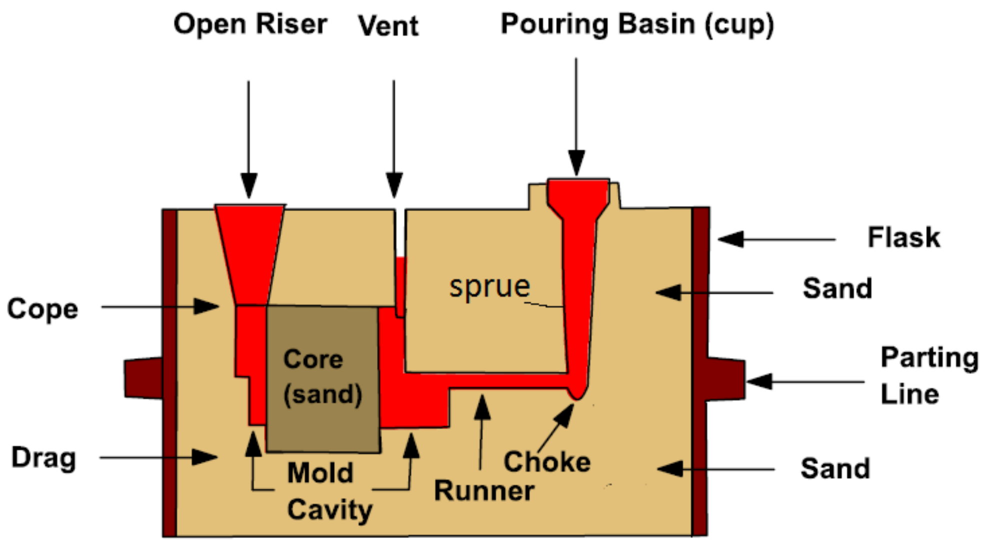
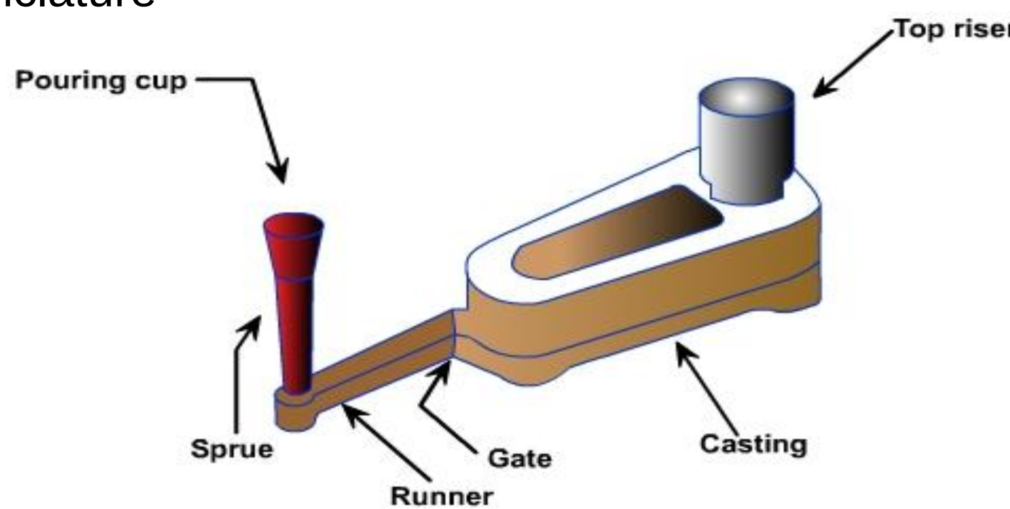
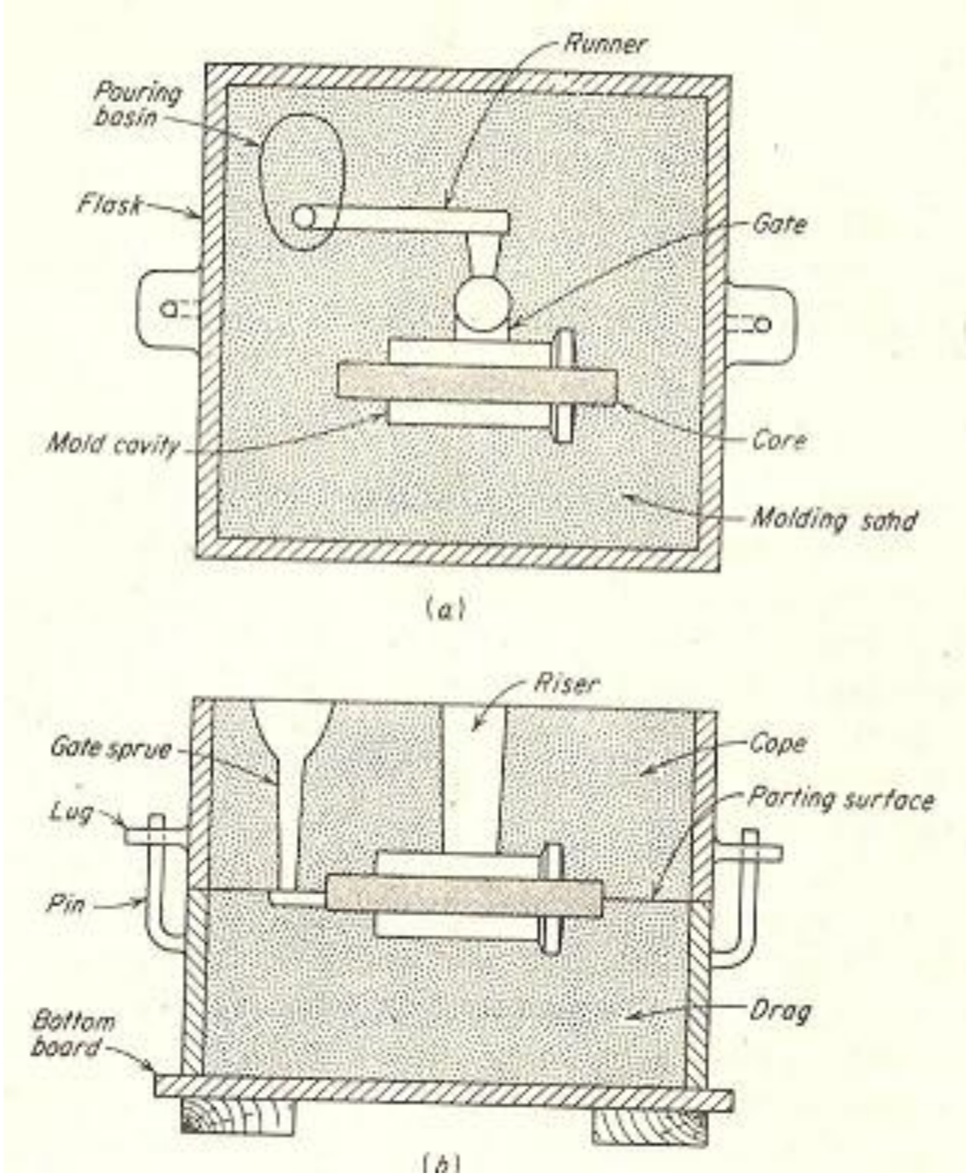
Typical sand mould



Mould Section and casting nomenclature



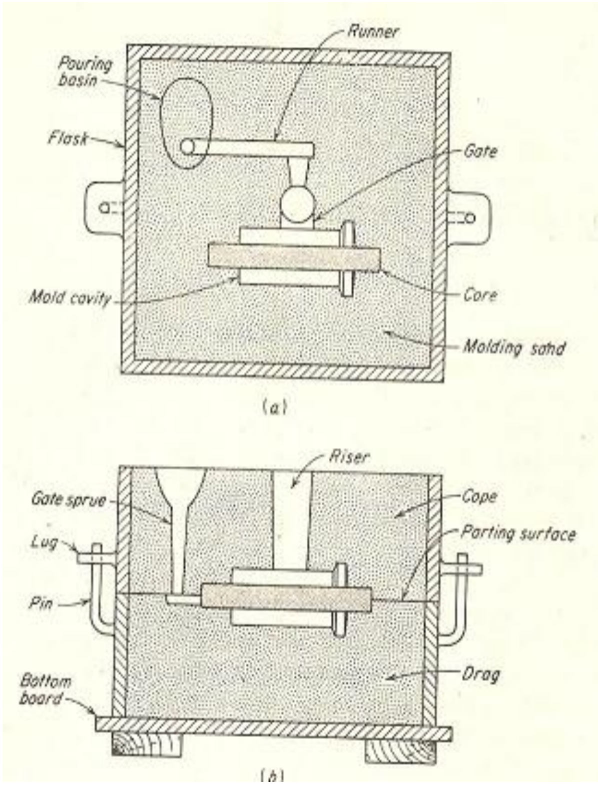
pattern attached with gating and risering system

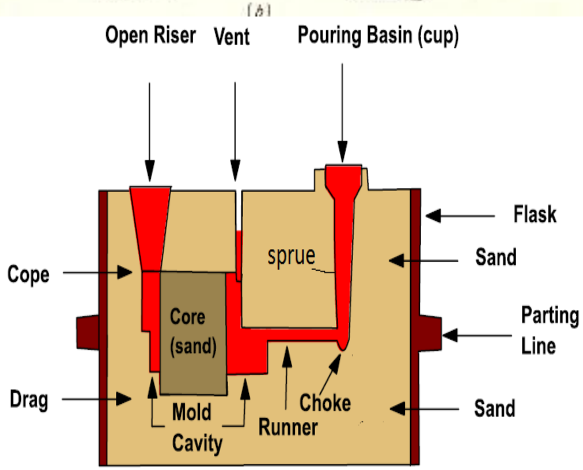


Mould Section and casting nomenclature, (a) top view, (b) front view

J S Campbell, *Principles Of Manufacturing Materials And Processes*

Important casting terms





Flask: A metal or wood frame, without fixed top or bottom, in which the mould is formed. Depending upon the position of the flask in the moulding structure, it is referred to by various names such as drag – lower moulding flask, cope – upper moulding flask, cheek – intermediate moulding flask used in three piece moulding.

Pattern: It is the replica of the final object to be made. The mould cavity is made with the help of pattern.

Parting line: This is the dividing line between the two moulding flasks that makes up the mould.

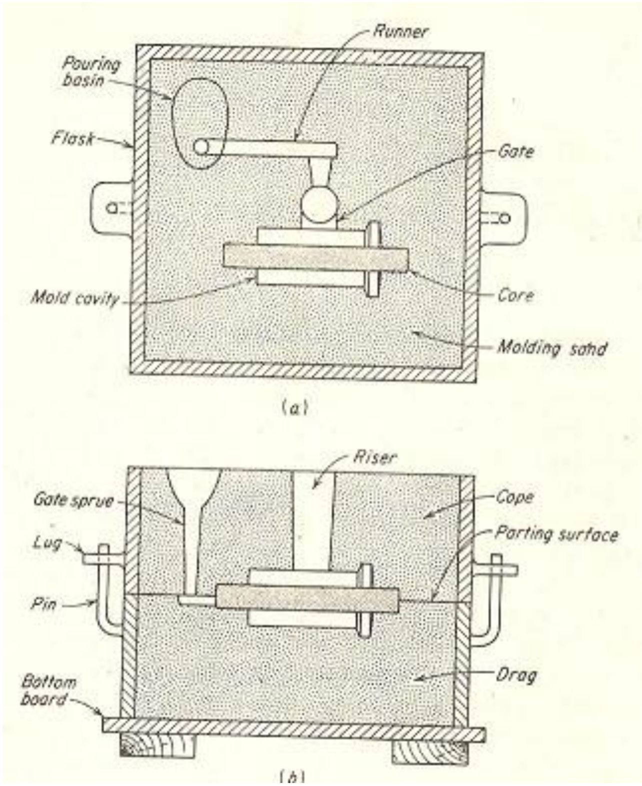
Moulding sand: Sand, which binds strongly without losing its permeability to air or gases. It is a mixture of silica sand, clay, and moisture in appropriate proportions.

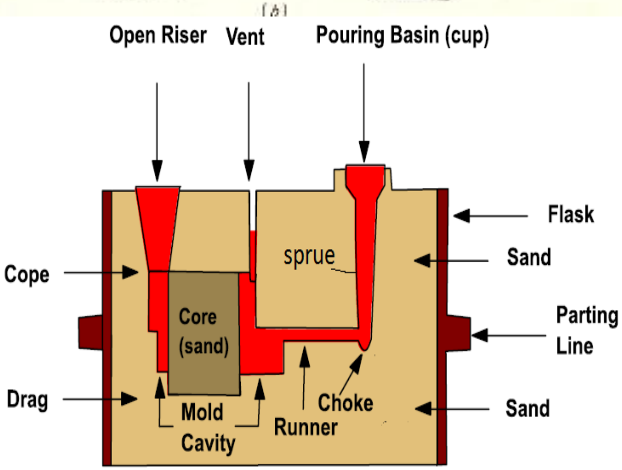
Facing sand: The small amount of carbonaceous material sprinkled on the inner surface of the mould cavity to give a better surface finish to the castings.

R.Ganesh Narayanan, IITG

J S Campbell, *Principles Of Manufacturing Materials And Processes*

NPTEL course on Manufacturing processes – I, Pradeep Kumar et al.





Core: A separate part of the mould, made of sand and generally baked, which is used to create openings and various shaped cavities in the castings.

Pouring basin: A small funnel shaped cavity at the top of the mould into which the molten metal is poured.

Sprue: The passage through which the molten metal, from the pouring basin, reaches the mould cavity. In many cases it controls the flow of metal into the mould.

Runner: The channel through which the molten metal is carried from the sprue to the gate.

Gate: A channel through which the molten metal enters the mould cavity.

Chaplets: Chaplets are used to support the cores inside the mould cavity to take care of its own weight and overcome the metallostatic force.

Riser: A column of molten metal placed in the mould to feed the castings as it shrinks and solidifies. Also known as “feed head”.

Vent: Small opening in the mould to facilitate escape of air and gases.

Steps in making sand castings

The six basic steps in making sand castings are,
(i) Pattern making, (ii) Core making, (iii) Moulding, (iv) Melting and pouring, (v) Cleaning

Pattern making

- Pattern: Replica of the part to be cast and is used to prepare the mould cavity. It is the physical model of the casting used to make the mould. Made of either wood or metal.

-The mould is made by packing some readily formed aggregate material, such as moulding sand, surrounding the pattern. When the pattern is withdrawn, its imprint provides the mould cavity. This cavity is filled with metal to become the casting.

- If the casting is to be hollow, additional patterns called ‘cores’, are used to form these cavities.

Core making

Cores are placed into a mould cavity to form the interior surfaces of castings. Thus the void space is filled with molten metal and eventually becomes the casting.

Moulding

Moulding is nothing but the mould preparation activities for receiving molten metal.

Moulding usually involves: (i) preparing the consolidated sand mould around a pattern held within a supporting metal frame, (ii) removing the pattern to leave the mould cavity with cores.

Mould cavity is the primary cavity.

The mould cavity contains the liquid metal and it acts as a negative of the desired product.

The mould also contains secondary cavities for pouring and channeling the liquid material in to the primary cavity and will act a reservoir, if required.

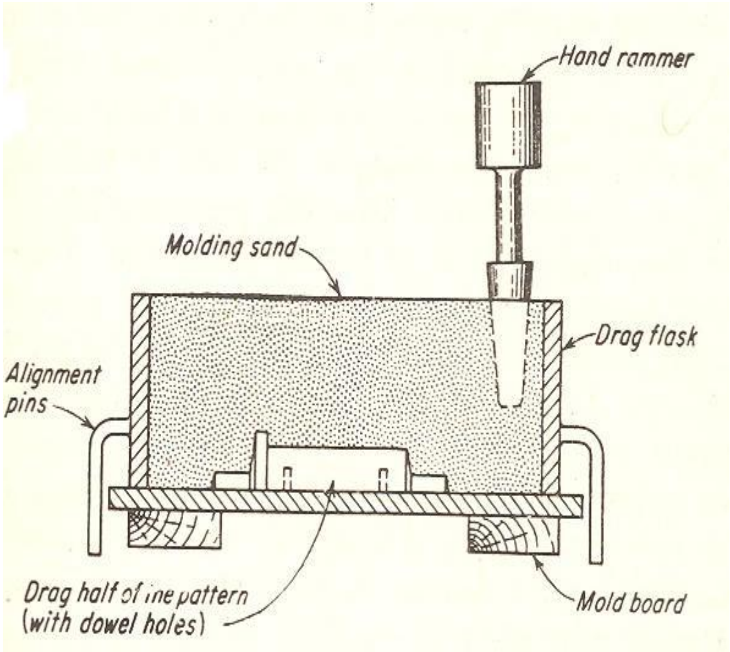
Melting and Pouring

The preparation of molten metal for casting is referred to simply as melting. The molten metal is transferred to the pouring area where the moulds are filled.

Cleaning

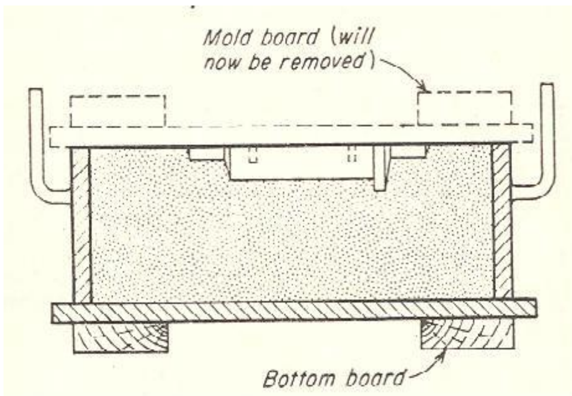
Cleaning involves removal of sand, scale, and excess metal from the casting. Burned-on sand and scale are removed to improved the surface appearance of the casting. Excess metal, in the form of fins, wires, parting line fins, and gates, is removed. Inspection of the casting for defects and general quality is performed.

Making a simple sand mould



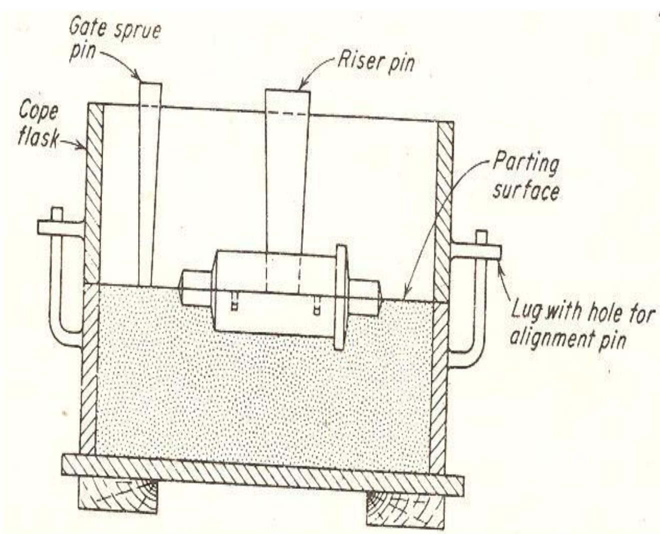
1) The drag flask is placed on the board
2) Dry facing sand is sprinkled over the board
3) Drag half of the pattern is located on the mould board. Dry facing sand will provide a non-sticky layer.
4) Molding sand is then poured in to cover the pattern with the fingers and then the drag is filled completely
5) Sand is then tightly packed in the drag by means of hand rammers. Peen hammers (used first close to drag pattern) and butt hammers (used for surface ramming) are used.

6) The ramming must be proper i.e. it must neither be too hard or soft. Too soft ramming will generate weak mould and imprint of the pattern will not be good. Too hard ramming will not allow gases/air to escape and hence bubbles are created in casting resulting in defects called 'blows'. Moreover, the making of runners and gates will be difficult.
7) After the ramming is finished, the excess sand is leveled/removed with a straight bar known as strike rod.



8) Vent holes are made in the drag to the full depth of the flask as well as to the pattern to facilitate the removal of gases during pouring and solidification. Done by vent rod.

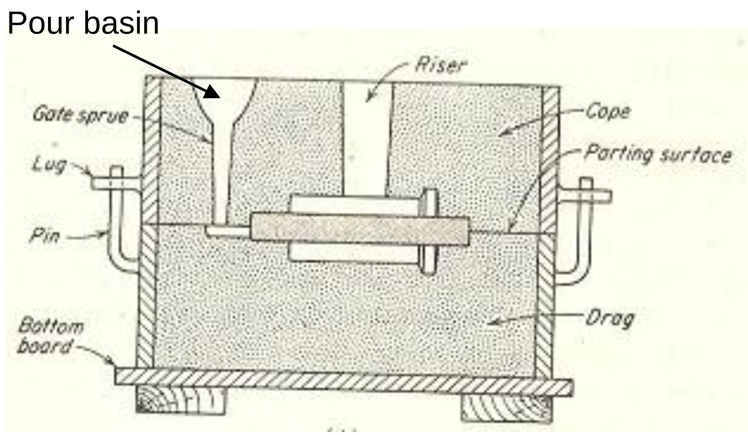
9) The finished drag flask is now made upside down exposing the pattern.



10) Cope half of the pattern is then placed on the drag pattern using locating pins. The cope flask is also located with the help of pins. The dry parting sand is sprinkled all over the drag surface and on the pattern.

11) A sprue pin for making the sprue passage is located at some distance from the pattern edge. Riser pin is placed at an appropriate place.

12) Filling, ramming and venting of the cope is done in the same manner.



13) The sprue and riser are removed and a pouring basin is made at the top to pour the liquid metal.

14) Pattern from the cope and drag is removed.

15) Runners and gates are made by cutting the parting surface with a gate cutter. A gate cutter is a piece of sheet metal bent to the desired radius.

16) The core for making a central hole is now placed into the mould cavity in the drag. Rests in core prints.

17) Mould is now assembled and ready for pouring.

Pattern

The pattern and the part to be made are not same. They differ in the following aspects.

1.A pattern is always made larger than the final part to be made. The excess dimension is known as Pattern allowance.

Pattern allowance => shrinkage allowance, machining allowance

2.Shrinkage allowance: will take care of contractions of a casting which occurs as the metal cools to room temperature.

Liquid Shrinkage: Reduction in volume when the metal changes from liquid state to solid state. Riser which feed the liquid metal to the casting is provided in the mould to compensate for this.

Solid Shrinkage: Reduction in volume caused when metal looses temperature in solid state. Shrinkage allowance is provided on the patterns to account for this.

Shrink rule is used to compensate solid shrinkage depending on the material contraction rate.

Cast iron: One foot (=12 inches) on the **1/8-in-per-foot shrink rule** actually measures 12-1/8 inches.

So, **4 inch** will be **4-1/24 inch** for considering shrinkage allowance.

Shrink rule for other materials

Material	Dimension	Shrinkage allowance (inch/ft)
Grey Cast Iron	Up to 2 feet	0.125
	2 feet to 4 feet	0.105
	over 4 feet	0.083
Cast Steel	Up to 2 feet	0.251
	2 feet to 6 feet	0.191
	over 6 feet	0.155
Aluminum	Up to 4 feet	0.155
	4 feet to 6 feet	0.143
	over 6 feet	0.125
Magnesium	Up to 4 feet	0.173
	Over 4 feet	0.155

2. The shrinkage allowance depends on the coefficient of thermal expansion of the material (**α**). A simple relation indicates that higher the value of ***α***, more is the shrinkage allowance.
3. For a dimension 'l', shrinkage allowance is $\alpha l\,(\theta_f - \theta_0)$. Here θ_f is the freezing temperature and θ_0 is the room temperature.
4. Machining allowance: will take care of the extra material that will be removed to obtain a finished product. In this the rough surface in the cast product will be removed. The machining allowance depends on the size of the casting, material properties, material distortion, finishing accuracy and machining method.

A Ghosh and A K Mallik, *Manufacturing Science*

Machining allowances of various metals

Metal	Dimension (inch)	Allowance (inch)
Cast iron	Up to 12 12 to 20 20 to 40	0.12 0.20 0.25
Cast steel	Up to 6 6 to 20 20 to 40	0.12 0.25 0.30
Non ferrous	Up to 8 8 to 12 12 to 40	0.09 0.12 0.16

5. Draft allowance:

All the surfaces parallel to the direction in which the pattern will be removed are tapered slightly inward to facilitate safe removal of the pattern. This is called ‘draft allowance’.

General usage:

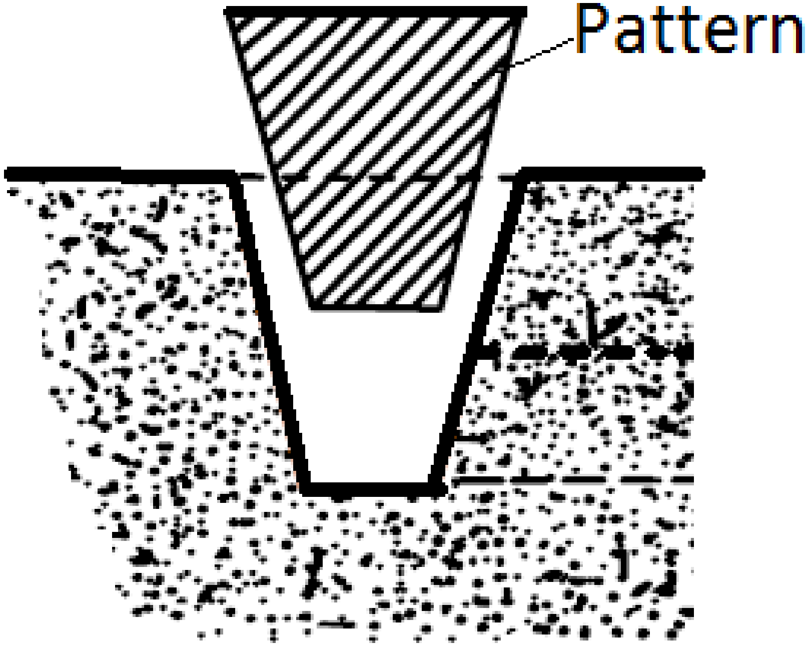
External surfaces ; Internal surfaces, holes, pockets

Typical Draft Allowances

Pattern material	Height of the given surface (inch)	**Draft angle (External surface)**	**Draft angle (Internal surface)**
Wood	1	3.00	3.00
	1 to 2	1.50	2.50
	2 to 4	1.00	1.50
	4 to 8	0.75	1.00
	8 to 32	0.50	1.00
Metal and plastic	1	1.50	3.00
	1 to 2	1.00	2.00
	2 to 4	0.75	1.00
	4 to 8	0.50	1.00
	8 to 32	0.50	0.75

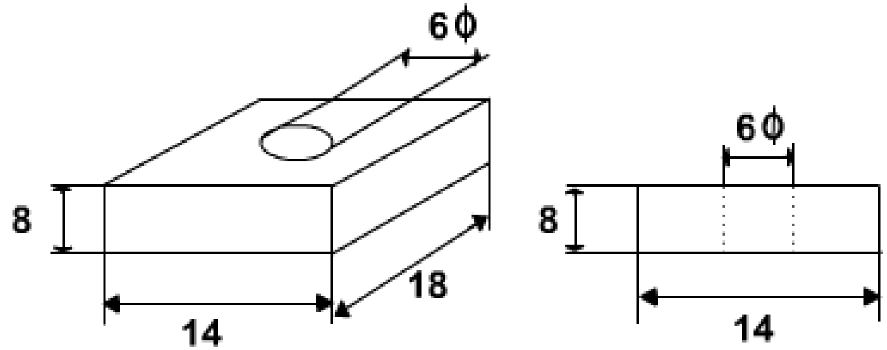
cracks

Pattern having no draft on vertical surfaces



Pattern having draft allowance on vertical surfaces

The casting shown is to be made in CI using a wooden pattern. Assuming only shrinkage allowance, calculate the dimensions of the pattern. All dimensions are in inches



Material	Dimension	Shrinkage allowance (inch/ft)
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	2 feet to 6 feet	0.191
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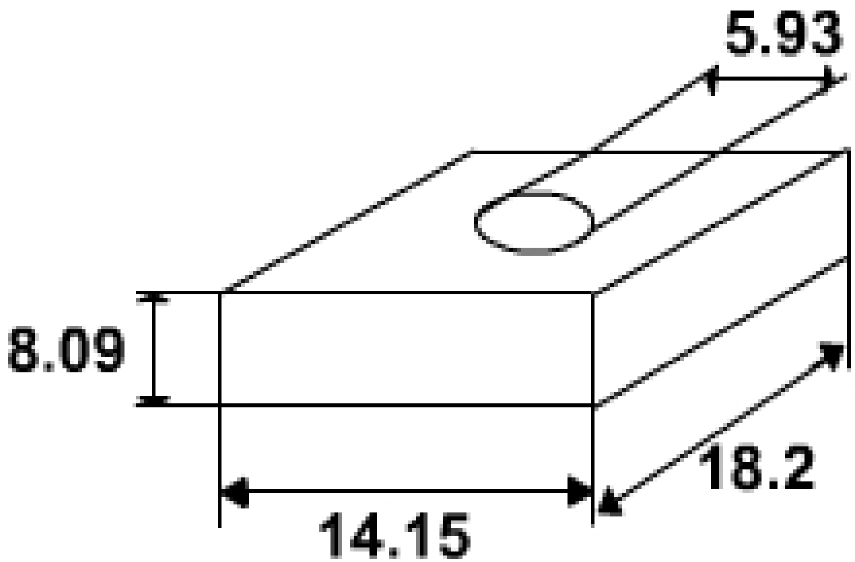
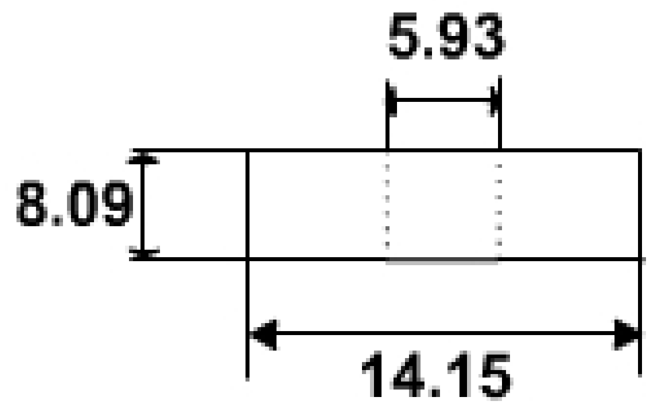
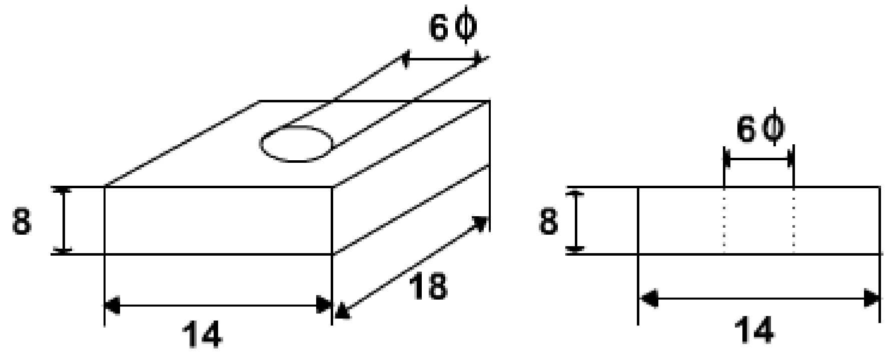
	4 feet to 6 feet	0.143
	over 6 feet	0.125
Magnesium	Up to 4 feet	0.173
	Over 4 feet	0.155

NPTEL course on Manufacturing processes – I, Pradeep Kumar et al.


5.93
8.09
14.15
18.2


5.93
8.09
14.15

The casting shown is to be made in CI using a wooden pattern. Assuming only machining allowance, calculate the dimension of the pattern. All dimensions are in Inches



Metal	Dimension (inch)	Allowance (inch)
Cast iron	Up to 12 12 to 20 20 to 40	0.12 0.20 0.25
Cast steel	Up to 6 6 to 20 20 to 40	0.12 0.25 0.30
Non ferrous	Up to 8 8 to 12 12 to 40	0.09 0.12 0.16

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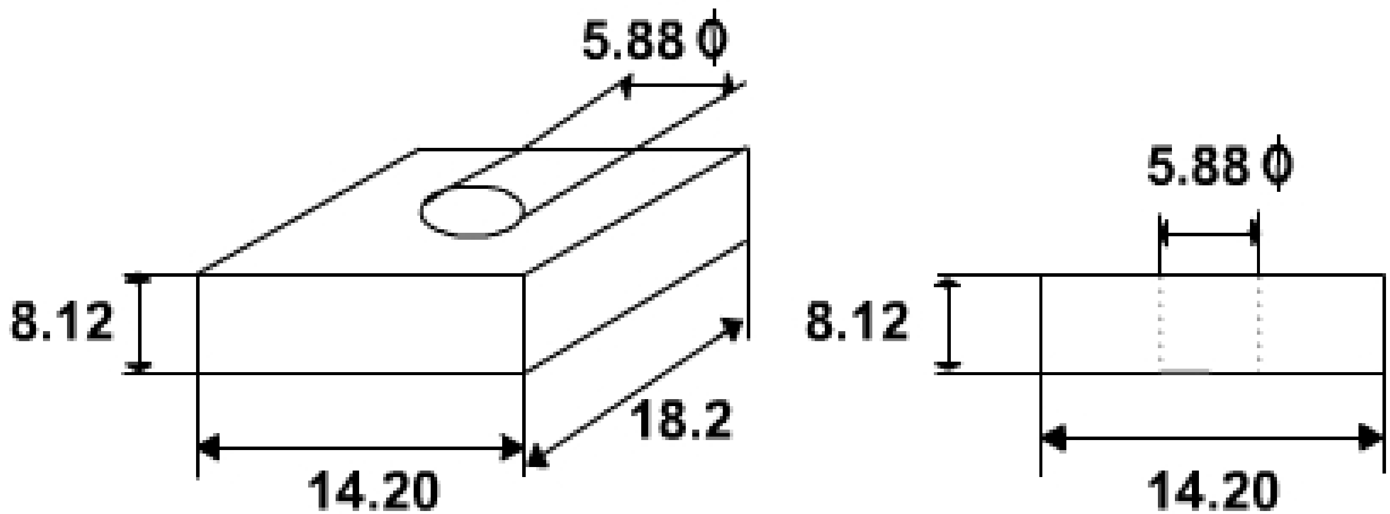
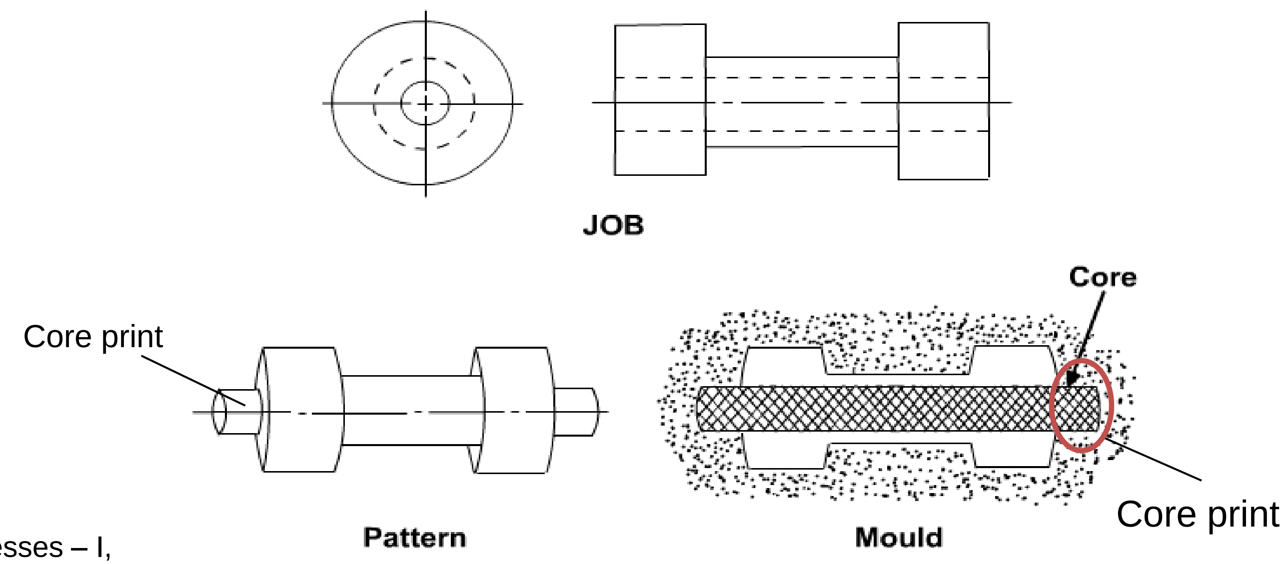

5.88 ϕ
8.12
14.20
18.2
5.88 ϕ
8.12
14.20

6. Core and core print:

- Cores are used to make holes, recesses etc. in castings

- So where coring is required, provision should be made to support the core inside the mould cavity. Core prints are used to serve this purpose. The core print is an added projection on the pattern and it forms a seat in the mould on which the sand core rests during pouring of the mould.

- The core print must be of adequate size and shape so that it can support the weight of the core during the casting operation.



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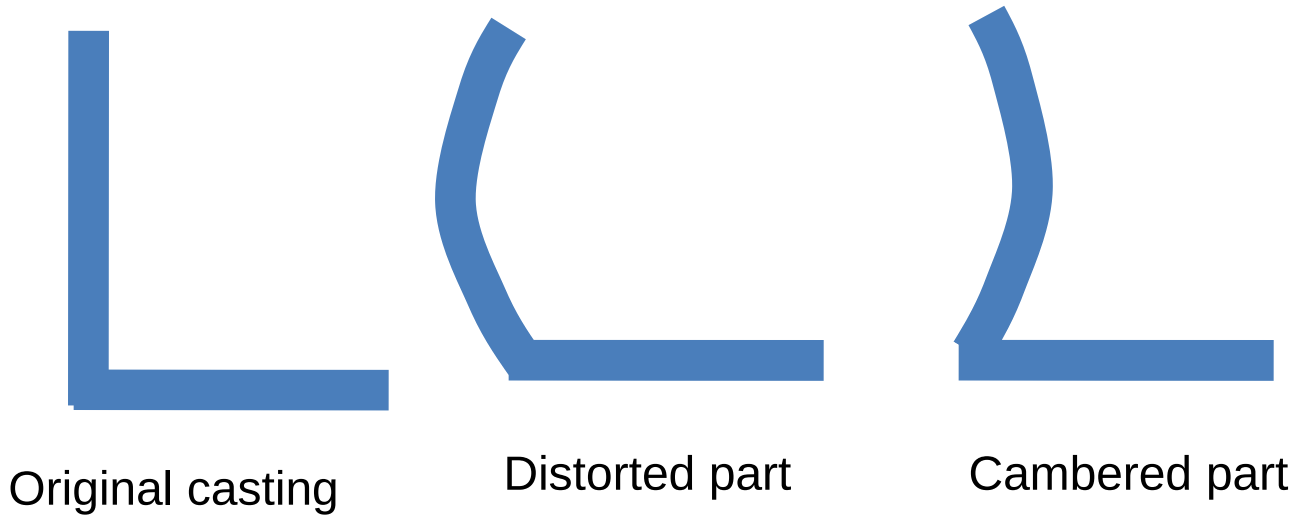
7. Distortion allowance (camber)

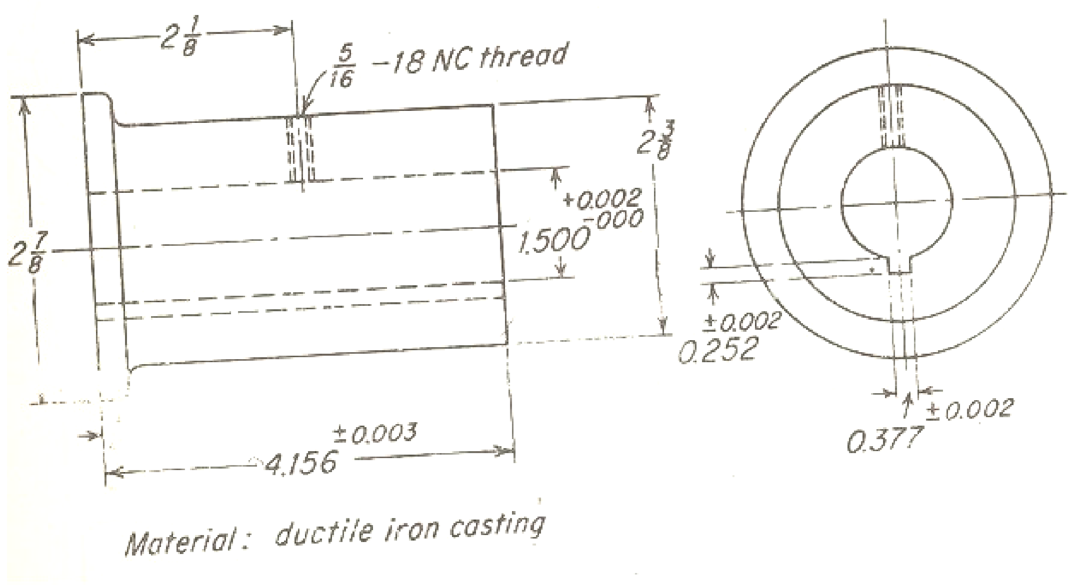
- Vertical edges will be curved or distorted
- This is prevented by shaped pattern converge slightly (inward) so that the casting after distortion will have its sides vertical
- The distortion in casting may occur due to internal stresses. These internal stresses are caused on account of unequal cooling of different sections of the casting and hindered contraction.

Prevention:

- providing sufficient machining allowance to cover the distortion affect
- Providing suitable allowance on the pattern, called camber or distortion allowance (inverse reflection)



8. The tapped hole and slot will not be sand cast. They will be made by machining operations.
9. The pattern shown is made in two halves which are located by dowel pins. This is called ‘split pattern’.
10. Pattern material: wood => light, easily workable, minimum tendency for checking and warping



Pattern materials

- Patterns for sand castings are subjected to considerable wear and tear due to ramming action that is required and the abrasive action of the sand
- Should be impervious to moisture because of changing surroundings
- Made of: wood, metal, plastics, plaster and synthetic materials
- Woods => white pine, sugar pine; The wood should be straight grain, light, easy to work, little tendency to develop crack and warp.
- More durable: Mahogany
- For large castings: metal such as cast iron or aluminium
- When metal pattern are cast from the wooden master pattern, double shrinkage must be provided on the wooden master pattern
- Assume metal pattern is made of aluminium and castings are made of CI, the shrinkage allowance for the wooden master pattern is:

5/32 inch per foot for Al+ 1/8 inch per foot CI = 9/32 inch per foot

Solid shrinkage for cast metals

Material	Dimension	Shrinkage allowance (inch/ft)
Grey Cast Iron	Up to 2 feet	0.125
	2 feet to 4 feet	0.105
	over 4 feet	0.083
Cast Steel	Up to 2 feet	0.251
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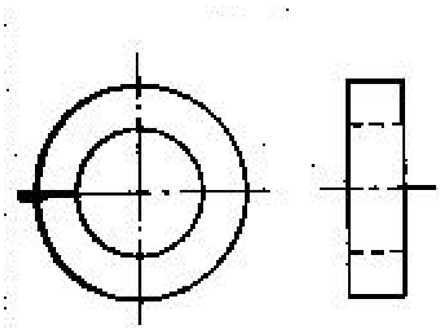
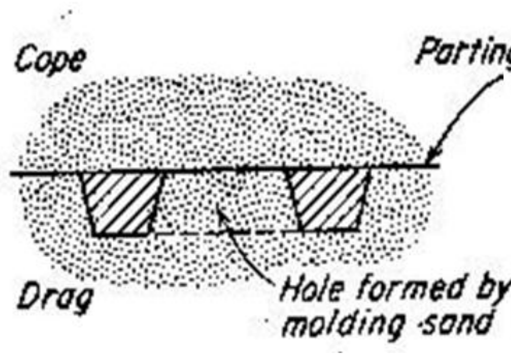
Aluminum	Up to 4 feet	0.155
	4 feet to 6 feet	0.143
	over 6 feet	0.125
Magnesium	Up to 4 feet	0.173
	Over 4 feet	0.155

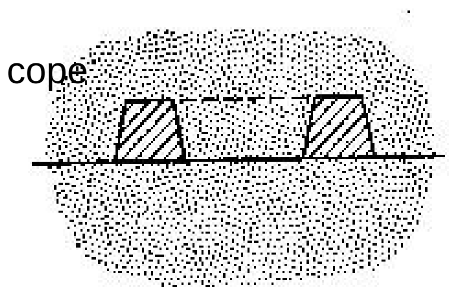
Different ways for making a casting mold

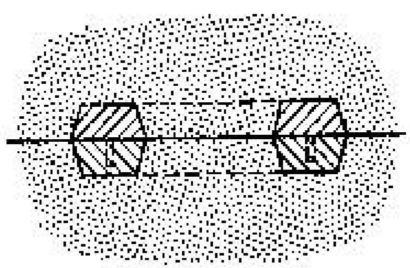


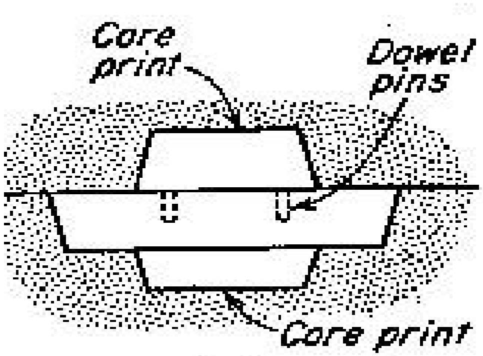
Simple bushing:
Sand casting to be molded

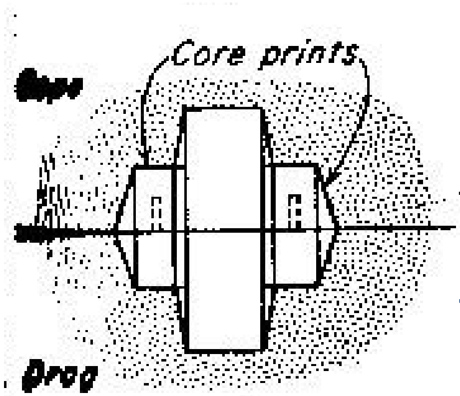


Flat back pattern can be used for this. In this after completing, the mold cavity is either in the drag side or in cope side or in both. The hole is formed by the molding sand.
The outside edge around the flat back is the parting line and it is the starting place for draft.
This is the simplest and easiest method.





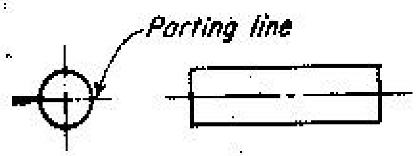




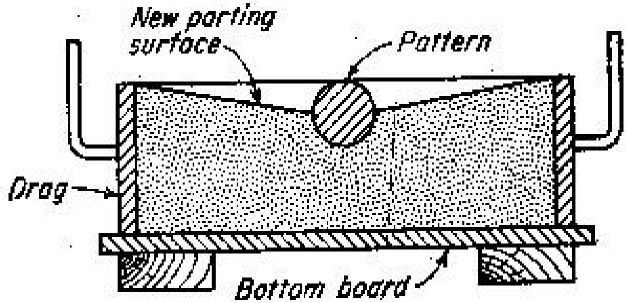
Using a dry sand core to obtain the core and this is split pattern. The axis of the hole (and core print) is vertical in first case.

The second case is same as first, except that the hole axis is horizontal.

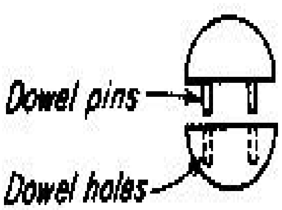
J S Campbell, *Principles Of Manufacturing Materials And Processes*

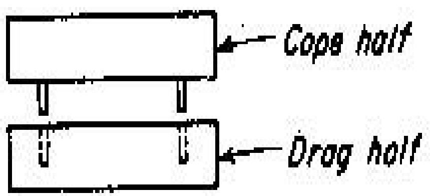


solid cylindrical pattern



Consider a solid cylindrical pattern as shown above. The pattern is placed on the molding board, rammed and rolled over. In order to withdraw the pattern from the sand, some of the sand is removed and smoothened as shown. This creates a new parting surface. Thus a parting line is made which joins parting line around the pattern. The operation of removing the sand and making a new parting surface is called 'Coping down'.
The mold is completed by ramming up the cope in a usual manner.





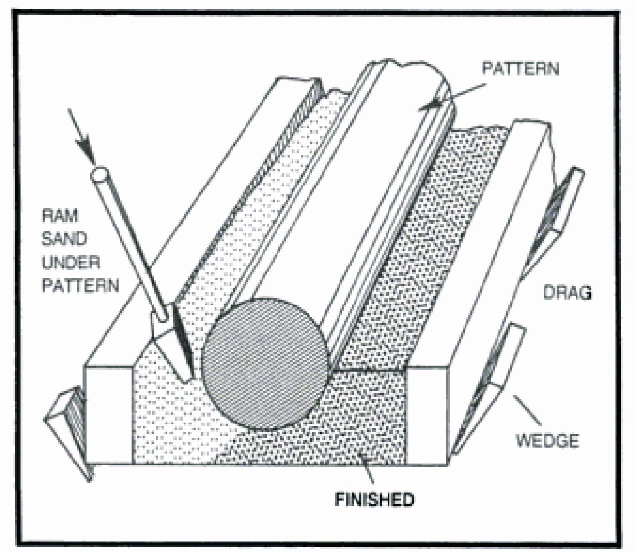
Split pattern for molding cylindrical casting

Other methods:

- cylindrical pattern standing on the end, if it were not too long
- cylindrical pattern can be molded using split pattern/mold also as shown in above figure.

J S Campbell, *Principles Of Manufacturing Materials And Processes*

Bedding-in method

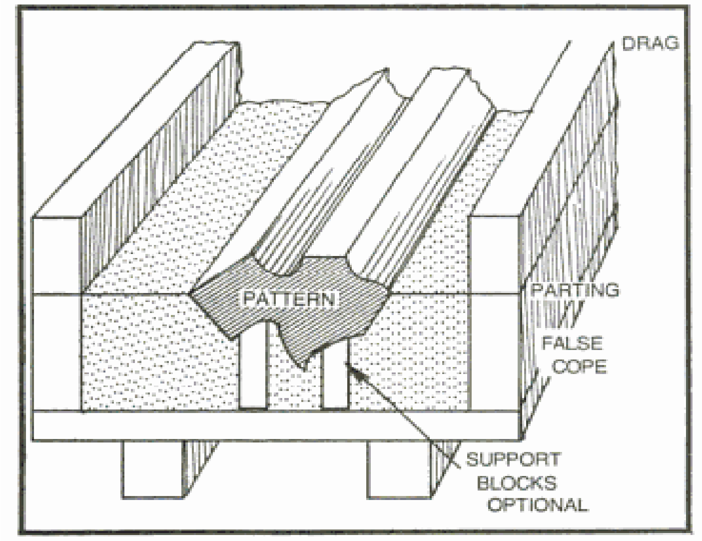


A complete handbook of sand casting, C.W. Ammen

- The solid cylindrical pattern can also be molded using 'bedding-in method'.
- In this method, first the drag is partially filled with molding sand and rammed.
- After sufficient ramming, the pattern is pressed into the sand. In this, to have proper ramming of sand, the sand close to the pattern is tucked and rammed tightly.
- Sometimes, the pattern is removed and the sand is surface tested for soft spots. In case of soft spots, ramming is continued with additional sand till the sand is packed tightly.

- The pattern is again pressed downwards to have a properly rammed mold cavity.
- Bedding-in is done so that the parting line is about level with the surrounding flat sand surface.
- Whenever a pattern is bedded-in, the drag need not be rolled over.
- Bedding-in can be employed for making larger molds using pit molding

False cope (sometimes called ‘odd side’)



A complete handbook of sand casting, C.W. Ammen

False cope technique is another method of molding the solid cylindrical pattern.

This is similar to bedding-in method, except that it is not required to ram the sand tightly under the pattern, or the pattern shape is such that it is not possible to ram the sand tightly.

The pattern is first bedded into the cope without giving importance to the ramming of sand beneath the pattern and a smooth parting surface is made.

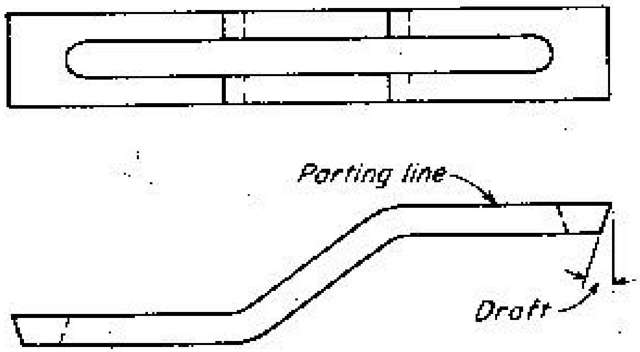
The cope and pattern is then dusted with parting sand and drag part of flask is placed on top of the cope. Ramming is then completed in a usual manner.

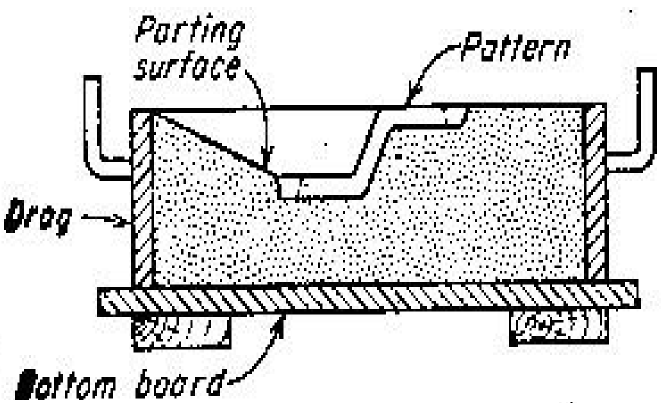
The entire assembly is clamped and rolled over on a sand bed. The clamps are removed and the cope, cope bottom board are removed and destroyed.

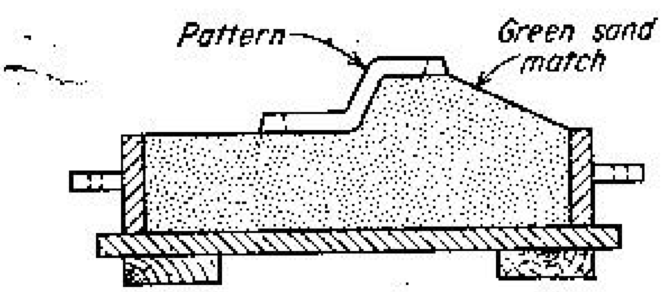
The empty cope is then placed on the drag and usual ramming is performed.

It should be observed that the cope, first used, is a dummy block for creating the drag correctly. This is called ‘FALSE COPE’.

Green sand match







Green sand match ready for further drag making

The main reason for making a green sand match is that the coping down operations can be reduced to a greater extent, reducing the costs and time.

Take an example like a pattern with a parting line not lying in one plane (shown in first figure).

This pattern should be supported on a moldboard at the elevated end by a wood piece.

Once the ramming, rolling over and coping down are completed, the drag will look like as shown in second figure.

On top of this drag, a green sand match may be rammed up extra hard without sprue and riser pins.

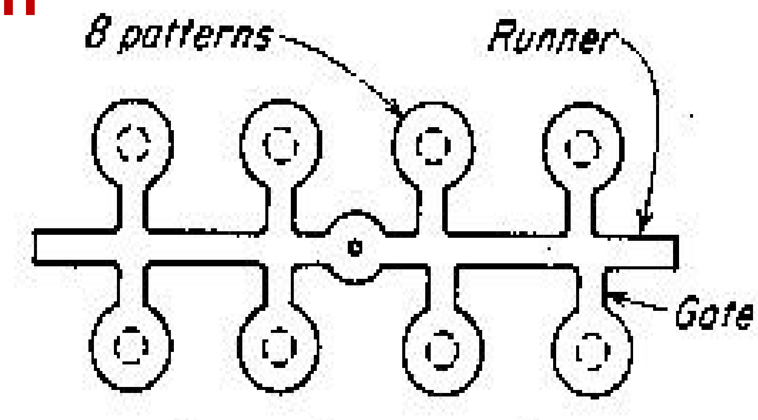
The completed **green sand match** with pattern in place is shown in last figure.

The sand match is now retained with the uneven parting surface to support pattern and for further making of rammed drags.

Also called hard sand match, POP match, cement match

J S Campbell, *Principles Of Manufacturing Materials And Processes*

Gated pattern



Gated pattern for making eight small patterns

In this, the gate is made part of the pattern.

In general, a gated pattern consists of many small patterns fastened together through gating.

Since gates, runners are part of the pattern, time and cost are not spent in making them separately.

A number of patterns are rapped and drawn from the mold at the same time, saving additional time.

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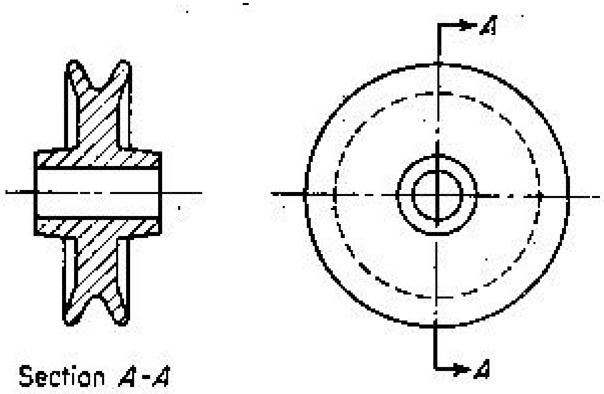
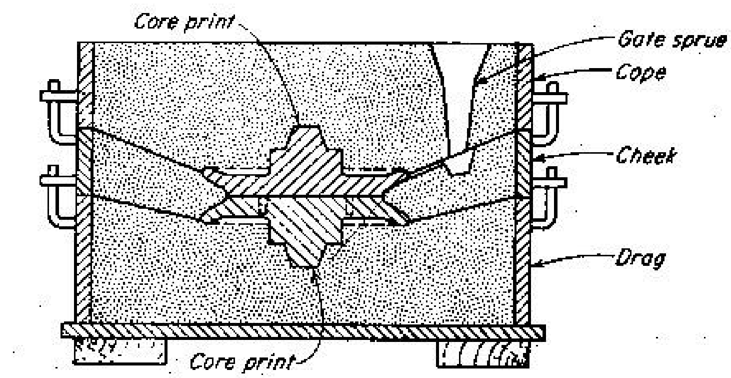
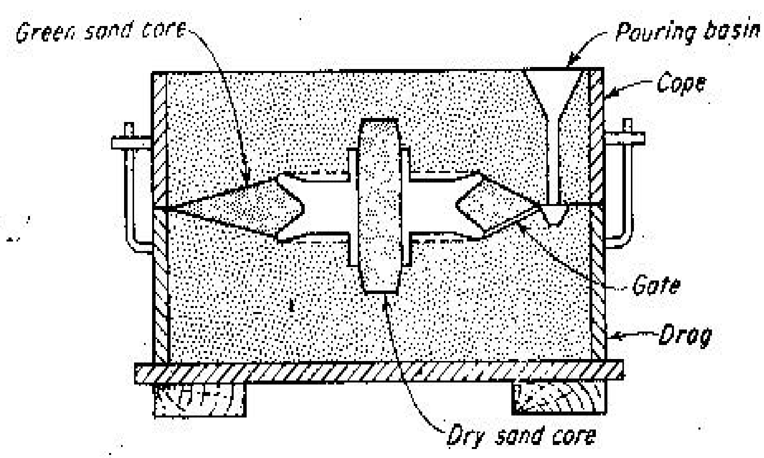
Patterns requiring two or more parting surfaces



Sheave wheel to be molded



Three part mold for sheave wheel casting



Using green sand core for making sheave wheel casting

- First method of making a sheave wheel mold is through three part flask, having a middle flask region called 'cheek'.

- another way is by using special green sand core.

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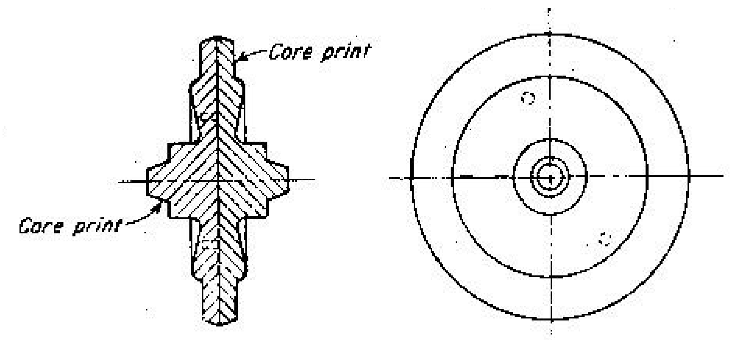
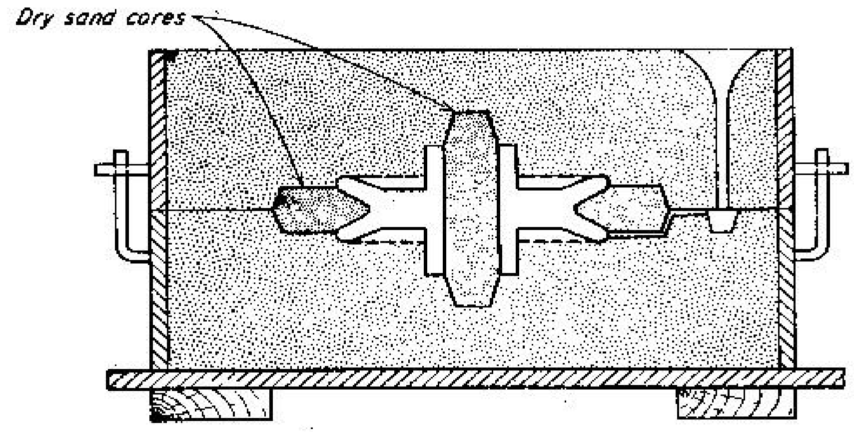
Cores for exterior casting surfaces



Pattern for making a sheave wheel casting using a dry sand core for groove making



Mold with dry sand cores for making a sheave wheel casting

- Dry sand cores can be used for making the grooves

- Usage of core box is required for making core which makes this method not suitable below certain quantity

- For large quantity, this method is preferred

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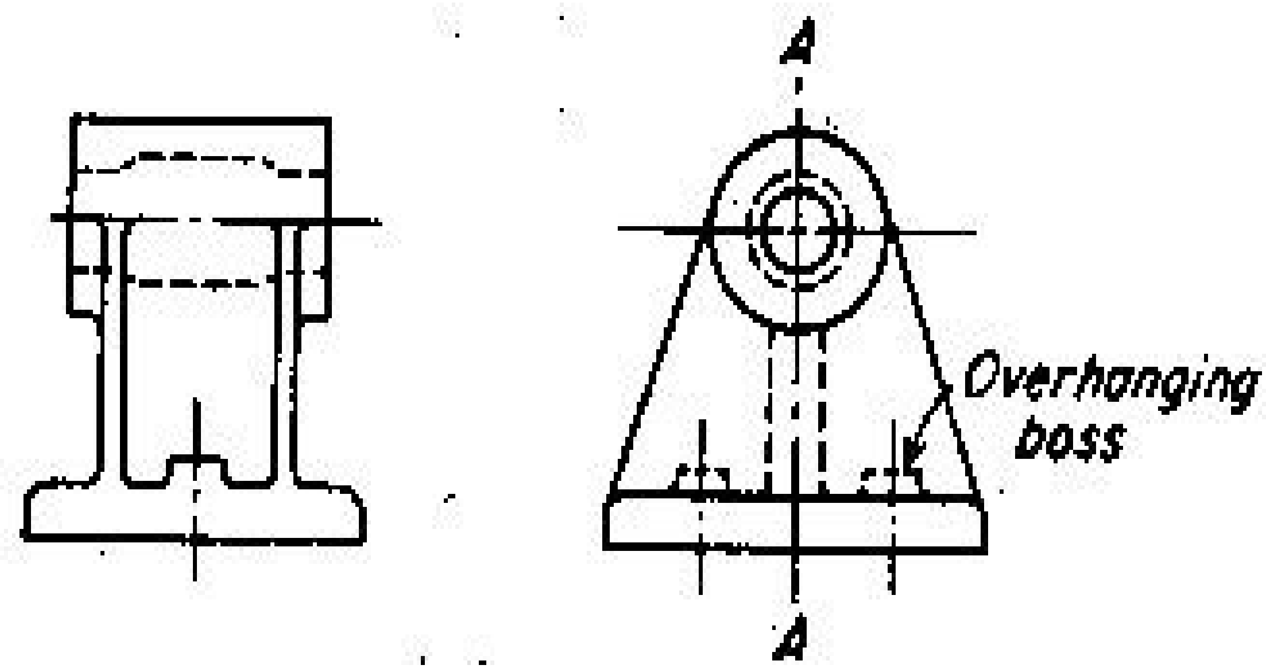
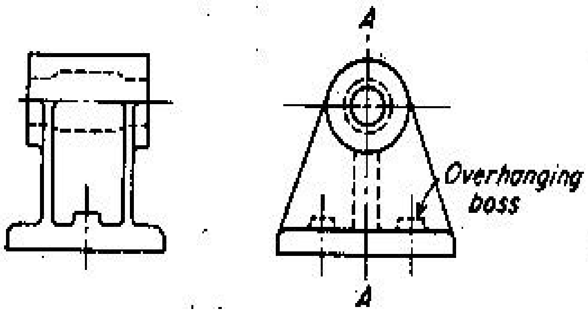
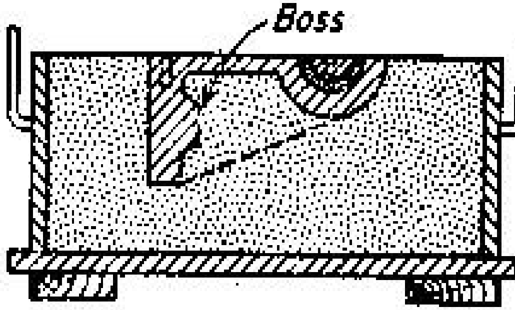


Bearing frame casting having overhanging bosses

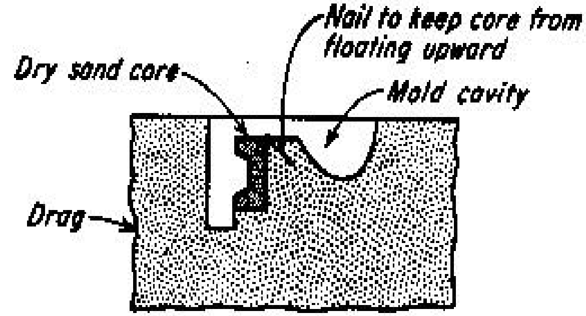
Cores for exterior casting surfaces



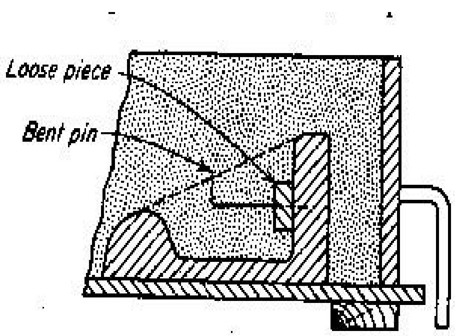
Bearing frame casting having overhanging bosses



Drag showing half of the pattern rammed up in the molding sand



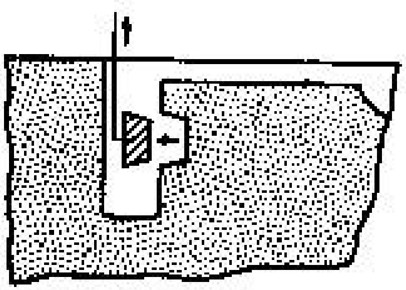
Using **<u>a dry sand core</u>** held using a nail to produce a boss



Using a dry core sand:

- The over-hanging bosses are made using core prints, dry sand core in place

-The dry sand core part is held in mold by using <u>a nail to keep the core from floating upward</u>. Chaplets can also be used (described later).

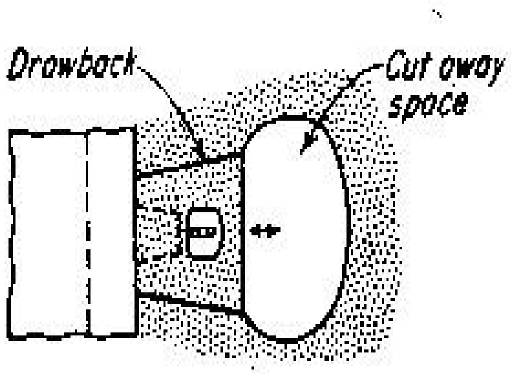


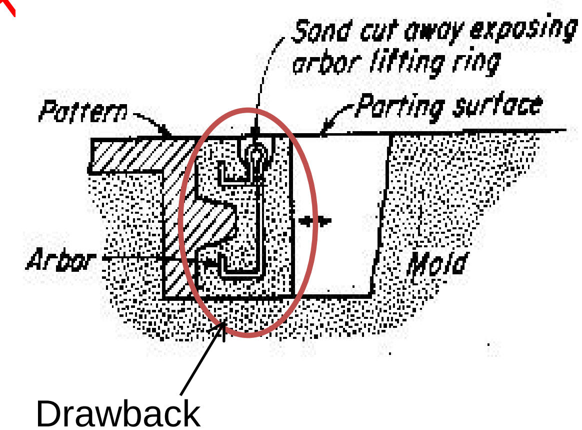
<u>Using a loose piece</u>

Using a loose piece:

- A loose piece is held by using a bent pin
- Ramming is done properly around the loose piece. Later pattern and pin are withdrawn carefully as shown.
- **Disadvantage:** shifting of loose piece while ramming
- Loose pieces are used in core boxes for making cores with backdraft (horizontal depression or projection)

Using Drawback





Drawback is employed for patterns with backdrafts (horizontal depression or projection).

A drawback consists of mold that can be drawn back in order to remove the pattern.

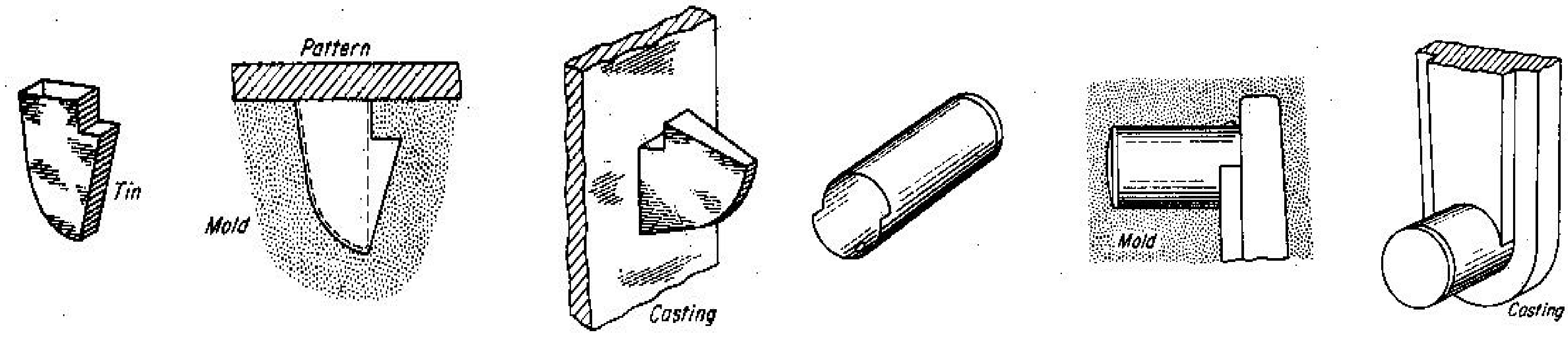
As shown in figure, a drawback is rammed around a rigid support called **‘arbor’** that is used to move it.

Drawback is like a green sand core rammed up against the mold instead of making it in core box.

Once the pattern is removed, the drawback is located in the original place. It is backed up with additional sand so that it will not displace during fluid filling.

It is also used for large molds for certain castings.

Tins



• Tins are made of sheet metal shapes that are used with patterns to make certain internal and external shapes, but at the same time patterns can be removed from the mold cavity

• They are thin hollow sheet metal shells that are attached to pattern before the pattern in rammed up in sand

• When the pattern is withdrawn, they remain in mold and should fuse into the casting

• For ferrous castings, a tin plated sheet steel of about 0.012 inch thick is used

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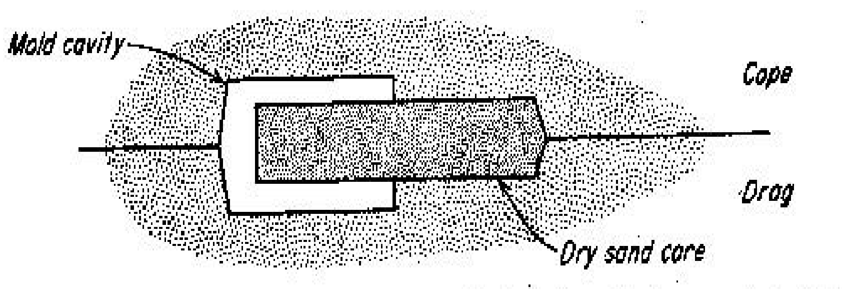
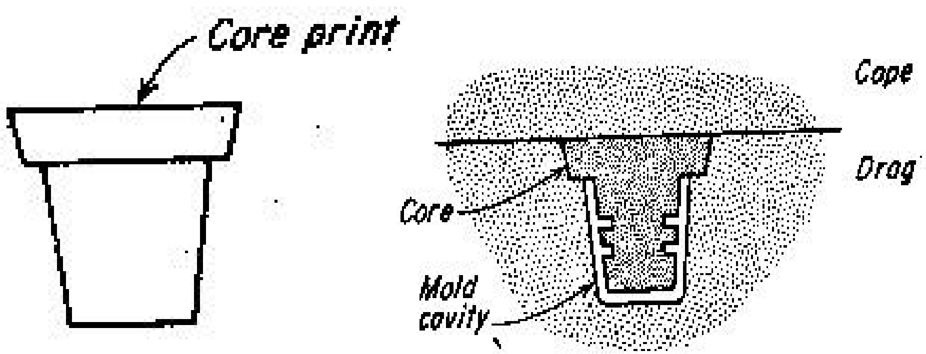
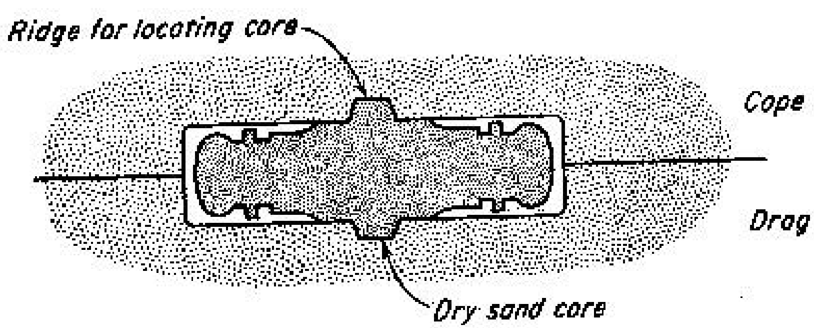
Core and core print



Where a core does not extend entirely through the casting, it should be fixed/balanced properly as shown. Too long cores can not be balanced properly.

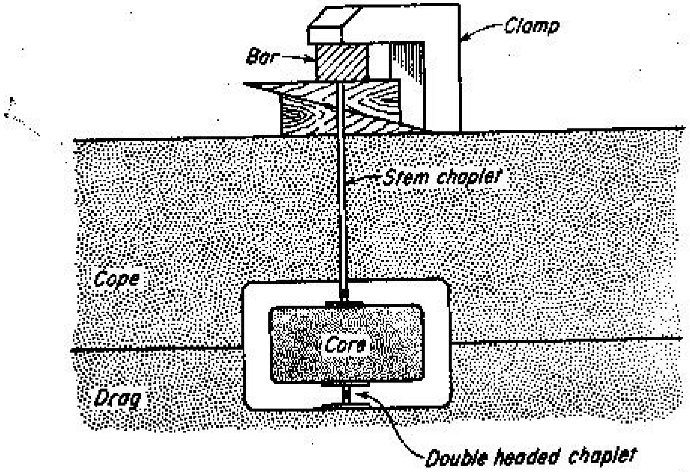


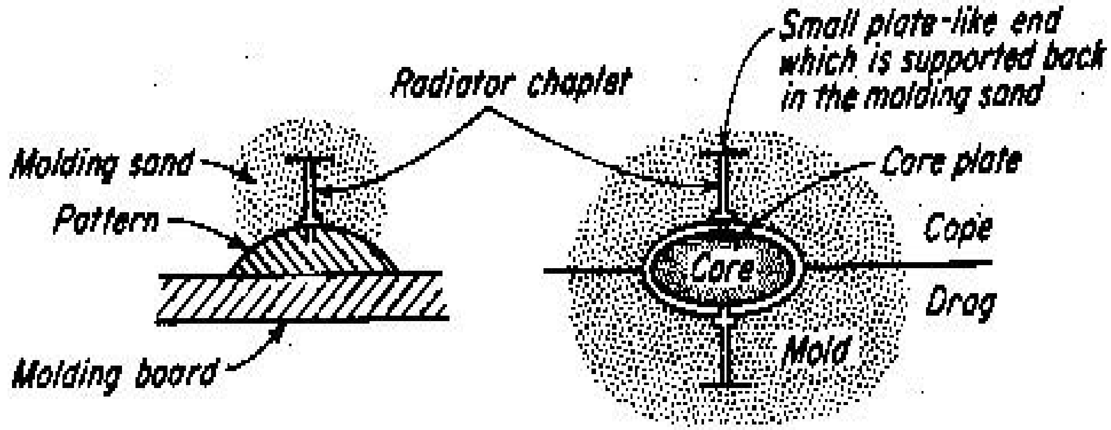
A pattern with a hanging core print is shown for making a piston. The core in the mold acts as a cover for mold cavity and hence cope is not needed.



A method for molding two pistons at a time having one balanced core.

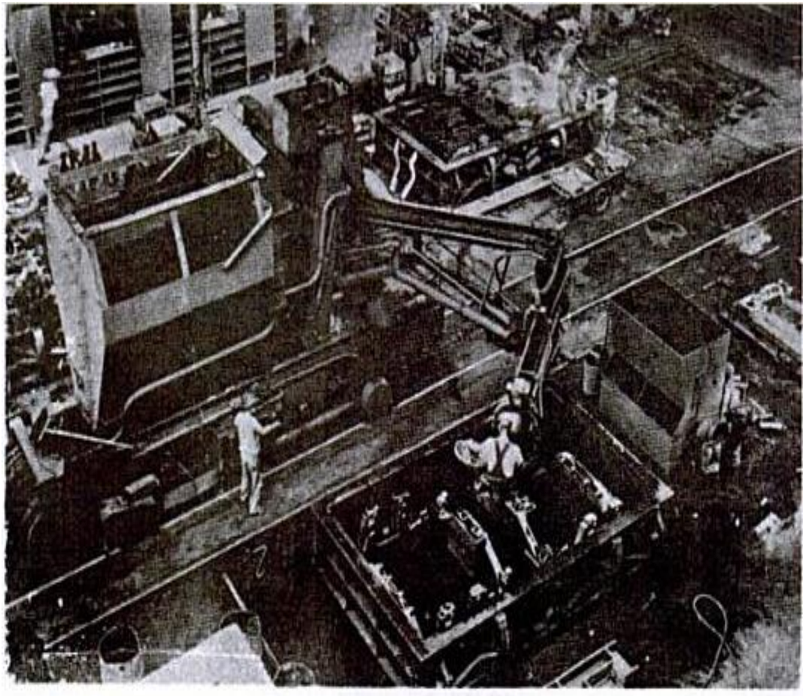
Using chaplets





- Chaplets are used to support a core and are placed between a core and the mold wall.
- As the mold is filled with molten metal, the chaplet prevents the core to float and move upwards dislocating from its position.
- The part of chaplet in mold will be fused into the casting.
- chaplets not fused properly will create mechanical weakness and mold wall leak.
- They are generally made heavier rather than lighter, such that they seldom unite with the surrounding metal.
- Tin or copper plated chaplets are used for ferrous castings to avoid rusting.
- Radiator chaplets having a flat square ends are fixed in the pattern itself and will provide good support to core along with rammed sand.

Ramming a large mold



- First few inches of sand over the pattern should be carefully rammed and tightly packed.
- soft spots, packets should be rammed properly
- Large mold of considerable depth should be rammed layer by layer
- Floor rammers that are heavy and measure up to 5 feet long can be used. The molder will stand on the rammed sand.
- Nowadays pneumatic rammer is operated by compressed air with a butt shaped end
- Ramming should be done as close to vertical surfaces of pattern

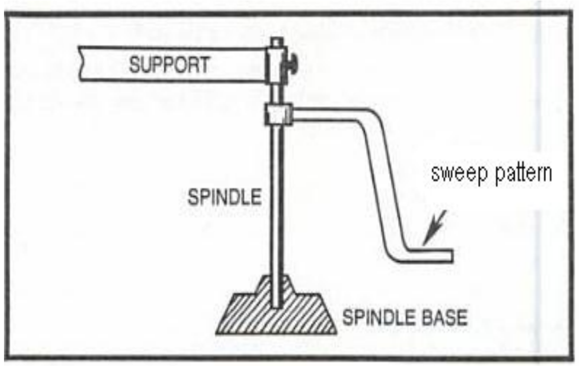
Pit molding

Pit mold for diesel engine

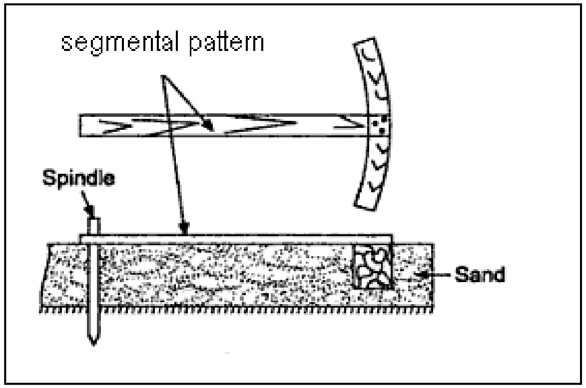
- Large castings are made in pits in foundry floor. Reinforced concrete is used to make sides and bottom of pits.
- a bed of charcoal is used at the bottom of a pit to aid the escape of gases.
- bedding-in technique may be used since rolling over of drag is not possible.
- appropriate placing of pattern is done.
- several cores can be used for making delicate shapes.
- Pit molding may take few days to weeks for completion, and hence binders are added to the molding sand which harden when air-dried.
- sometimes, the mold cavity is heated to harden with time, by placing a stove down into the mold cavity and covering the entire mold to keep the heat inside the cavity.
- slow cooling of molten metal is allowed so that the internal stresses can be minimized.

Low cost patterns for large molding

Meant for large, but few, castings: sweep, segmental pattern, partial pattern, skeleton pattern



Sweep pattern: A sweep pattern consists of a board having a profile of the desired mold, which is revolved around a spindle or guide produces the mold. Two are used – one for sweeping the cope and other for drag.

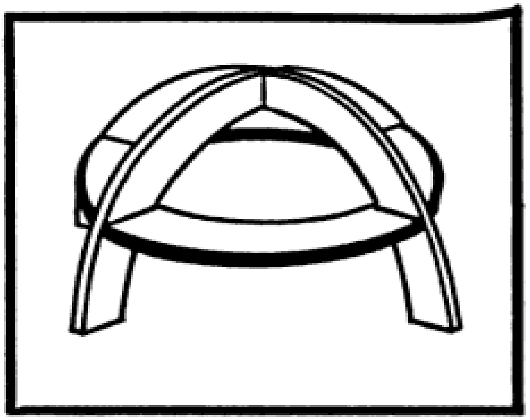


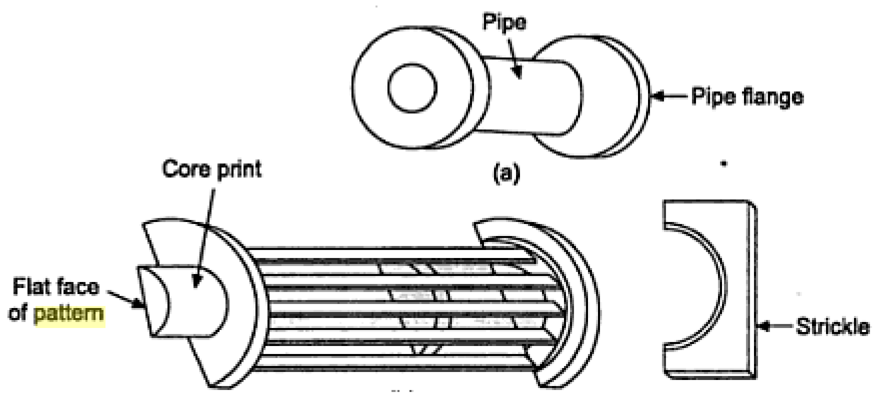
Segmental pattern: meant for circular ring shaped large sections. Instead of using a full pattern, part pattern is used. Once molding is done at one place, it is rotated to the adjacent region and molding is done.

Manufacturing Processes, By Kaushish

A complete handbook of sand casting, C.W. Ammen

Skeleton pattern:





Manufacturing Processes, By Kaushish

This consists of frame of wood representing the interior and exterior forms. Strickles (like strike off bars) are used to remove excess sand which is purposely rammed with extra thickness than required for desired mold surfaces

Loam molding: Loam consists of 50% clay as compared to ordinary molding sand. Mixed consistently to resemble mortar. Loam is applied on the surface of the brick framework. The molds are dried in ovens before put into use.

This was used for making casting bells for cathedrals or cannons for war in 13th century

Ingredients used in sand for making molds/cores

Refractory sand grains	Binder	Facing material	Cushion
Silica Zircon (has chilling properties) Olivine Magnesite Dolomite Sillimanite Carbon Coke	For bonding materials see next table *Note:* Cle required with practically all binders.	Sea coal Pitch (dry powder) Graphite Coke Silica flour	Wood flour Cereal hulls Cereal Cellulose Sea coal Coke Perlite (a siliceous lava, quick heating causes bubbles of steam, also has insulating properties)

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Binders Used in Sand Casting for Molds, Cores

Clays:

Fire clay (kaolinite)

Southern bentonite (calcium montmorillonite)

Western bentonite (sodium montmorillonite)

Secondary mica clays (illite)

Oils:*

Vegetables (e.g. linseed oil)

Marine animal (e.g., whale oil)

Mineral (used for diluting oils given above)

Synthetic resins, thermosetting:*‡

Urea formaldehyde

Phenol Formaldehyde

Cereal binders made from corn:*

Gelatinized starch (made by wet milling, contains starch and gluten)

Gelatinized corn flour (made by dry-milling hominy)

Dextrin (made from starch, a water-soluble sugar)

Wood –product binders:*‡

Natural resin (e.g., rosin, thermoplastic)

Sulfite binders (contain lignin, produced in the paper pulp process)

Water-soluble gums, resins, and organic chemicals

Protein binders (containing nitrogen):*

Glue

Casien

Other binders:

Portland cement†

Pitch (a coal-tar product)*†

Molasses (usually applied in water as a spray)

Cements (e.g., rubber cement)†

Sodium silicate (water glass, CO_2 hardening binders)†

* Harden by baking.

† Harden at room temperature.

‡ Available as either a liquid or a dry powder.

Natural and Synthetic molding sand

Natural molding sand:

This is ready for use as it is dug from the ground. Good natural molding sand are obtained from Albany, New york etc.

The following average compositions are seen in natural molding sand:
65.5% silica grains, 21.7% clay content, 12.8% undesirable impurities.

Too much clay content and other impurities fill up the gaps between the sand grains. This will hinder the necessary passage of steam and other gases during pouring of the mold.

Synthetic molding sand

Synthetic molding sand is made by mixing together specially selected high quality clay free silica, with about 5% of clay. They are tailor made to give most desirable results.

Some of the advantages of synthetic molding sand are:

1. Refractory grain sizes are more uniform, 2. Higher refractoriness (= 3000^{o}F), 3. less bonding agent is required (about 1/3rd of the clay percentage found in natural molding sand), 4. More suitable for use with mechanical equipment

Advantages of natural molding sand: 1. moisture content range is wide, 2. molds can be repaired easily

Core making

• Generally Cores are used for making interior surfaces of hollow castings and now-a-days it is used for making exterior surfaces and for other purposes.

• Green sand cores contain ordinary molding sand and dry sand core contains hardened or baked sand.

• Core mix contains clay free silica sand. This is suitably mixed with binders, water and other ingredients to produce a core mix.

• Synthetic core binders have some unusual properties like shorter baking times and excellent collapsibilities which reduces the defect castings.

• Urea formaldehyde binders burn out faster and collapse at lower temperature as compared to phenol formaldehyde binders. Thus urea formaldehyde binders are suitable for use at lower temperature metals like Al, Mg, thin sections of brass, bronze.

• Phenol formaldehyde binders are employed for thick sections of CI, steel castings

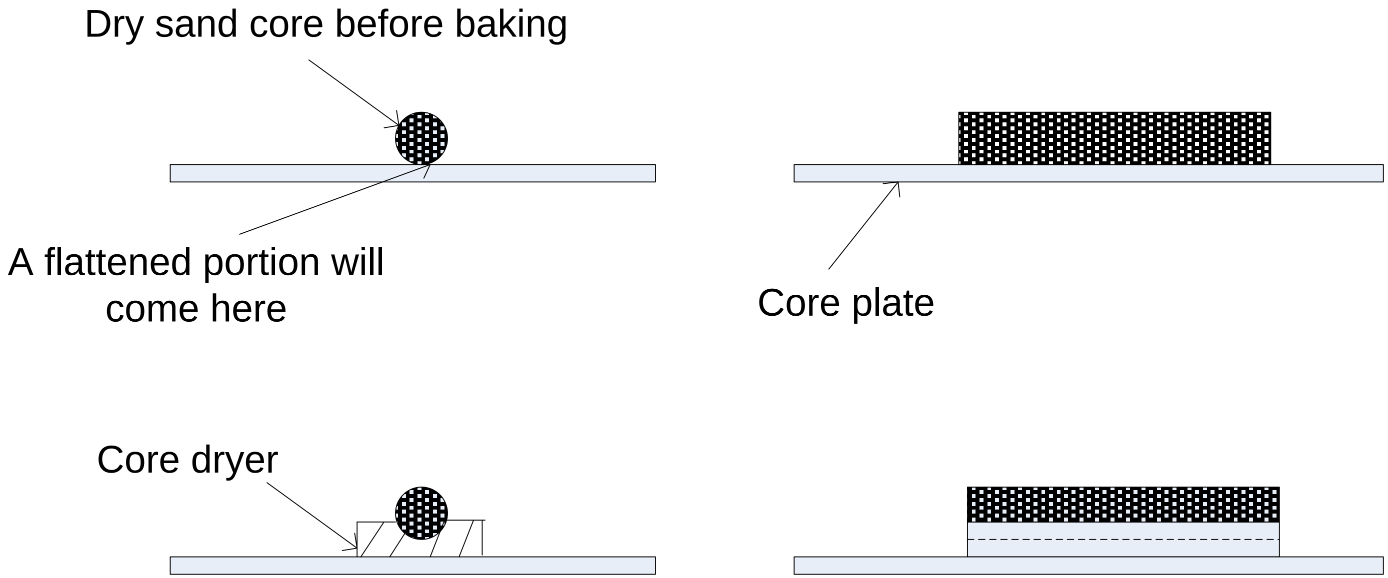
Core characteristics

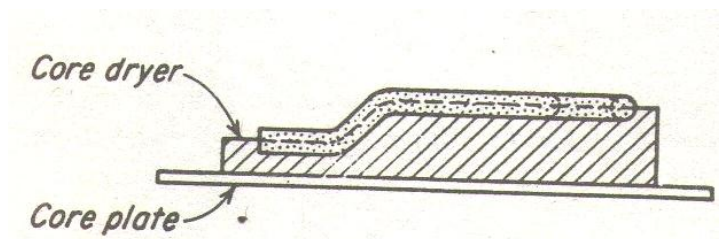
Good dry sand cores should have the following characteristics:

1. Good dry strength and hardness after baking
2. Sufficient green strength to retain the shape before baking
3. Refractoriness
4. Surface smoothness
5. Permeability
6. Lowest possible amount of gas created during the pouring of casting

Core dryers

- cores must be supported properly in the green state, before they are baked, hardened.
- Curved surfaces of the cores will be flattened if placed on the flat core plates
- Cores should be prevented from sagging and breaking
- Flat surfaces are required for supporting the cores. These are called ‘Core dryers’. They are designed to support the cores.





• Core dryers may be made as metal castings, with thin sections in order to absorb minimum heat.

• They are perforated for easy escape of gases.

• For large quantity production, many core dryers are required.

Loose pieces in core boxes

- Loose pieces are required for cores having backdraft on vertical sides. Such a loose piece will form an entire side of the core.
- The loose piece remains on the core, which will be removed later by horizontal movement.

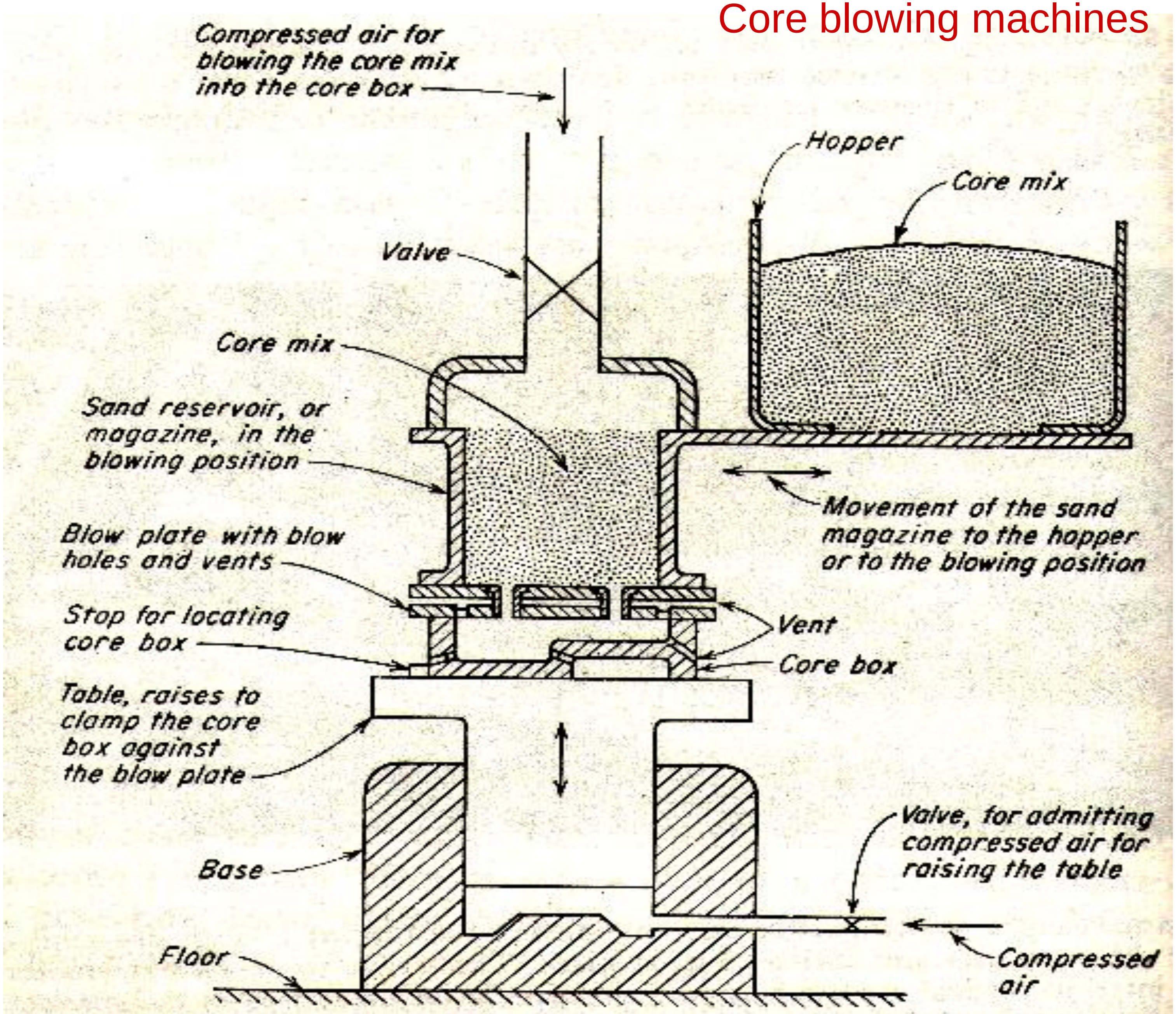
Core wires, rods, arbors

- Small core have sufficient strength after baking to withstand the molten metal upward force. For iron castings the lifting force is four times the weight of a core.
- Certain cores and slender cores which do not have strength are supported by embedding wires, rods, arbors into the core sections.
- Wires are meant for small cores, where as arbors are CI or steel based skeleton structures. Removing arbors is an issue here, sometimes arbors are made in parts, bolted together to facilitate easy removal. Hooks are provided in the arbors for easy removal. They sometimes project outside the core prints.

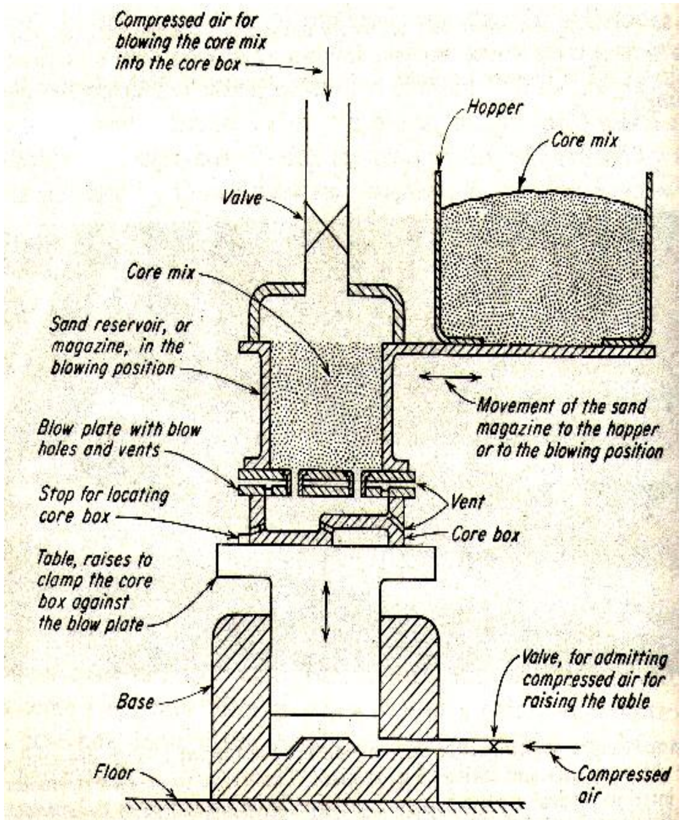
Core venting

- Proper core venting is required especially if the cores are surrounded largely by molten metal. The cores containing binders will produce gases, steam because of the heat generated due to molten metal.
- These gases should be vented out through core prints so that defects like 'blows' can be avoided.
- Large cores are sometimes made hollow.

Core blowing machines



Core blowing machines



- Core blowing machines are mainly suitable for large quantity parts manufacturing.
- The sand reservoir is first moved below the hopper, where it is filled with sand.
- The sand reservoir is then moved to the blowing position. The core box is placed on the table and pressed up with the blow plate.
- The core box is rapidly filled with sand using a blower at the top with the help of compressed air at high pressures.
- The air thus got trapped in the core box is vented out by suitable vents provided in the core box.
- It is generally understood that because of blowing operation, larger grains tend to move to the interior of the core and finer grains at the surface, creating a smoother surface.

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Core box equipment for core blowing

• Core box should be complemented with core dryers for proper support, a blow plate to fasten to the reservoir

• The core box contains blowing holes and the number, locations, size of the blowing holes are important in proper filling of the core box. This prevents the presence of soft cores and soft spots.

• vent area to blowing hole area is 5:1

• Sometimes the sand grains may not be conveyed properly due to the presence of entrapped air channels.

• For continuous operation of the machine, many duplicate core boxes should be used. Conveyors are also used to handle the operations properly.

• The upper half of the core box is sometimes used as the blow plate that is fastened to the sand magazine.

• CORE SHOOTING can also be used to prevent some of the difficulties of core blowing.

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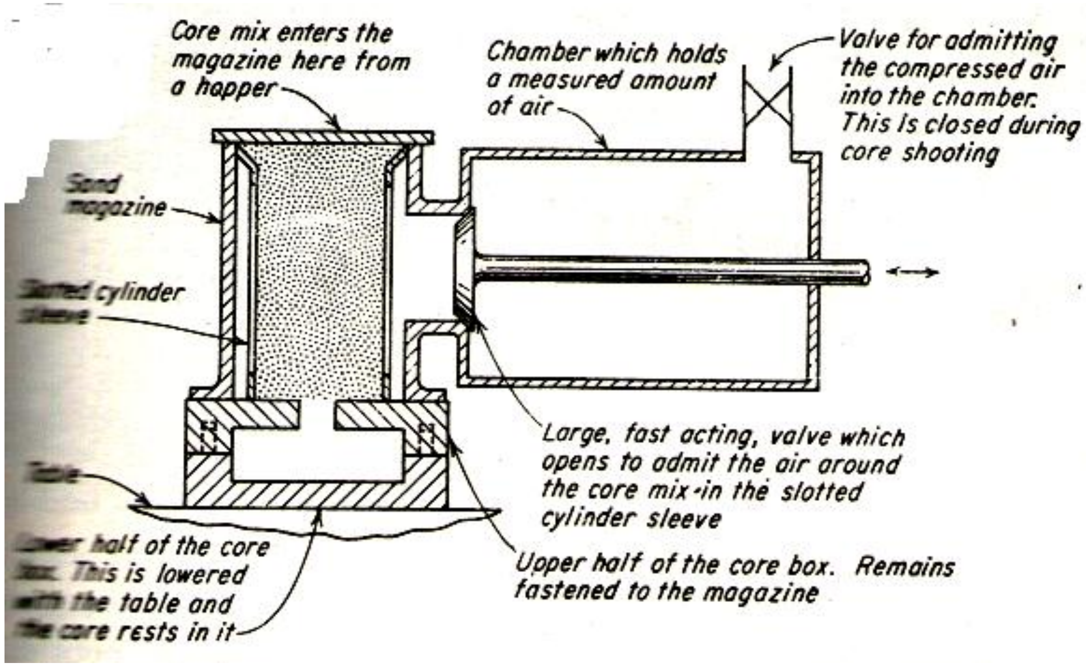

CORE SHOOTING MACHINE

- Compressed air is admitted into the chamber and the chamber is closed during core shooting
- large, fast acting valve is opened to admit the air around sand magazine
- this pressurizes the core mix and because of which sand gets filled in the core box

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Core baking

- After cores are made and placed on the core dryer, they are taken to ovens for baking
- Baking removes moisture and hardens core binders
- generally core sand is a poor conductor of heat and hence heat penetrates slowly into the interior sections of the cores
- In a core having thin and thick sections, the thin sections will be over baked, while thick sections will be optimally baked
- Over baking of cores will result in destroying the binders and hence core will be just a heap of sand
- Large core will be baked differently on the surface and in interiors, especially if the oven is too hot
- cores that are not baked fully will create an excess of gas and cause blows in castings

Core ovens

Continuous ovens:

- Are those through which the core moves slowly on the conveyor.

- Continuous loading and unloading is followed and hence the baking time is controlled by the rate of travel of the conveyor.

- Generally same sized cores are used in this.

Batch type ovens:

- No movement of cores occur

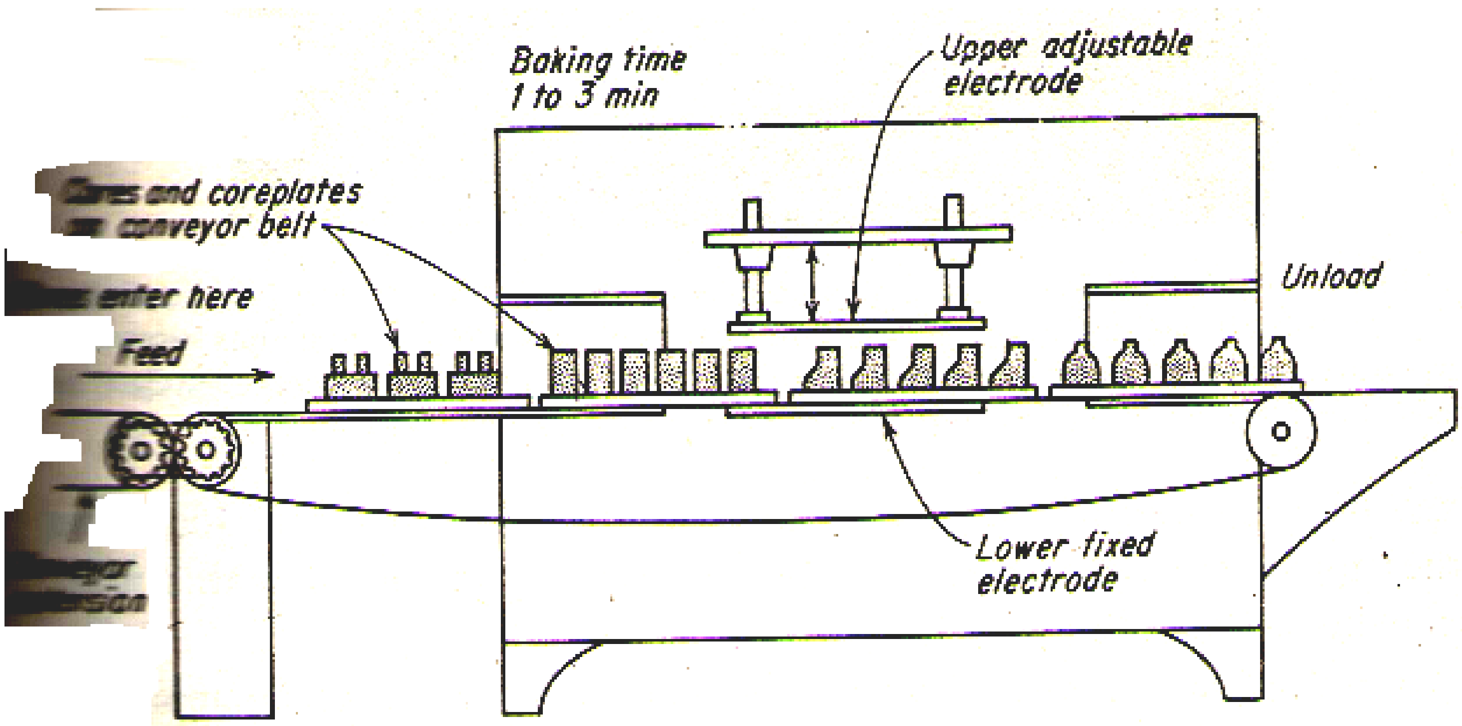
- Electricity, gas, oil are used for heating and temperature is maintained uniformly and closely controlled by suitable instruments.

- Temperature is of the order of 450^oF and this depends upon the binder.

- heating elements are properly spaced to have uniform/same temperature distribution throughout the container.

- replacing new air from outside is done through blowers so that moisture can be controlled.

Dielectric core baking



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- Rapid baking is possible by dielectric heating.
- Induction heating: used for heating materials which are conductors of electricity, like metals, and is done in continuously varying magnetic field.
- Dielectric heating is done for non-conductors of electricity. In this alternating electric field is established betn two parallel plates which act as an electric condenser.

- The material to be heated is placed in between these parallel electrodes
- With a high frequency electric current (15 million times/sec) in ON condition, heat is generated into the molecules.
- IN this case, the interior of the cores are heated rapidly as outer surfaces.
- Thermosetting synthetic resin binders, which cure app. at 250°F and which do not require oxidation are well suited for dielectric heating.
- Small sized samples can be baked within 30 secs, while large sections need few minutes
- less chance of over baking or under baking

Core coatings

- A fine refractory coating or facing is generally applied on the core surface by spraying or by dipping the core into a tank containing facing liquid
- this is done to have a smoother cast surface by preventing the penetration of molten metal into spaces between sand grains.
- Facing materials: finely ground graphite, silica, zircon flour
- after coating, the layer is dried, usually by torches, burners

Green sand cores

- Yield considerable cost savings.
- Handling them and keeping them in mold is tricky.
- Method 1: A green sand core can be rammed up on the dry sand core base.
- Method 2: Ram the green sand core around an arbor, by which it can be lifted.

Sand testing

Criteria used for sand testing:

Moisture content, green and dry sand permeabilities, compression, tension, transverse and shear strengths, deformation during compression tests, green and dry hardness, clay content, grain-size distribution, combustible content, pressure, volume of gases evolved, flowability, sintering point, resistance to spalling etc.

Moulding sand preparation and moisture content determination:

The moisture content controls practically all other properties of the sand. It is a varying property since water content constantly evaporates during mold preparation.

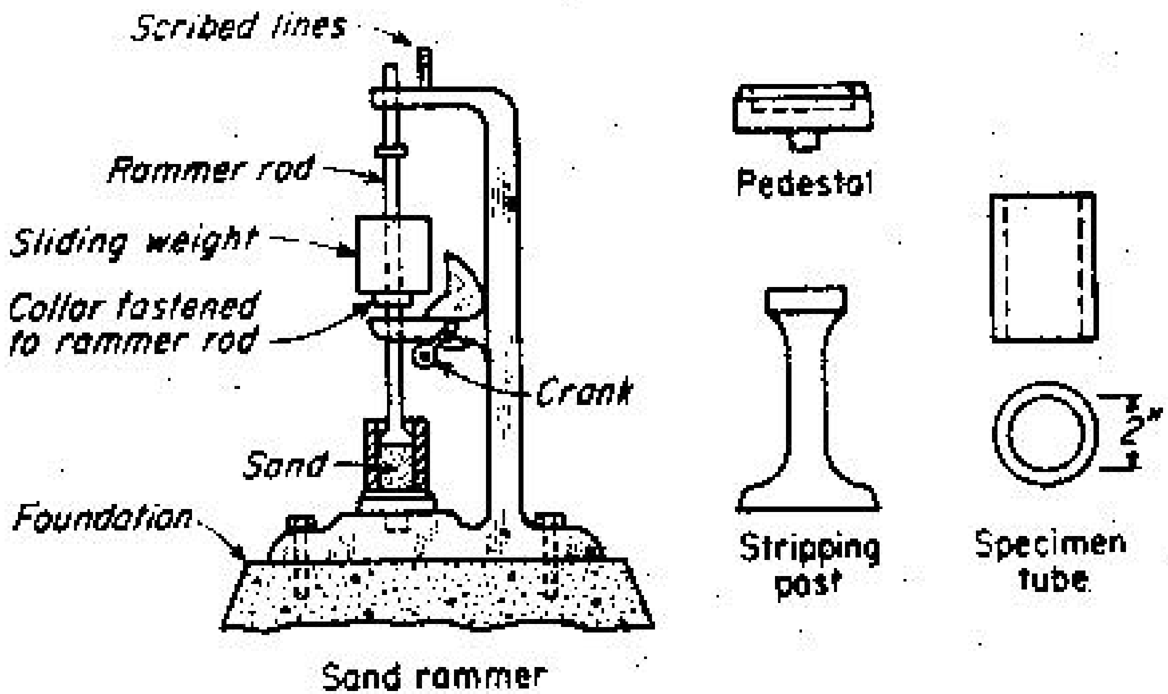
Purpose: adding sufficient water to bring the moisture content to within desired limits, uniform distribution of water, adequate coating of colloidal clay to each sand grain.

Moisture content determination:

- The simplest method is to dry a sample thoroughly at a few degrees above 212^{o}F and to consider its loss in weight as moisture.
- Drying can be done in a thermostatically controlled oven or in a instrument designed for this purpose
- There is one MOISTURE TELLER which blows air through a 50 gm sample of sand that is placed in a plate.

Testing rammed sand:

- Green permeability, green compression and few other properties are tested when the sand is in rammed condition.
- The rammed densities should be within some range which is actually encountered in the sand molds
- A predetermined weight of sand is placed into the hardened steel tube, which is closed at the bottom by a pedestal
- actually the tube filled with sand and the pedestal are weighed
- the entire set up is placed into the sand rammer and the rammer is dropped few times depending on particular standards, like three times etc.



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• the weight used will be a standard one. Depending on the ramming times, a standard density is obtained.

• once the ramming is completed, the height of the rammed sand is evaluated and this should be equal to 2 inches in length. If it is equal to this height, required density is expected to be in the rammed sand.

• If the sand height is outside the range, the entire procedure will be repeated.

Green compression strength

The sand specimen is compressed between two plates connected to the ram of the universal testing machine.

The load at which the sand sample breaks will give the compression strength.

The same tests can be performed at high temperatures in furnaces to find the compression strength at elevated temperatures.

Deformation and green hardness

During compression tests, the deformation of the sample can be recorded. The toughness can be obtained from its ultimate strength times its corresponding deformation.

Green hardness is the hardness of the rammed sand that is measured by hardness tester like Brinell hardness tester. A ½ inch diameter, spring loaded ball indenter is forced into the rammed sand surface. The resistance to penetration will give the hardness of the sand surface.