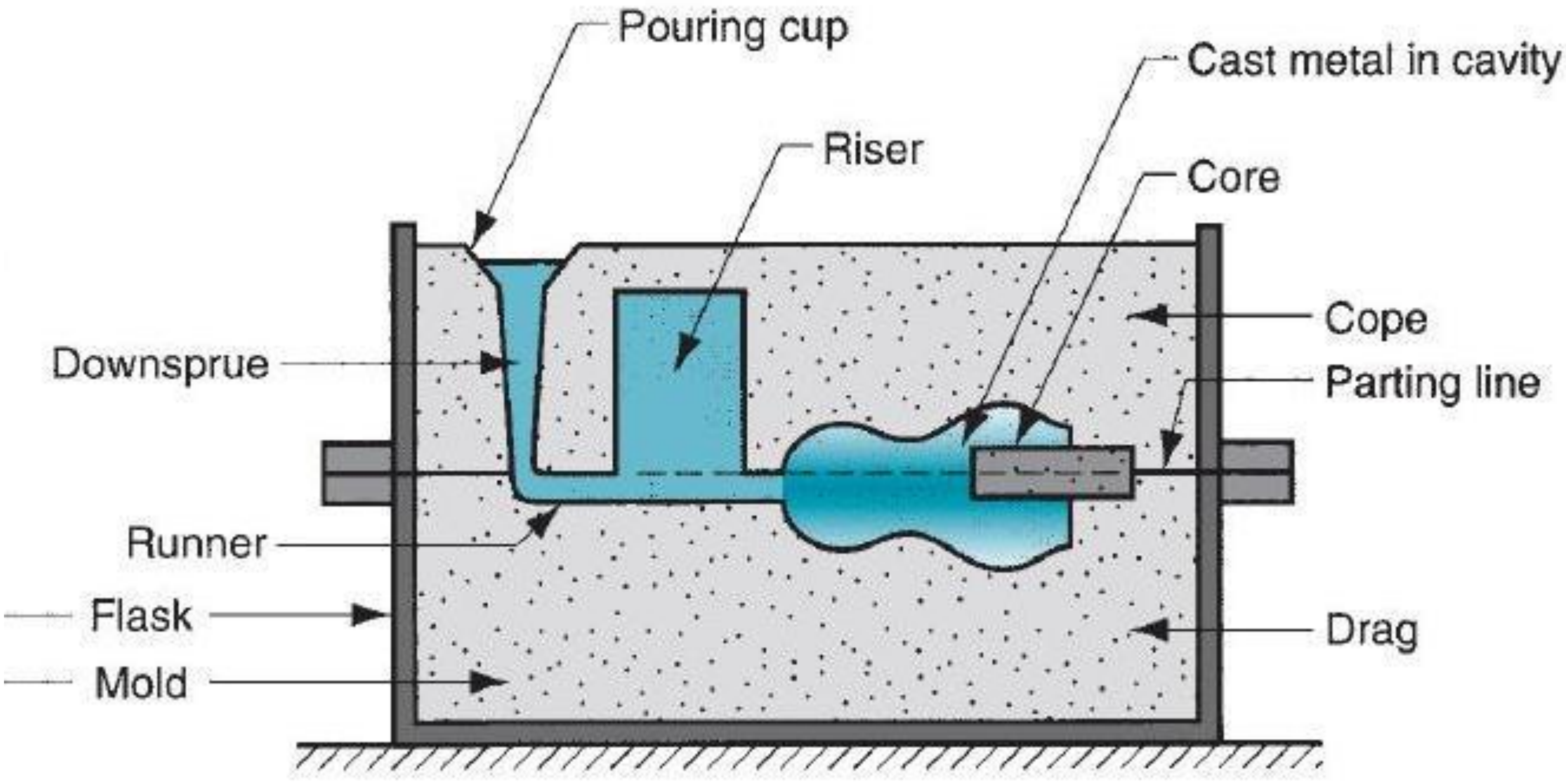
University of Technology
Materials Engineering Department

General Materials Branch
Casting Technology
Fourth Class
Lecture Four :Riser and Gating System Design
Class Code :ofp4npn

Riser Design

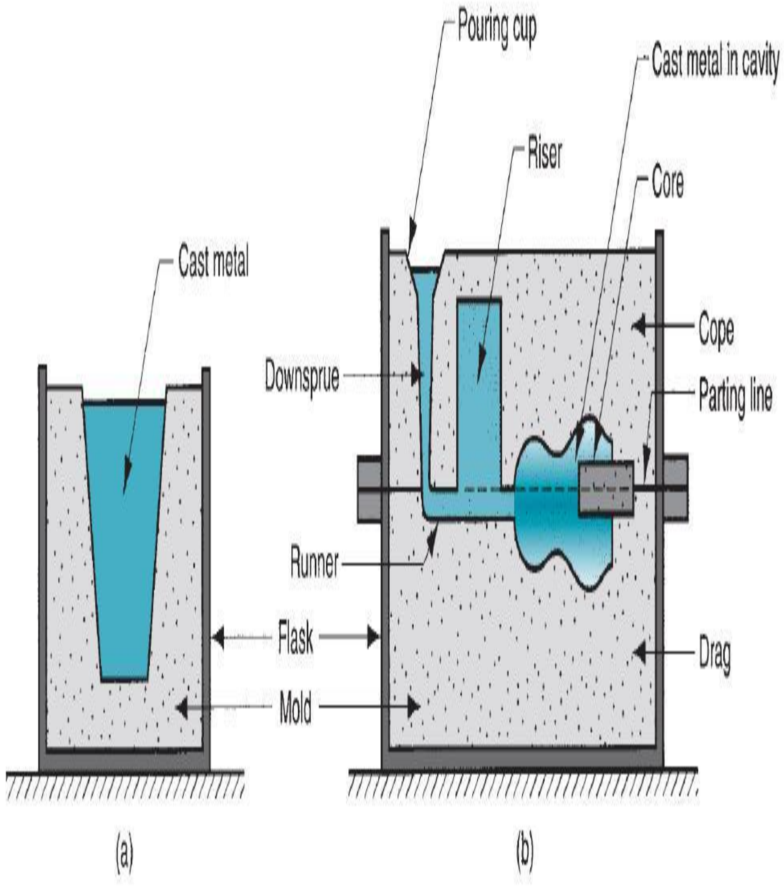


(b)

Riser Type

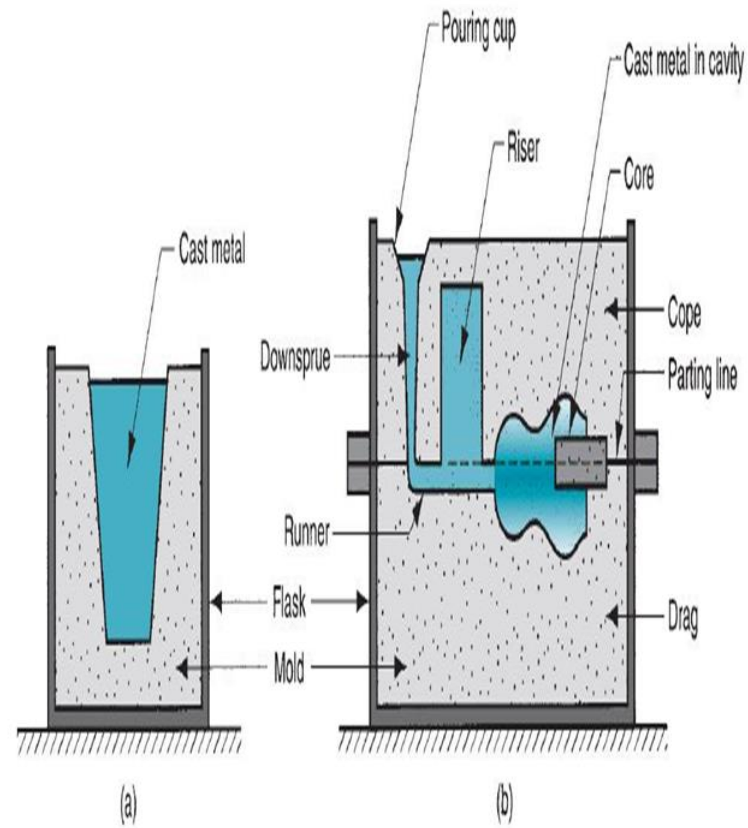
There are two categories of Riser type

1. By location (Top , Side)
2. By Connection to Air (open ,Blind)



Secondary Riser Functions

1. A Vent of Gases
2. It's help to know when the mold is completely filled
3. It help to force metal into mold cavity by pressure Head



<u>The basic Rule of Optimum Riser Design</u>

The role of the methods engineer in designing risers can be stated simply as making sure that risers will provide the feed metal:

- · In the right amount
- · At the right place
- · At the right time

Optimum Riser Design Economical Point of View

1. The riser/casting junction should be designed to minimize riser removal costs
2. The number and size of risers should be minimized to increase mold yield and to reduce production costs
3. Riser placement must be chosen so as not to exaggerate potential problems in a particular casting design (for example, tendencies toward hot tearing or distortion)

Conditions of Riser Design

1. The riser must not solidify before the casting. This rule usually is satisfied by avoiding the use of small risers and by using cylindrical risers with small aspect ratios (small ratios of height to cross section). Spherical risers are the most efficient shape, but are difficult to work with.
2. The riser volume must be large enough to provide a sufficient amount of liquid metal to compensate for shrinkage in the casting.
3. Junctions between the casting and the riser should not develop a hot spot where shrinkage porosity can occur.

Conditions of Riser Design

4. Risers must be placed so that the liquid metal can be delivered to locations where it is most needed.
5. There must be sufficient pressure to drive the liquid metal into locations in the mold where it is needed. Risers therefore are not as useful for metals with low density (such as aluminum alloys) as they are for those with a higher density (such as steel and cast iron).
6. The pressure head from the riser should suppress cavity formation and encourage complete cavity filling

Riser Location

- To determine the correct riser location, the methods engineer must make use of the concept of directional solidification.
- If shrinkage cavities in the casting are to be avoided, solidification should proceed directionally from those parts of the casting farthest from the riser, through the intermediate portions of the casting, and finally into the riser itself, where the final solidification will occur.
- Shrinkage at each step of solidification is thus fed by liquid feed metal being drawn out of the riser.

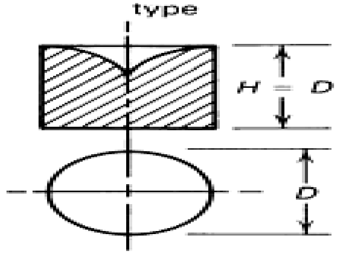
Riser Location

The ability to achieve such directional solidification will depend on:

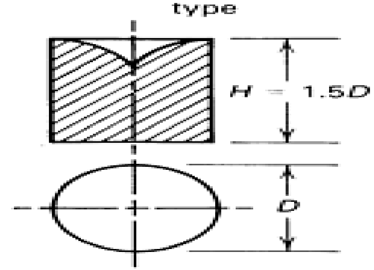
1. The alloy and its mode of solidification (Long range ,Medium or Short range)
2. The Mold Medium (Metal , Sand ,Plaster)
3. The Casting Design (complex or Simple)

Riser shape

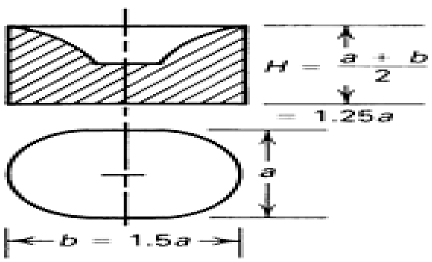
Riser type — Characteristic values



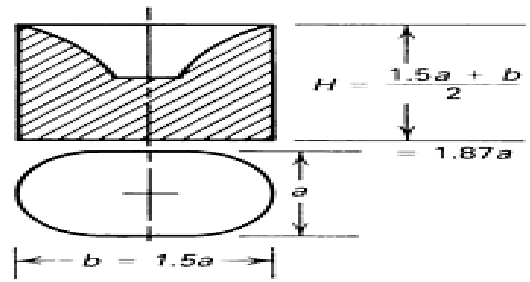
$V_r = 0.785D^3$
$= 1.69M_r^3$
$M_r = 0.1667D$
$D = 6M_r = H$



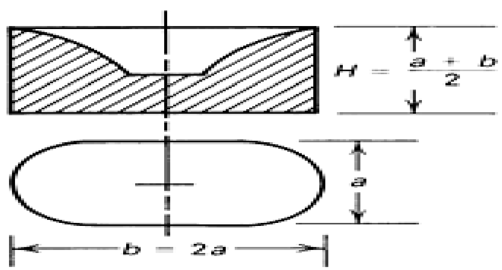
$V_r = 1.18D^3$
$= 179M_r^3$
$M_r = 0.187D$
$D = 5.35M_r$
$H = 8.02M_r$



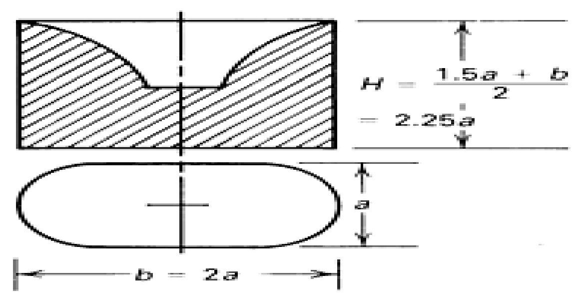
$V_r = 1.605a^3$
$= 181.5M_r^3$
$M_r = 0.207a$
$a = 4.84M_r$
$b = 7.25M_r$
$H = 6.05M_r$



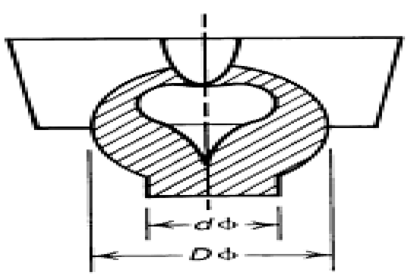
$V_r = 2.4a^3$
$= 189M_r^3$
$M_r = 0.233a$
$a = 4.29M_r$
$b = 6.43M_r$
$H = 8.03M_r$



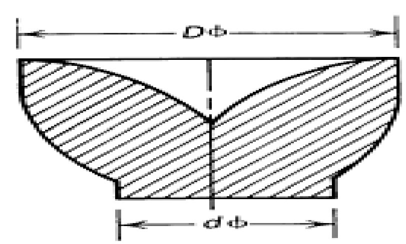
$V_r = 2.67a^3$
$= 200M_r^3$
$M_r = 0.237a$
$a = 4.22M_r$
$b = 8.45M_r$
$H = 6.32M_r$



$V_r = 4.01a^3$
$= 211M_r^3$
$M_r = 0.267a$
$a = 3.75M_r$
$b = 7.5M_r$
$H = 8.42M_r$



$V_r = 0.533D^3$
$= 115M_r^3$
$M = 0.1667M_r$
$D = 6M_r$
$d = 0.61D$
$= 3.66M_r$



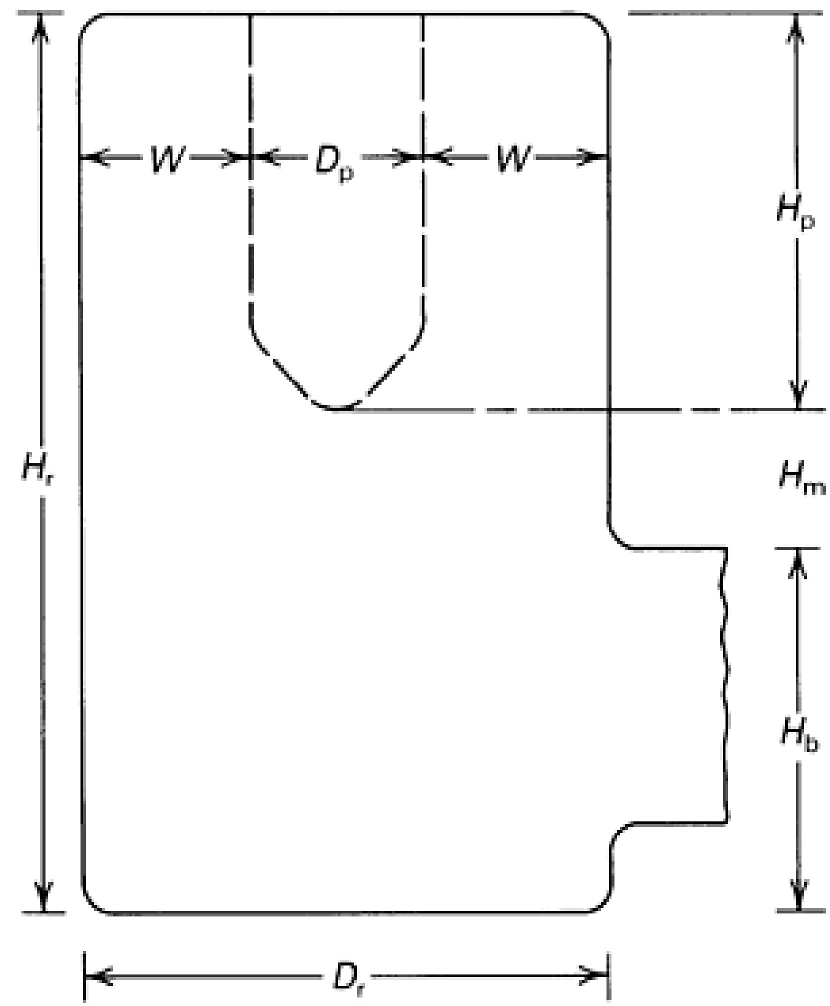
$V_r = 0.261D^3$
$= 196M_r^3$
$M_r = 0.11D$
$D = 9.1M_r$
$d = 0.4D$
$= 3.64M_r$

Casting Yield

- An important factor do discuss while Riser Design it's the ratio between the casting weight and the total weight of metal
- The energy is wasted and runner and risers so reduce the riser volume is a way to increase the yield
- $Y = \frac{W_c}{(W_{c+W_r+W_g+W_{ru}})}$

Pipes and Necking

- Necking is used to slow down the Liquid metal into the Mould cavity
- It is important that piping occur in the riser not in casting
- We can use either exothermic or endothermic material to preserve Heat in riser avoiding early solidification of riser



ENGINEERING ANALYSIS OF POURING

Bernoulli's theorem,

- There are several relationships that govern the flow of liquid metal through the gating system and into the mold. An important relationship is which states
- *that the sum of the energies (head, pressure, kinetic, and friction) at any two points in a flowing liquid are equal. This can be written in the following form* :

$$h_1 + \frac{P_1}{\rho} = \frac{v_1^2}{2g} + F_1 = \frac{P_2}{\rho} + \frac{v_2^2}{2g} + F_2$$

ENGINEERING ANALYSIS OF POURING

- Bernoulli's equation can be simplified in several ways. If we ignore friction losses (to be sure, friction will affect the liquid flow through a sand mold), and assume that the system remains at atmospheric pressure throughout, then the equation can be reduced to

$$h_1 + \frac{v_1^2}{2g} = h_2 + \frac{v_2^2}{2g}$$

ENGINEERING ANALYSIS OF POURING

- This can be used to determine the velocity of the molten metal at the base of the sprue.
- Let us define point 1 at the top of the sprue and point 2 at its base.
- If point 2 is used as the reference plane,
- then the head at that point is zero ($h_2 = 0$) and h_1 is the height (length) of the sprue.
- When the metal is poured into the pouring cup and overflows down the sprue, its initial velocity at the top is zero (v1 = 0). Hence, Eq. (3) further simplifies to

$$h_1 = \frac{v_2^2}{2g}$$

ENGINEERING ANALYSIS OF POURING

- which can be solved for the flow velocity
- $$v = \sqrt[2]{2gh}$$
- where
- v=the velocity of the liquid metal at the base of the sprue, cm/s;
- g=981 cm/s/s
- h = the height of the sprue, cm

Continuity Law

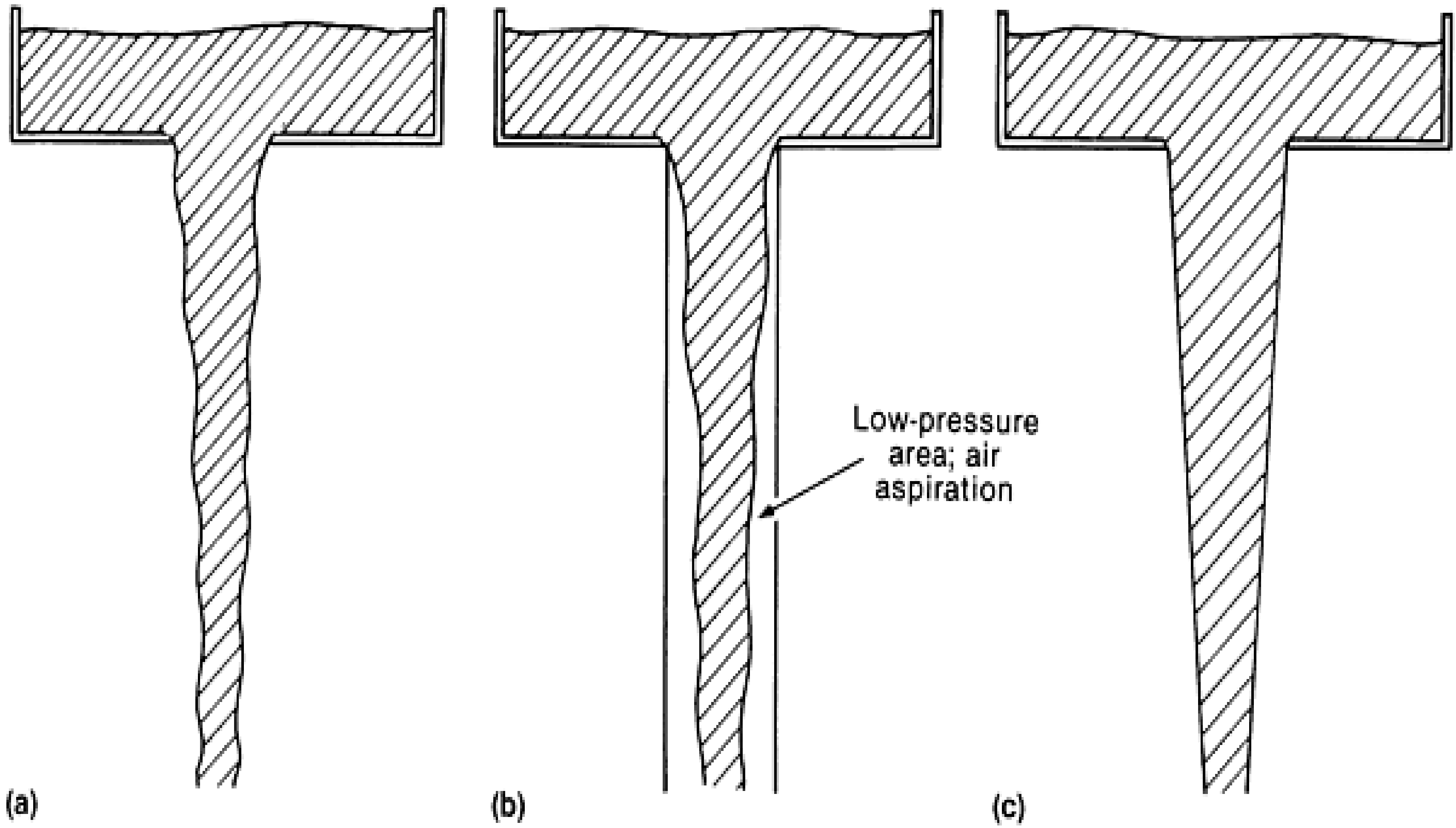
- Another relationship of importance during pouring is the continuity law, which states that the volume rate of flow remains constant throughout the liquid. The volume flow rate is equal to the velocity multiplied by the cross-sectional area of the flowing liquid

Continuity Law

- The continuity law can be expressed :

$$Q = v_1 A_1 = v_2 A_2$$

- where
- Q = volumetric flow rate, cm^3/s
- v = velocity as before cm/s
- A = cross sectional area of the liquid, cm^2
- Note *the subscripts refer to any two points in the flow system.*
- *Thus, an increase in area results in a decrease in velocity, and vice versa.*


Low-pressure
area; air
aspiration
(a)
(b)
(c)

ENGINEERING ANALYSIS OF POURING

- Accordingly, we can estimate the time required to fill a mold cavity of volume V as

$$MFT = \frac{V}{Q}$$

- Where TMF=mold filling time (sec)
- V=volume of mold cavity cm^3
- Q=volume flow rate, as before (cm^3 .Sec)

Patterns

- Casting requires a pattern—a full-sized model of the part, enlarged to account for shrinkage and machining allowances in the final casting.
- Materials used to make patterns include wood, plastics, and metals. Wood is a common pattern material because it is easily shaped.

Patterns

- Its disadvantages are that it tends to warp, and it is abraded by the sand being impacted around it, thus limiting the number of time sit can be reused .
- Metal patterns are more expensive to make, but they last much longer. Plastics represent a compromise Between wood and metal. Selection of the appropriate pattern material depends to a large extent on the total quantity of castings to be made

Pattern Materials

Material	Pattern Life	Relative Machining cost
Wood	5 Mold Impressions	1X
Plastic	1,000 Mold Impressions	2X
Metal	100,000 Mold Impressions	3X

Shrinkage Allowance in Metals

Metal	Shrinkage Allowances
Cast iron	0.8–1.0%
Steel	1.5–2.0%
Magnesium	1.0–1.3%
Brass	1.5%
Aluminum	1.0–1.3%

Type of Patterns

1. Solid Pattern
2. Split Pattern
3. Match Plate Pattern
4. Cope & drag Patterns

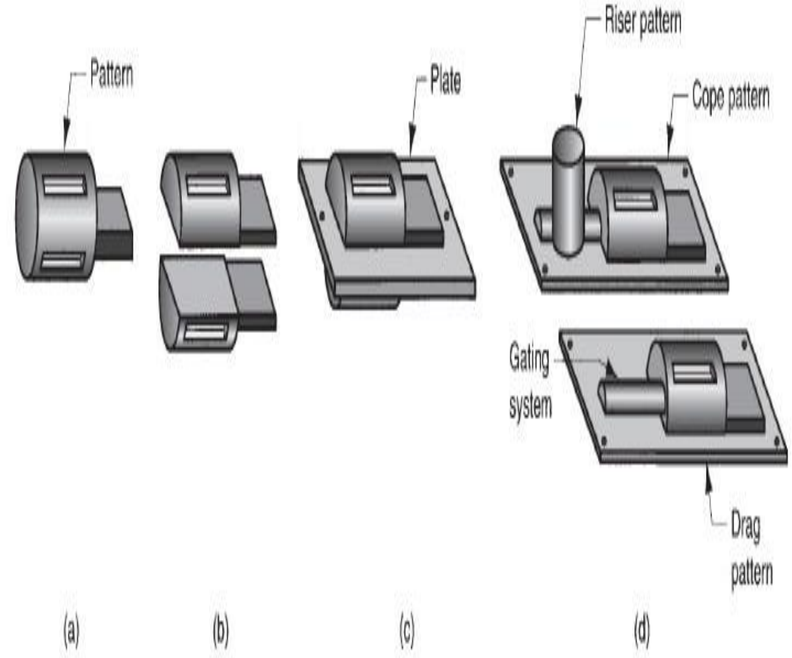
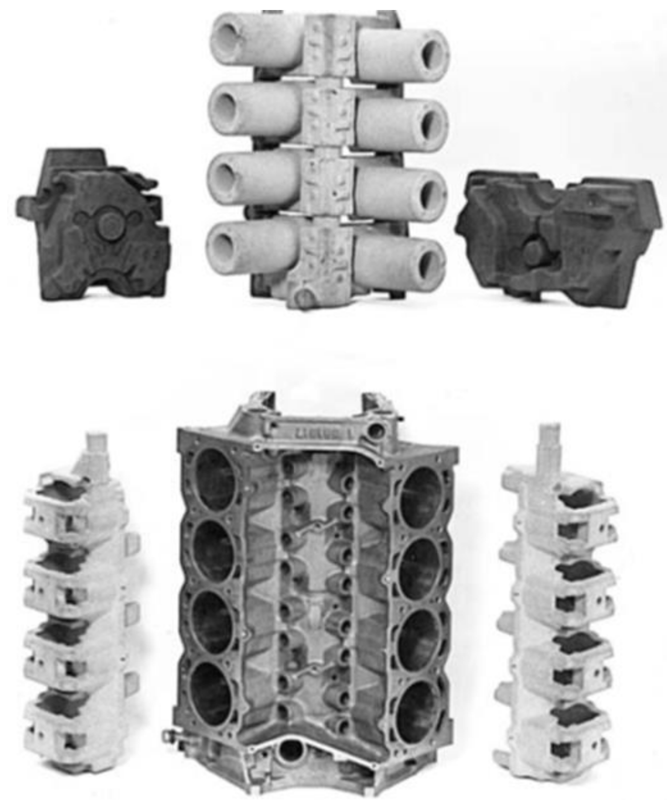


FIGURE 11.3 Types of patterns used in sand casting: (a) solid pattern, (b) split pattern, (c) match-plate pattern, and (d) cope-and-drag pattern.

Core

- A **core is a device used in casting and molding processes** to produce internal cavities and reentrant angles.
- The core is normally a disposable item that is destroyed to get it out of the piece.
- They are most commonly used in sand casting, but are also used in injection molding



Core Manufacturing Machine

Various machines have been developed to mechanize the packing procedure. , These machines operate by any of several mechanisms, including

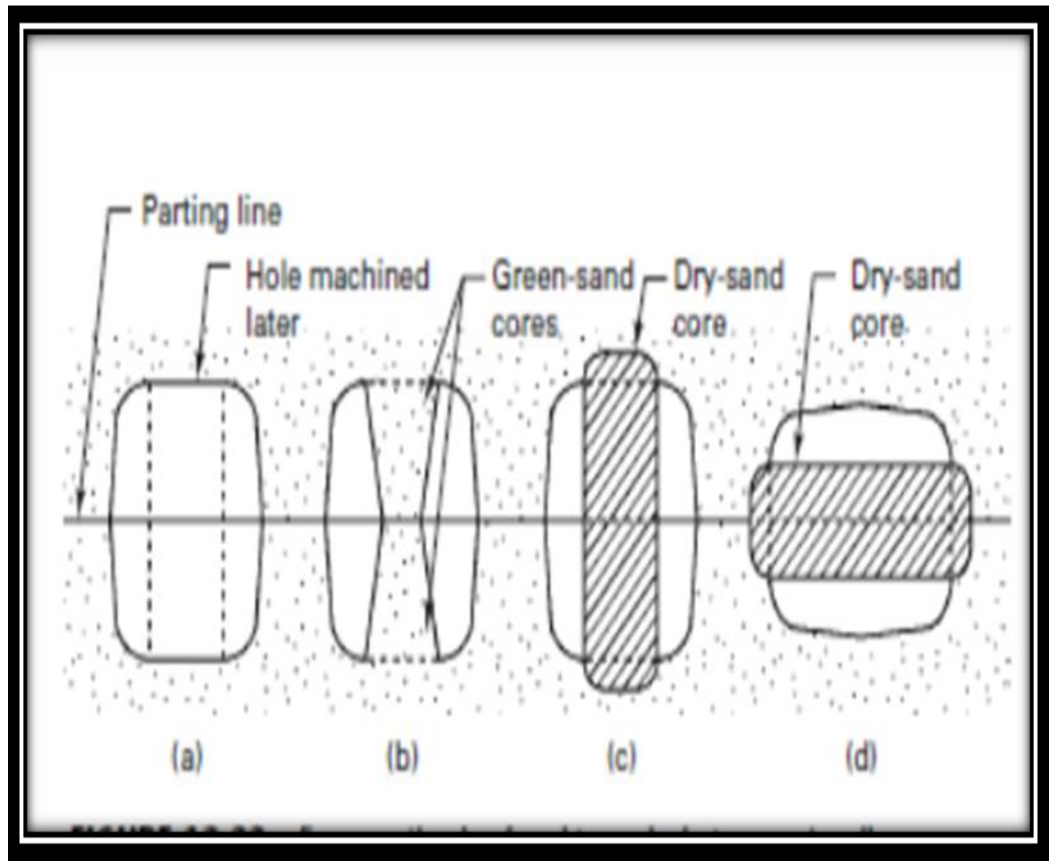
1. Squeezing the sand around the pattern by pneumatic pressure;
2. A jolting action in which the sand, contained in the flask with the pattern, is dropped repeatedly in order to pack it into place; and
3. A slinging action, in which the sand grains are impacted against the pattern at high speed.

Core Requirements

1. Green Strength: In the green condition there must be adequate strength for handling.In the hardened state it must be strong enough to handle the forces of casting; therefore the compression strength should be 0.69 to 2.07MPa.
2. Permeability must be very high to allow for the escape of gases.
3. Friability: As the casting or molding cools the core must be weak enough to break down as the material shrinks. Moreover, they must be easy to remove during shakeout.
4. Good refractoriness is required as the core is usually surrounded by hot metal during casting or molding.
5. A smooth surface finish.
6. Minimum generation of gases during metal pouring

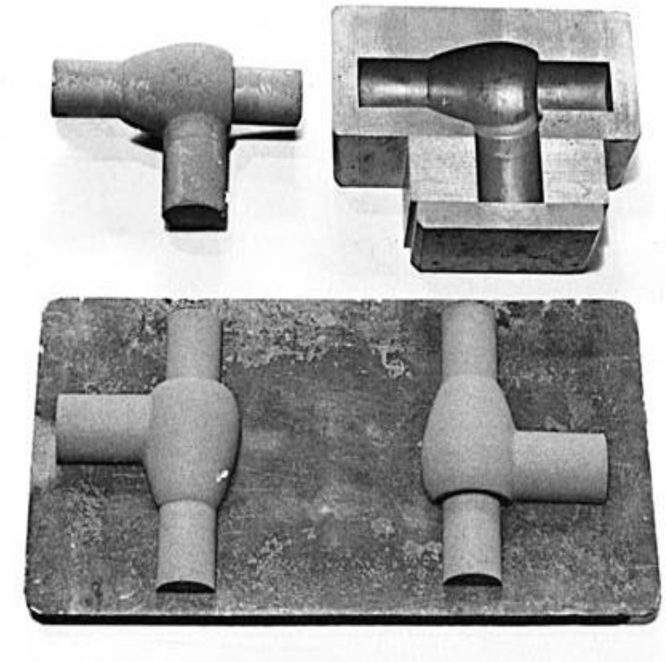
Type of Core

1. Green Sand Cores
2. Dry Sand Cores
3. Lost Cores

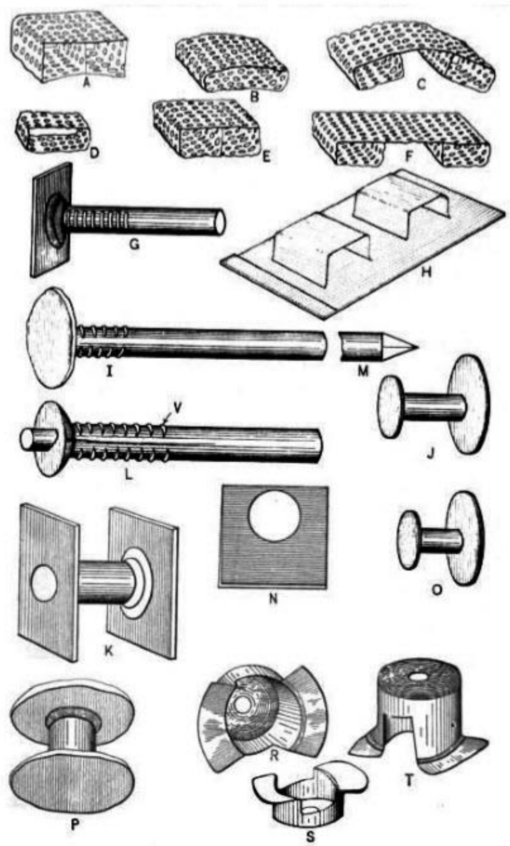


Types of Core box

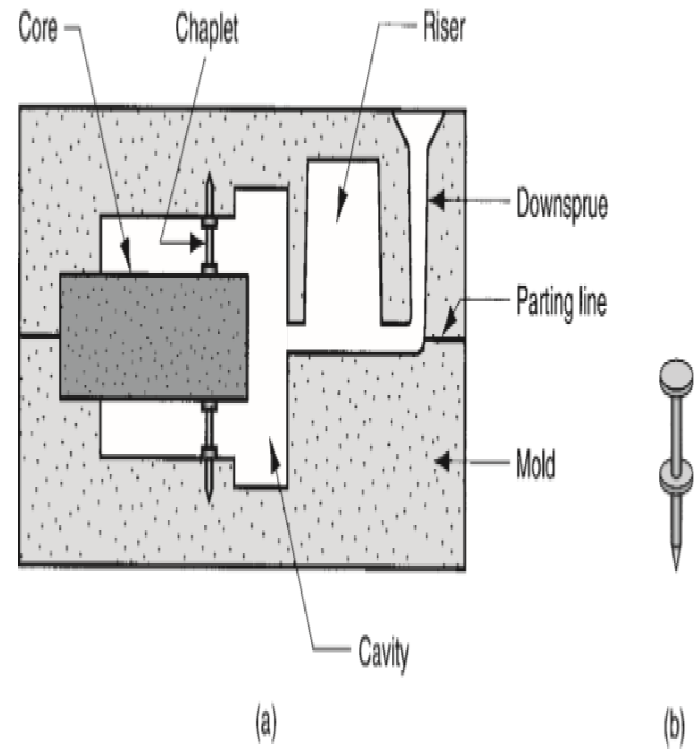
1. Half core box
2. Dump core box
3. Split core box
4. Left and right core box
5. Gang core box
6. Strickle core box
7. Loose piece core box
8. Ghayoor



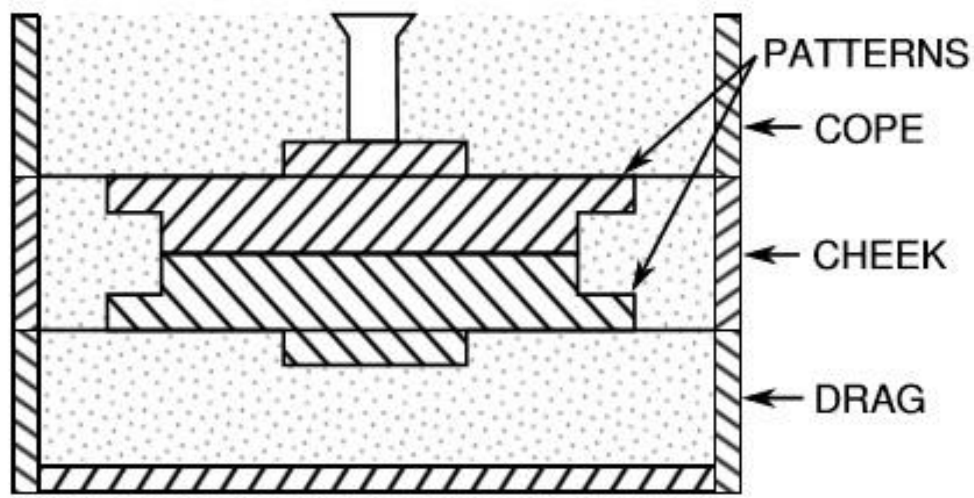
Chaplets



Various types of chaplets.



Cheeks



A cheek used to create a pulley

The Buoyancy Force

- $F_b = W_m - W_c$

Where

- F_b= buoyancy force(N)
- W_m=weight of molten metal displaced (N)
- W_c = weight of the core (N) .

Weights are determined as the volume of the core multiplied by the respective densities of the core material (typically sand) and the metal Being cast.

- The density of a sand core is approximately=$1.6 g/cm^3$

Densities of several common casting alloys are given

TABLE 11.1 Densities of selected casting alloys.

Metal	Density g/cm³	Density lb/in³	Metal	Density g/cm³	Density lb/in³
Aluminum (99% = pure)	2.70	0.098	Cast iron, gray[a]	7.16	0.260
Aluminum-silicon alloy	2.65	0.096	Copper (99% = pure)	8.73	0.317
Aluminum-copper (92% Al)	2.81	0.102	Lead (pure)	11.30	0.410
Brass[a]	8.62	0.313	Steel	7.82	0.284

Source: [7].

[a]Density depends on composition of alloy; value given is typical.