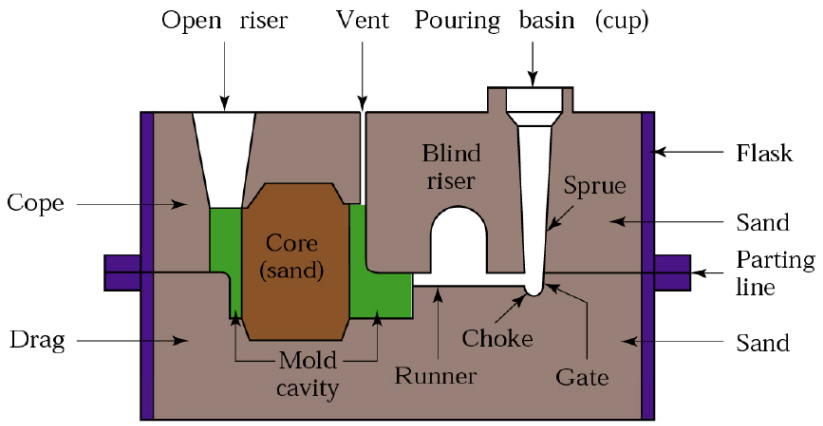
Lecture # 3

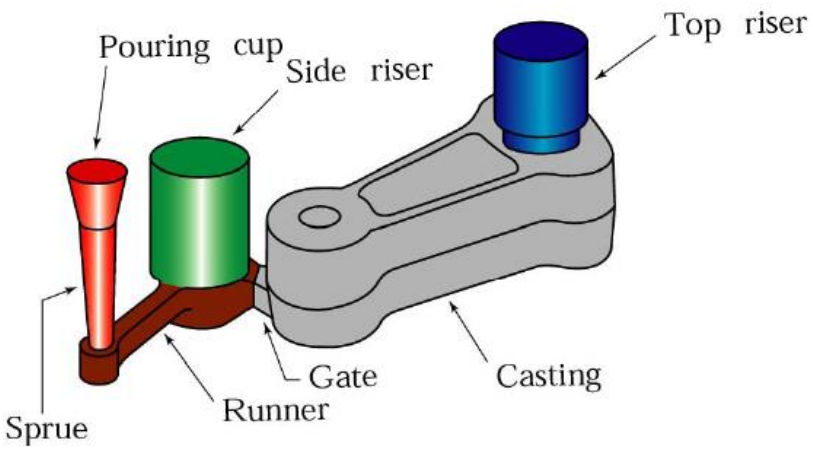
15 September 2020

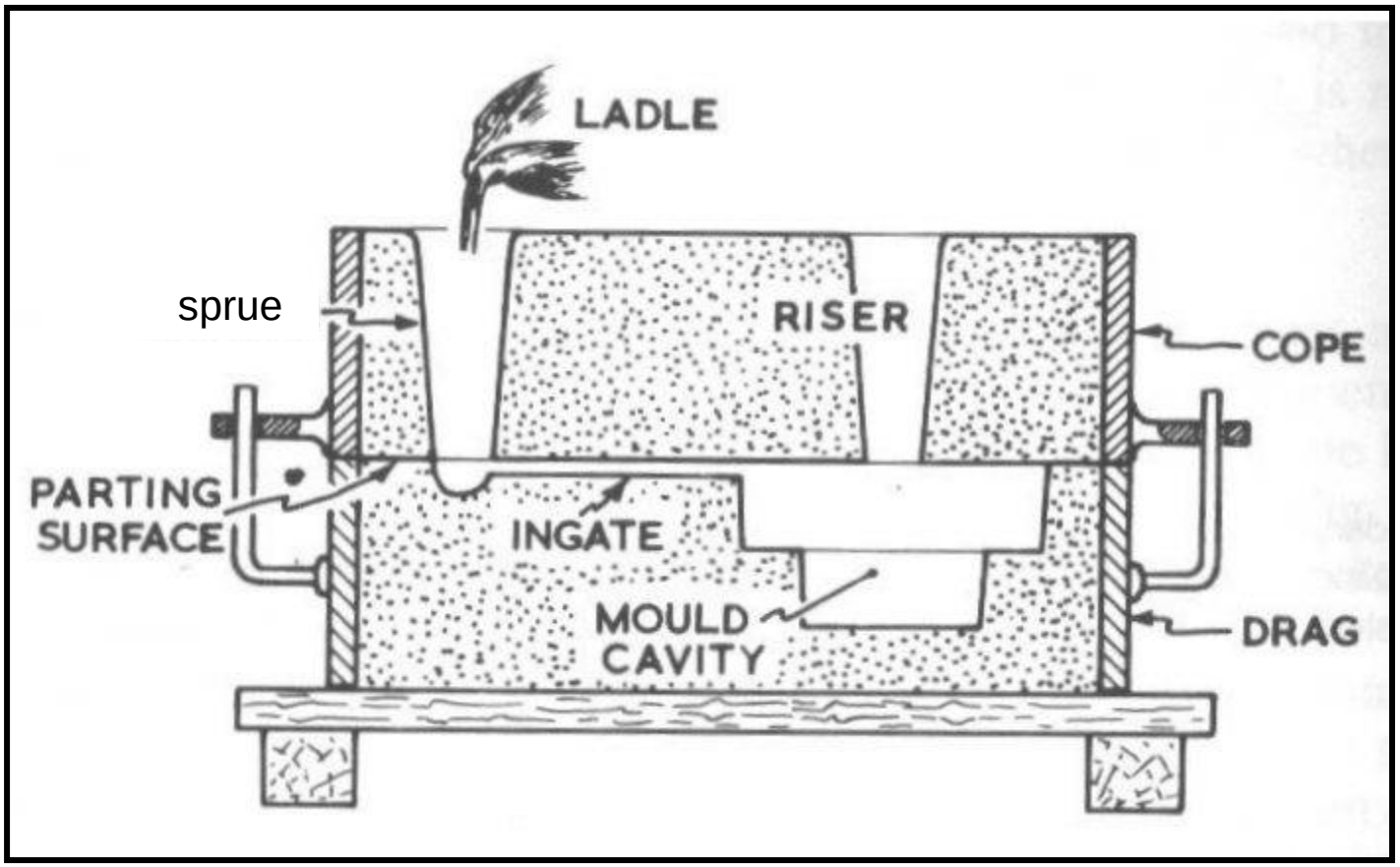
Solidification Processing (Casting)

How would you make Engine block?

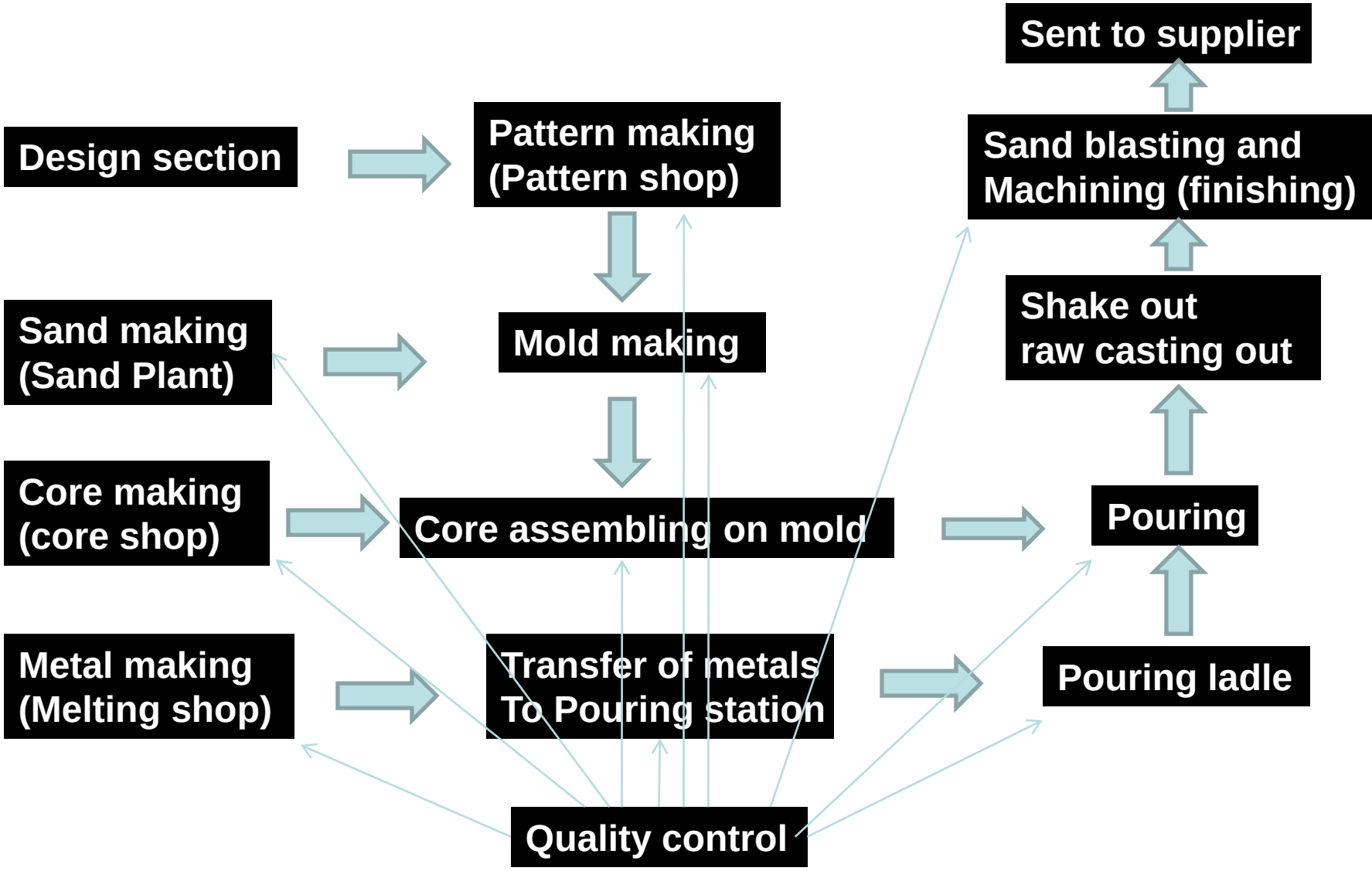
Engine-block





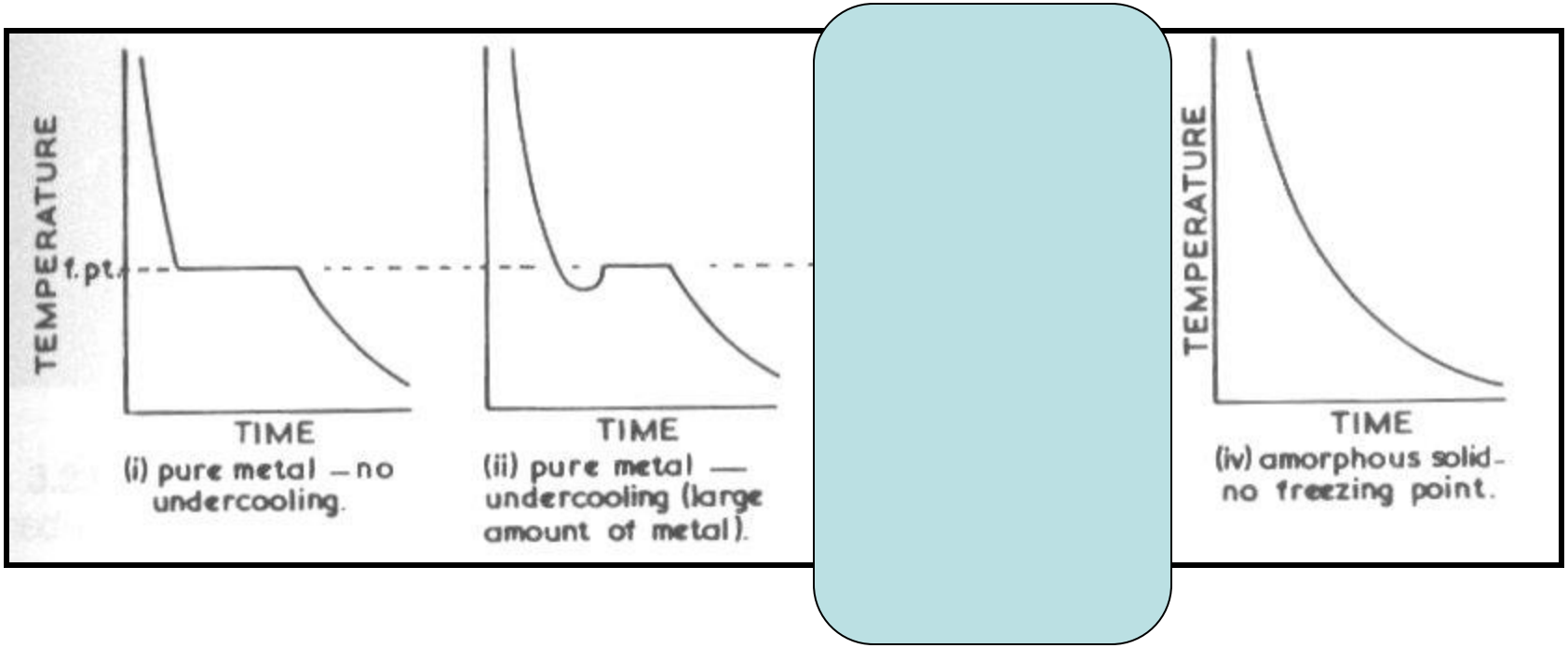


A simple two-part sand mould with the wooden pattern removed and ready to receive the charge of molten metal

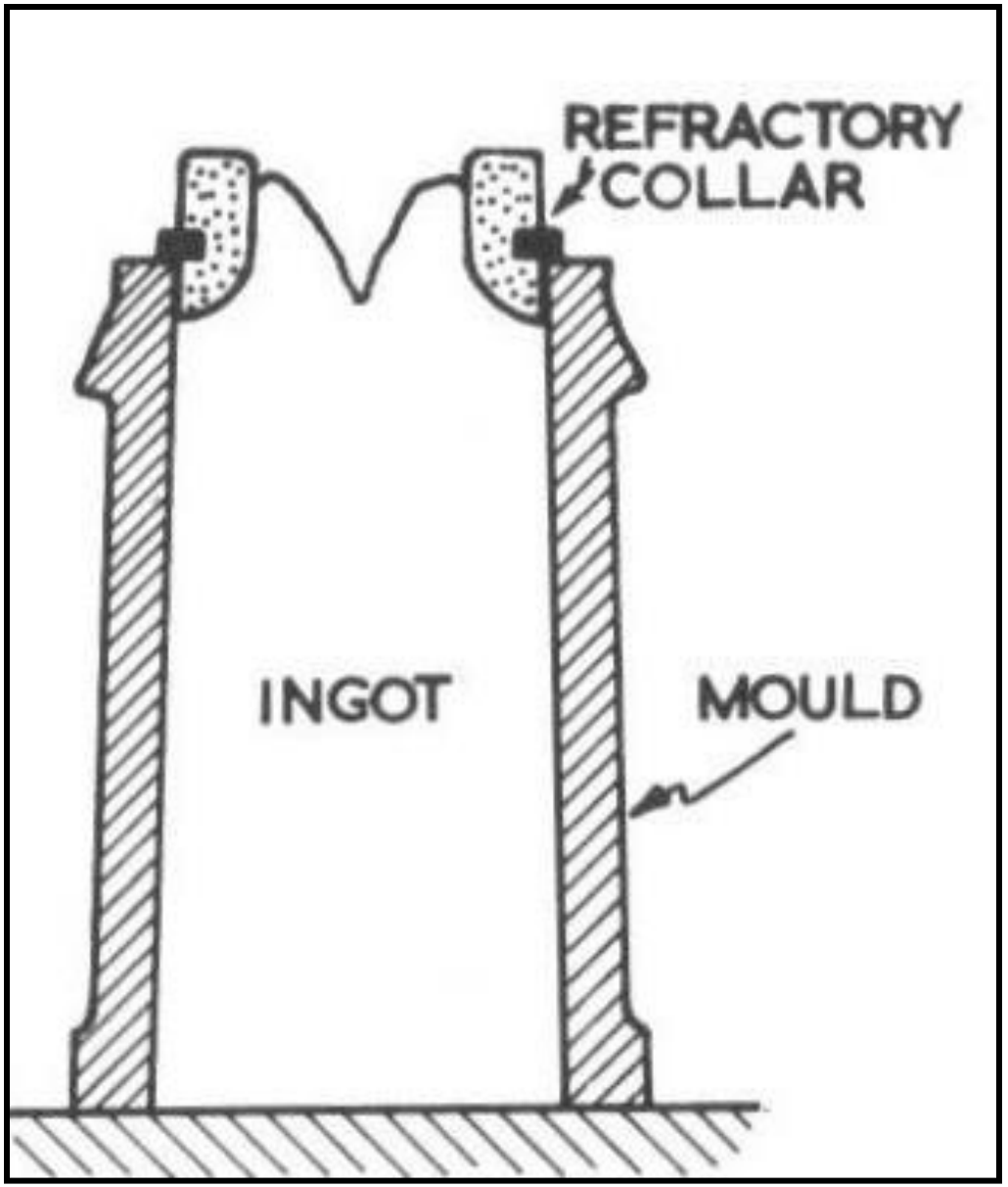

Sent to supplier
Design section
Pattern making
(Pattern shop)
Sand blasting and
Machining (finishing)
Sand making
(Sand Plant)
Mold making
Shake out
raw casting out
Core making
(core shop)
Core assembling on mold
Pouring
Metal making
(Melting shop)
Transfer of metals
To Pouring station
Pouring ladle
Quality control

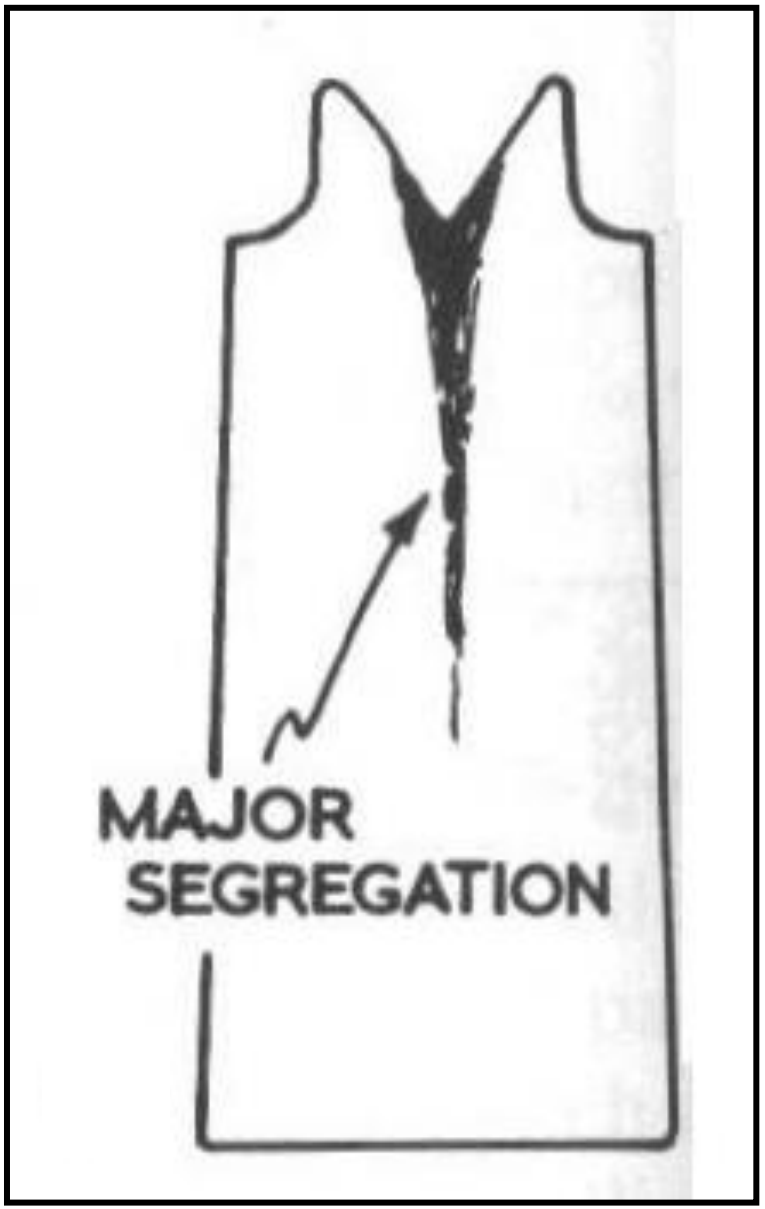
Solidification Processing

Fundamentals

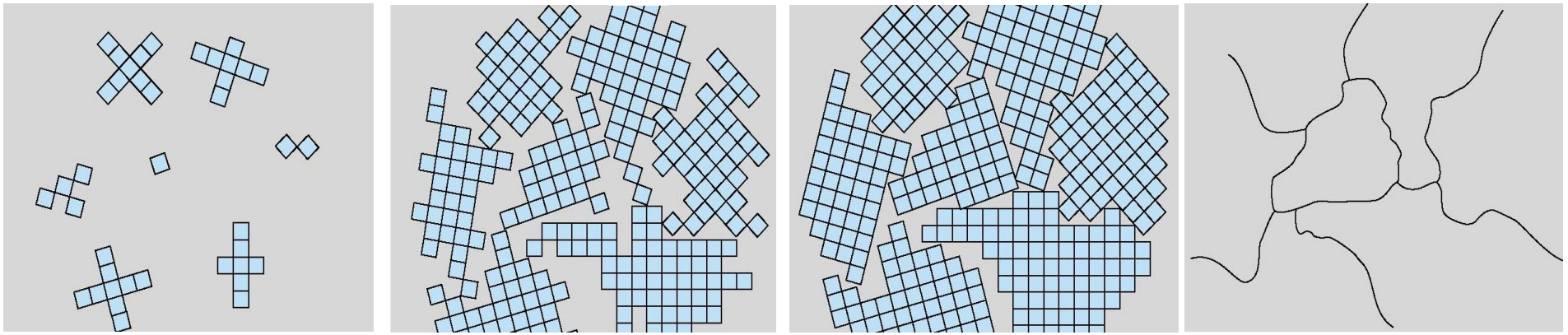


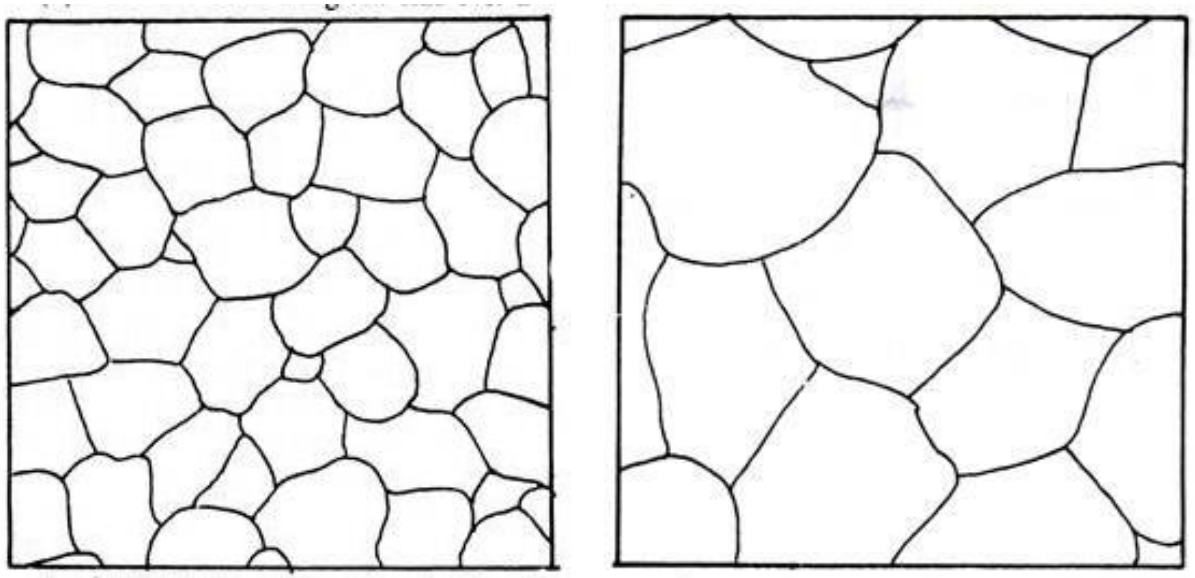
Typical cooling curves for crystalline and amorphous solids.
In (ii) there was insufficient molten metal to provide latent heat which would otherwise have caused a return to equilibrium as in (ii)


REFRACTORY
COLLAR
INGOT
MOULD


MAJOR
SEGREGATION

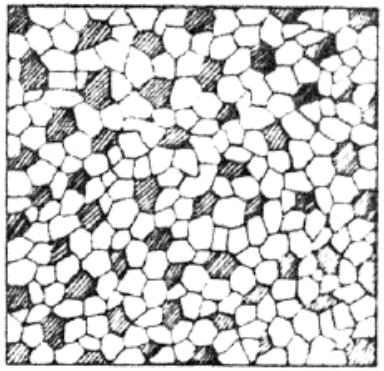
Development of Equiaxed Microstructure

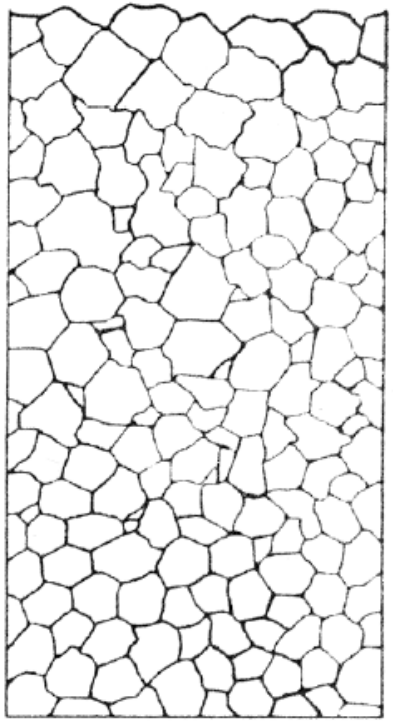




Equiaxed *versus* Columnar Microstructure

Equiaxed structure

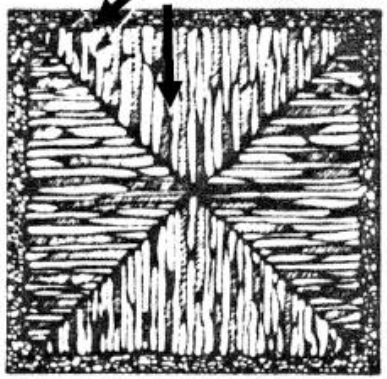




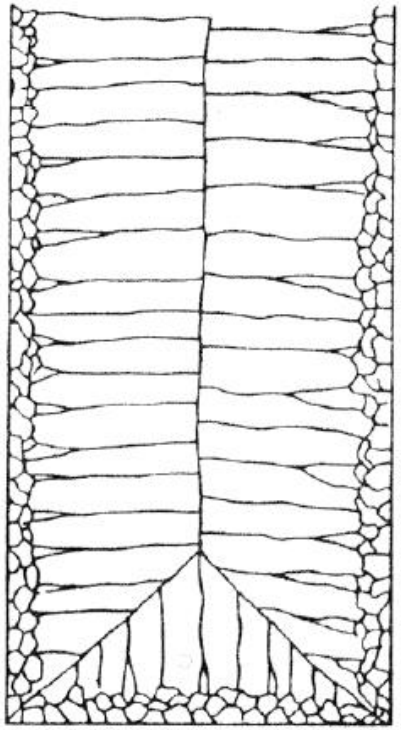
Chill zone

Columnar zone

Horizontal Section



Vertical Section



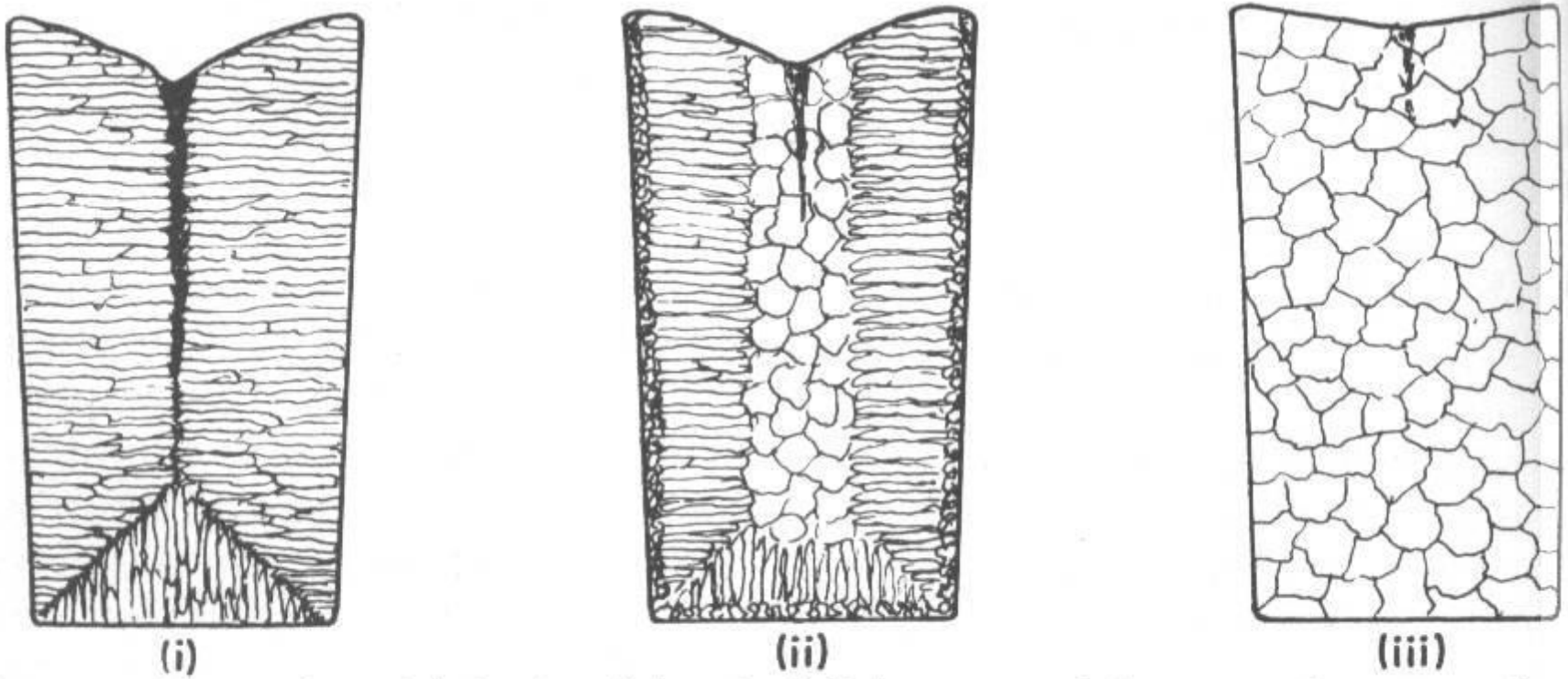
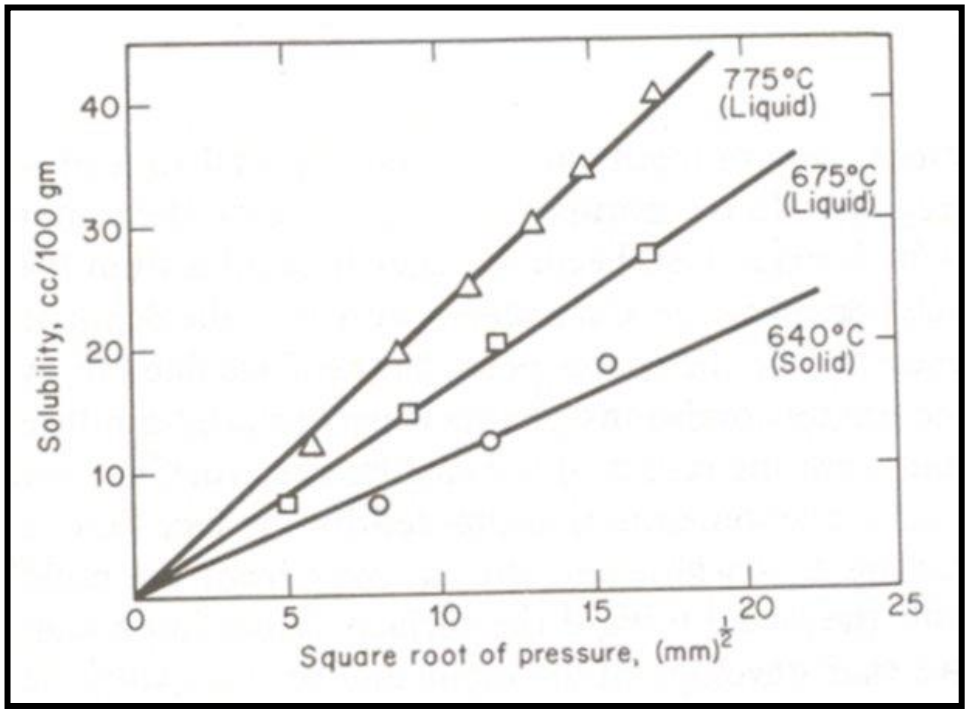


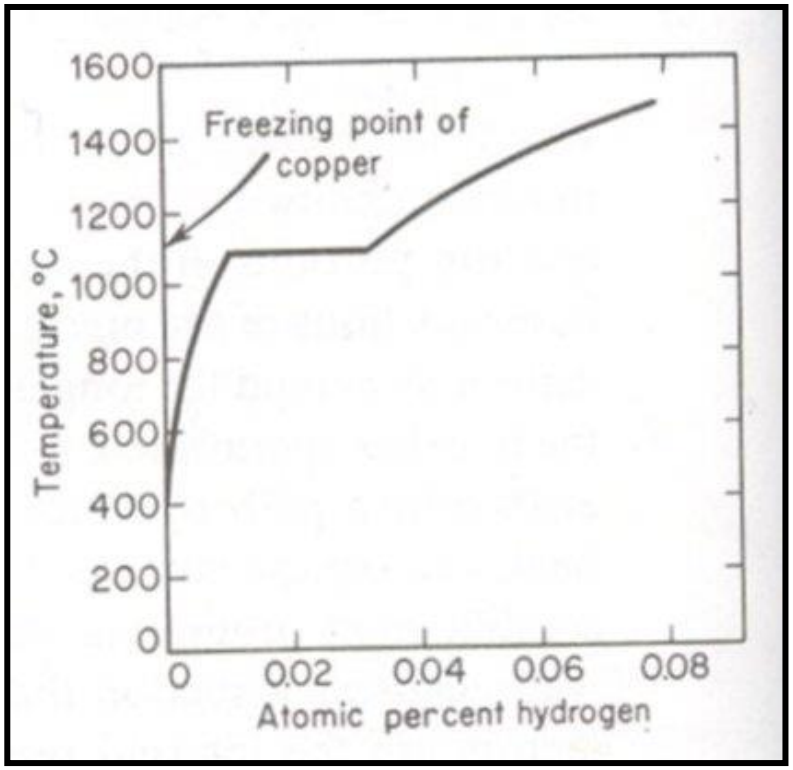
Fig. Types of crystal structure in ingots. (i) Columnar crystals—excessive segregation of impurities at the core. (ii) Zones containing chill, columnar and equi-axed crystals. (iii) Large equi-axed crystals—less segregation because the cooling rate was low.

Mixed Microstructures

Solubility of Gas in Metals

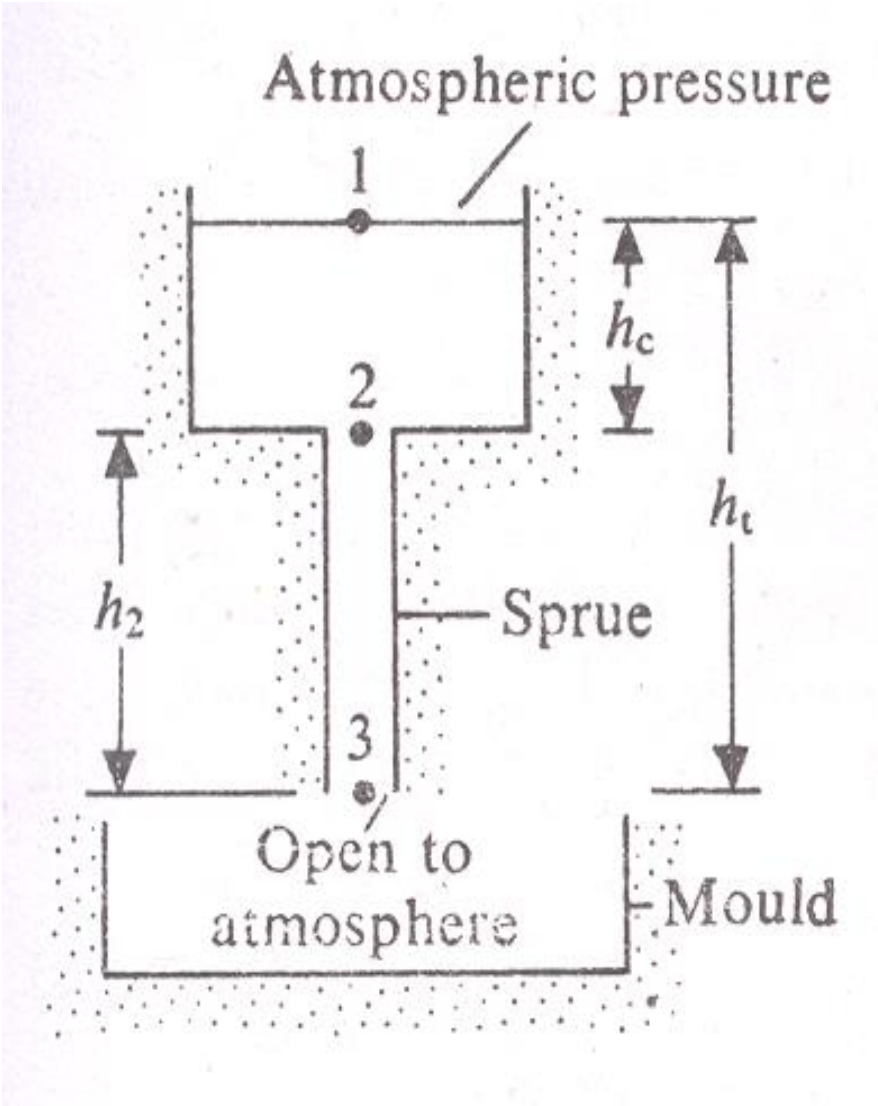
Solubility of H_2 in Mg



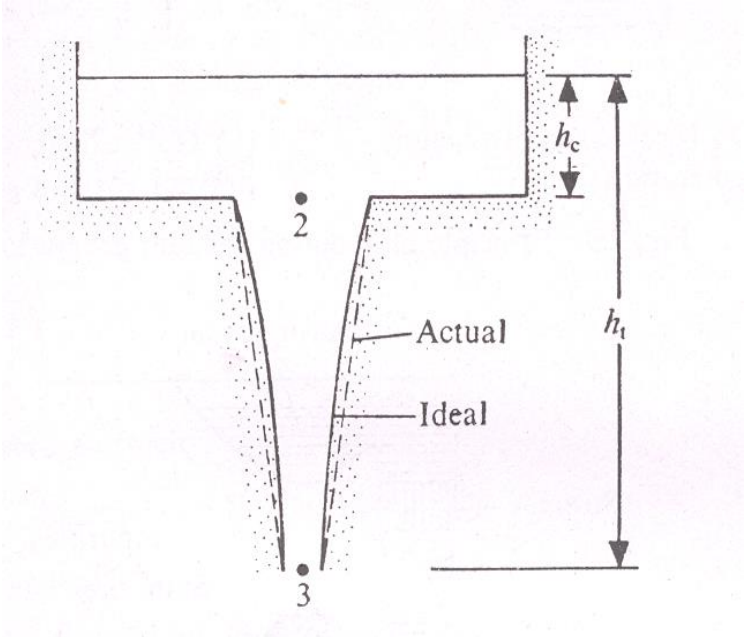


Solubility of H_2 in Cu at 1 atm

Vertical Gating

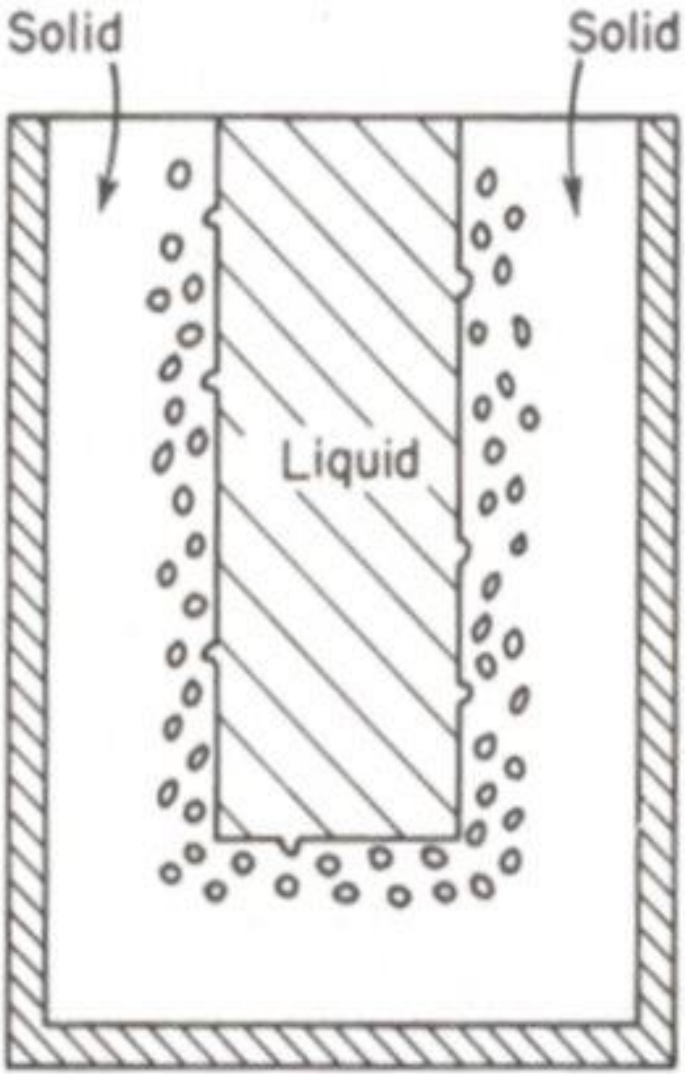


Correctly designed sprue

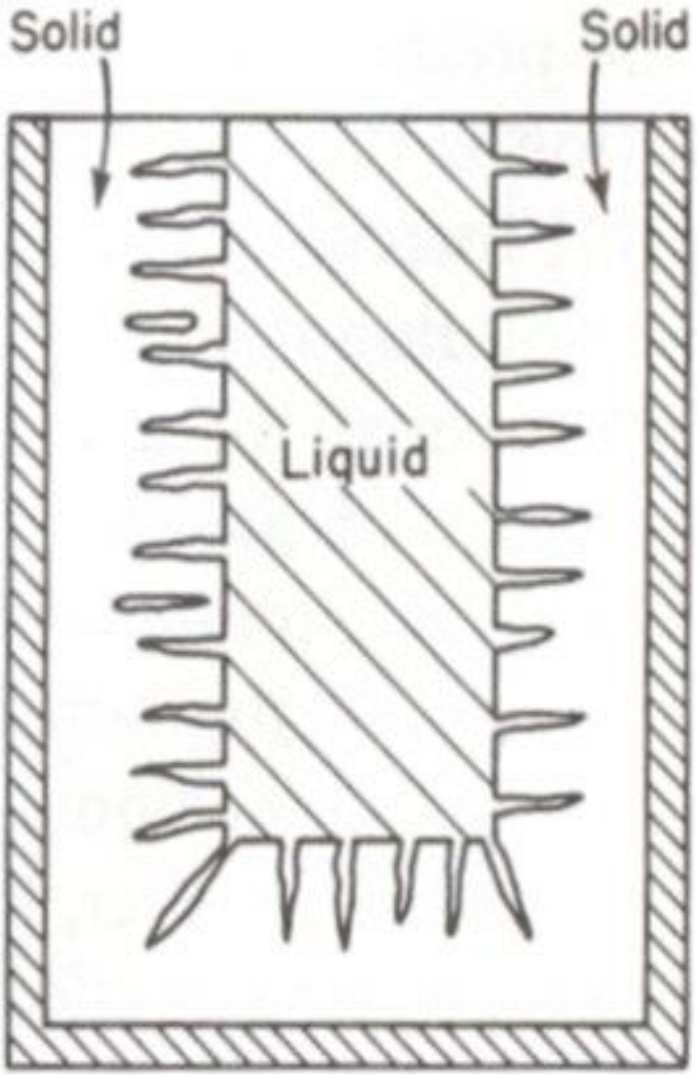


- to prevent *Aspiration Effect*, the sprue is tapered

Macroscopic Pores



- blowhole



- wormhole porosity

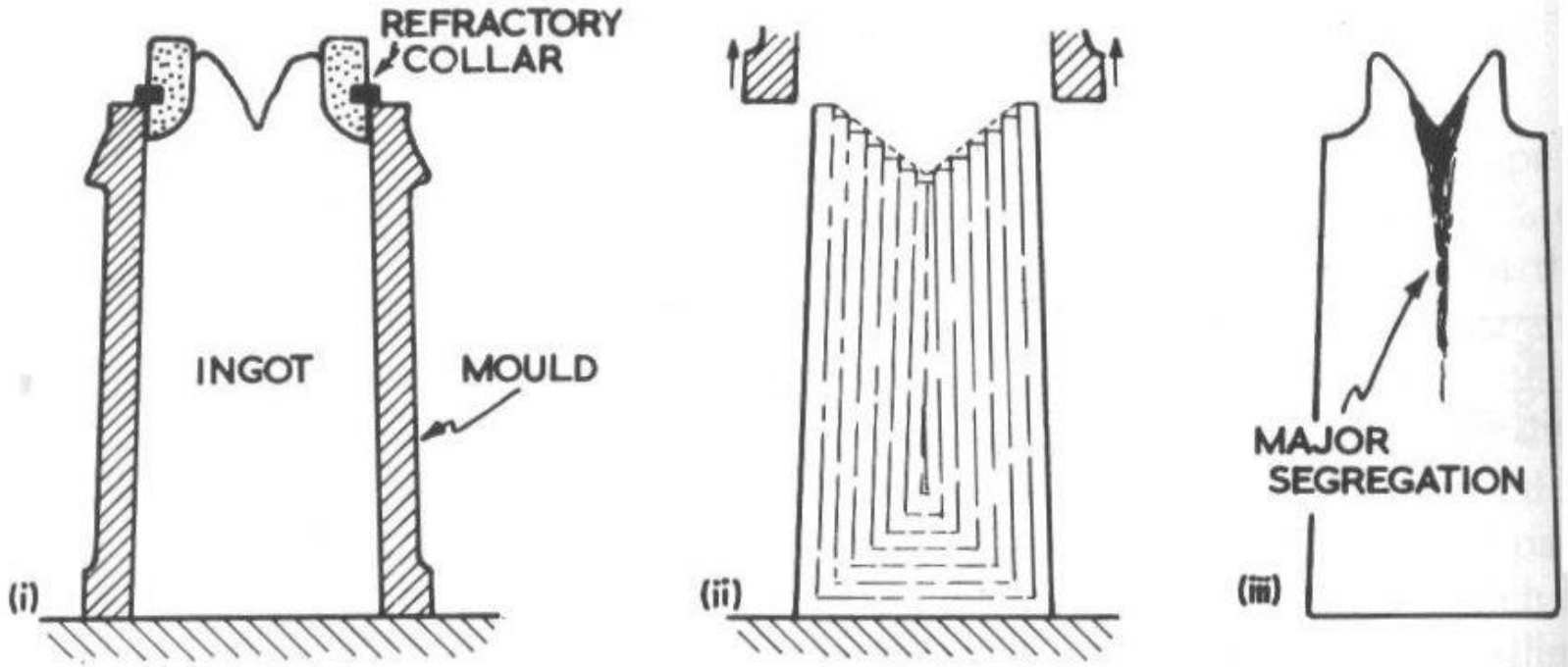
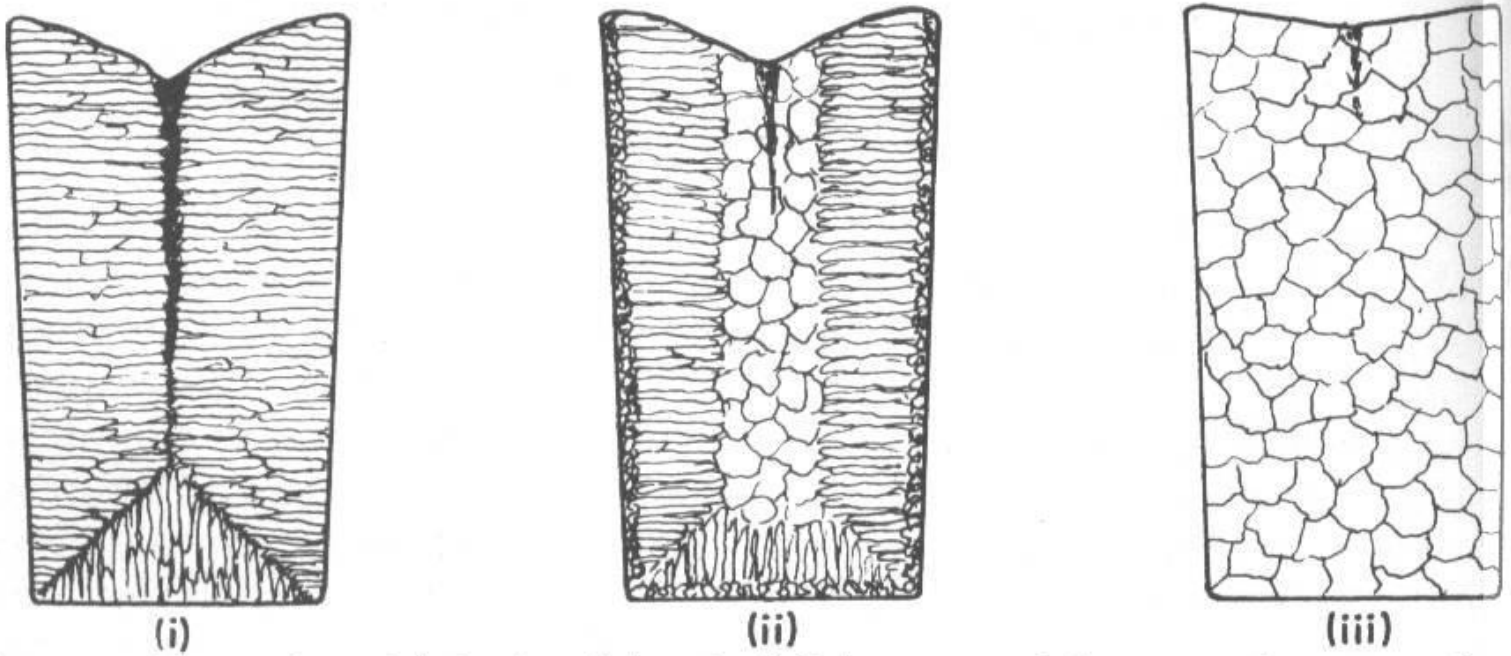


Fig. The structure of steel ingots. (i) A typical 'big-end-down' ingot mould showing how the 'pipe' can be restricted. (ii) The development of the 'pipe' by successive solidification of elemental 'shells'. (iii) Major segregation of impurities in the central pipe.



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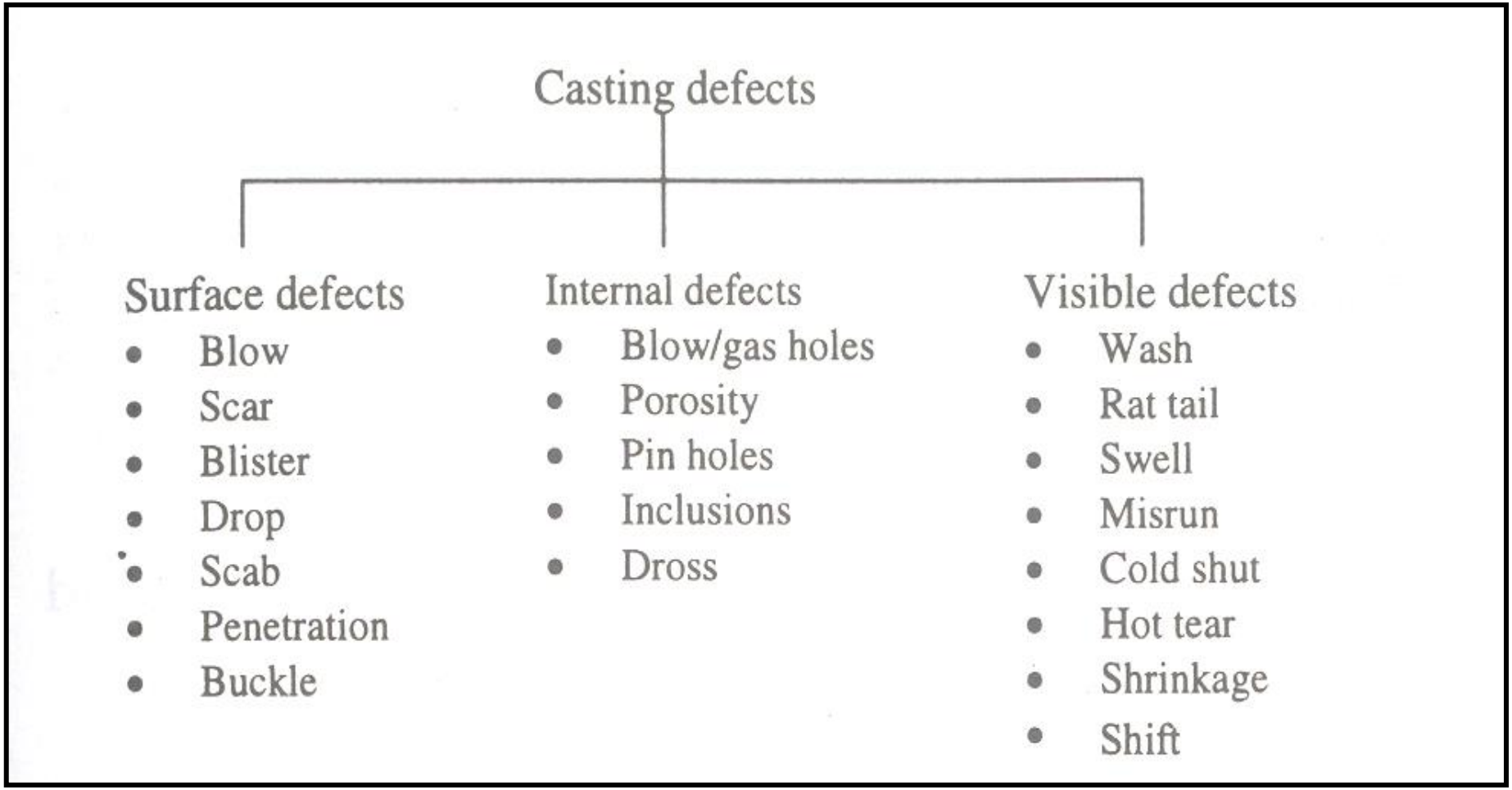
Casting Defects

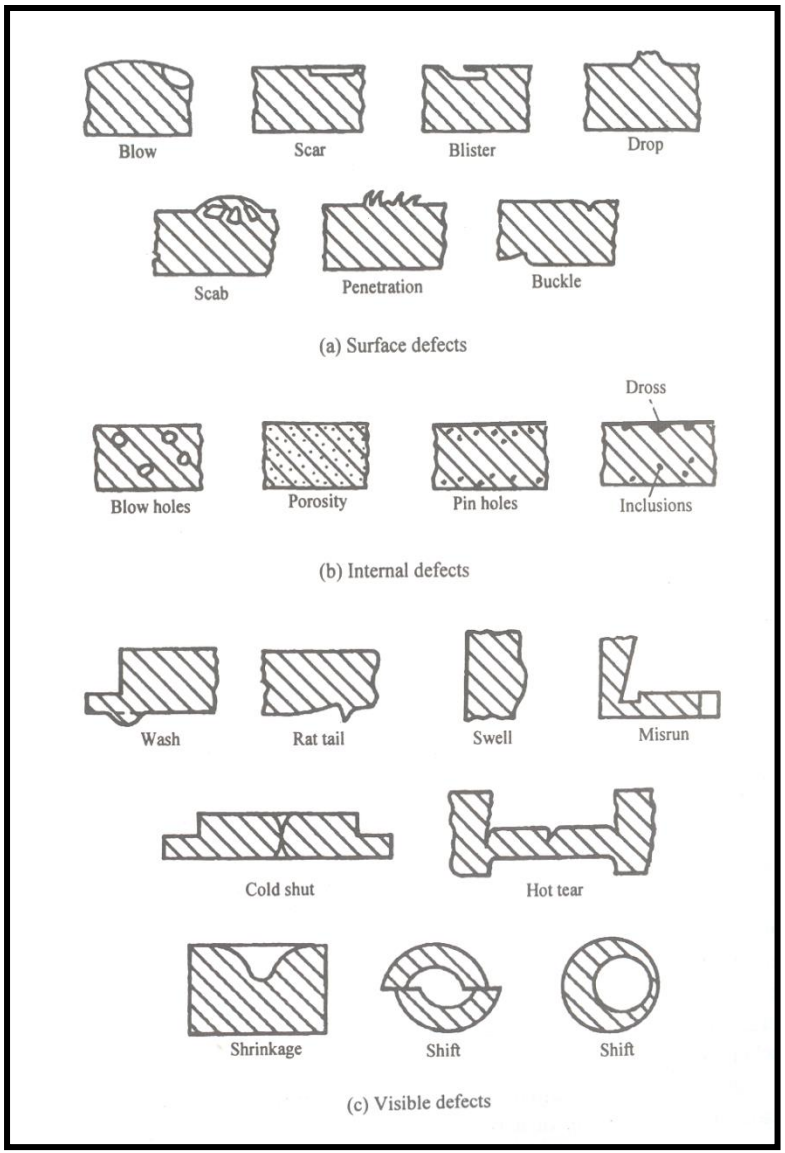
- Pipe formation
- Macro-segregation
- Micro-segregation
- Blowholes and Wormholes
- .....and many more

Classification of Casting Defects



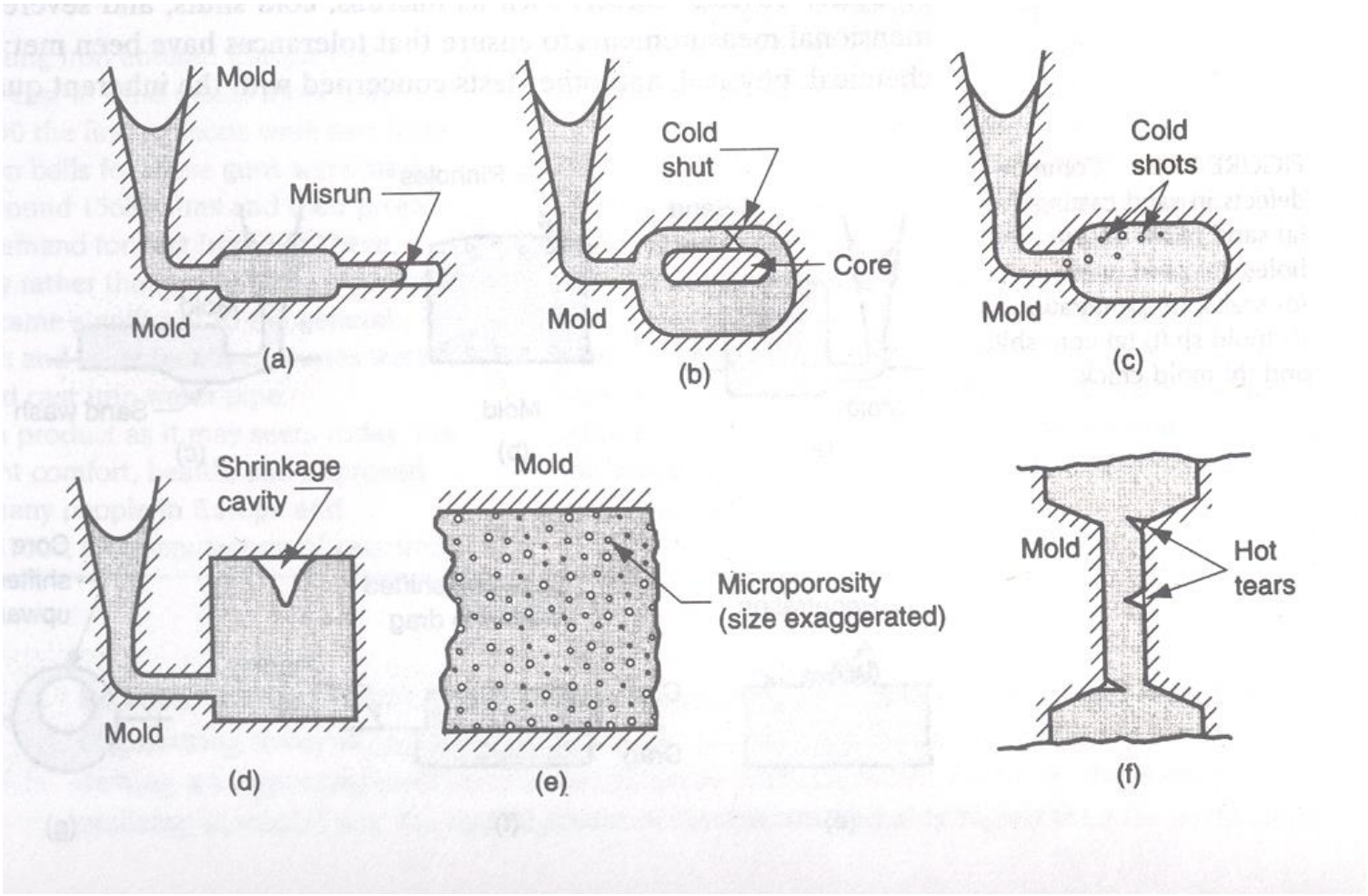
Source:
G.K. Lal, S.K. Choudhury: Fundamentals of Manufacturing Processes, p. 61

Casting Defects

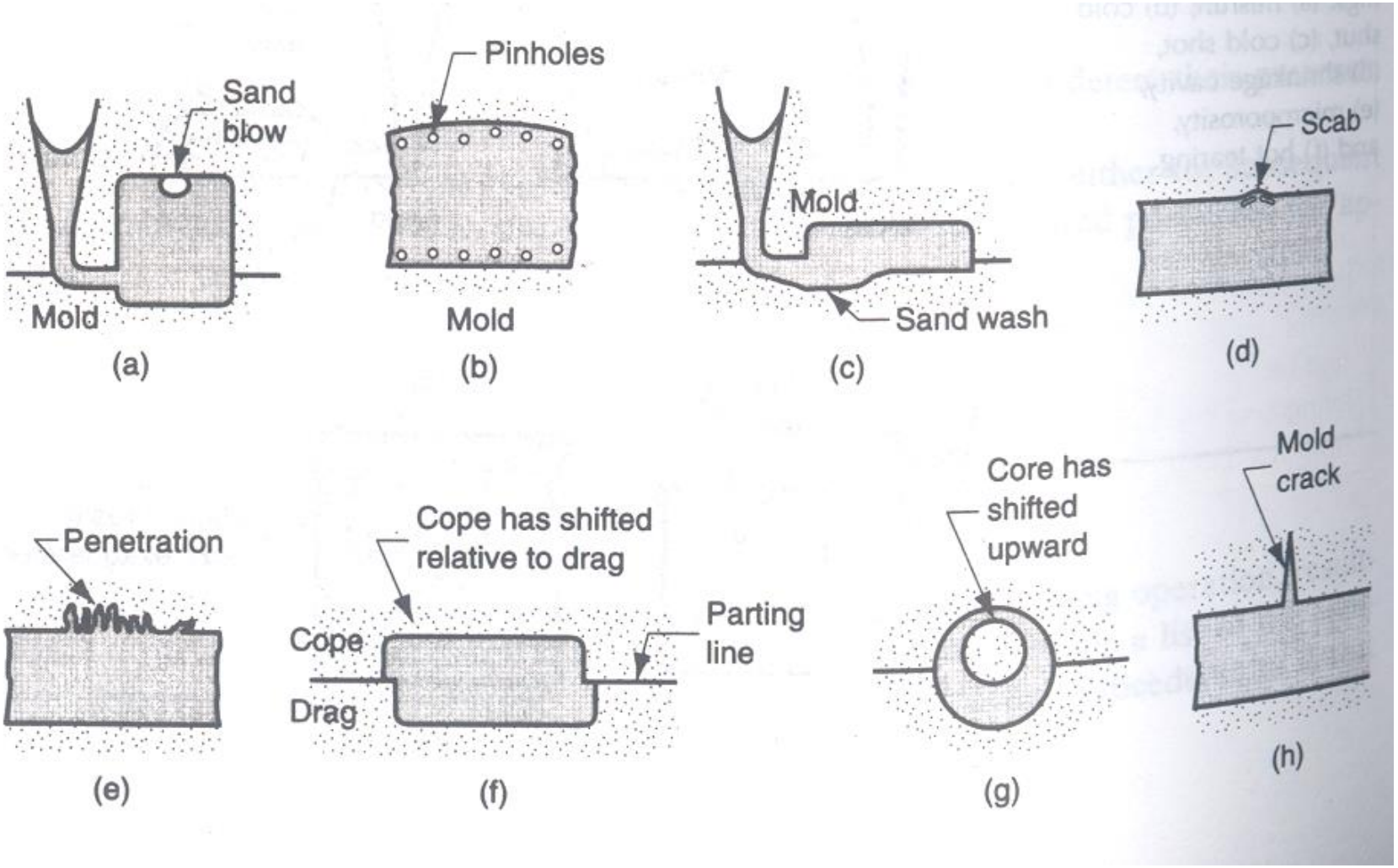


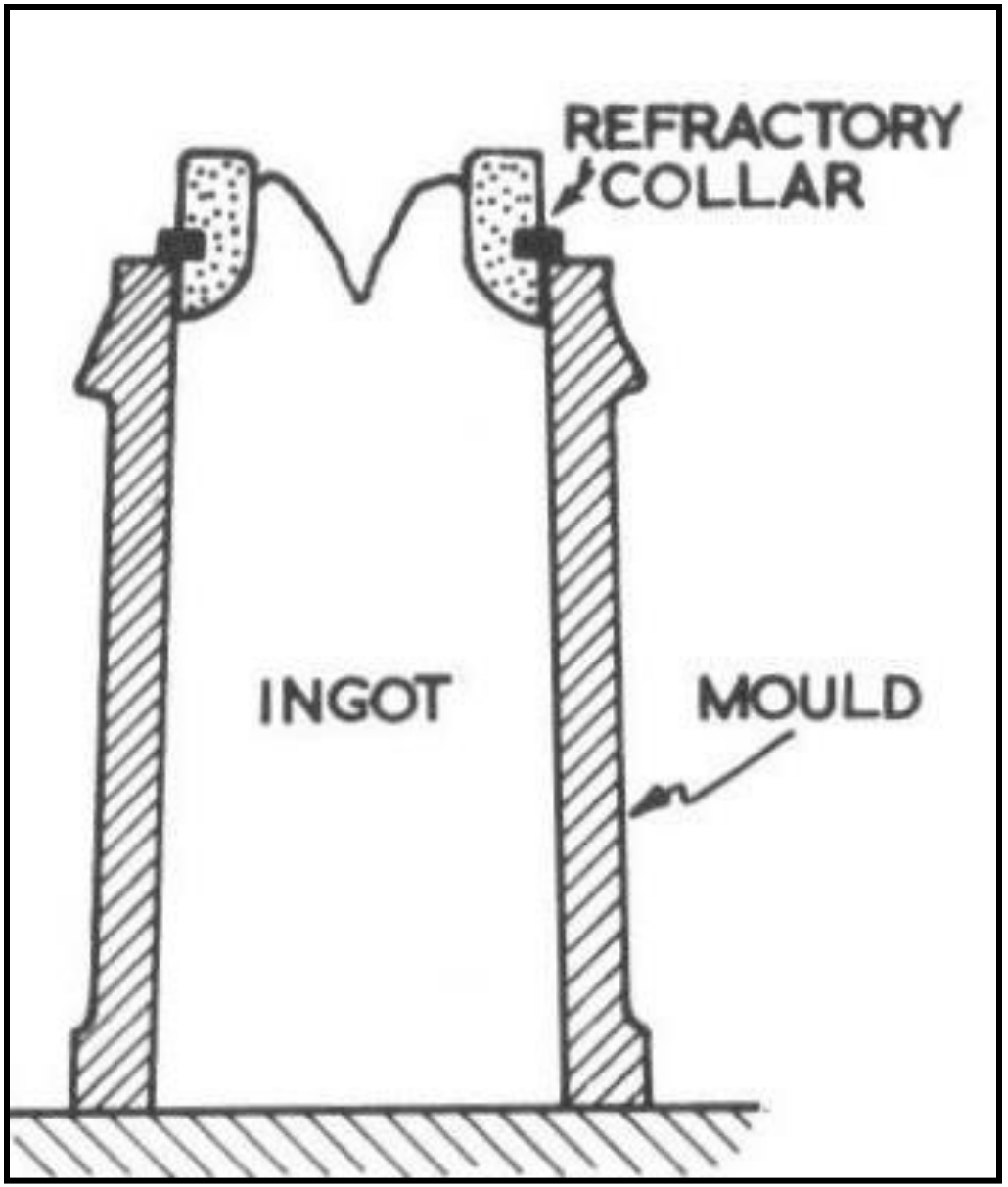
Source:
G.K. Lal, S.K. Choudhury: Fundamentals of Manufacturing Processes, p. 60
A. Ghosh, A.K. Mallik: Manufacturing Science, p. 91

Common Defects in Castings



Common Defects in Sand Castings

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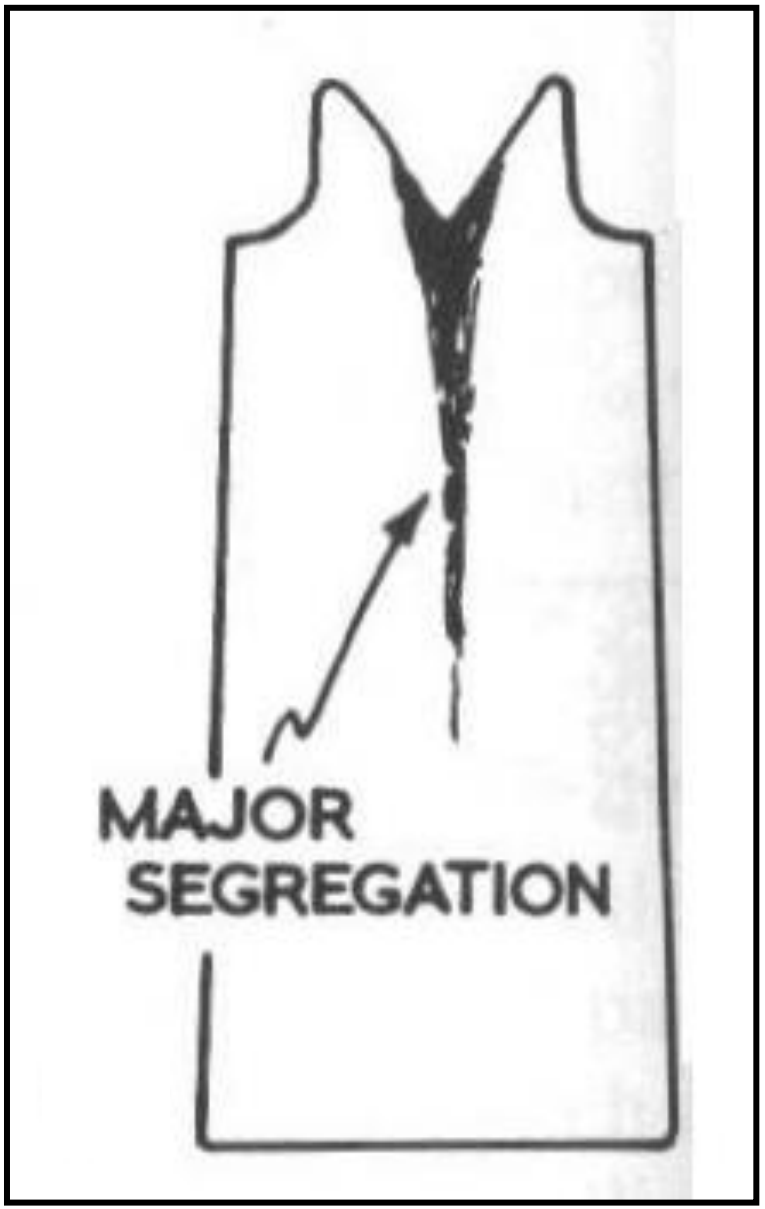
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