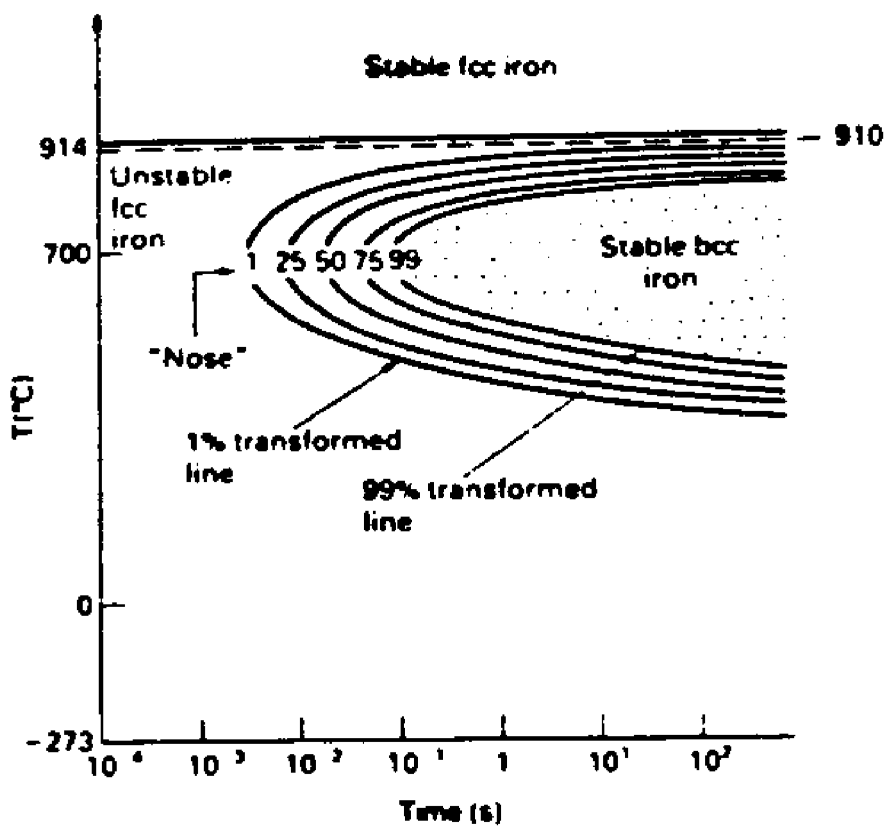
METALURGI FISIK

Diagram TTT dan CCT

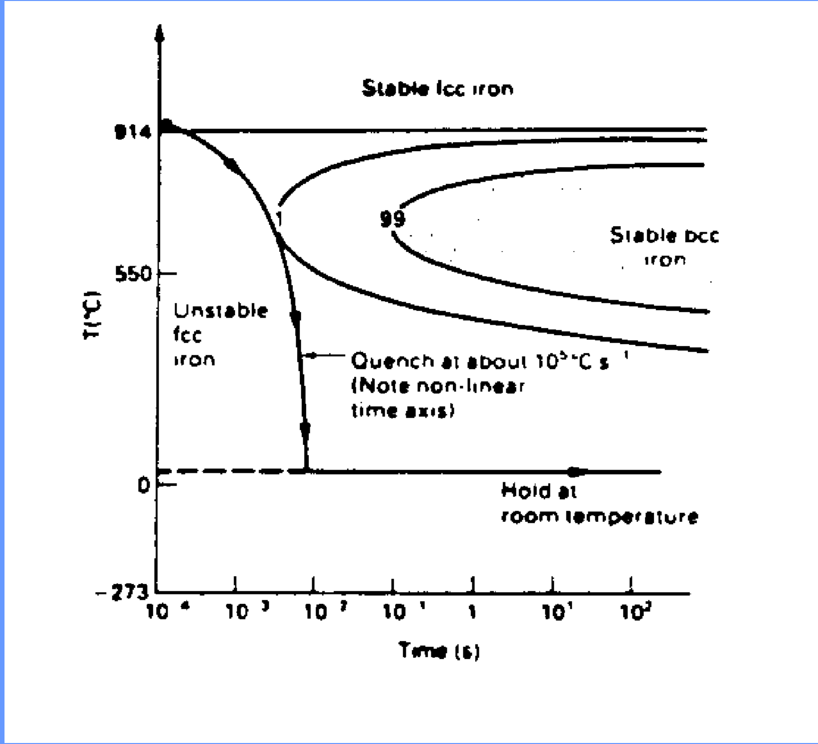
Time-Temperature-Transformation (TTT) Diagram

- The standard practice to display diffusive transformations is with t "Time-Temperature-Transformation" (TTT) diagram. It is also know as the "Isothermal-Transformation" diagran or "C-curve".
- The TTT diagram for the diffusive f.c.c.->b.c.c. transformation of pure F is shown at the right.



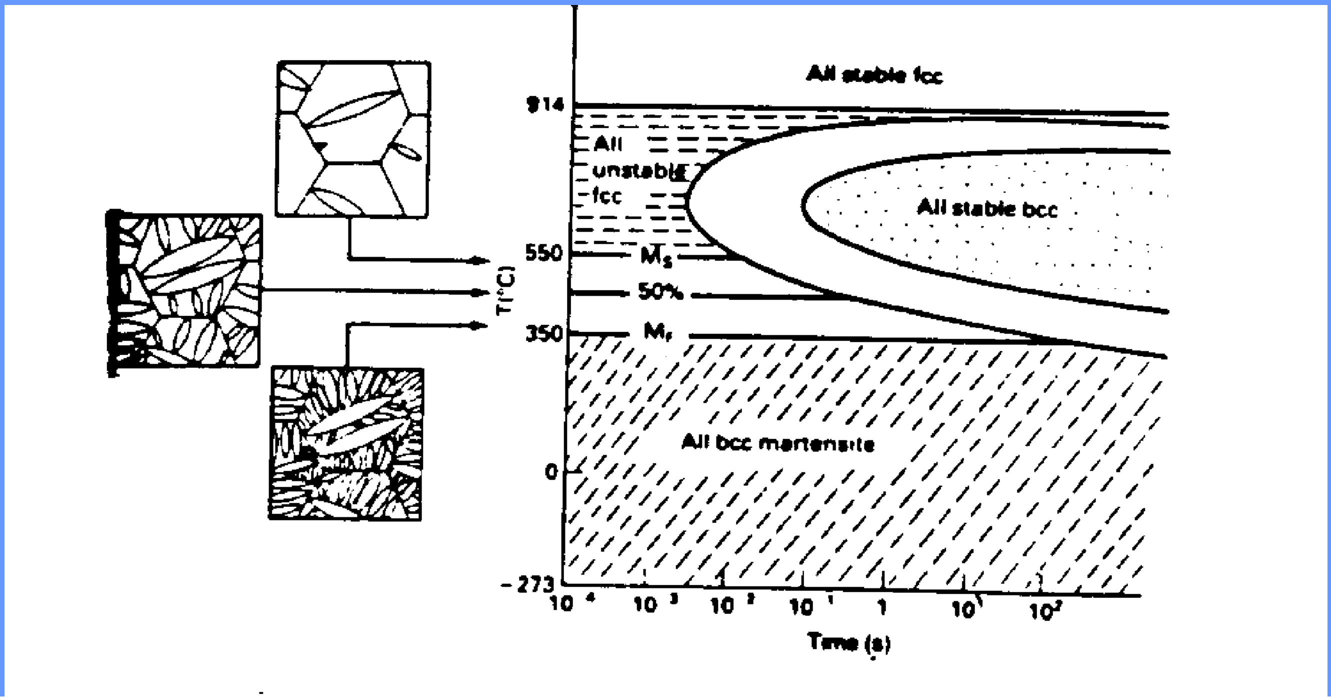
Displacive Transformation of f.c.c. -> b.c.c. in Pure Fe

- If we quench f.c.c. Fe from 914°C at a rate of about 10°Cs^{-1}, we expect to prevent the diffusive
- The TTT diagram for the diffusive f.c.c.->b.c.c. transformation from taking place.
- In reality, below 550°C the Fe will transform to b.c.c. by a *displacive* transformation.

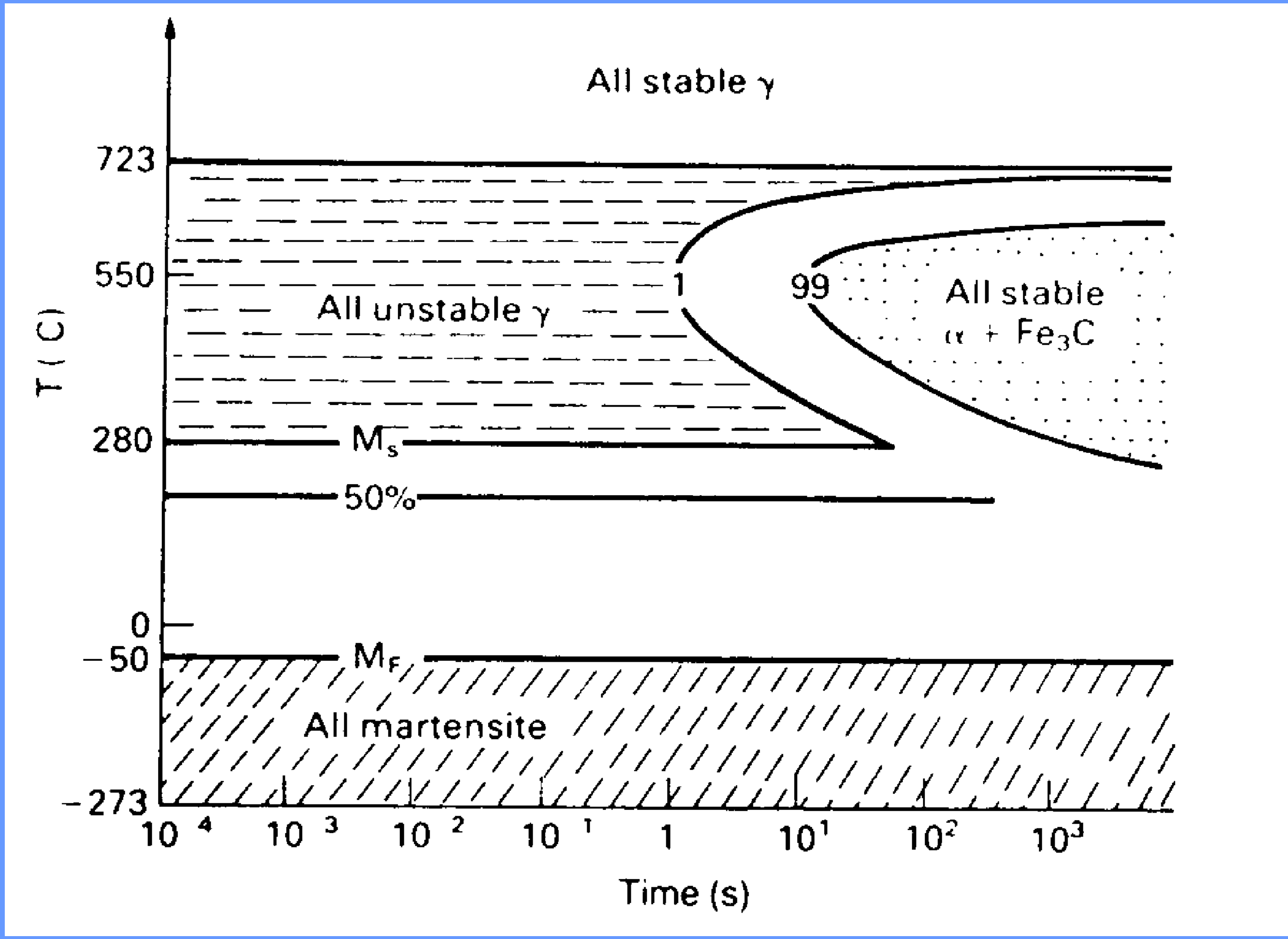


Complete TTT Diagram for Pure Fe

- The is shown below. The “M_s” stands for “*Martensite Start Temperature”* and the “M_f” stands for “*Martensite Finished Temperature*”.
- If a sample is cooled fast enough to prevent the diffusive transformation from taking place, then martensite will be formed as schematically shown at the left.

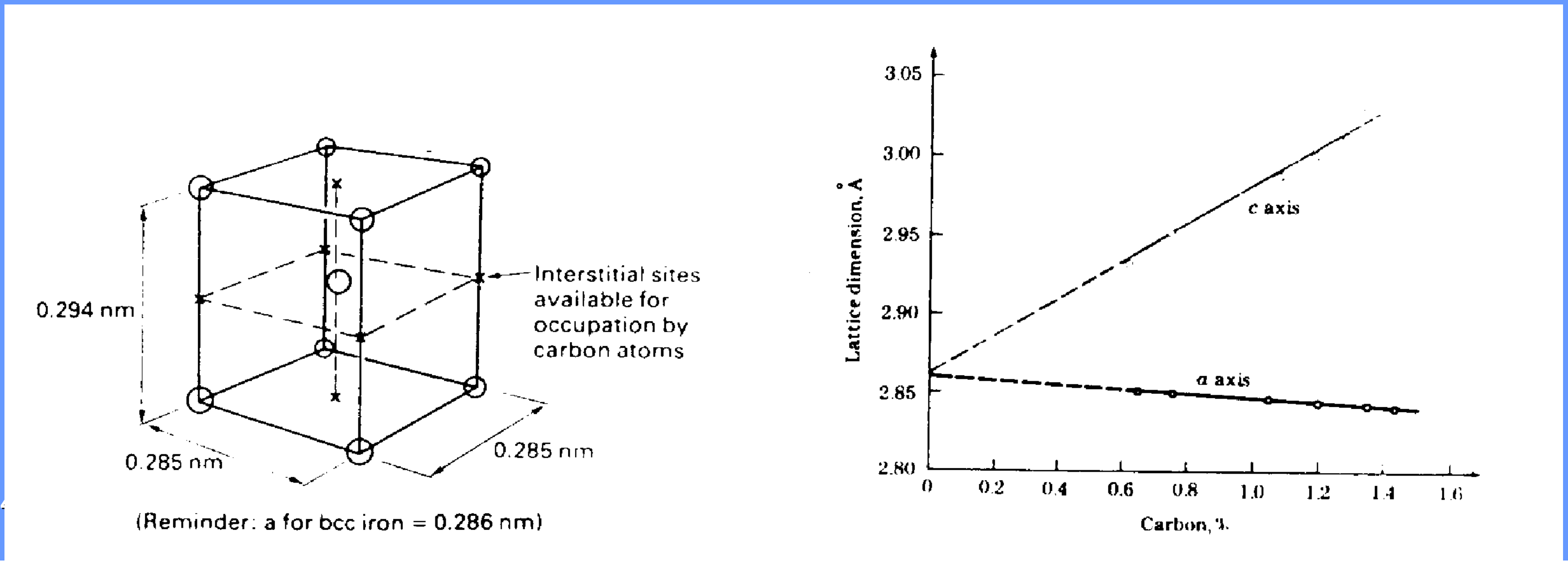


Martensite Transformation in Steels



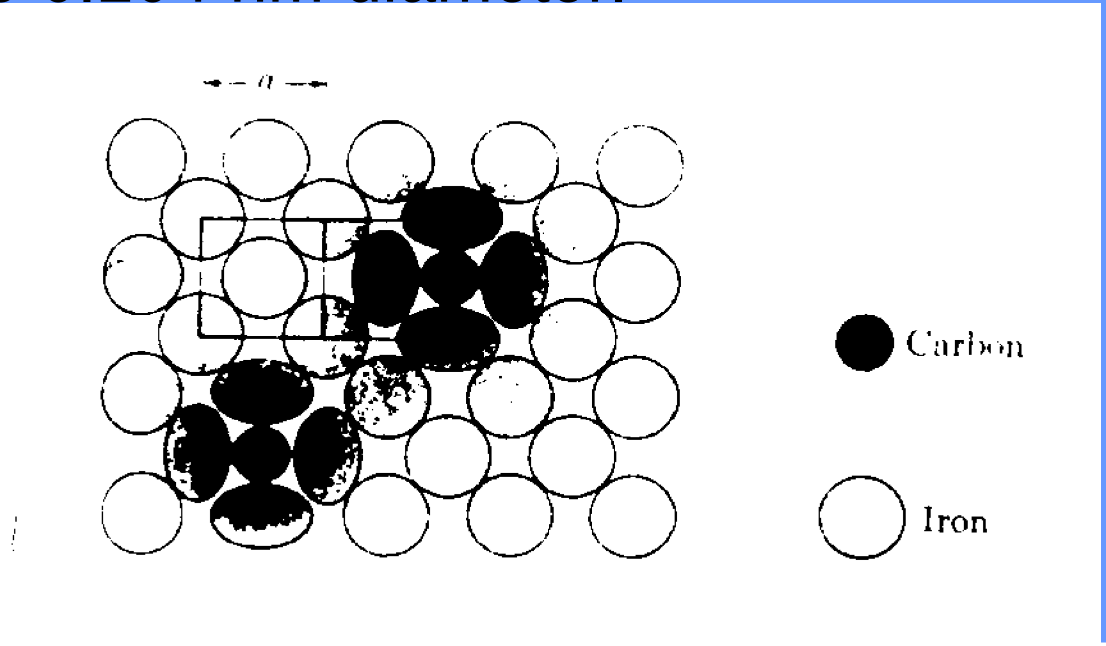
The Martensite in Steel is Not Cubic

- The crystal structure of 0.8% Carbon martensite is shown below.
- To make room for the carbon atoms the lattice stretches along on crystal direction. This produces a face centered tetragonal unit cell.
- Note that only a small proportion of the labelled sites actually contain a carbon atom.



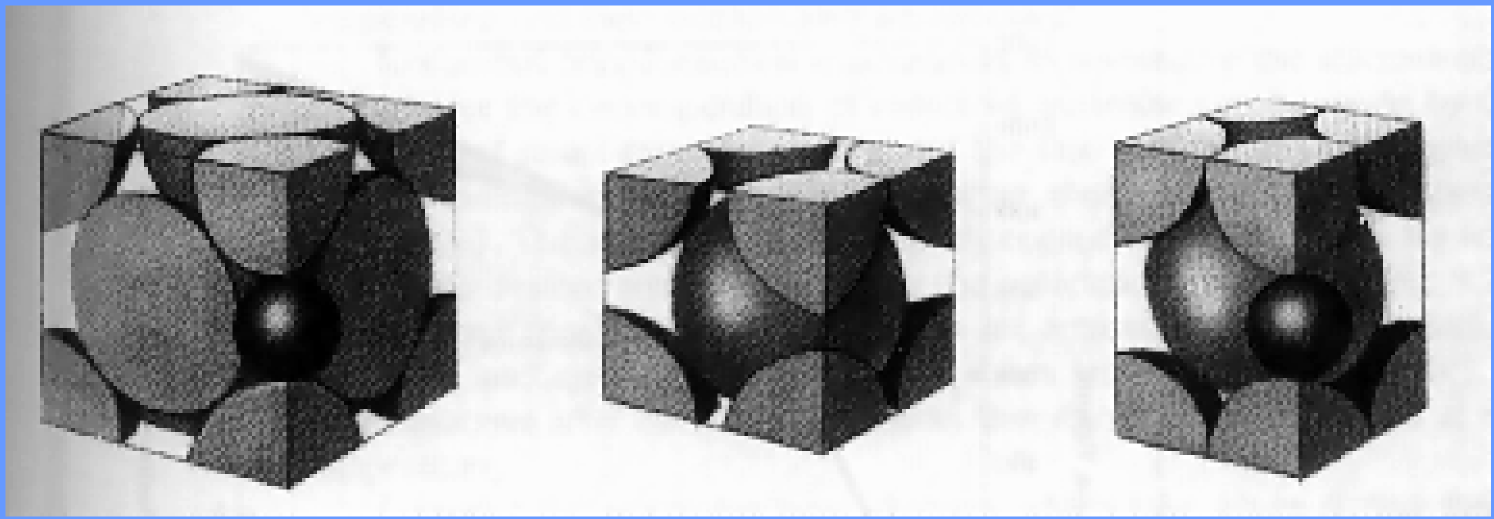
Fe-C Interstitial Solid Solution in Austinite

- The Carbon atoms fit into interstitial spaces in the FCC Austinite structure schematically shown below.
- Note the distortion of the Fe atoms [0.258-nm diameter] around the Carbon atoms [0.154-nm diameter] since the voids are 0.104-nm diameter.



Fe-C Interstitial Solid Solution in Ferrite & Martensite

- The Carbon atoms cannot fit into interstitial spaces in the BCC ferrite structure like they can in the FCC Austinite and produce a BCT (schematically shown below).
- Note in the BCT the Carbon atoms force the unit cell to be alongated in the c-direction. The largest interstitial void in BCC iron has a diameter of 0.072-nm.

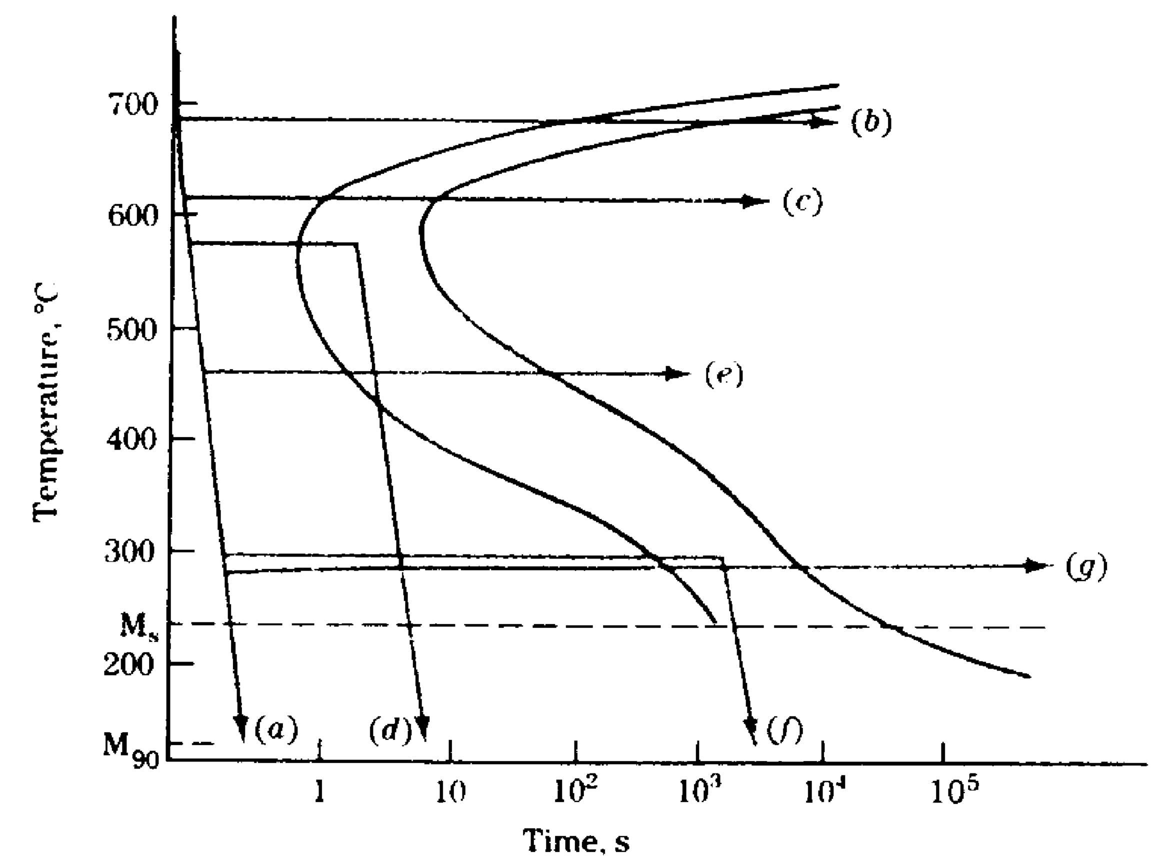


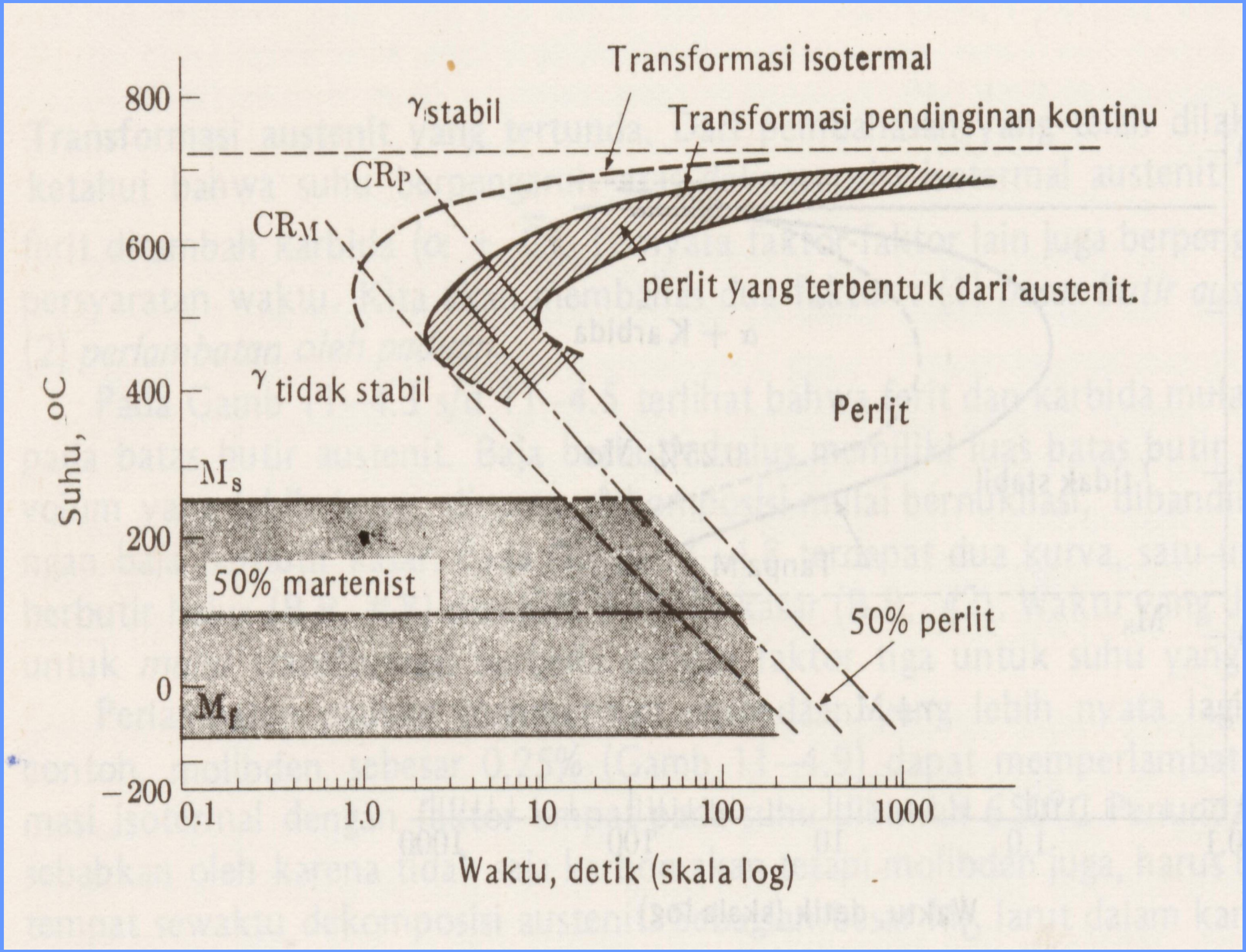
FCC BCC BCT

An Example Problem

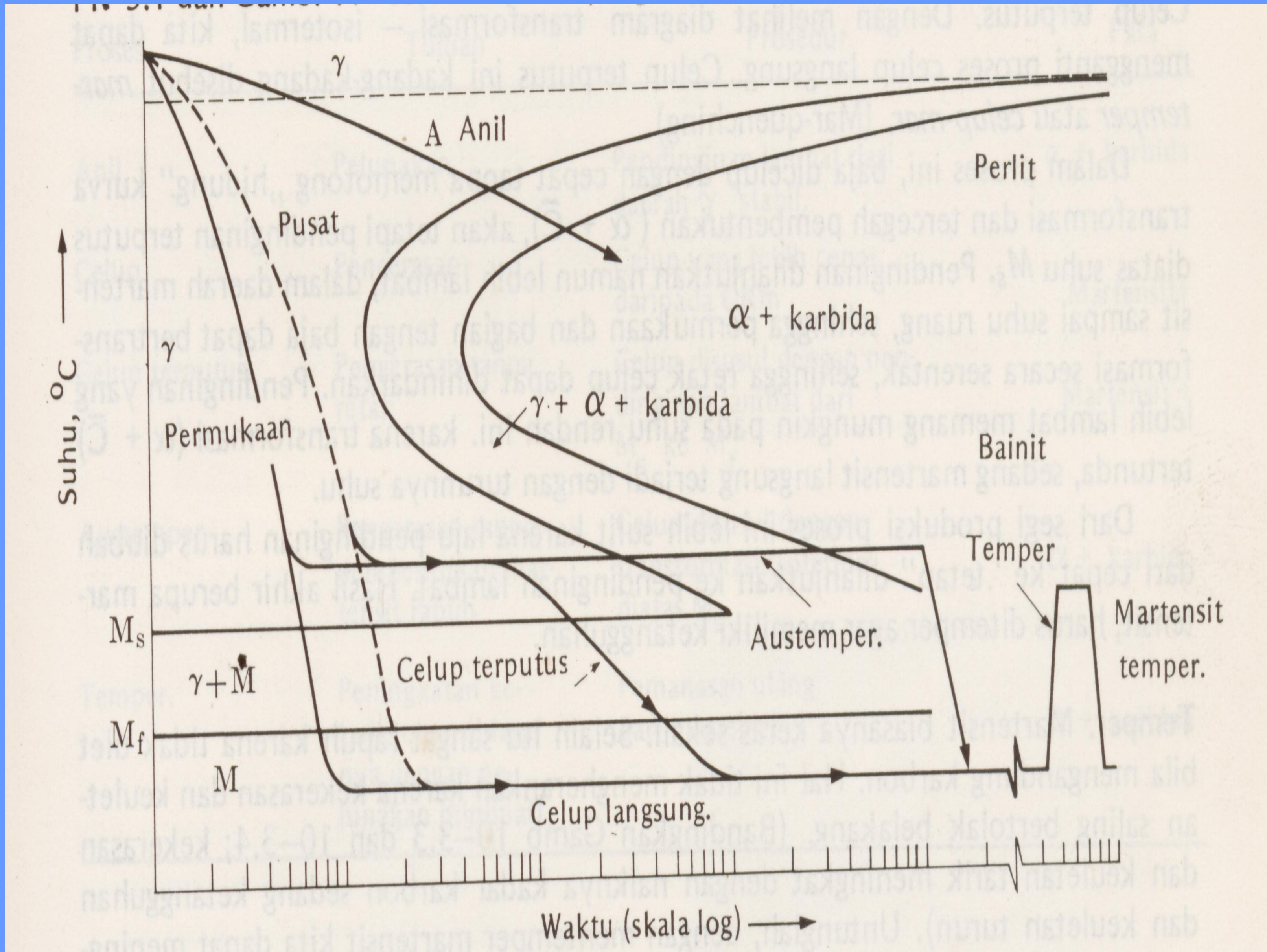
(Assume a Eutectoid Low Carbon Steel)

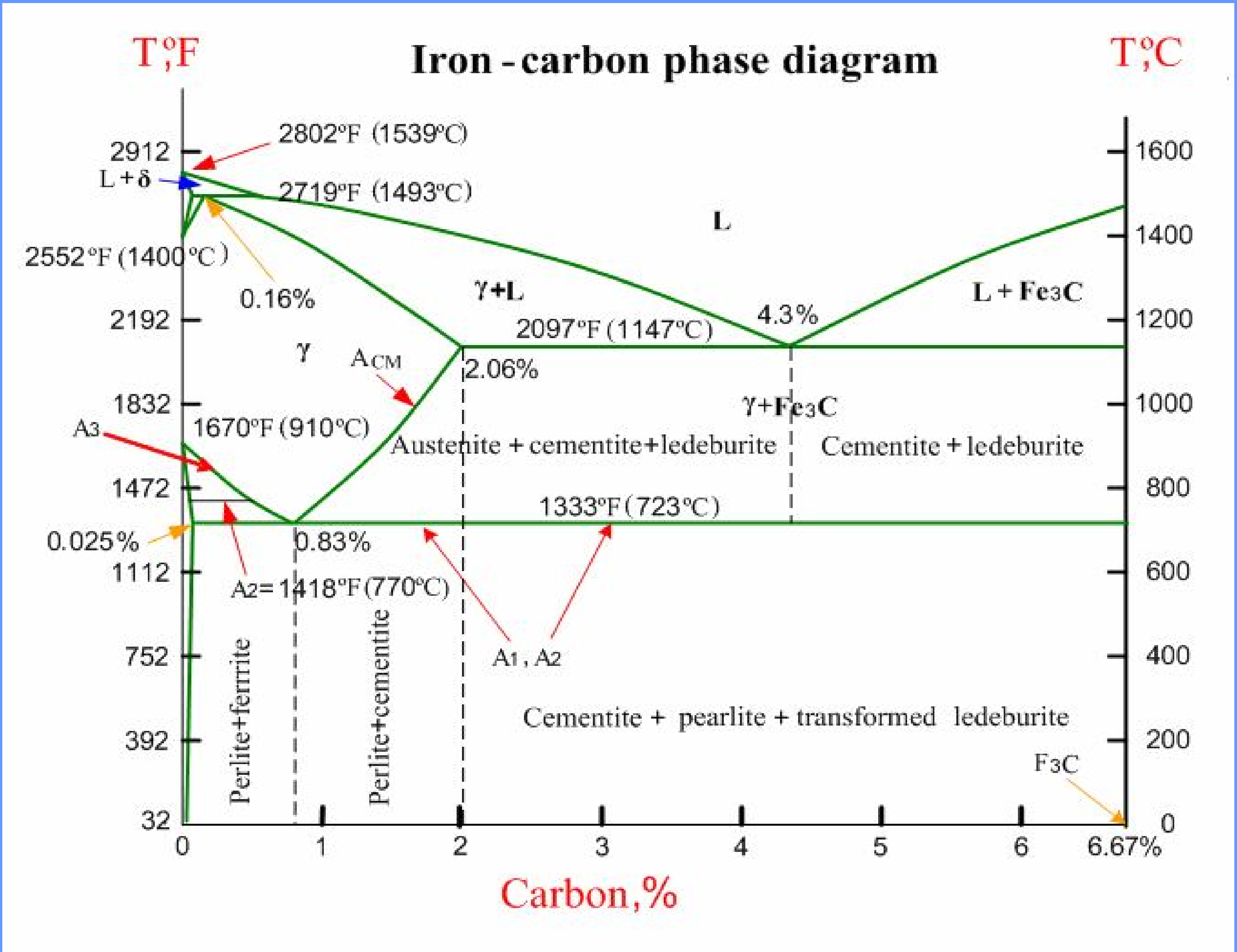
- (a) Water-quench to room Temperature.
- (b) Hot-quench at 690°C & hold 2 hr; water-quench
- (c) Hot-quench at 610°C & hold 3 min; water-quench
- (d) Hot-quench at 580°C & hold 2 sec; water-quench
- (e) Hot-quench at 450°C & hold 1 hr; water-quench
- (f) Hot-quench at 300°C & hold 30 min; water-quench
- (f) Hot-quench at 300°C & hold 5hr; water-quench





Transformasi isotermal
γ stabil
Transformasi pendinginan kontinu
CRP
CRM
perlit yang terbentuk dari'austenit.
γ tidak stabil
Perlit
Ms
50% martenist
50% perlit
Mf
800
600
400
200
0
−200
Suhu, oC
0.1
1.0
10
100
1000
Waktu, detik (skala log)


γ
A Anil
Perlit
Pusat
α + karbida
γ
γ + α + karbida
Permukaan
Bainit
Suhu, °C
Temper
Martensit temper.
Ms
Austemper.
γ+M
Celup terputus
Mf
M
Celup langsung.
Waktu (skala log)


T,°F
Iron - carbon phase diagram
T,°C
2802°F (1539°C)
2912
L + δ
2719°F (1493°C)
L
2552°F (1400°C)
0.16%
γ+L
L + Fe3C
2192
4.3%
2097°F (1147°C)
γ
ACM
2.06%
1832
γ+Fe3C
A3
1670°F (910°C)
Austenite + cementite+ledeburite
Cementite + ledeburite
1472
1333°F (723°C)
0.025%
0.83%
1112
A2= 1418°F (770°C)
752
A1, A2
Perlite+ferrite
Perlite+cementite
Cementite + pearlite + transformed ledeburite
392
F3C
32
0
1
2
3
4
5
6
6.67%
1600
1400
1200
1000
800
600
400
200
0
Carbon, %