ELEMENTS OF GATING SYSTEM

GATING SYSTEM

- The term gating system refers to all passageways through which the molten metal passes to enter the mould cavity.
- The gating system is composed of

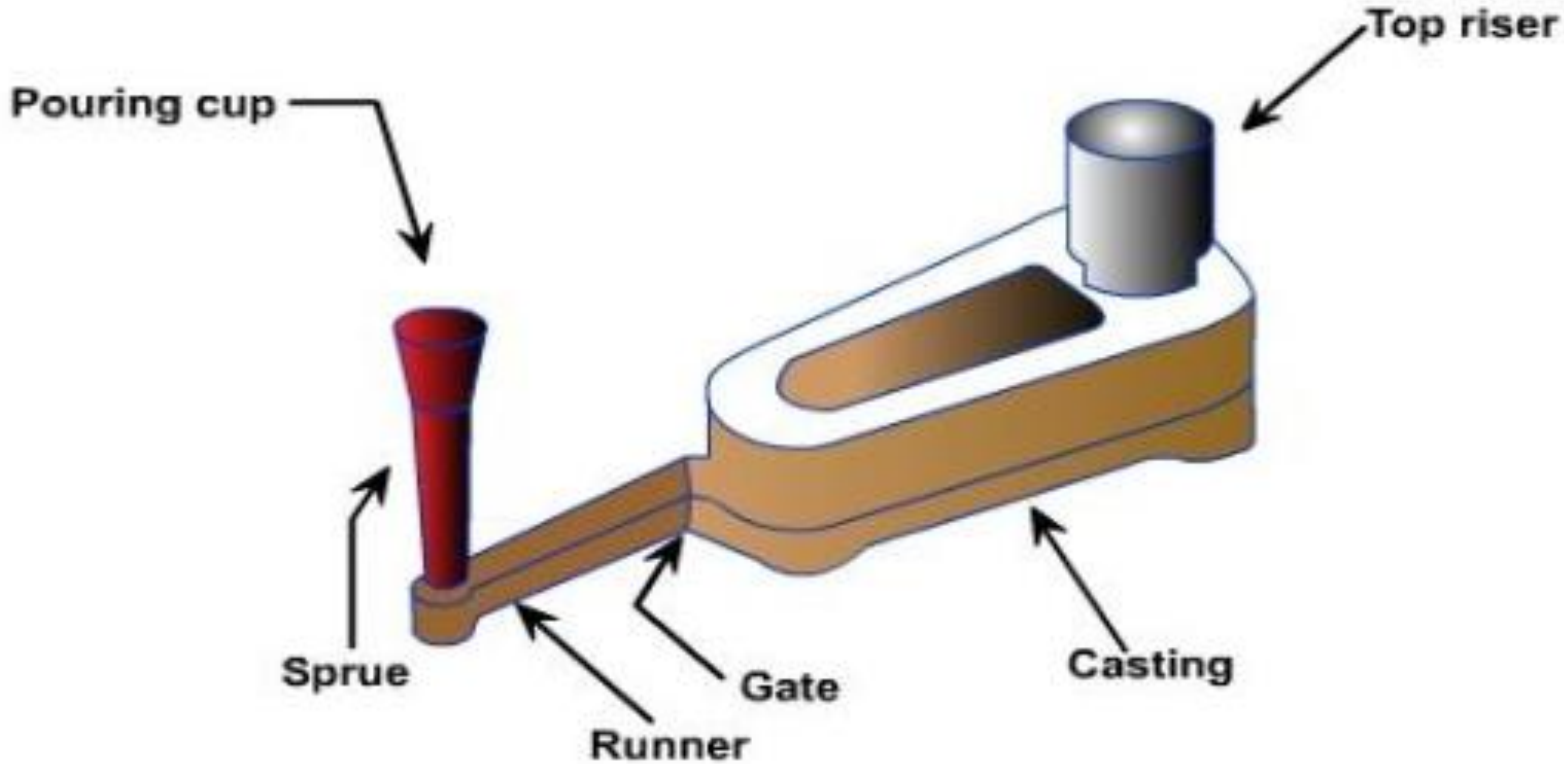
✓ Pouring basin

✓ Sprue

✓ Runner

✓ Gates

✓ Risers



Components of Gating System

- Any gating system designed should aim at providing a defect free casting. This can be achieved by considering following requirements.

✓ A gating system should avoid sudden or right angle changes in direction.

✓ A gating system should fill the mould cavity before freezing.

✓ The metal should flow smoothly into the mould without any turbulence. A turbulence metal flow tends to form dross in the mould.

✓ Unwanted materials such as slag, dross and other mould materials should not be allowed to enter the mould cavity.

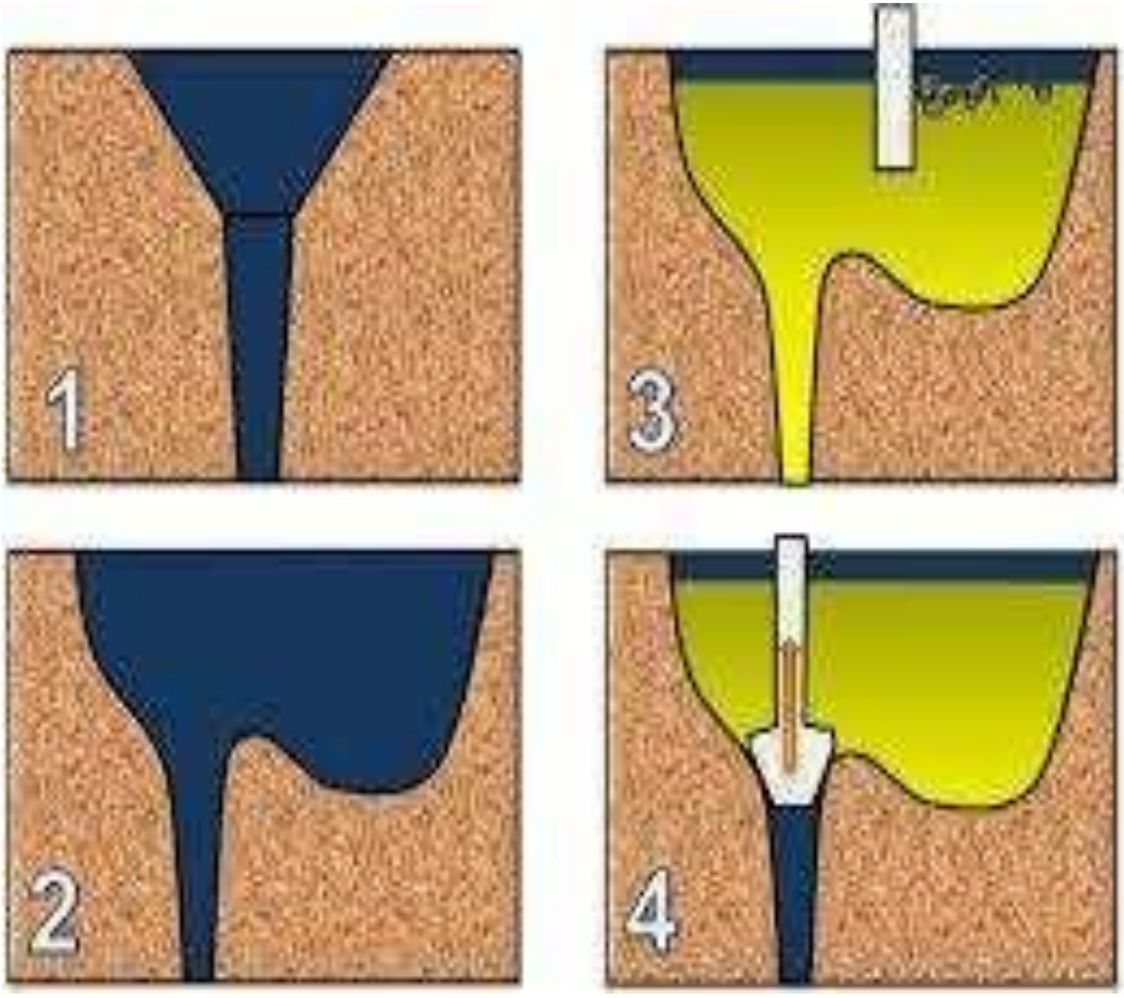
✓ The metal entry into the mould cavity should be properly controlled in such a way that aspiration of the atmospheric air is prevented.

- ✓ A proper thermal gradient should be maintained so that the casting is cooled without any shrinkage cavities or distortions.
- ✓ Metal flow should be maintained in such a way that no gating or mould erosion takes place.
- ✓ The gating system should ensure that enough molten metal reaches the mould cavity.
- ✓ It should be economical and easy to implement and remove after casting solidification.

- For proper functioning of the gating system, the following factors need to be controlled.

- ✓ Type of pouring equipment, such as ladles, pouring basin etc.
- ✓ Temperature/ Fluidity of molten metal.
- ✓ Rate of liquid metal pouring.
- ✓ Type and size of sprue.
- ✓ Type and size of runner.
- ✓ Size, number and location of gates connecting runner and casting.
- ✓ Position of mould during pouring and solidification.

POURING BASINS



- A pouring basin makes it easier for the ladle or crucible operator to direct the flow of metal from crucible to sprue.

- Helps maintaining the required rate of liquid metal flow.

- Reduces turbulence at the sprue entrance.

- Helps separating dross, slag etc., from metal before it enters the sprue.

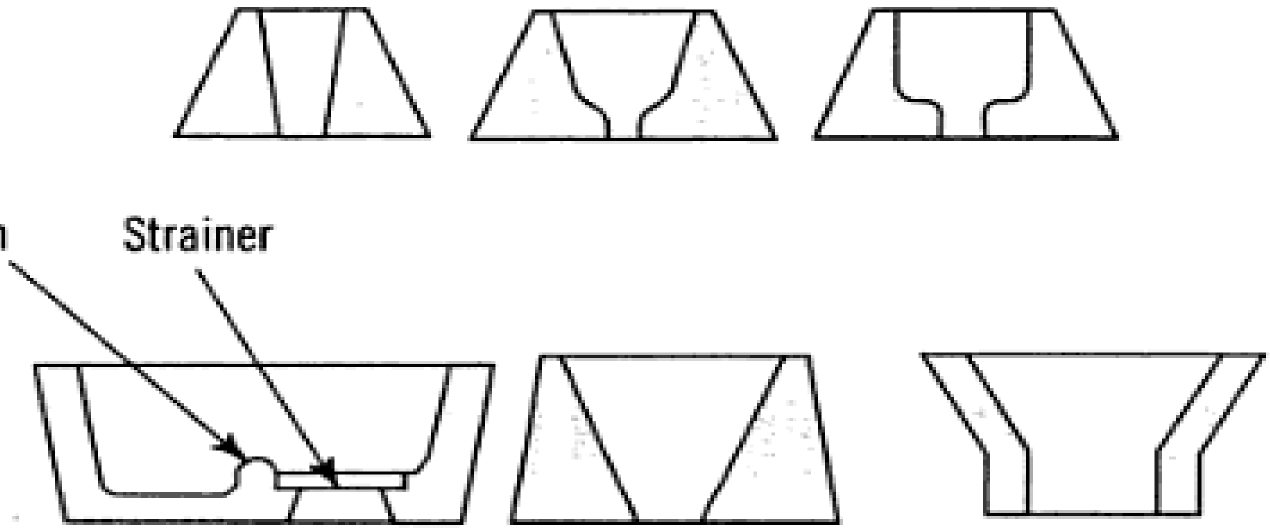


Fig. 5.2 *Typical shapes of pouring basins*

•If the pouring basins are made large,

✓Dross and slag formation will tend to float on the surface of the metal and may be stopped from entering the sprue and hence the mould.

✓They may be filled quickly without overflowing and may act as a reservoir of liquid metal to compensate metal shrinkage or contraction.

SPRUE

- A sprue feeds metal to runner which in turn reaches the casting through gates.

- A sprue is tapered with its bigger end at top to receive the liquid metal. The smaller end is connected to runner.

GATES

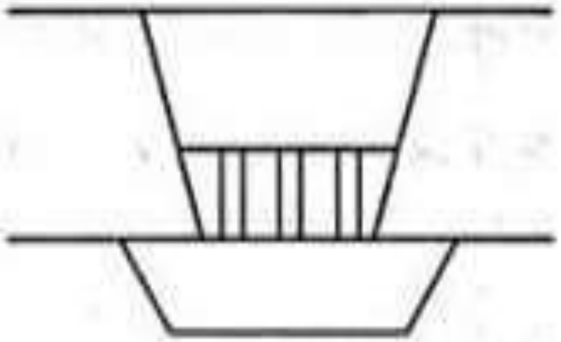
- A gate is a channel which connects runner with the mould cavity and through which molten metal flows to fill the mould cavity.
- A small gate is used for a casting which solidifies slowly and vice versa.
- A gate should not have sharp edges as they may break during pouring and sand pieces thus may be carried with the molten metal in the mould cavity.
- **Types** Top
- gate Bottom
- gate
- Parting line side gate

Top gate

- A top gate is sometimes also called as Drop gate because the molten metal just drops on the sand in the bottom of the mould.

- Generation of favourable temperature gradients to enable directional solidification from the casting towards the gate which serves as a riser too.


(A)


(E)

Disadvantages

- The dropping liquid metal stream erodes the mould surface.

- There is a lot of turbulence.

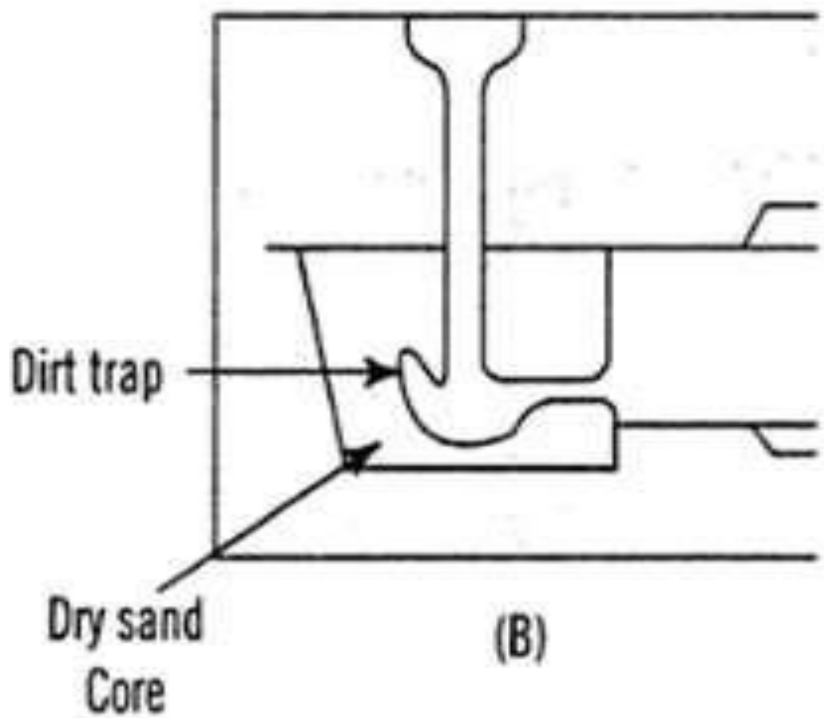
Bottom gates

- A bottom gate is made in the drag portion of the mould.

- In a bottom gate the liquid metal fills rapidly the bottom portion of the mould cavity and rises steadily and gently up the mould walls.

- As comparison to top gate, bottom gate involves little turbulence and sand erosion.

- Bottom gate produces good casting surfaces.



(B)

Disadvantages

- In bottom gates, liquid metal enters the mould cavity at the bottom. If freezing takes place at the bottom, it could choke off the metal flow before the mould is full.

- A bottom gate creates an unfavourable temperature gradient and makes it difficult to achieve directional solidification.

PARTING LINE SIDE GATE

- Middle or side or parting gating systems combine the characteristics of top and bottom gating systems.

- In this technique gate is provided along the parting line such that some portion of the mould cavity will be below the parting line and some portion will be above the parting line.

- The cavity below the parting line will be filled by assuming top gating and the cavity above the parting line will be filled by assuming bottom gating.

DESIGN OF GATING SYSTEM

- To fill the mould cavity without breaking the flow of liquid metal and without using very high pouring temperatures.
- To avoid erosion of mould cavity.
- To minimize turbulence and dross formation.
- To prevent aspiration of air or mould gases in the liquid metal stream.
- To obtain favourable temperature gradients to promote directional solidification.

Defects occurring due to improper design of gating system

- Oxidation of metal
- Cold shuts
- Mould erosion
- Shrinkages
- Porosity
- Misruns
- Penetration of liquid metal into mould walls.

Reynold's number (Re)

$$\mathrm{Re} = \frac{\rho\, Vd}{\mu}$$

$$= \frac{(\text{density}) * (\text{velocity}) * (\text{diameter})}{(\text{viscosity})}$$

Critical Reynold's number

- $Re < 2{,}000$
  - viscosity dominated, laminar flow
- $Re > 4{,}000$
  - inertia dominated, turbulent flow
- Controlled through gate and runner design

Metal flow rate and velocity calculations

- Studies of gating system have been based upon two laws of fluid dynamics.
- Law of continuity
- $Q = A_1V_1 = A_2V_2$
- Q = volume rate of flow
- A = cross sectional area of flow passage
- V = linear velocity of flow

Bernoulli’s Equation

- Used to calculate flow velocities
- Assumptions: steady state, incompressible, inviscid Flow

$$P_1/\rho g + V_1^2/\,2g + h_1 = P_2/\rho g + V_2^2/\,2g + h_2$$

P = pressure h = height above the datum plane

ρ= density

v = velocity

Design criteria for pouring basin

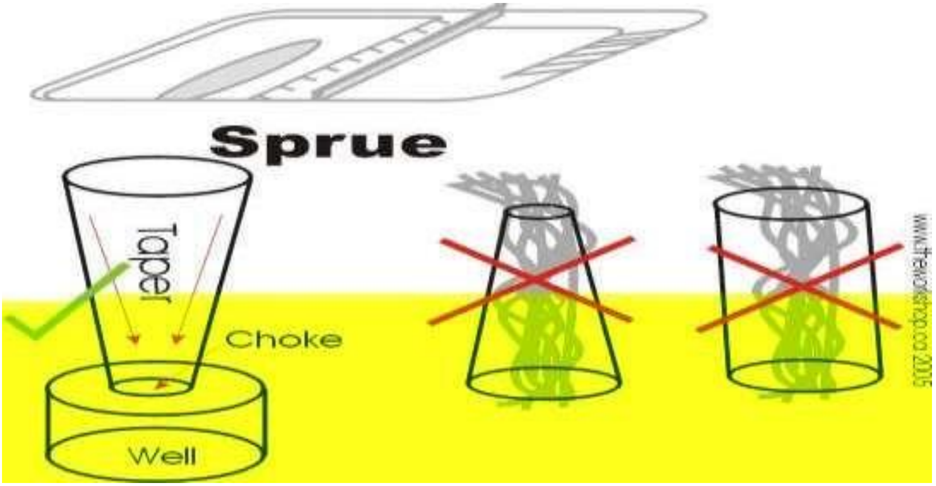
- The pouring basin should be designed such that the proper uniform flow system is rapidly established.
- This can be achieved by-

✓ Use of strainer core
✓ Use of DAM to make steady flow
✓ Use of sprue plug

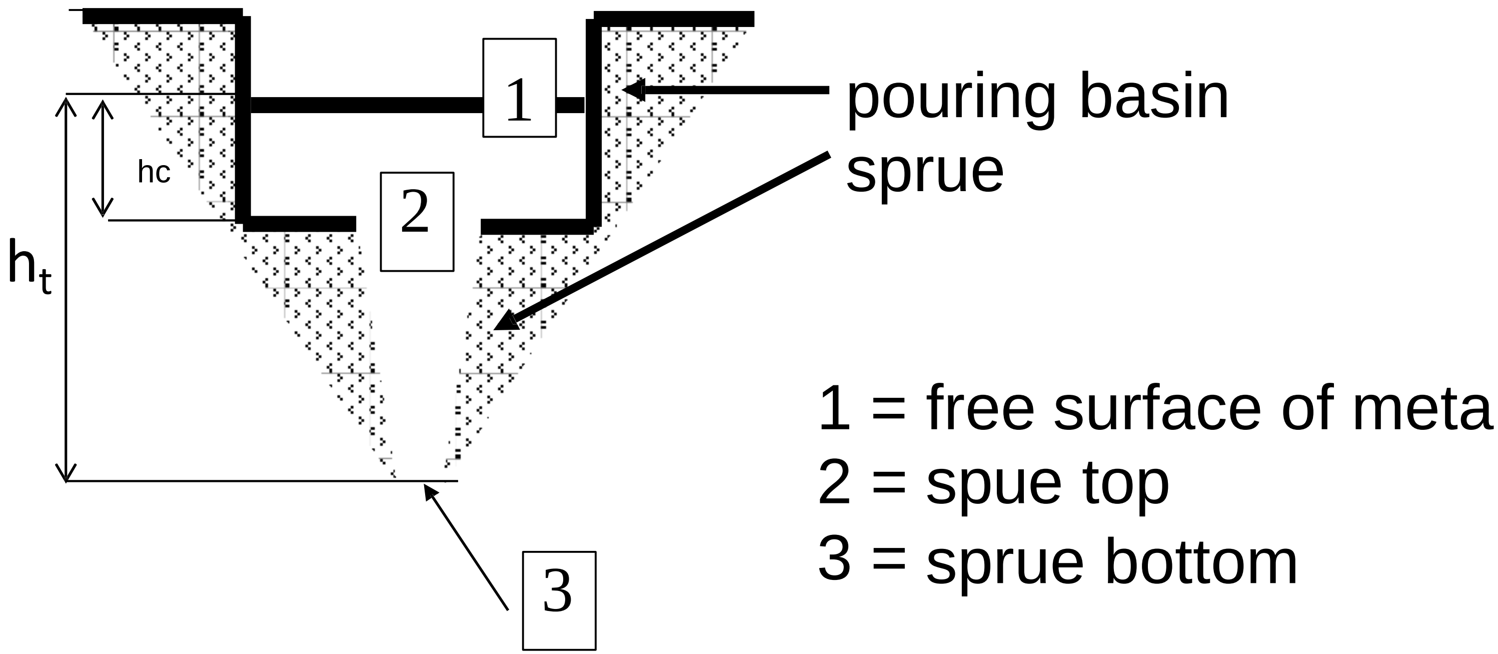
- It should be easy and convenient to fill pouring basin.

Design of sprue

- As the liquid metal passes down the sprue it loses its pressure head but gains velocity.



To reduce turbulence and promote Laminar Flow, from the Pouring Basin, the flow begins a near vertical incline that is acted upon by gravity and with an accelerative gravity force



- Assuming
  - entire mould is at atmospheric pressure (no point below atmospheric)
  - metal in the pouring basin is at zero velocity (reservoir assumption)

Mass flow rate = ρ A V = constant

Applying continuity equation between point 2 and 3 we get-

$$\frac{A_2}{A_3} = \frac{V_3}{V_2} = \sqrt{\frac{2gh_t}{2gh_c}} = \sqrt{\frac{h_t}{h_c}}$$

$$\frac{h_t}{h_c} = \left(\frac{A_2}{A_3} \right)^2$$

✓Actual shape of sprue is Parabola

✓But in order to avoid manufacturing difficulty we use tapered cylinder shape.

- Tapered sprue reduces the rate of flow at which the liquid metal enters the mould cavity and hence mould erosion is reduced.
- The area at the sprue exit controls-

✓ Flow rate of liquid metal into mould cavity

✓ Velocity of liquid metal

✓ Pouring time

➢ **Choke** is that part of the gating system which has the smallest cross section area.

➢ **In a free gating system** sprue serves as choke.

- ✓ This reduces mould erosion and turbulence because velocity of liquid metal is less.
- ✓ This system causes air aspiration effect.

- ➢ In a **choked system,** gate serves as the choke.
- ✓ This creates a pressurized system.
- ✓ Due to high metal velocity and turbulence, this system experiences oxidation and erosion in mould cavity.
- ➢ The area at the sprue exit which if is the least is known as choke area and can be calculated from the following relation-

$$C_A = \frac{W}{c.dt\sqrt{2gH}}$$

C_A is choke area

W is the weight of casting

C is nozzle coefficient

d is density of liquid metal

t is pouring time

H effective liquid metal head

Pouring time

- High pouring rates leads to mould erosion, rough surface, excessive shrinkages etc.

- Low pouring rate may not permit the complete filling of the mould cavity in time if the molten metal freezes fast and thus defects like cold shuts may develop.

- It is very necessary to know optimum pouring rate or pouring time for metals to be cast. Optimum pouring rate a function of casting shape and size.

- Pouring time for brass or bronze
- Varies from 15 seconds to 45 seconds may be used for casting weighing less than 150 kg.
- Pouring time for steel casting
- Steel has a high freezing range as compared to other cast alloys, it is poured rapidly to avoid early freezing.
- Pouring time = $K\sqrt{W}$ seconds

W is weight of casting in lbs
K is fluidity factor

- Pouring time for gray cast iron casting

➢ casting weighing more than 1000 lbs.

✓ $$K\left[0.95 + \frac{T}{0.853}\right]\sqrt[3]{W} \text{ seconds}$$

➢ Casting weighing less than 1000 lbs

✓ $$K\left[0.95 + \frac{T}{0.853}\right]\sqrt{W} \text{ seconds}$$

W is weight of casting in lbs

T is average section thickness in inches

K is fluidity factor

- Pouring time of light metal alloys

- Unlike steel, Al and Mg alloys are poured at a slow rate, this is necessary to avoid turbulence, aspiration and drossing.

DESIGN OF RUNNER AND GATES

- In a good runner and gate design-

✓ Abrupt changes in section and sharp corners which create turbulence and gas entrapment should be avoided.

✓ A suitable relationship must exist between the cross-sectional area of sprue, runner and in gates.

GATING RATIO

- Gating ratio= a:b:c where,
- a= cross-sectional area of sprue
- b= cross-sectional area of runner
- c= total cross-sectional area of ingates.
- Gating ratio reveals-
- whether the total cross- section decreases towards the mould cavity. This provides a choke effect which pressurizes the liquid metal in the system.
- Whether the total cross-sectional area increases so that the passages remain incompletely filled. It is an unpressurized system.

S.N.	Pressurized gating systems	Unpressurized gating systems
1.	Gating ratio may be of the order of 3: 2: 1	Gating ratio may be of the order of 1: 3: 2
2.	Air aspiration effect is minimum	Air aspiration effect is more
3.	Volume flow of liquid from every ingate is almost equal.	Volume flow of liquid from every ingate is different.
4.	They are smaller in volume for a given flow rate of metal. Therefore the casting yield is higher.	They are larger in volume because they involve large runners and gates as compared to pressurized system and thus the cast yield is reduced.
5.	Velocity is high, severe turbulence may occur at corners.	Velocity is low and turbulence is reduced.

- Ideally, in a system, pressure should be just enough to avoid aspiration and keep to all feeding channels full of liquid metal.

- Gating ratio and positions of ingates should be such that the liquid metal fills the mould cavity just rapidly to-

- ✓ Avoid misruns and coldshuts in thin sectioned castings.

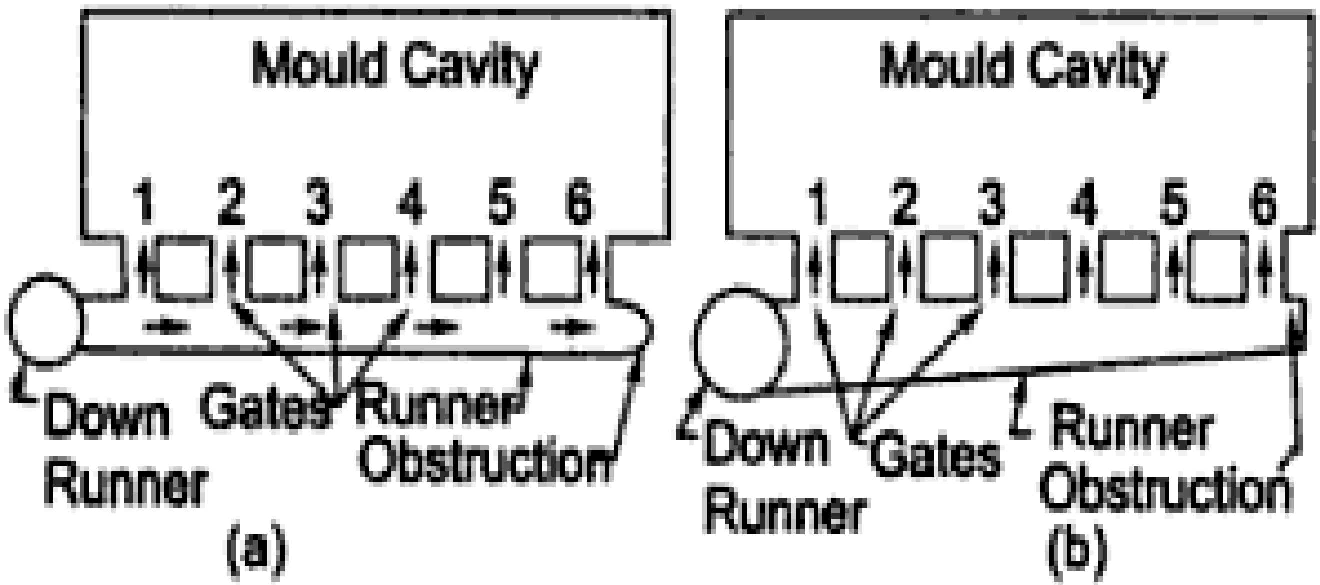
- ✓ Reduce turbulence and mould erosion in casting of thicker casting.

- The maximum liquid metal tends to flow through the farthest ingate.

- For a gating ratio 1:2:4, 66% of liquid metal enters through gate no. 2 and only 34% does so through gate no. 1.

- Total ingate area is reduced by making gates farthest from sprue of smaller cross-section so that less volume of metal flows through them and makes a uniform distribution of metal at all ingates.

- Besides with reduced total ingate area, still more satisfactory result may be obtained if runner beyond each ingate is reduced in cross section to balance the flow in all parts of the system and to equalise further velocity and pressure.



Streamlining the gating system

- Streamlining includes-
- Removing sharp corners or junction by giving a generous radius.
- Tapering the sprue.
- Providing radius at sprue entrance and exit.

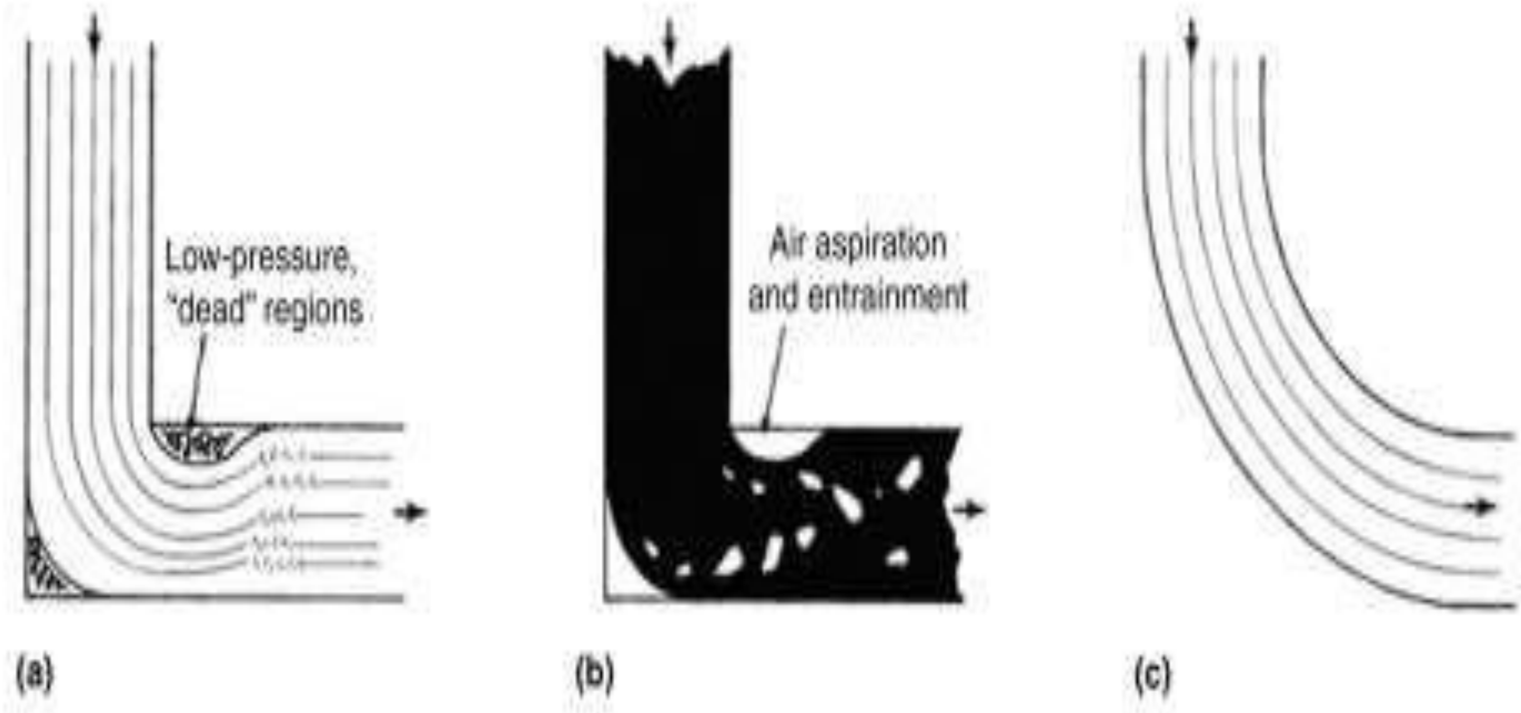


Fig. 7 Schematic illustrating fluid flow around right-angle and curved bends in a gating system. (a) Turbulence resulting from a sharp corner. (b) Metal damage resulting from a sharp corner. (c) Streamlined corner that minimizes turbulence and metal damage

ADVANTAGES OF STREAMLINING

- Metal turbulence is reduced.
- Air aspiration is avoided.
- Mould erosion and dross are minimized.
- Sound and clean casting are obtained.