MSE Exam 2 Class Notes

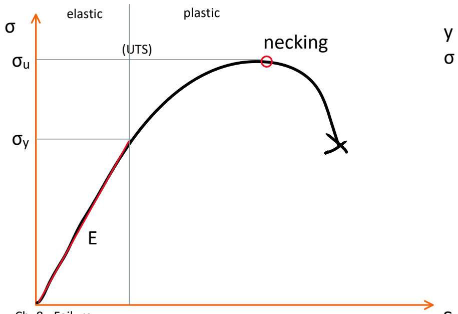
Saturday, April 6, 2024 4:52 PM

Ch. 7 - Strengthening Mechanisms in Metals

1. Grain Size
2. Solid Solution
3. Adding another Material (Precipitate)
4. Increasing Imperfections

Why are metals relatively ductile? Non-directional bonding, densely packed atoms, presence and movement of dislocations

If the goal is to strengthen the metal, what is the objective? Need to make dislocation movement more difficult (Thru strengthening)



y = mx + b

σ = Eε (Hooke's Law)

A-36 Steel:

σ_y = 250 MPa, 36 ksi

E = 200 GPa, 29 Msi

Ch. 8 - Failure

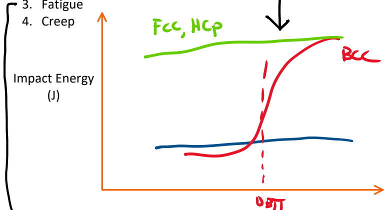
Reasons why samples may fail unexpectedly well below its σ_y

1. Macroscopic flaws -> cracks
2. Temperature effects -> DBTT (graph)
3. Fatigue
4. Creep

$$K_{Ic} = \underbrace{Y}_{(=1)} \sigma_c \sqrt{\pi a} \qquad [MPa\sqrt{m}]$$

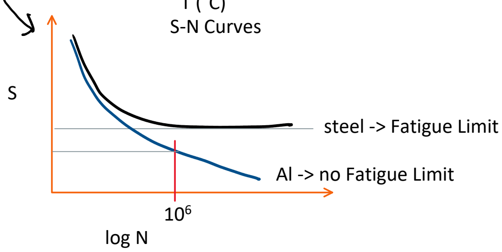
(=1) geometric consideration

K_{Ic}: Plain Strain Fracture Toughness (more conservative value)



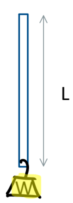
NDE techniques help us identify flaws/cracks in the sample

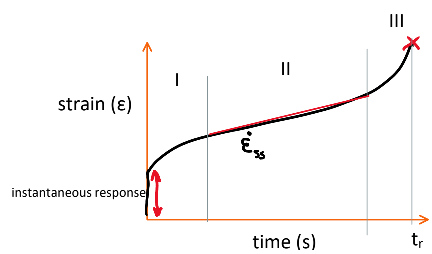
S-N Curves



4) Creep

Re-watch W8D2 for creep

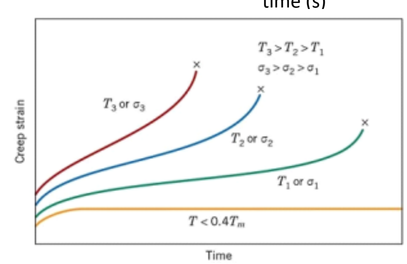


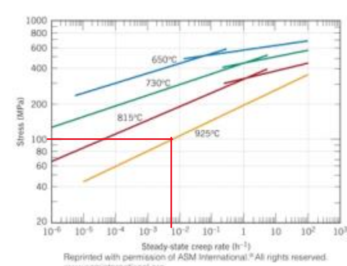


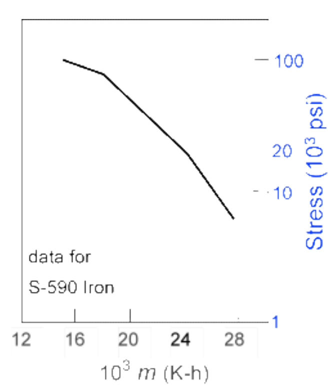
activation energy for creep

$$\dot{\varepsilon}_{ss} = K_2 \sigma^n \exp\left(-\frac{Q_c}{RT}\right)$$

time to rupture



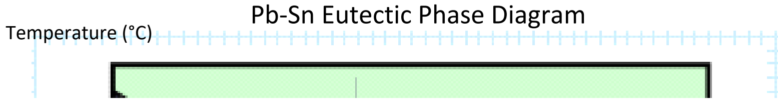




$$m = T(c + \log t_r)$$

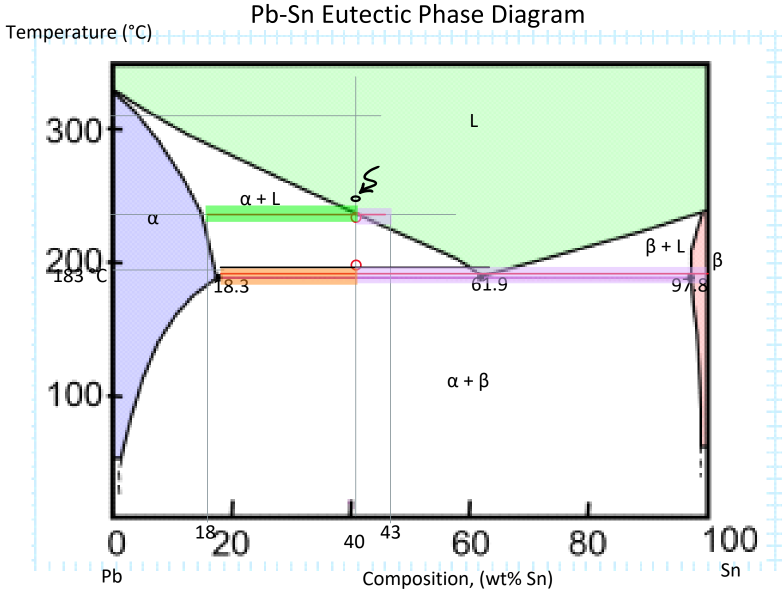
Ch. 9 - Phase Diagrams

Pb-Sn Eutectic Phase Diagram



Label the regions on the Eutectic Phase Diagram.

Pb-Sn Eutectic Phase Diagram



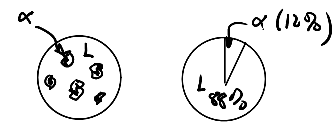
Label the regions on the Eutectic Phase Diagram.

Then answer the 4 questions for each of the following:

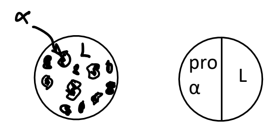
For a 40 wt% Sn alloy:

18*0.12 + 43*0.88 = 40

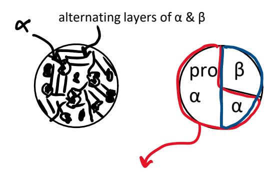
1. 300 °C
2. 220 °C
   a. α + L
   b. Compositions
      i. α -> 18 wt% Sn
      ii. L -> 43 wt% Sn
   c. Amounts
      i. α -> (43 - 40)/(43 - 18) = 0.12 -> 12%
      ii. L -> (40 - 18)/(43 - 18) = 0.88 -> 88%

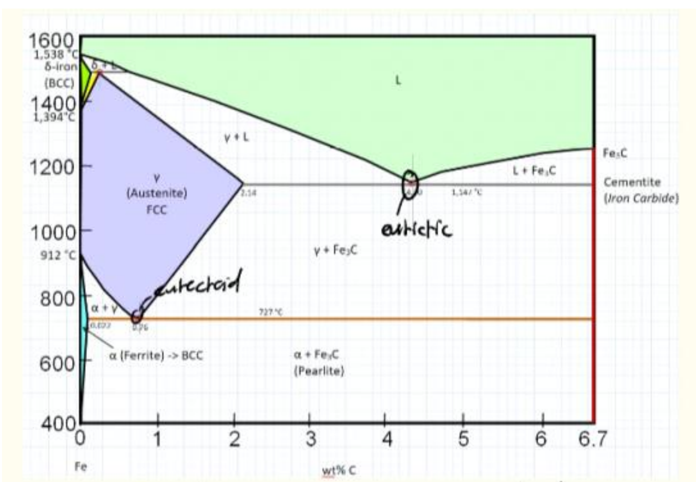


3. 184 °C
   a. α + L
   b. Compositions
      i. α -> 18.3 wt% Sn
      ii. L -> 61.9 wt% Sn
   c. Amounts
      i. α -> (61.9 - 40)/(61.9 - 18.3) = 0.50 -> 50%
      ii. L -> (40 - 18.3)/(61.9 - 18.3) = 0.4977 -> 50%



4. 182 °C
   a. α + L
   b. Compositions
      i. α -> 18.3 wt% Sn
      ii. β -> 97.8 wt% Sn
   c. Amounts
      i. α -> (97.8 - 40)/(97.8 - 18.3) = 0.727 -> 73%
      ii. β -> (40 - 18.3)/(97.8 - 18.3) = 0.273 -> 27%





eutectic

$L \rightleftharpoons \gamma + Fe_3C$

L S S

eutectoid

$\gamma \rightleftharpoons \alpha + Fe_3C$

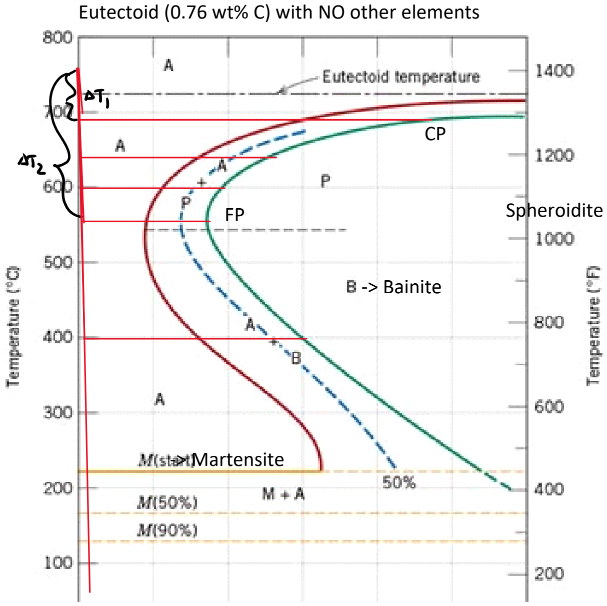
S S S

<u>Ch. 10 - Phase Transformations</u>

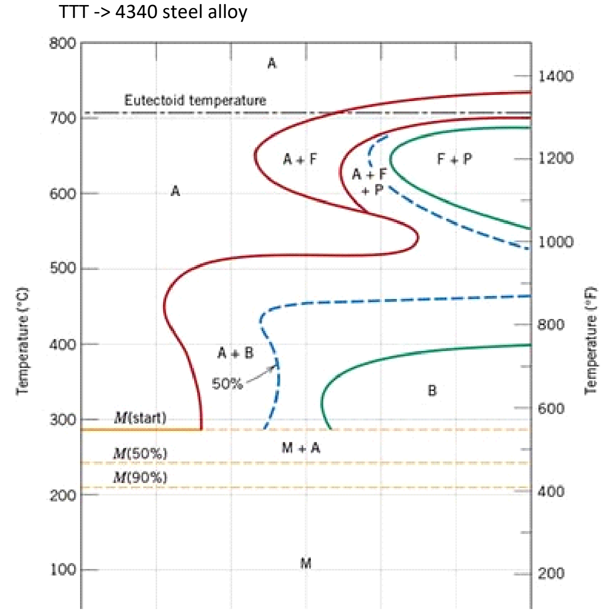
Time-Temperature-Transformation (TTT) Graph

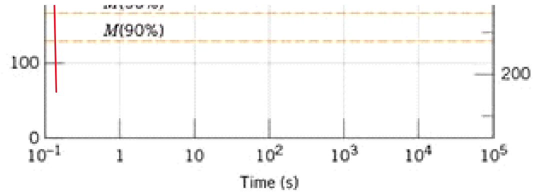
Watch W9D3 on TTT & W10D1

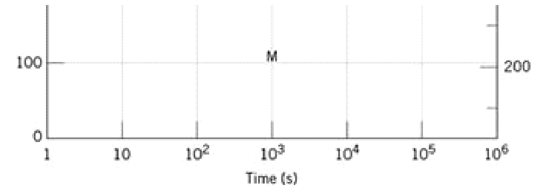
Eutectoid (0.76 wt% C) with NO other elements



TTT -> 4340 steel alloy

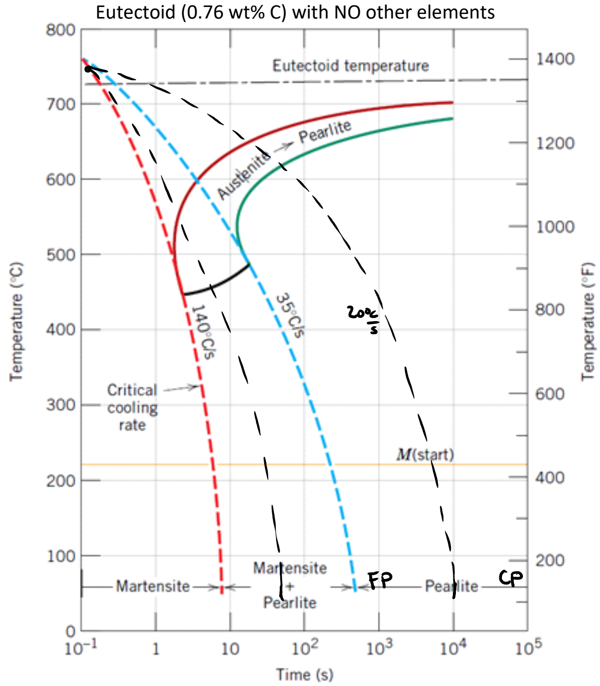




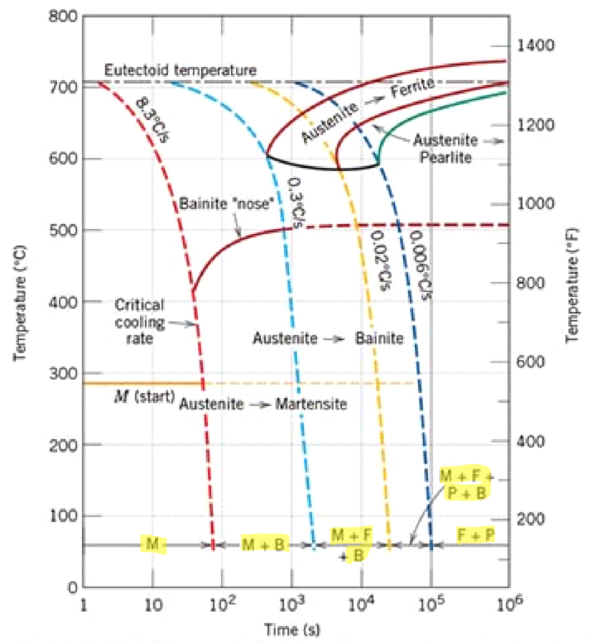


Continuous Cooling Transformation (CCT) Diagram

Eutectoid (0.76 wt% C) with NO other elements



CCT -> 4340 steel alloy



Adapted from H. E. McGannon (Editor), *The Making, Shaping and Treating of Steel*, 9th edition, United States Steel Corporation, Pittsburgh, 1971, p. 1096.

Ch. 11 - Overview of Metals & Processing

1. Classification/Applications
2. Processing of Metals
3. Hardenability
4. Precipitation Hardening Procedure

General Categories of Metals:

1. Ferrous
   a. Steels
   b. Irons
2. Non-ferrous
   a. Al
   b. Cu
   c. Ti
   d. Mg
   e. ...