Casting & Welding Engineering (IE 203)

Second Year,

Industrial Engineering Dept.,

Faculty of Engineering,

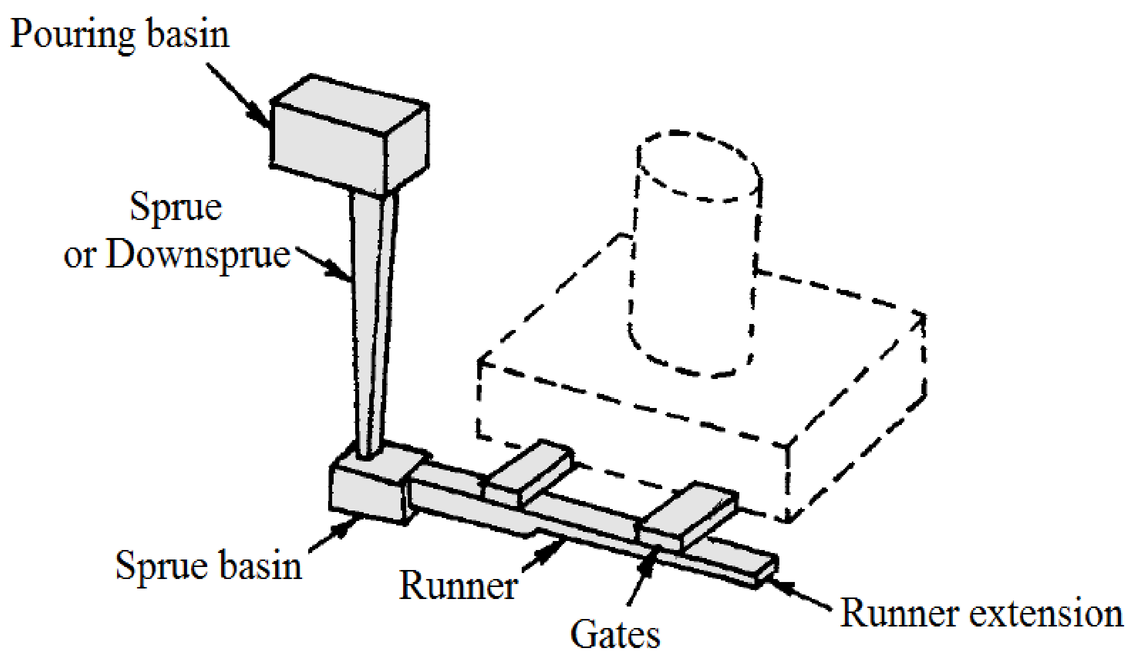
Fayoum University

Dr. Ahmed Salah Abou Taleb

Gating System

Elements of Gating Systems

- 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



Gating Systems

Requirements needed in gating system to achieve a free casting defects:

1- The mould should be **completely filled in the smallest time** possible without having to rise metal temperature.

2- The metal should **flow smoothly** into the mould.

3- The unwanted material – **slag** – should not be allowed to enter the mould cavity.

4- The **metal entry** into the mould cavity **should be controlled**.

5- A proper **thermal gradient** be maintained.

6- Metal flow should be maintained to **avoid erosion**.

7- Be ensure that **enough molten metal** reaches the mould cavity.

8- The gating system should be **economical** and **easy to implement** and remove after casting solidification.

9- The **casting yield** should be maximized.

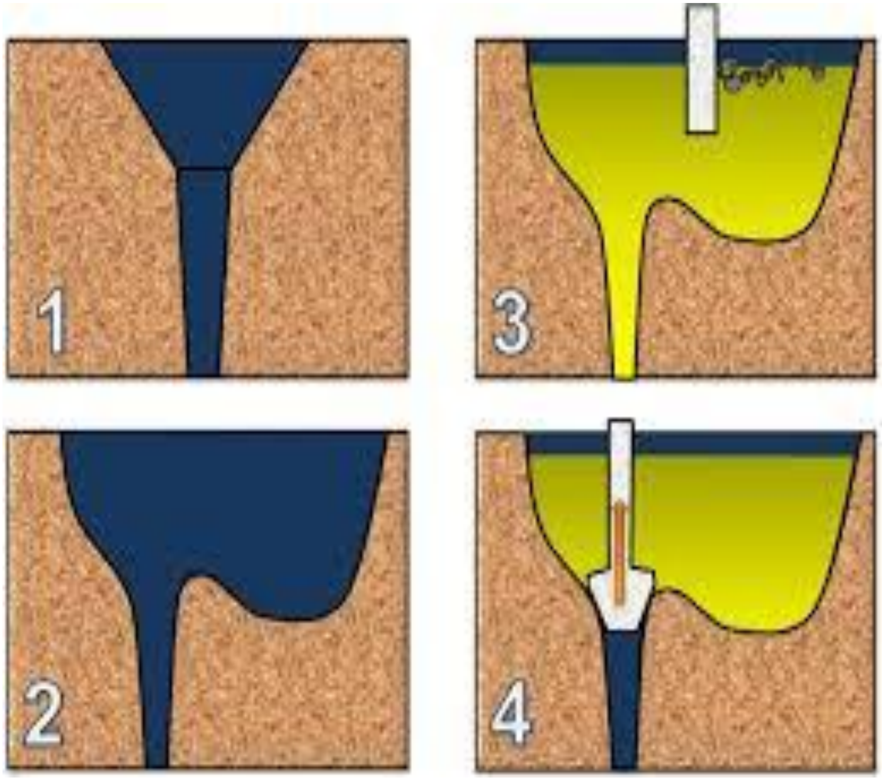
Gating Systems

Factors controlling the functioning of gating system:

- ✓ 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 Basin

- 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.



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.

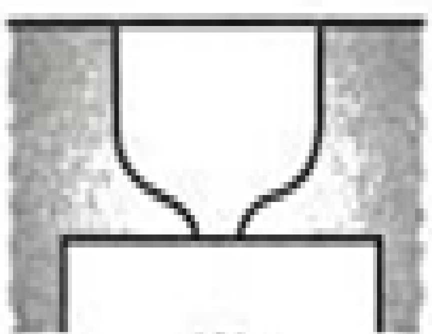
Gates

- 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

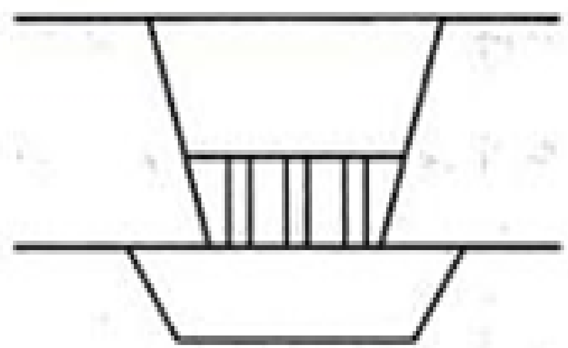
Gates

Top Gate:

- A top gate is made in the cope portion of the mould.
- In a top gate the molten metal enters the mould cavity from the top.
- Top gate involves high turbulence and sand erosion.
- Top gate produces poor casting surfaces.

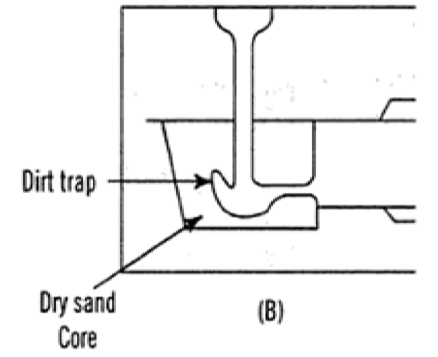


(A)



(E)

Gates



Bottom Gate:

- A bottom gate is made in the drag portion.
- 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.
- If freezing takes place at the bottom, it could choke off the metal flow before the mould is full.
- Creates an unfavourable temperature gradient and makes it difficult to achieve directional solidification.

Gates

Parting Line Side Gate:

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

Runner

- It is horizontal plane which connects the sprue to gate.
- The runner should be filled with molten metal to avoid slag entering to cavity.

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.

Improper Gating System Design Defects

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

Gating System Design

1- Pouring time.

2- Choke area.

3- Sprue.

4- Gating ratios.

5- Slag trap system.

Gating System Design

Pouring Time

The time for complete filling of a mould .

Too long pouring time ===== higher pouring temperature.

Too less pouring time ===== turbulent flow in mould.

Optimum time is required

Gating System Design

Pouring Time

The pouring time depends on:

- Casting materials,
- Casting complexity,
- Casting size, and
- Section thickness.

Gating System Design

Pouring Time

1- Gray cast iron: mass less than 450 kg:

$$t = K\left(1.41 + \frac{T}{14.59}\right)\sqrt{W}$$

$$K = \frac{fluidity\ of\ iron\ in\ inches}{40}$$

K: fluidity factor.

T: average section thickness, mm

W: mass of the casting, kg

2- Gray cast iron: mass greater than 450 kg:

$$t = K\left(1.236 + \frac{T}{16.65}\right)\sqrt[3]{W}$$

Gating System Design

Pouring Time

3- Steel casting:

$$t = \left(2.4335 - 0.3953 \log W\right)\sqrt{W}$$

4- Ductile iron:

$$t = K_1 \sqrt{W}$$

K_1 = 2.08 for thinner sections.

K_1 = 2.67 for sections of 10 to 25 mm thick.

K_1 = 2.97 for heavier sections.

Gating System Design

Pouring Time

5- Copper alloy castings:

$$t = K_2 \sqrt[3]{W}$$

Top gating	1.30
Bottom gating	1.8
Brass	1.9
Tin bronze	2.8

Gating System Design

Pouring Time

6- Intricately shaped Thin walled castings of mass up to 450 kg:

$$t = K_3 \sqrt[3]{W'}$$

W': mass of the casting with gates and risers, kg

T, (mm)	K_3
1.5 up to 2.5	1.62
2.5 up to 3.5	1.68
3.5 up to 8.0	1.85
8.0 up to 15.0	2.20

Gating System Design

Pouring Time

7- Castings above 450 kg and up to 1000 kg:

$$t = K_4 \sqrt[3]{W'T}$$

T, (mm)	K_4
up to 10	1.00
10 up to 20	1.35
20 up to 40	1.50
40 and above	1.70

Gating System Design

Choke Area

It is the main control area which meters the metal flow into the mould cavity so that the mould is completely filed within the calculated pouring time.

$$A = \frac{W}{d\,t\,C\sqrt{2gH}}$$

A: choke area, mm

W: casting mass, kg

t: pouring time, S

H: sprue height, mm

d: mass density of the molten metal, kg/mm^3

C: efficiency of the used gating system.

Gating System Design

Choke Area

Top gate

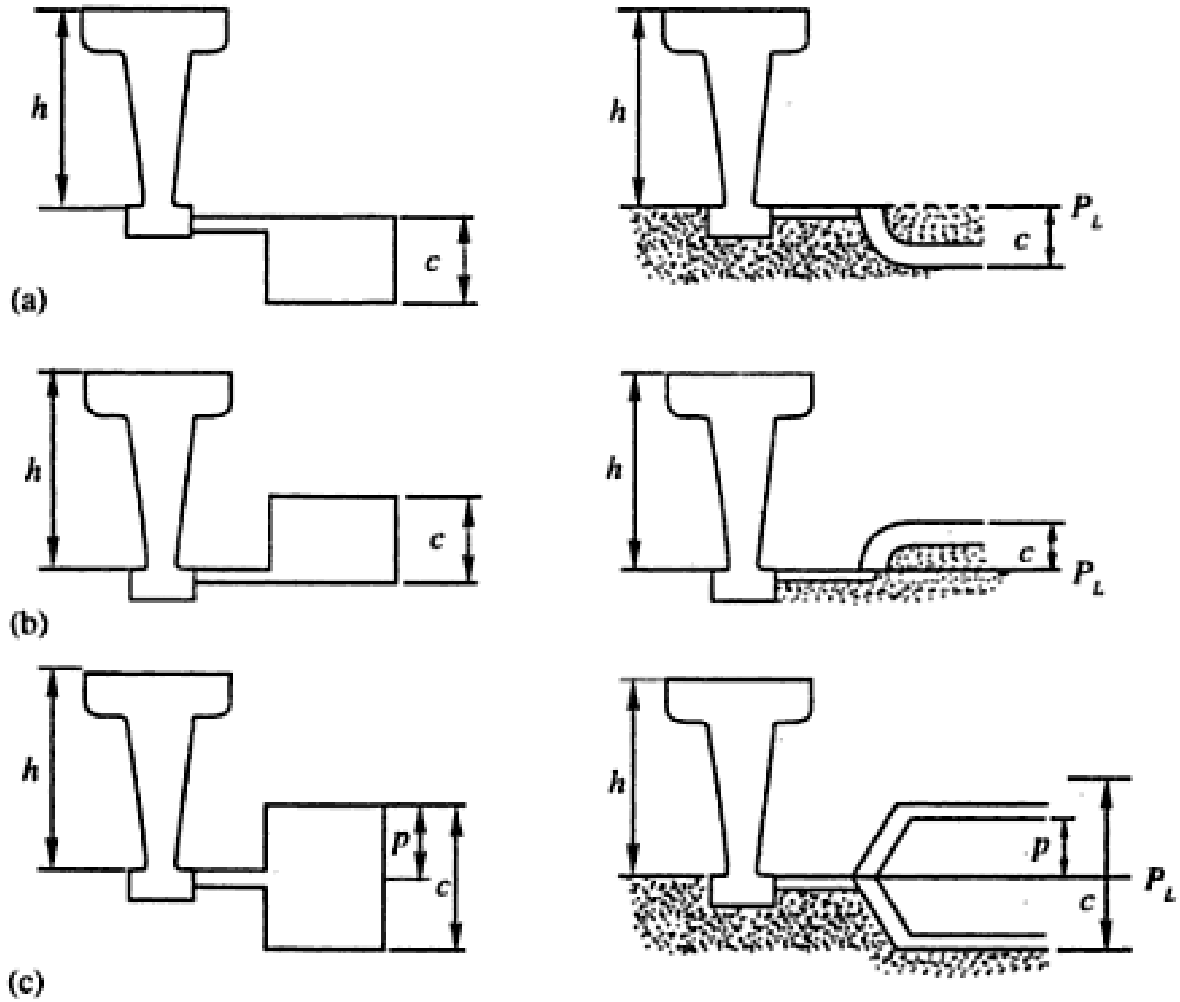
H = h

Bottom gate

H = h – c/2

Parting gate

H = h – P²/2c



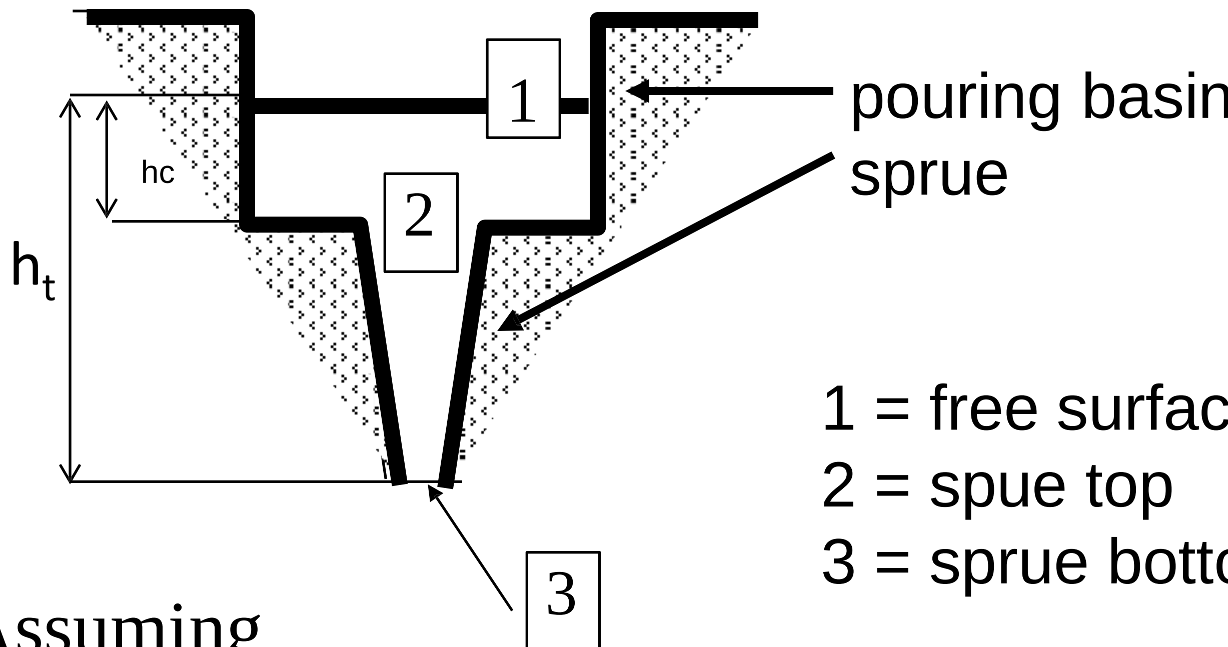
Gating System Design

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

Gating System Design

Sprue



1 = free surface of metal
2 = spue top
3 = sprue bottom

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

Gating System Design

Sprue

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.