium " " " - 60-80% alcohol
High " " " - >80% "

Catalyst - acid catalyst → 20-50% based on binder wt.
Acids like Phosphoric acid, benzene sulphonic acid used to promote the polymerization.
Acid generally soluble in water or methanol sol^n

Curing Mechanism

Fural binder + acid catalyst → Cured polymer + water.

Additives
Silan — 0.1 - 0.3% to resist humidity.
Low & medium alcohol type used for cast iron & non ferrous metal.
High furfuryl binder with low N_2 & H_2O is used for steel catalyst.

ADVANTAGES -

* Fural binder available with various N_2 content.
& gives high tensile strength & high hot strength.
* Suitable for fluxless moulding

Cast Irons

- iron-carbon alloys with more than 2.11% carbon
  - It pass through the eutectic reaction during solidification.
- Properties
  - Inexpensive
  - Have good fluidity
  - Have low liquidus temperature
  - Readily castable

Cast Irons

- typically cast iron contains 2–4% C and 0.5–3% Si
- Effect of Si
  - reduces the amount of carbon contained in the eutectic. carbon equivalent (CE):

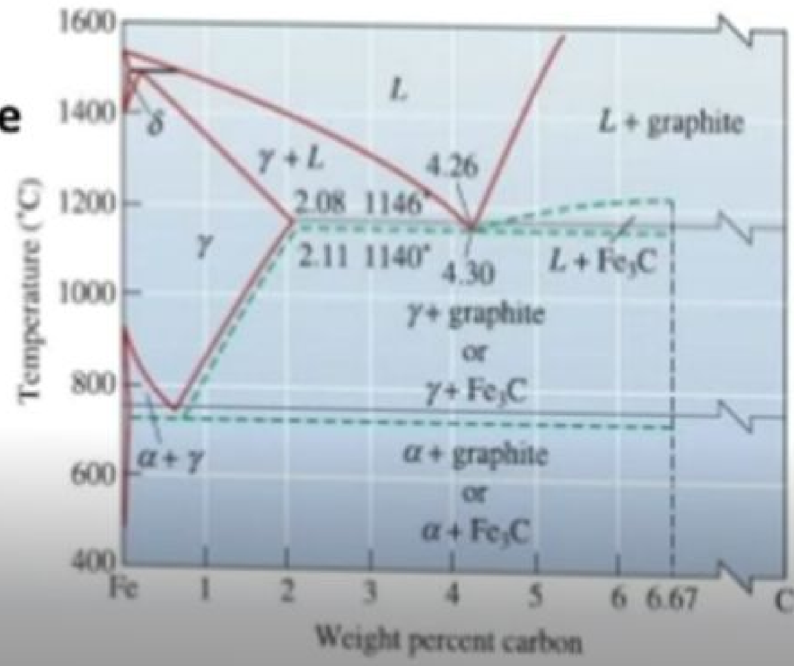
$$CE = \%C + \frac{1}{3}\%Si$$

  - Enhances oxidation and corrosion resistance by forming a tight adhering surface oxide.
  - It is a *graphite stabilizing element.*
- **Eutectic Reaction in Cast Irons**
  - **Metastable phase diagram**

$$L \rightarrow \gamma + Fe_3C$$

  - **Stable rxn**

$$L \rightarrow \gamma + \text{graphite}$$



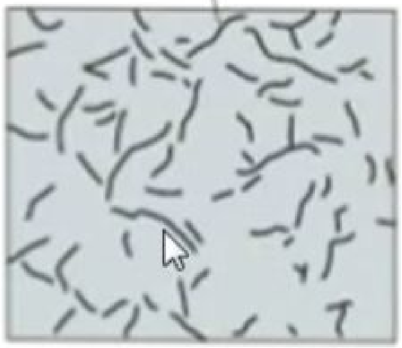
as Roy

Cast Irons

- *The microstructure of cast iron has two extremes*
  1. *Liquid* $\longrightarrow$ *austenite + Fe_3C (white cast iron)*
  2. *Liquid* $\longrightarrow$ *austenite + graphite (gray, ductile…)*
- *graphite formation is promoted by*
  - *Slow cooling*
  - *High C and Si content*
  - *Heavy or thick section size*
  - *Inoculation particles*
  - *Presence of S, P, Al, Ni, Sn, Mn, Cu, Cobilt, antimony*
- Formation of cementite (*Fe_3C*) is favored by
  - Fast cooling
  - Low C and Si contents
  - Thin sections
  - Alloying elements, titanium, vanadium, zirconium, chromium, manganese, and molybdenum

Types of Cast Iron

- Depending on chemical composition, cooling rate, types and amount of inoculants that are used we can have
  a. Gray iron
  b. White iron
  c. Malleable iron
  d. Ductile iron
  e. Compacted graphite iron



(a)

(b)

- **Gray cast iron**
  - The least expensive and most common type
  - Characterized by formation of graphite
  - Typical composition ranges from 2.5-4.0% C, 1.0-3.0% Si, and 0.4-1.0% Mn.
  - contains small, interconnected graphite flakes that cause low strength and ductility.
  - It is the most widely used cast iron
  - It is named for the dull gray color of the fractured surface.
  - The gray irons are specified by a class number of 20 to 80.
- Properties
  - high compressive strength,
  - good machinability,
  - good resistance to sliding wear,
  - good resistance to thermal fatigue,
  - good thermal conductivity, and
  - good vibration damping.

Gray CI

- **Application**;
  - Damping vibrational energy
    - Base structures for machines and heavy equipment
  - High resistance to wear.
  - High fluidity at casting temperature
    - Intricate shapes; Low casting shrinkage allowance.
      - (strength is not a primary consideration)
      - Tensile strength 120 – 300 MPa
    - Small cylinder blocks, cylinder heads, pistons, liners, clutch plates, transmission cases.
    - gears, flywheels, water pipes, engine cylinders, brake discs, Machinery beds

odas Roy

- **White cast iron**
  - is a hard, brittle alloy containing massive amounts of Fe_3C.
  - A fractured surface of this material appears white, hence the name.
  - Features promoting formation of cementite over graphite
    - A low carbon equivalent (1.8-3.6 %C, 0.5-1.9%Si, 0.25-0.8%Mn) and
    - Rapid cooling
- A group of highly alloyed white irons are used for their hardness and resistance to abrasive wear.

as Roy

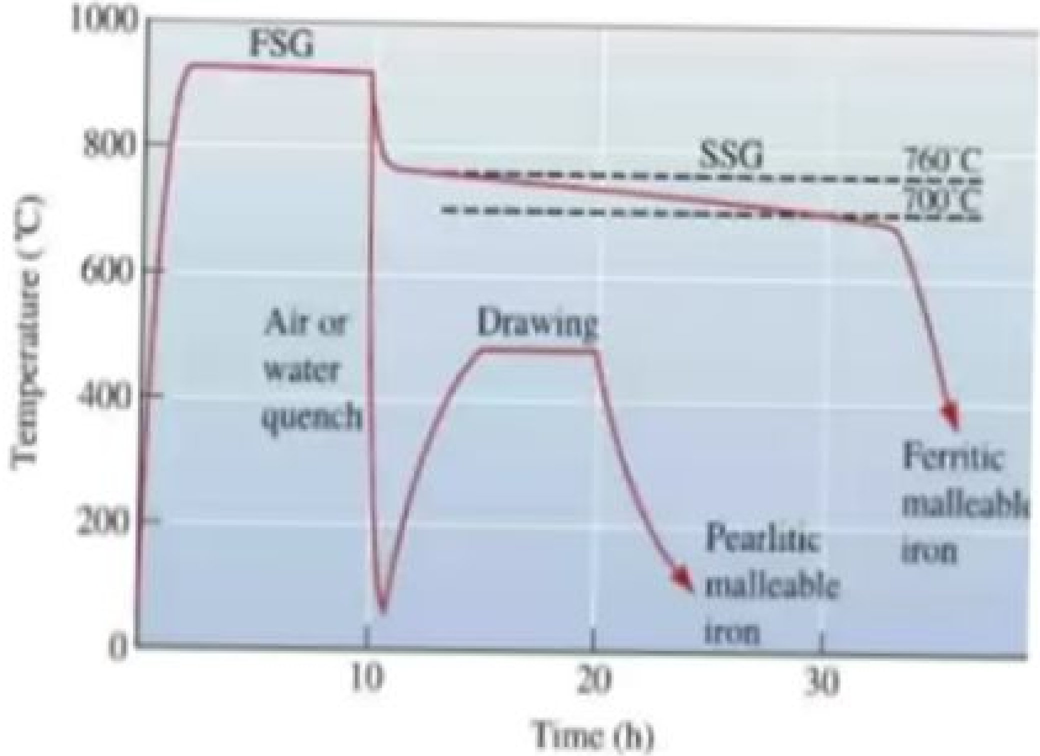
White CI

- **Application:**
  - brake shoes, shot blasting nozzles, mill liners, crushers, pump impellers and other abrasion resistant parts.
  - wear-resistant surface, example, as rollers in rolling mills. Generally, white iron is used as an intermediary in the production of yet another cast iron, **malleable iron**
- White fracture surface
- No graphite, because carbon forms Fe_3C or more complex carbides
- Abrasion resistant
- Often alloyed

as Roy

- **Malleable cast iron**
  - formed by the heat treatment (in range of $900^{\circ}C$) of unalloyed 3%C white cast iron (carbon equivalent 2.5%C, 1.5%Si)
  - the cementite dissociates into its component elements (graphite clumps, or nodules)
  - It exhibits better ductility than gray or white cast irons. It is also very machinable.
- The production steps
- **first stage graphitization:** cementite decomposes to the stable austenite and graphite phases
- **second stage graphitization:** slow cooling through eutectoid temperature to make *ferritic malleable iron*

- *when austenite is cooled in air or oil Pearlitic malleable iron is obtained (pearlite or martensite.)*
- **Drawing:** is a heat treatment that tempers the martensite or spheroidizes the pearlite.



Application

Connecting rods, transmission gears, and differential cases for the automotive industry, and also flanges, pipe fittings, and valve parts for railroad, marine, and other heavy-duty services

parts of power train of vehicles, bearing caps, steering gear housings, agricultural equipment, railroad equipment

- **Ductile or nodular cast iron**
  - contains spheroidal graphite particles.
  - produced by treating liquid iron with a carbon equivalent of near 4.3% with magnesium
- Steps
  - **Desulfurization**: CaO is used to remove sulfure and oxygen from the liquid.
  - **Nodulizing:** Mg in dilute form (MgFeSi alloy) is added, a residual of 0.03%Mg must be present after treatment in order for spheroidal graphite to grow
- **inoculation:** heterogeneous nucleation of the graphite is essential
- **Fading:** occurs by the gradual, nonviolent loss of Mg due to vaporization and/or reaction with oxygen

as Roy

Ductile or nodular cast iron

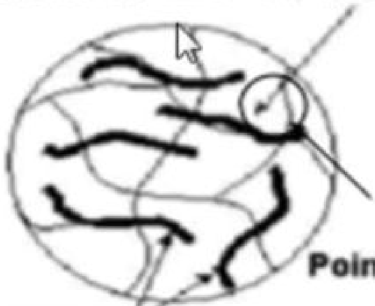
- **Application:**
  - valves, pump bodies, crankshafts, high-strength gears (heavy duty gears) and machine, rollers, slides, die material having high strength and high ductility.
- Inoculation with Ce or Mg or both causes graphite to form as spherulites, rather than flakes
- Also known as spheroidal graphite (SG), and nodular graphite iron
- Far better ductility than grey cast iron

- **Compacted graphite cast iron:** contains rounded but interconnected graphite also produced during solidification
- intermediate between flakes and spheres with numerous rounded rods of graphite that are interconnected to the nucleus of the eutectic cell.
- **vermicular graphite:** forms when ductile iron fades
- permits strengths and ductilities that exceed those of gray cast iron, but allows the iron to retain good thermal conductivity and vibration damping properties.

The mechanical characteristic of Gray cast Irons - summary

- **Less hard and brittle**
- **Very weak in tension due to the pointed and sharp end of graphite flakes, where the failure of component initiated at this point.**
- **Good during compression which graphite acts as a cushion or sponge that could absorb the compression energy.**
- Low shrinkage in mould due to formation of graphite flakes.
- Good dry bearing qualities due to graphite.

THE MICRISTRUCTURE OF GREY CAST IRON



GREY CAST IRON PRODUCTS

Sprockets

Park Bench

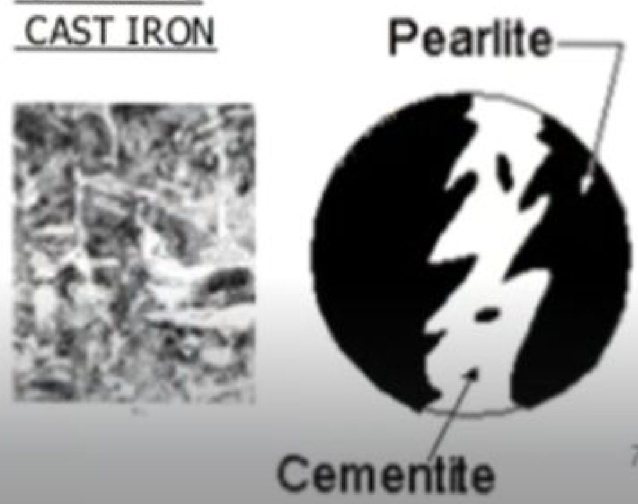
Manhole Covers with Frames

Gas Burners

White Cast Irons - summary

- The composition of Carbon and Silicon contents for white cast irons are in range between 2.5 to 4.0% and less than 1.0% respectively.
- With a rapid cooling rate most of the carbon in the cast irons consist of pearlite and cementite (Fe3C).
- The mechanical characteristic of White cast Irons are as follows:
  - Relatively very hard, brittle and not weldable compared to gray cast iron, since it is obtained from rapid cooling process.
  - When it's annealed, it becomes malleable cast iron.
- A fracture surface of these alloy has a white appearance and it is called white cast iron.
- <u>Typical Uses</u>:
  Necessitate a very hard and wear resistance surface such as rollers in rolling mills, railroads wheel.

THE MICRISTRUCTURE OF WHITE CAST IRON



as Roy

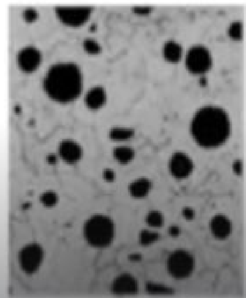
Ductile (Nodular) Cast Irons - summary

- **Ductile cast iron, which is sometimes called nodular or spheroidal graphite cast iron. It gets this name because its carbon is in the shape of small spheres, not flakes.**
- **Magnesium or cerium is added to the iron before casting occurs. The effect of these material is to prevent the formation of graphite flakes during the slow cooling of the iron.**
- **The structures of the cast irons is mainly pearlite with nodules of graphite.**
- **A heat treatment process can be applied to a pearlite nodular iron to give a microstructure of graphite nodules in ferrite. The ferrite structure is more ductile but has less tensile strength than the pearlite form. It's also weldable.**

- **<u>Typical Uses</u>:**
  Valves, pump bodies, gears crankshafts, and other machine components.

TEE pipe

THE MICRISTRUCTURE OF DUCTILE CAST IRON



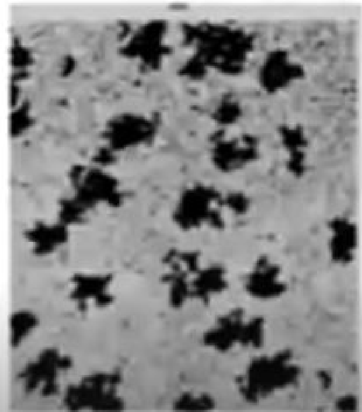
Malleable Cast Irons - summary

- **Malleable cast iron is produced by the heat treatment of white cast irons.**
- **Heating white iron at temperatures 800 c to 900 c for 50 hours in a neutral atmosphere (to prevent oxidation) causes a decomposition of the cementite, forming graphite in the form of clusters/ rossettes surrounded by a ferrite or pearlite matrix depending on cooling rate.**
- **The mechanical characteristic of malleable cast iron is similar to nodular cast iron and give higher strength and more ductility and malleability. The silicon content is low.**

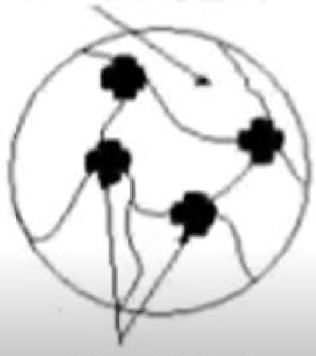
MALLEABLE CAST IRON PRODUCTS

CLAMPS

THE MICRISTRUCTURE OF MALLEABLE CAST IRON



Ferrite / Pearlite



Rossettes/cluster

Effect of alloying elemets

General Characteristics of White Cast Irons

- White Cast Irons contain **Chromium to prevent formation of Graphite** upon solidification and to ensure stability of the carbide phase.
- Usually, **Nickel, Molybdenum, and/or Copper** are alloyed to prevent to the **formation of Pearlite** when a matrix of **Martensite is desired**.
- Fall into three major groups:
- Nickel Chromium White Irons: containing 3-5%Ni, 1-4%Cr. Identified by the name Ni-Hard 1-4
- The chromium-molybdenum irons (high chromium irons): 11-23%Cr, 3%Mo, and sometimes additionally alloyed w/ Ni or Cu.
- 25-28%Cr White Irons: contain other alloying additions of Molybdenum and/or Nickel up to 1.5%

as Roy

Nickel Chromium

- Produced for more than 50 years, effective materials for crushing and grinding in industry.
- Consists of **Martensite matrix,** with Nickel alloyed at 3-5% in order to suppress transformation of Austenite to Pearlite.
- Chromium usually included between 1.4-4% to ensure Carbon phase solidifies to **Carbide**, not Graphite. (Counteracts the Graphitizing effect of Ni)
-

Fig. 5 Typical microstructure of class I type A nickel-chromium white cast iron, 340x

Fig. 6 Typical microstructure of class I type D nickel-chromium white cast iron, 340x

Abrasion resistance (usually desired property of this material) increases with Carbon content, but toughness decreases.

Applications: Because of low cost, used primarily in mining applications as ball mill liners and grinding balls.

CASTING DEFECTS

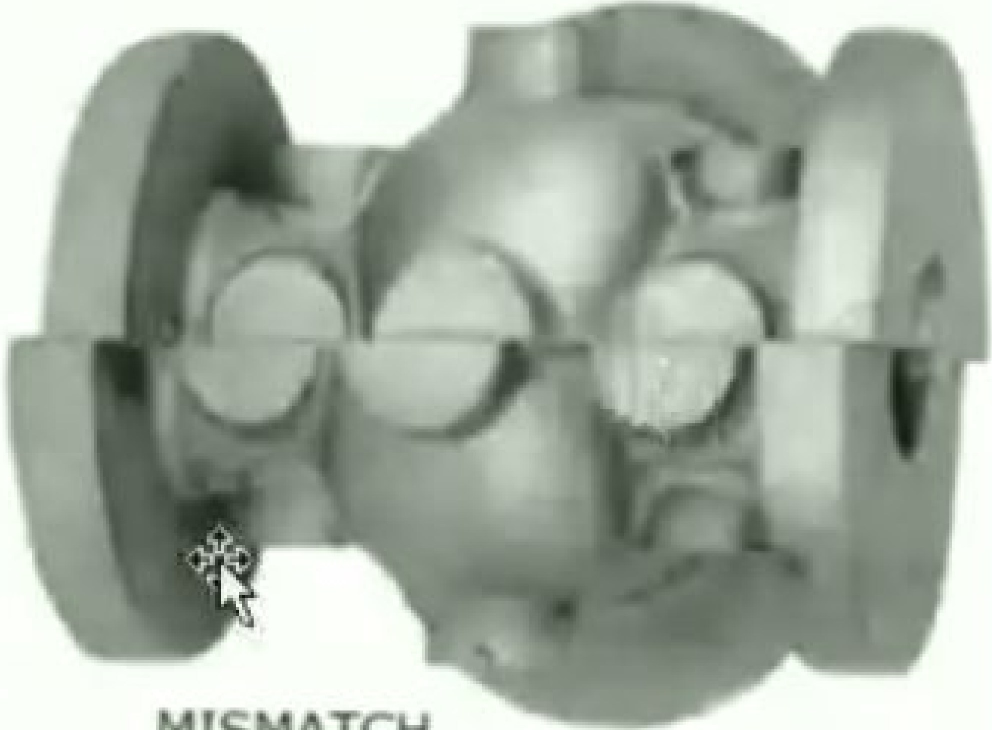
MISMATCH

- The casting that does not match at the parting line is known as Mismatch or Mould shift.
- **Causes** :
  - Worn out or bent clamping pins.
  - Misalignment of two halves of pattern.
  - Improper location & support of core.
  - Faulty core boxes.
  - Loose dowels.
- **Remedies** :
  - Increase strength of mould & core.
  - Provide adequate support to core.
  - Proper alignment of two halves of the pattern.
  - Proper clamping of mould box.
  - Repair or replace dowels & pin causing mismatch.

Moulding-related Defects

- **Improper Closure**
  - **Across parting plane**: flash
  - **Along parting line**: mismatch

FLASH

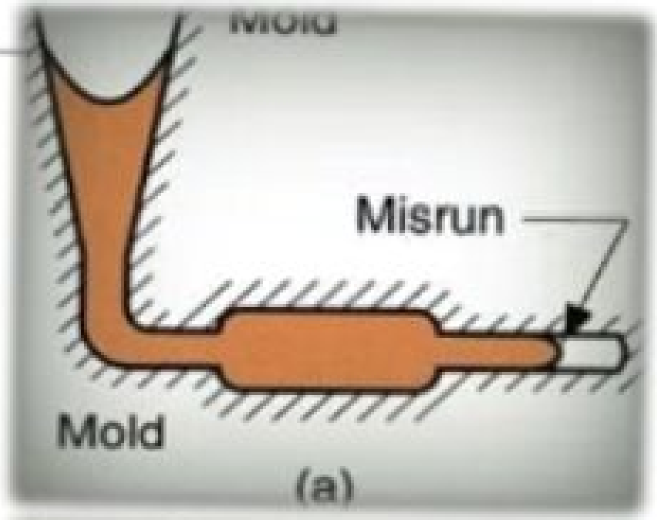


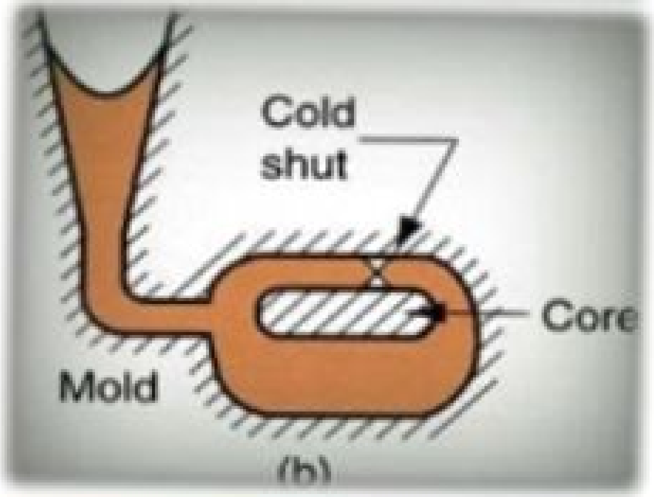
MISMATCH

[Atlas of Casting Defects, Institute of British Foundrymen]

MISRUN & COLD SHUTS

- When the metal is unable to fill the mould cavity completely & thus leaves unfilled cavities, it is called as misrun defect.
- When two metal streams meeting in the mould cavity, do not fuse together properly, causing discontinuity or weak spot inside casting, it is called as cold shuts.





MISRUN & COLD SHUTS

- **Causes :**
  - Low pouring temperature.
  - Faulty gating system design.
  - Too thin casting sections.
  - Slow and intermitted pouring.
  - Improper alloy composition.
  - Use of damaged pattern.
  - Lack of fluidity in molten metal.

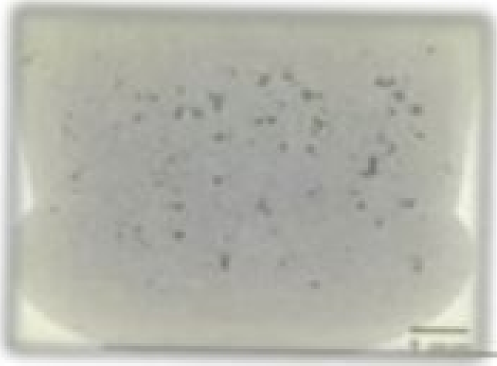
- **Remedies :**
  - Smooth pouring with the help of monorail.
  - Properly transport mould during pouring.
  - Providing appropriate pouring temperature.
  - Modifying the gating system design.

BLOW HOLES

- Balloon shaped gas cavities caused by release of mould gases during pouring are known as blow holes.

- **Causes** :
  - Ramming is too hard.
  - Cores are not sufficiently baked.
  - Excess moisture content.
  - Low sand permeability.
  - Excessive fineness of sand grains.
  - Rusted chills, chaplets & inserts.
  - Presence of gas producing ingredients.

- **Remedies** :
  - Baking of cores properly.
  - Control of moisture content in moulding sand.
  - Use of rust free chills, chaplets & inserts.
  - Provide adequate venting in mould and cores.
  - Ramming the mould less harder.



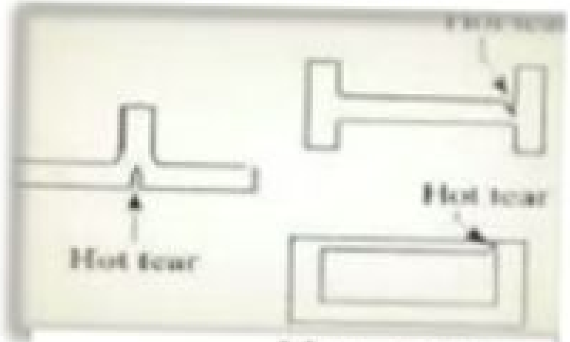
POROSITY

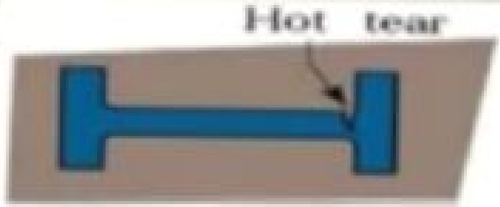
- Porosity is in the form of cavities caused due to gas entrapment during solidification.

- **Causes** :
  - High pouring temperature.
  - Gas dissolved in metal charge.
  - Less flux used.
  - Molten metal not properly degassed.
  - Slow solidification of casting.
  - High moisture and low permeability of mould.

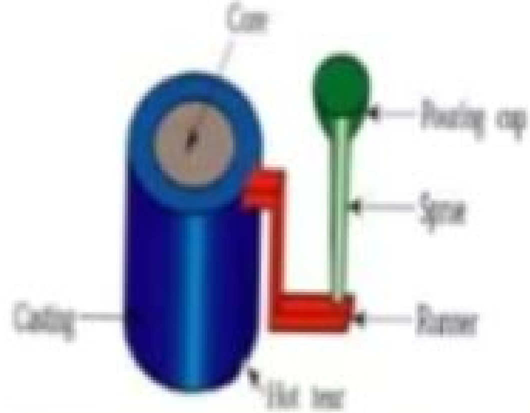
- **Remedies** :
  - Regulate pouring temperature
  - Control metal composition.
  - Increase flux proportions.
  - Ensure effective degassing.
  - Modify gating and risering.
  - Reduce moisture and increase permeability of mould.

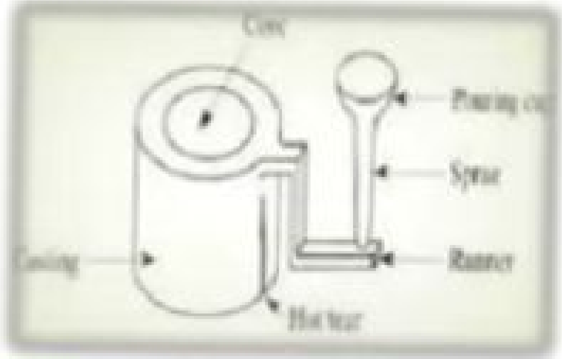
HOT TEARS or HOT CRACKING





- Hot tears are ragged irregular internal or external cracks occurring immediately after the metal have solidified.
- **Causes** :
  - Lack of collapsibility of core & mould.
  - Hard ramming of mould.
  - Faulty casting design.
- **Remedies** :
  - Providing softer ramming.
  - Improve casting design.
  - Improve collapsibility of core & mould.

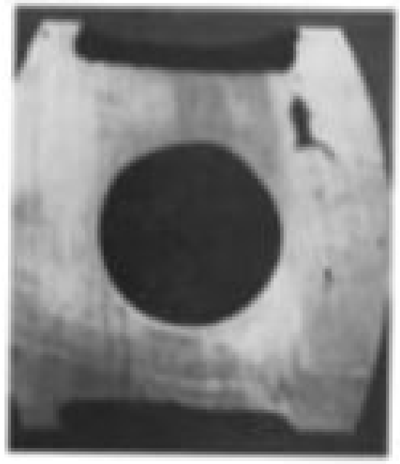


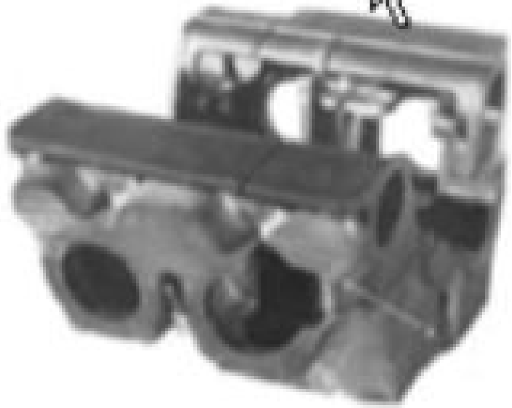


Solidification/Cooling-related Defects

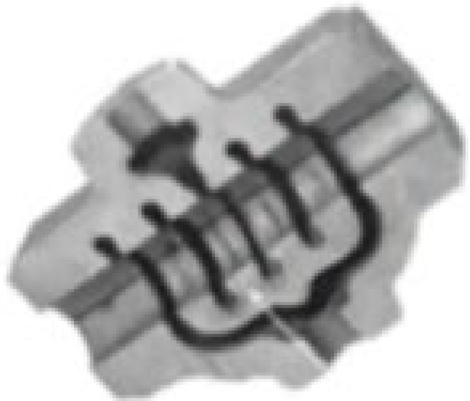
- **Solidification Shrinkage**: cavity, porosity, centerline, sink.
- **Hindered Cooling Contraction**: hot tear, crack, distortion.

SHRINKAGE CAVITY





POROSITY



SINK

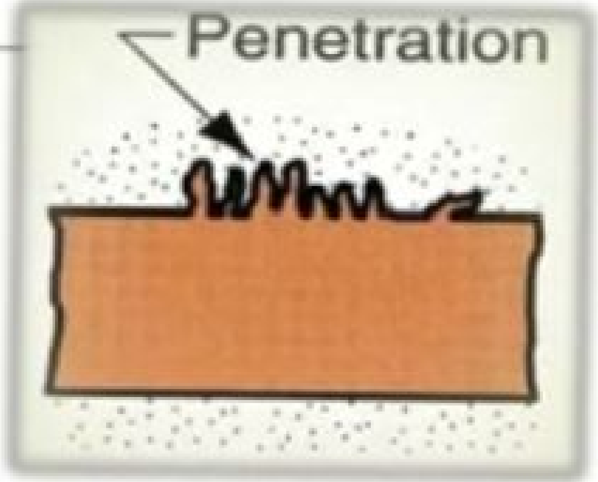
CORNER SHRINKAGE

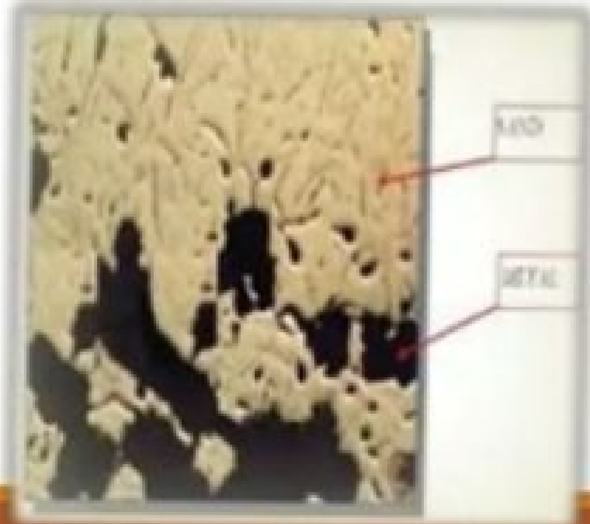
CRACK

(Atlas of Casting Defects, Institute of British Foundrymen)

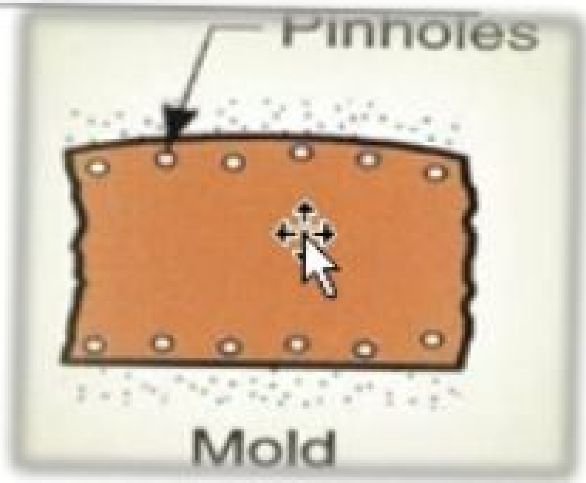
METAL PENETRATION

- Penetration occurs when the molten metal flows between the sand particles in the mould.
- **Causes**:
  - Low strength of moulding sand.
  - Large size of moulding sand.
  - High permeability of sand.
  - Soft ramming.
- **Remedies** :
  - Use of fine grain with low permeability.
  - Appropriate ramming.





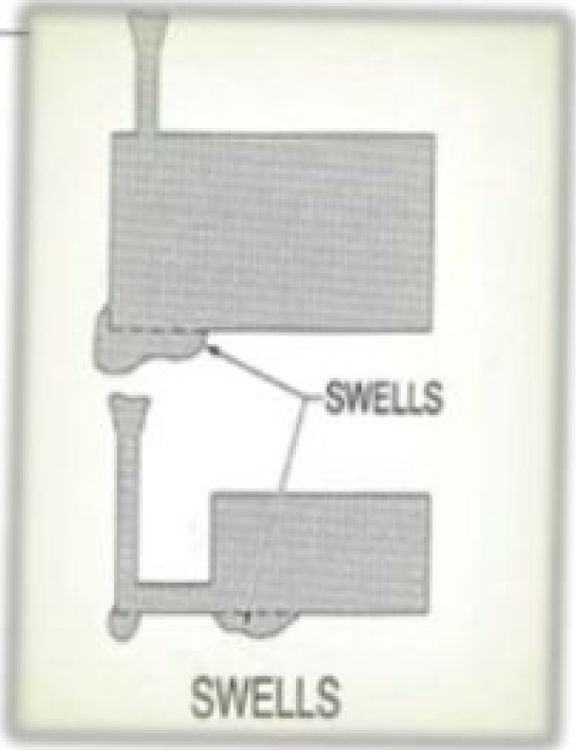
PIN HOLES

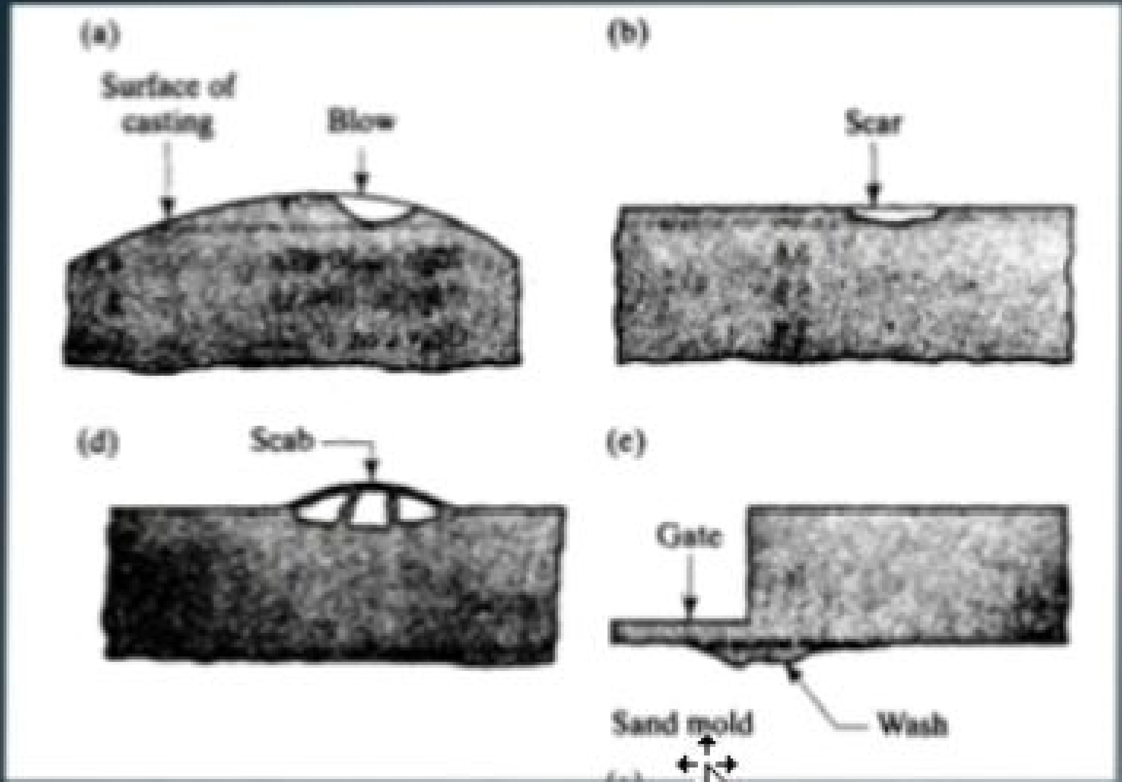


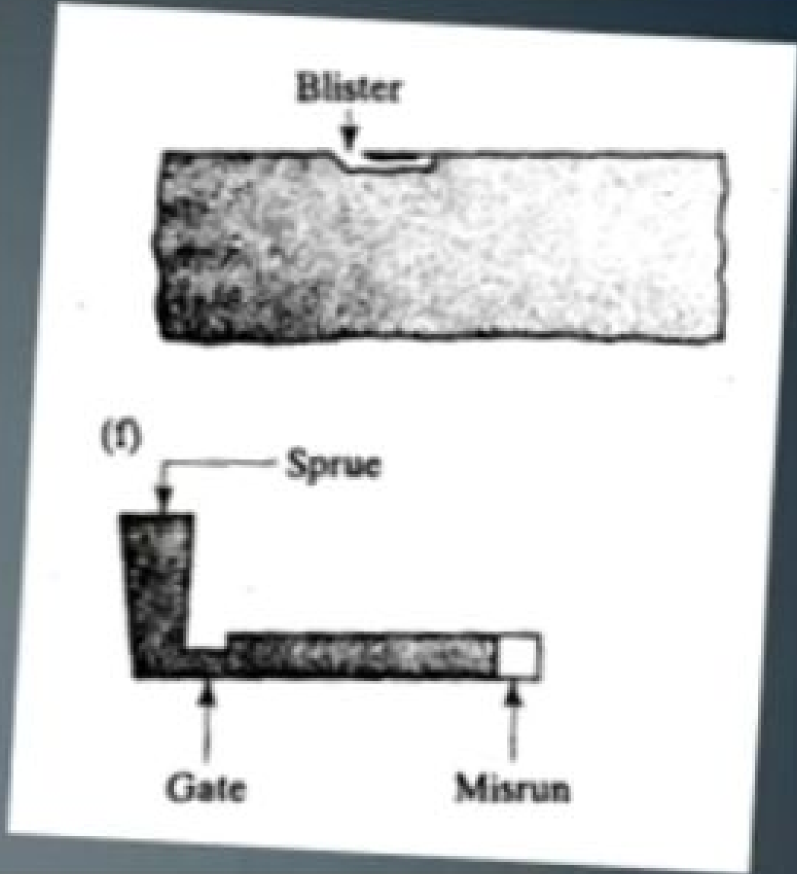
- Formation of many small gas cavities at or slightly below surface of casting is called as pin holes.
- **Causes** :
  - Sand with high moisture content.
  - Absorption of hydrogen/carbon monoxide gas in the metal.
  - Alloy not being properly degassed.
  - Sand containing gas producing ingredients.
- **Remedies** :
  - Reducing the moisture content & increasing permeability of moulding sand.
  - Employing good melting and fluxing practices.
  - Improving a rapid rate of solidification.

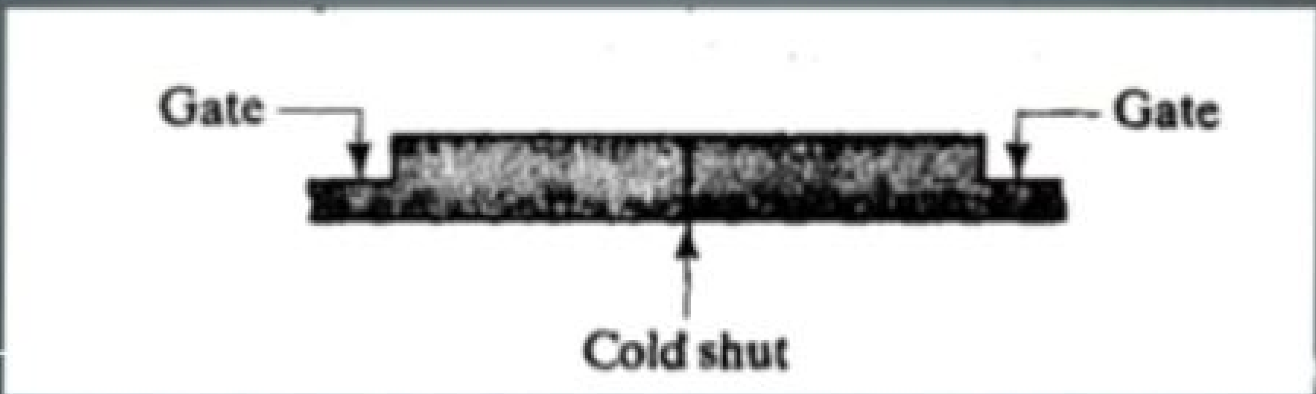
SWELL

- A swell is an enlargement of mould cavity by localized metal pressure.
- **Causes** :
  - Insufficient or soft ramming.
  - Low strength mould & core.
  - Mould not being supported properly.
- **Remedies**
  - Sand should be rammed evenly and properly.
  - Increase strength of mould & core.





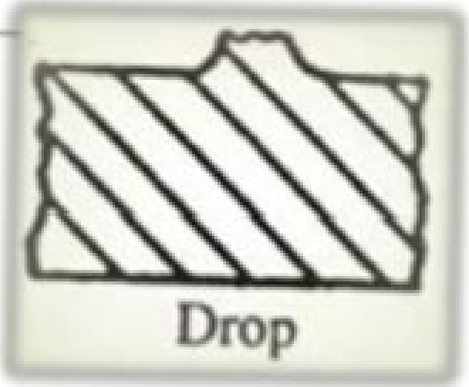




DEFECT MISED BY PROPER DESIGN. MOLD PREPARATION. PROPER POURING.

DROP

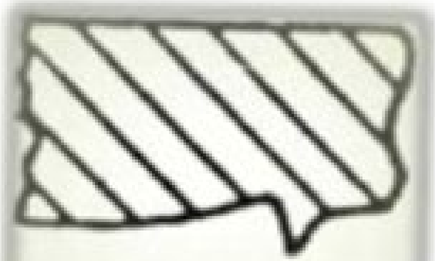
- Drop is a projection on drag part of casting due fall of its cope part.



- **Causes** :
  - Low green strength of the moulding sand.
  - Low mould hardness.
  - Insufficient reinforcement of sand projections in the cope.
- **Remedies** :
  - Moulding sand should have sufficient green strength.
  - Provide adequate reinforcement to sand projections and cope by using nails and gaggers.
  - Ramming should not be too soft.

RAT TAILS or BUCKLES

- Slight compression failure of a thin layer of moulding sand is called as rat tails & more severe compression failure is called as buckles i.e. Buckling of sand.



Rat tail

- **Causes** :
  - Excessive mould hardness.
  - Lack of combustible additives in the moulding sand.
  - Continuous large surfaces on the casting.
- **Remedies** :
  - Suitable addition of combustible additives to moulding sand.
  - Reduction in mould hardness.
  - Modifications in casting design.