How Metals Are Produced

Steel

Alloy

Iron

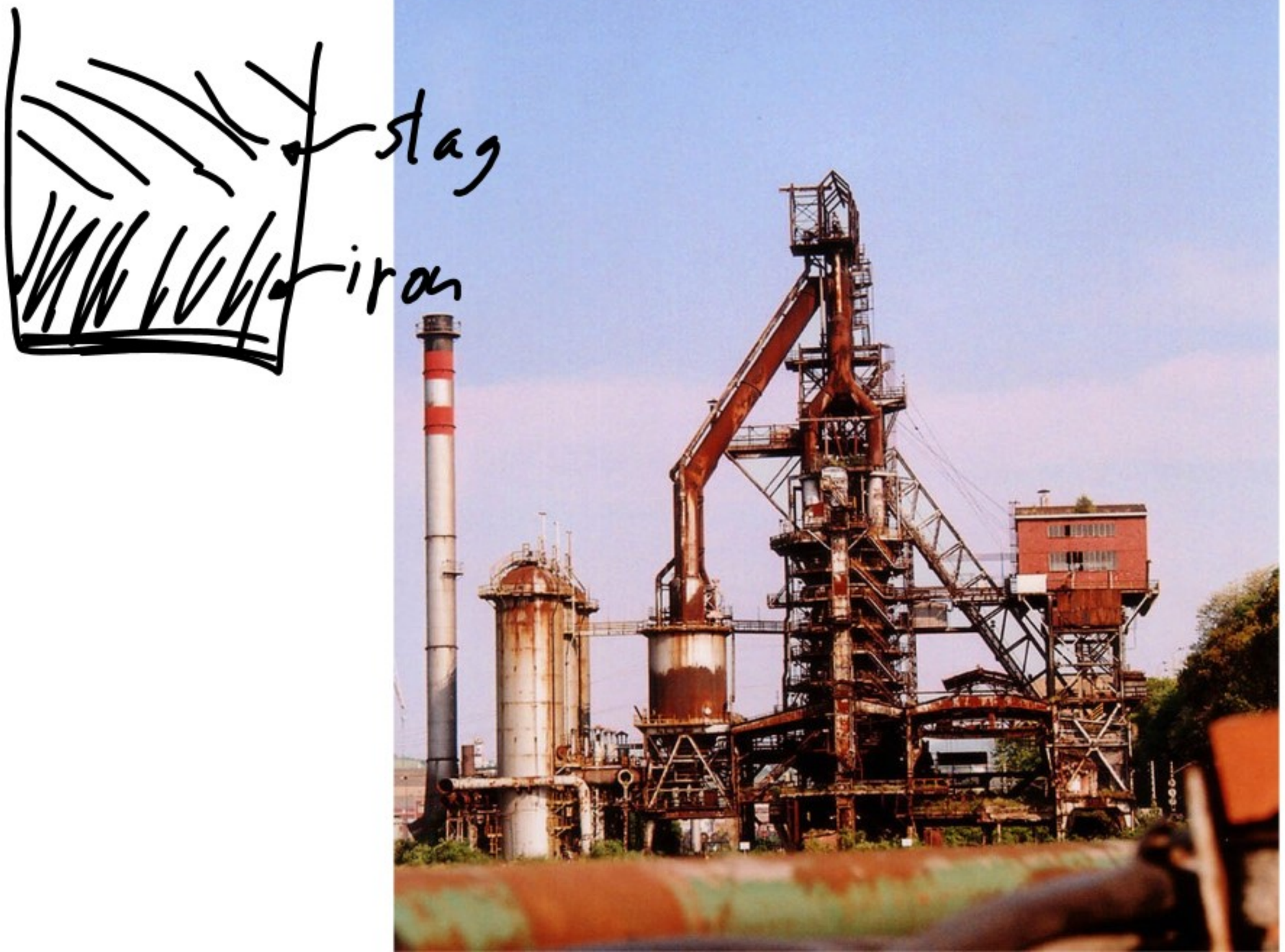
Iron ore

Crush

Melt at 1650 °C

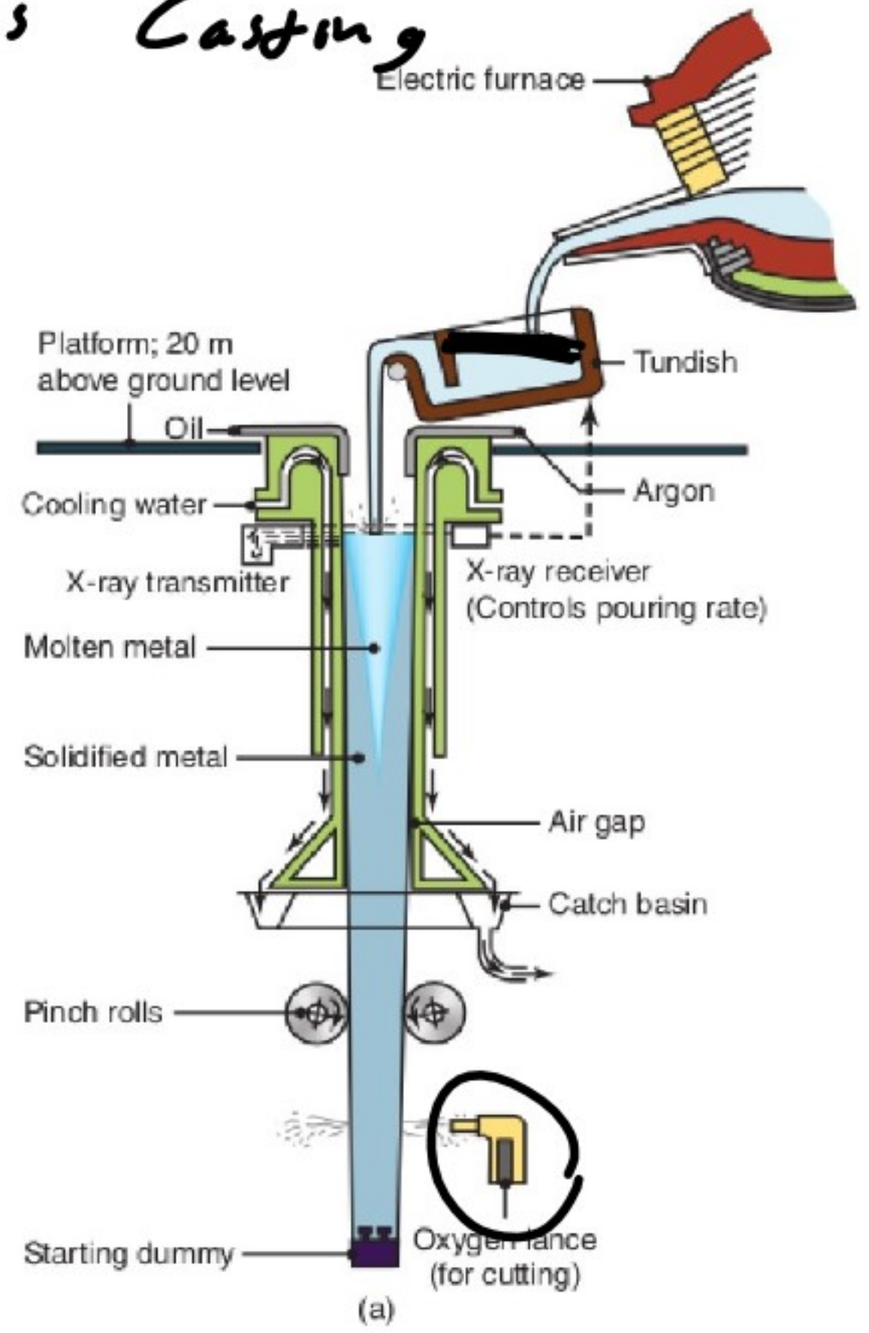
Blast Furnace

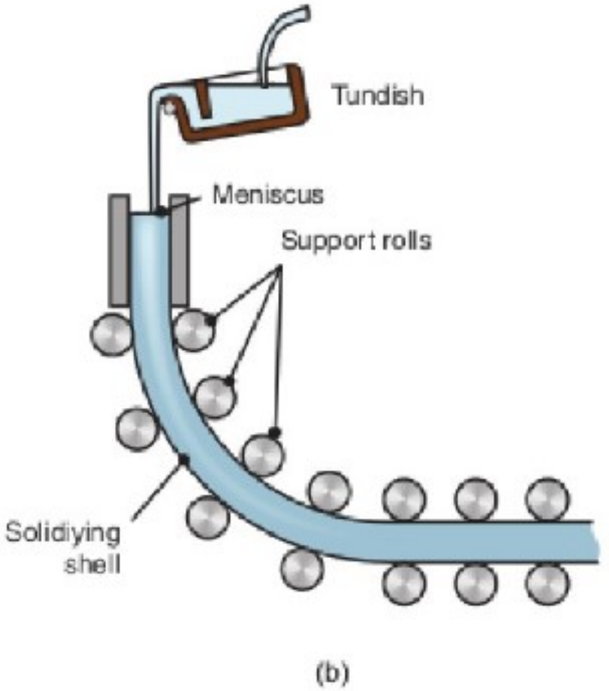
Iron first used 5000 – 3000 BC

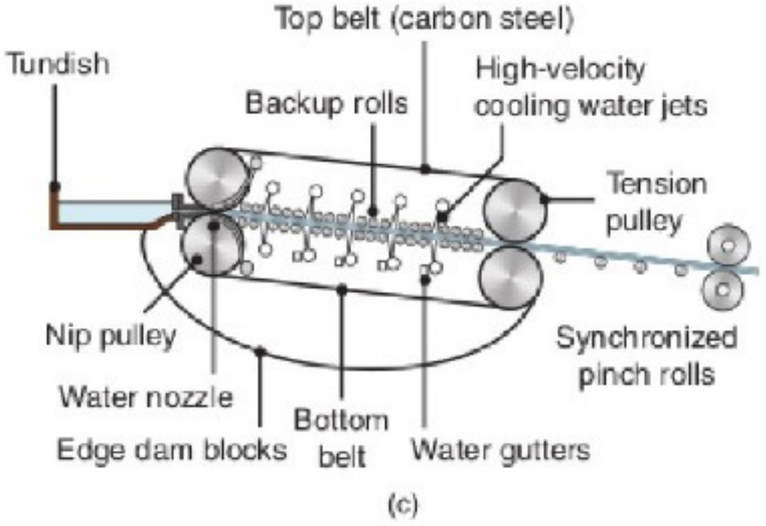

stag
iron

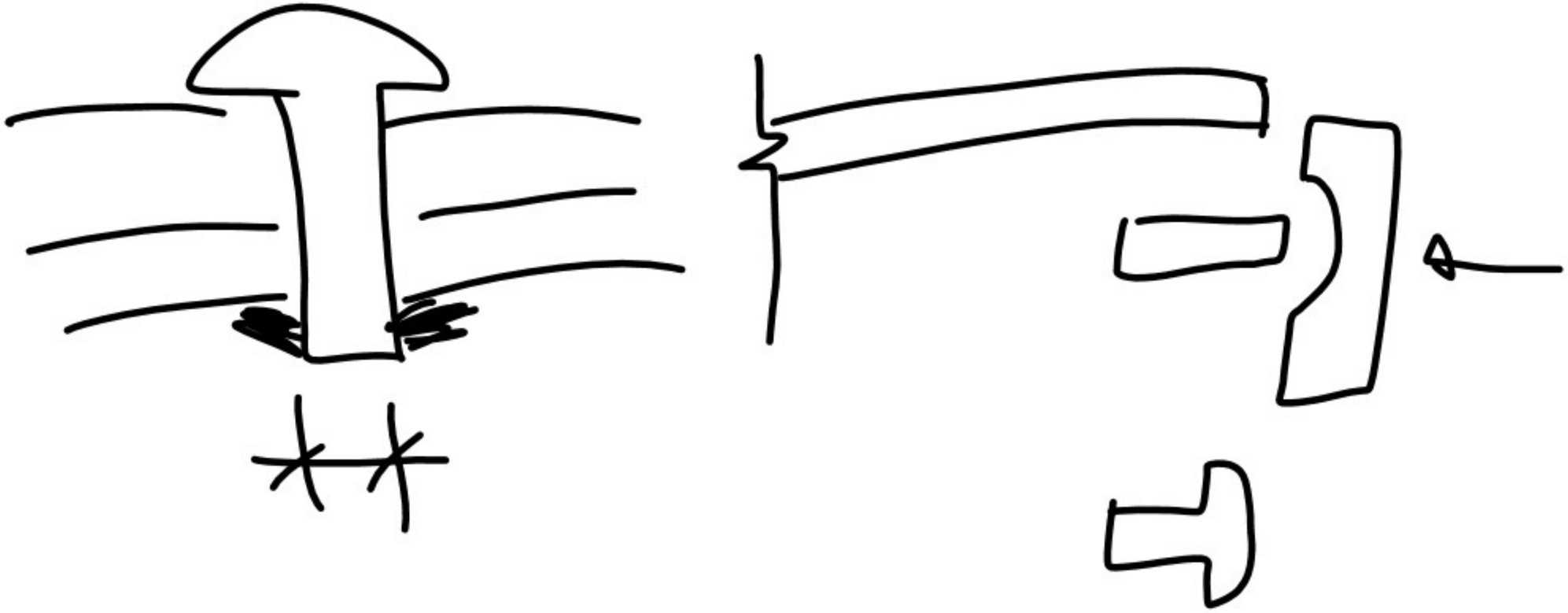
Continuous Casting

1860 s










Aluminum 1825
bauxite
crush

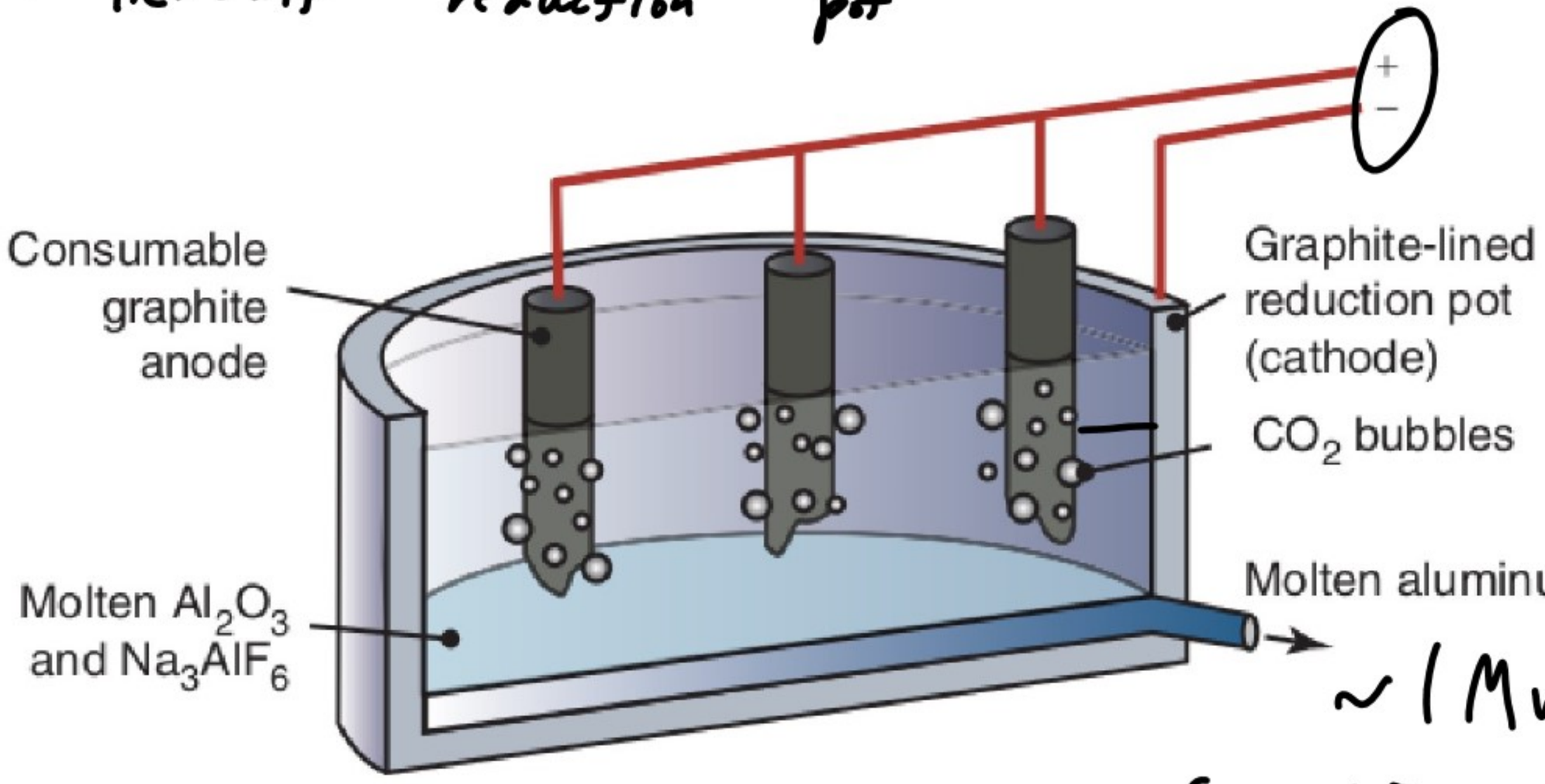
heat to 150 to 200 °C in sodium hydroxide

producing sodium aluminate

convert + aluminum hydroxide

heat to 1000 °C alumina

Hall – Heroult reduction pot



~1 Mw

6V 150000 A

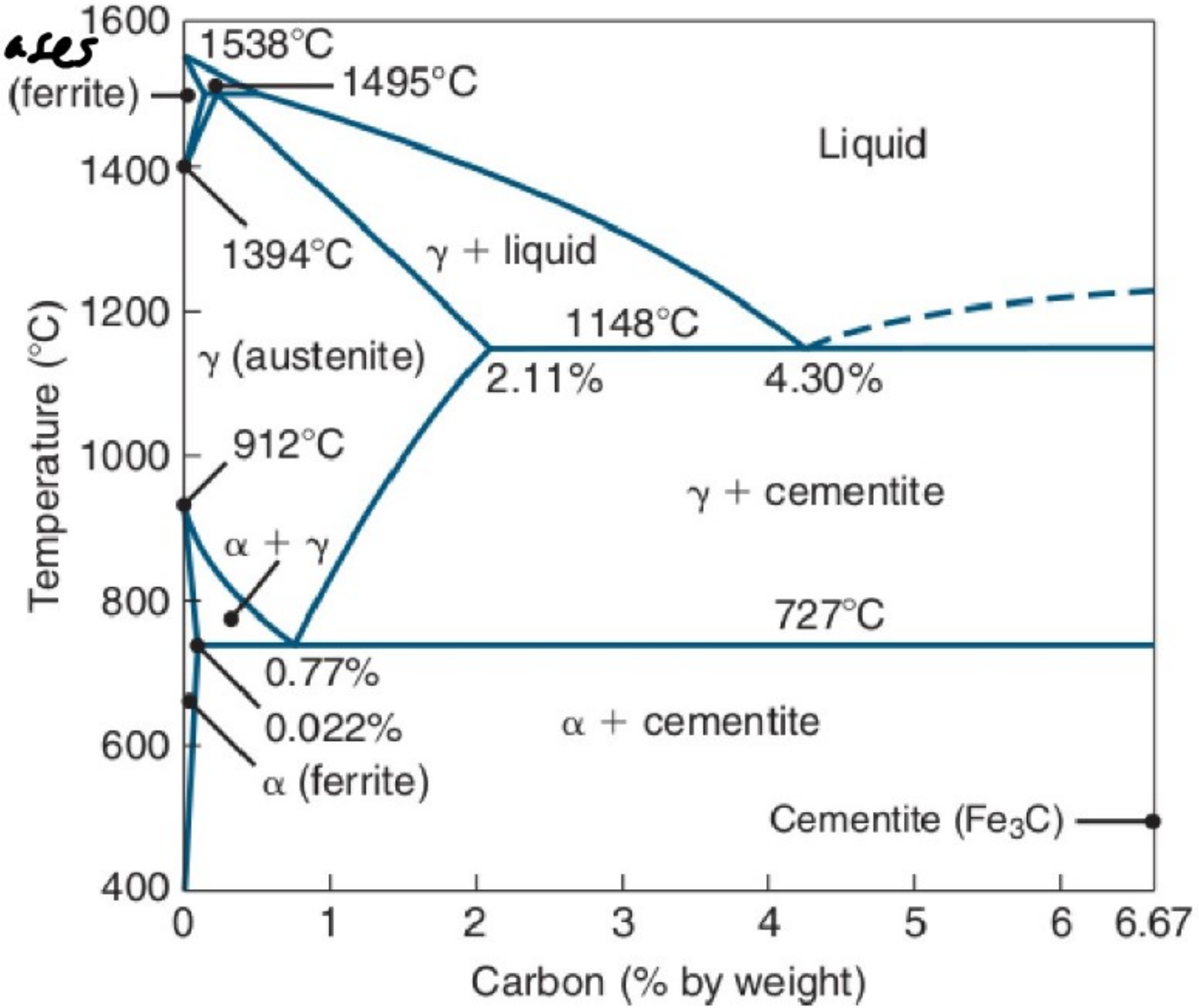
5% US electricity

Iron 5% of crust

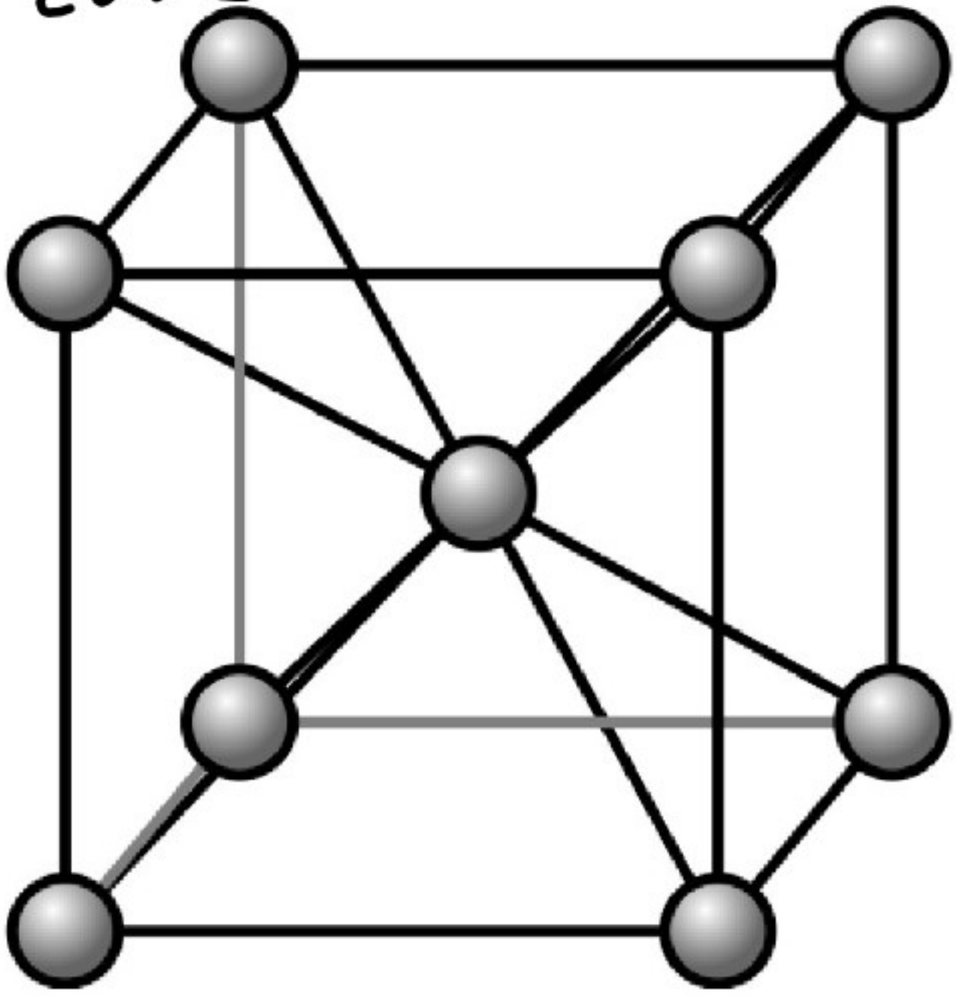
Bauxite 8%

Iron phases

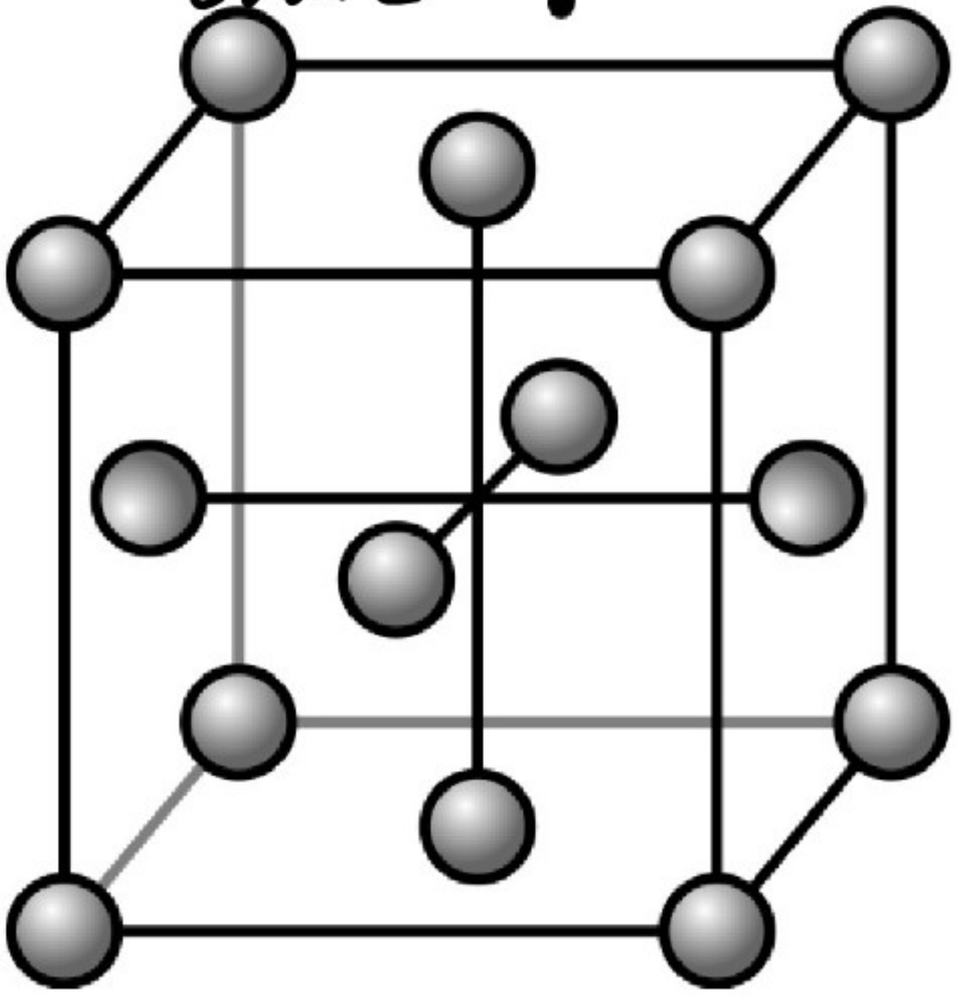
Water
Steam
Ice

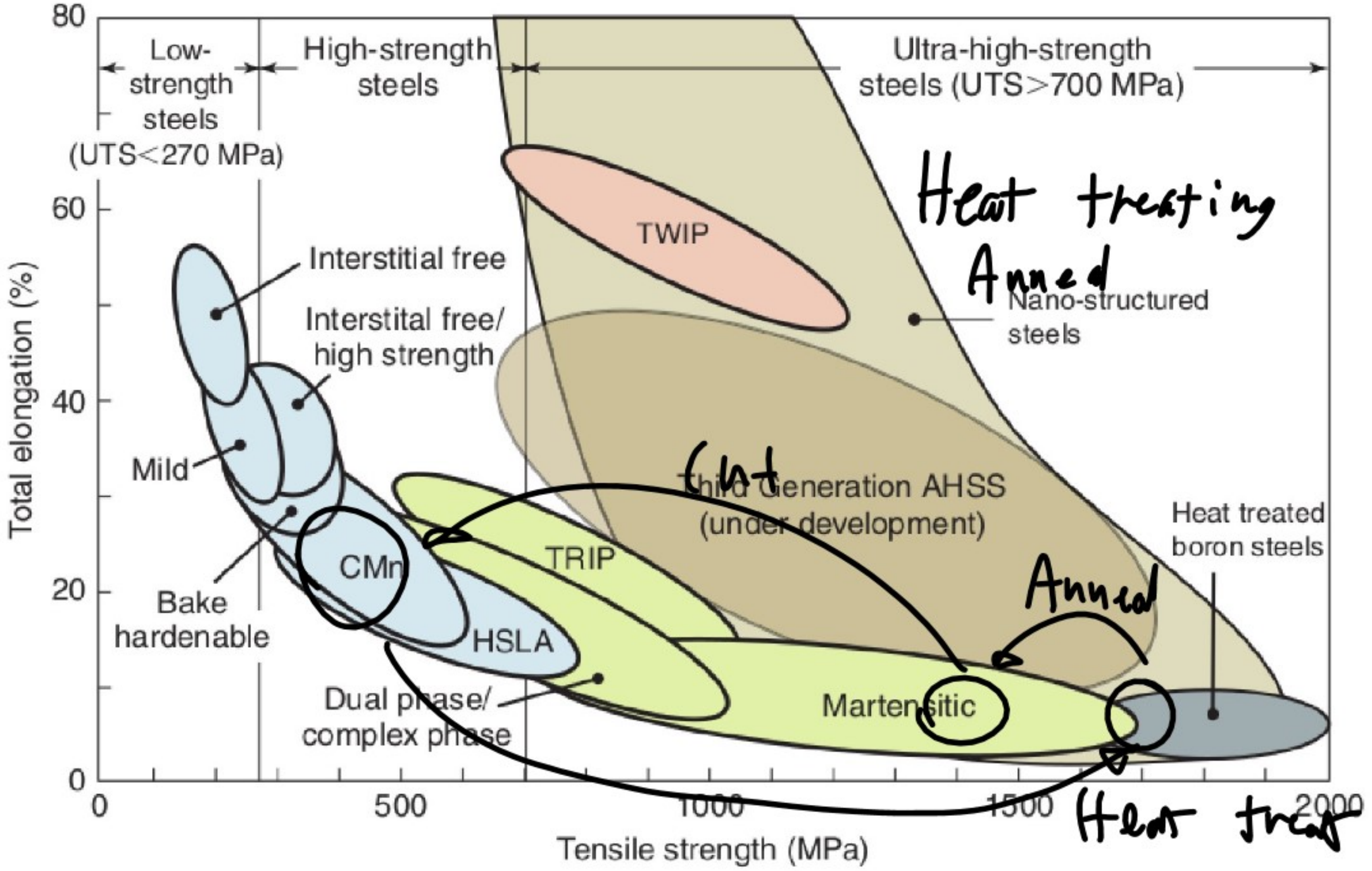


Body centered cubic α

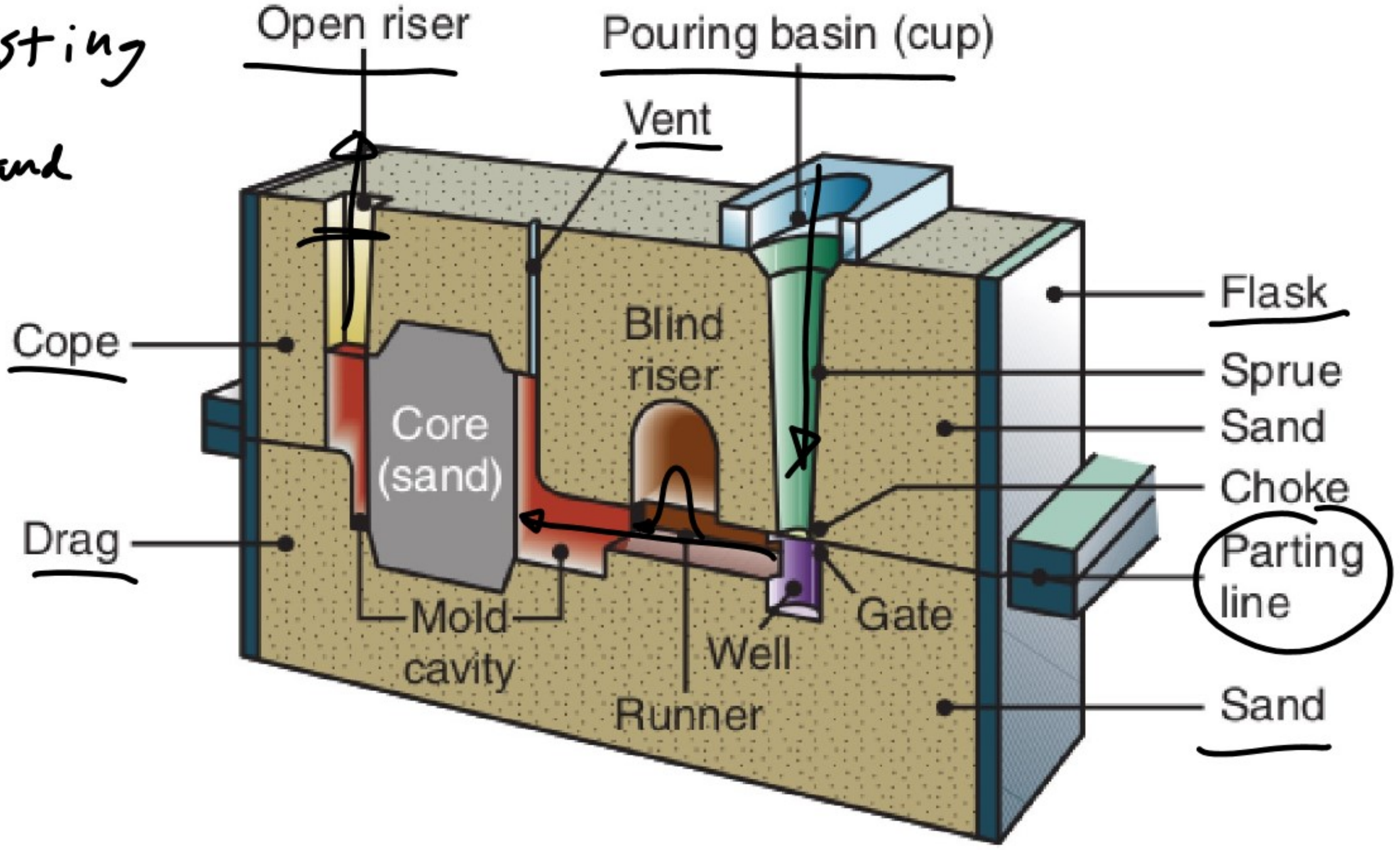


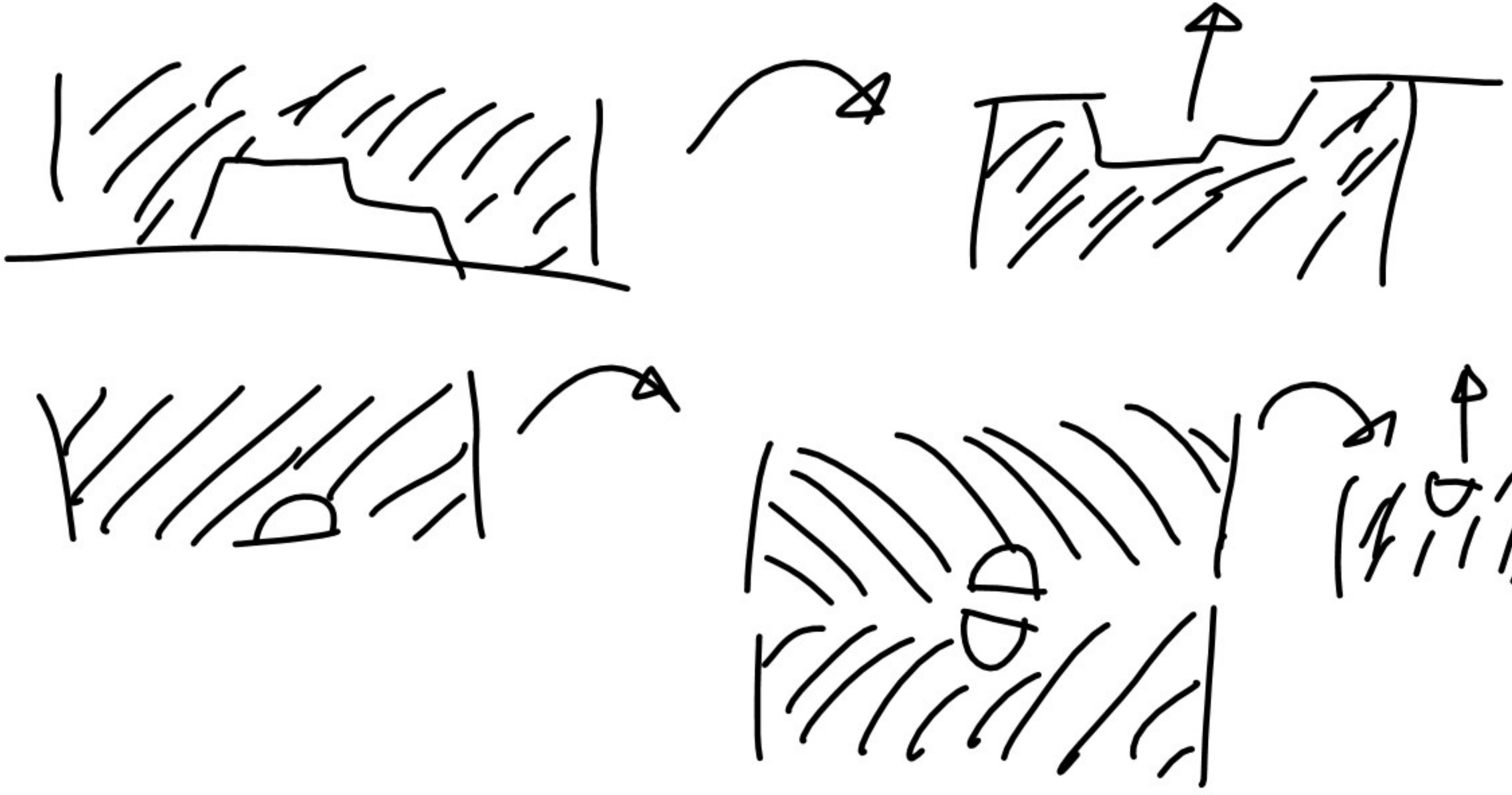
Face Centered Cubic γ

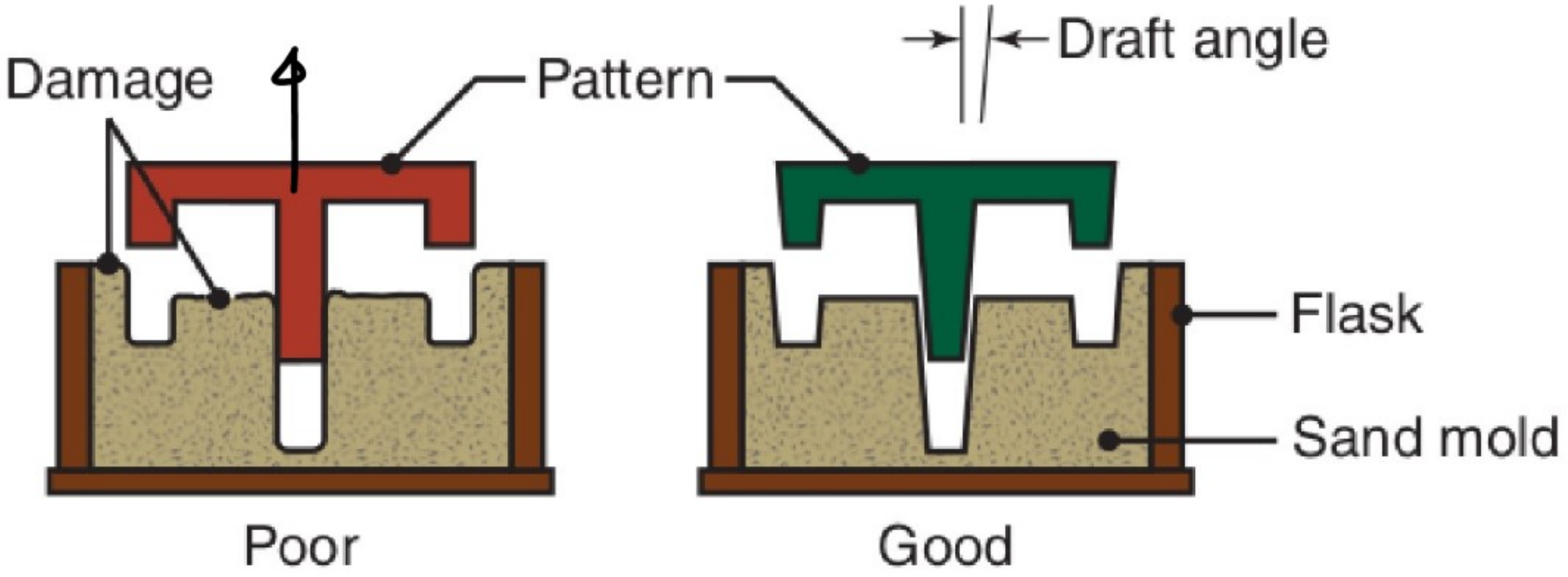


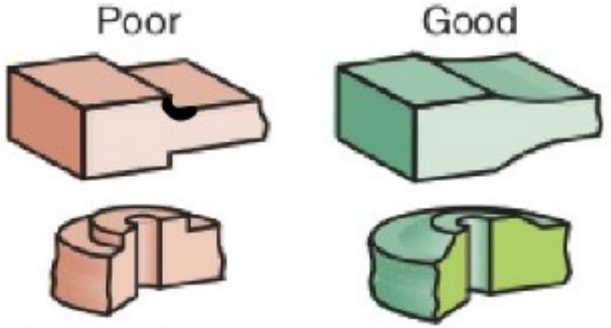

Low-strength steels (UTS<270 MPa)
High-strength steels
Ultra-high-strength steels (UTS>700 MPa)
Total elongation (%)
Tensile strength (MPa)
0
20
40
60
80
0
500
1000
1500
2000
Interstitial free
Interstital free/ high strength
Mild
Bake hardenable
CMn
HSLA
Dual phase/ complex phase
TRIP
TWIP
Third Generation AHSS (under development)
Martensitic
Nano-structured steels
Heat treated boron steels
Heat treating
Annea
Cut
Annea
Heat treat

Casting Sand

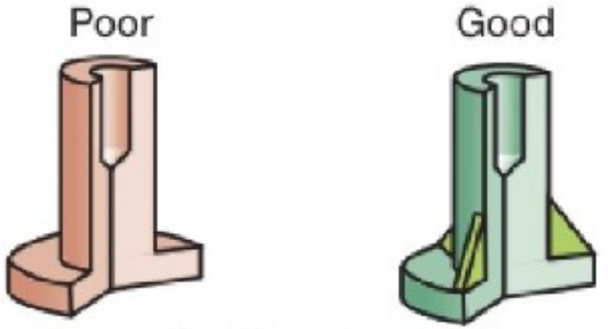




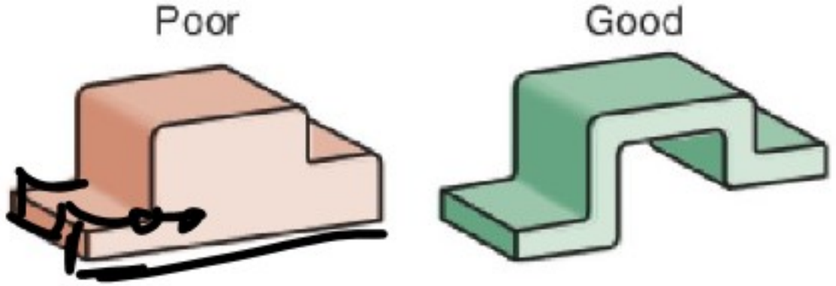

Damage
Pattern
Draft angle
Flask
Sand mold
Poor
Good



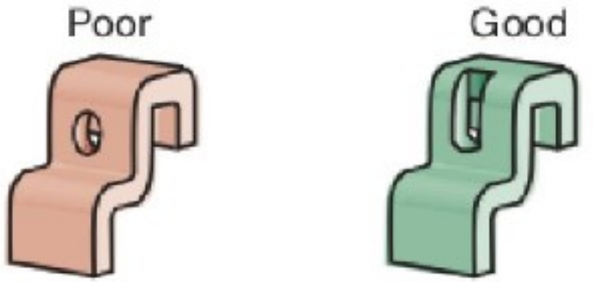
Use radii or fillets to avoid corners and provide uniform cross-section.



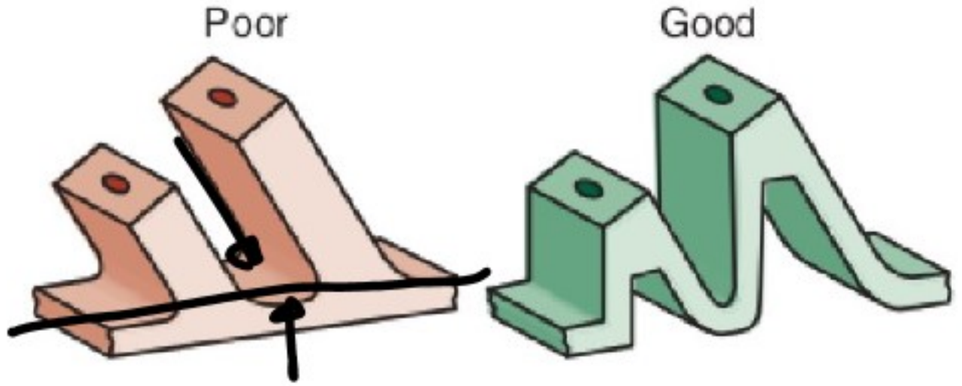
Ribs and/or fillets improve bosses.



Wall sections should be uniform.



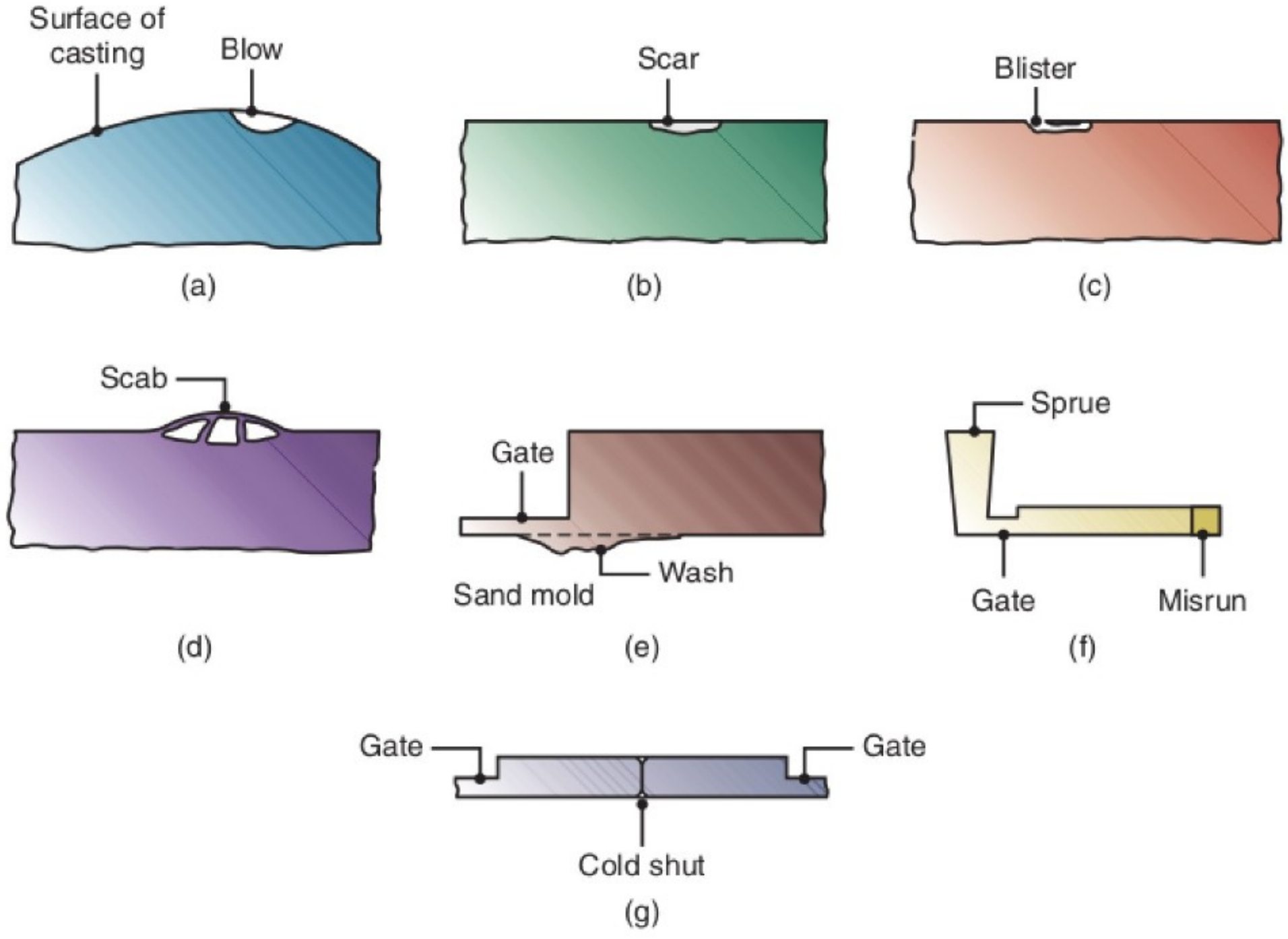
Side cores can be eliminated with this hole design.

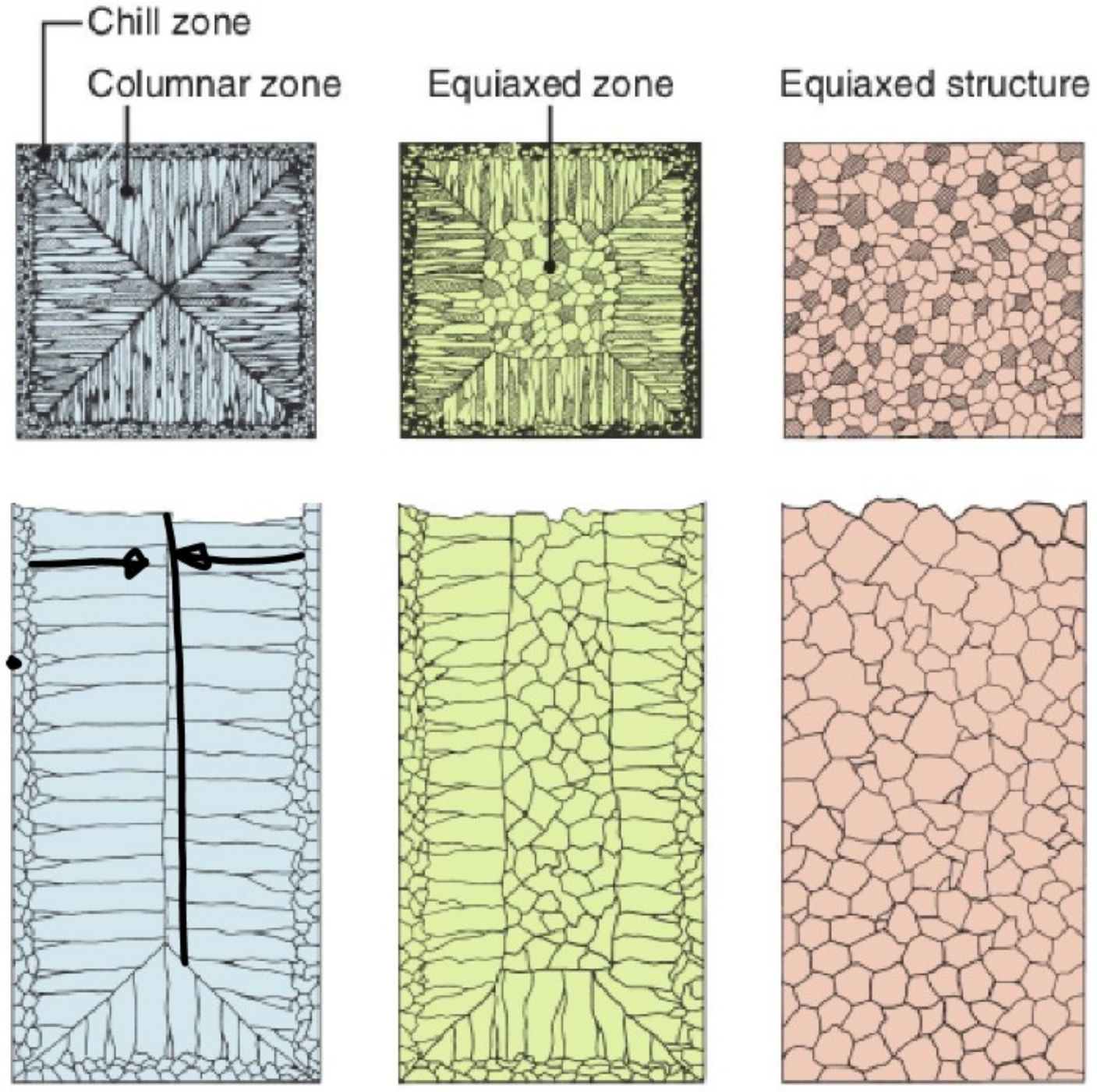


Sloping bosses can be designed for straight die parting to simplify die design.


SOAR
GPRV HYDROTURBINE

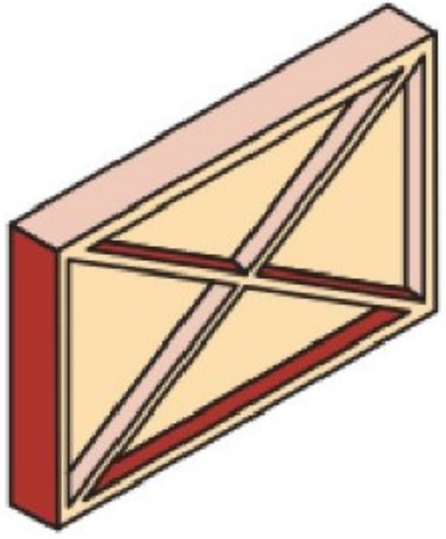

PRV
SOAR


Surface of casting
Blow
(a)
Scar
(b)
Blister
(c)
Scab
(d)
Gate
Wash
Sand mold
(e)
Sprue
Gate
Misrun
(f)
Gate
Gate
Cold shut
(g)


Chill zone
Columnar zone
Equiaxed zone
Equiaxed structure

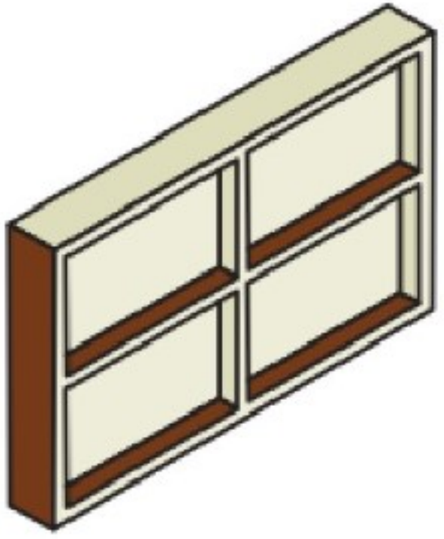
Metal	Shrinkage allowance (%)
Cast Irons	
Gray cast iron	0.83–1.3
White cast iron	2.1
Malleable cast iron	0.78–1.0
Aluminum alloys	1.3
Magnesium alloys	1.3
Copper alloys	
Yellow brass	1.3–1.6
Phosphor bronze	1.0–1.6
Aluminum bronze	2.1
High-manganese steel	2.6

Poor



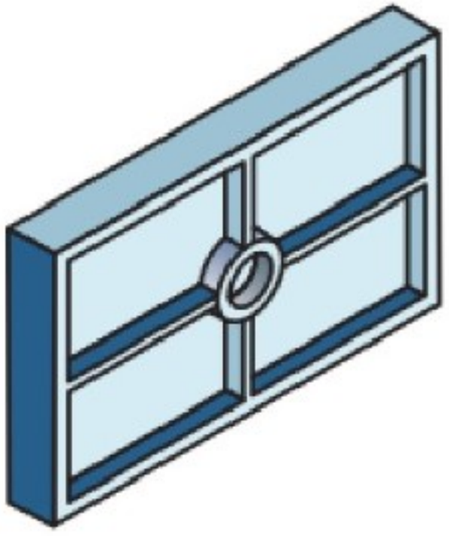
(a)

Poor



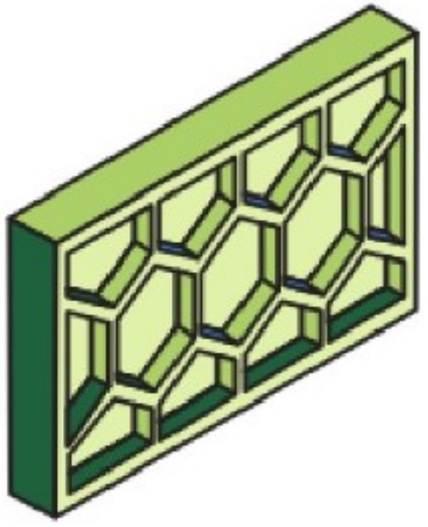
(b)

Good



(c)

Best



(d)