

Chapter 10: Phase Transformations

ISSUES TO ADDRESS...

- Phase transformations take time to occur.



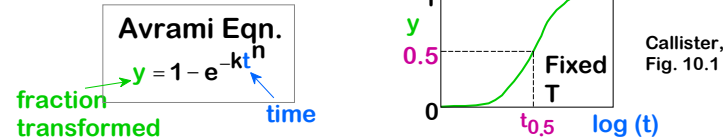
- How does the rate of transformation depend on time and temperature?
- How can we slow down the transformation so that we can engineer nonequilibrium structures?
- Are the mechanical properties of nonequilibrium structures better?

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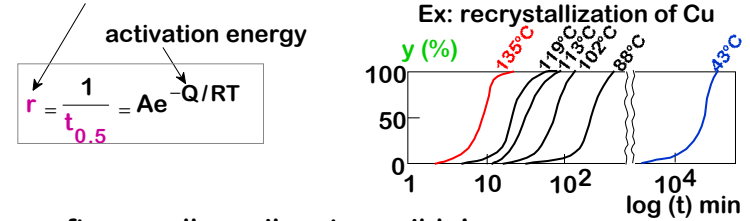


Fraction of Transformation

- Fraction Transformed depends on time



- Transformation rate depends on T



- r often small: equil. not possible!

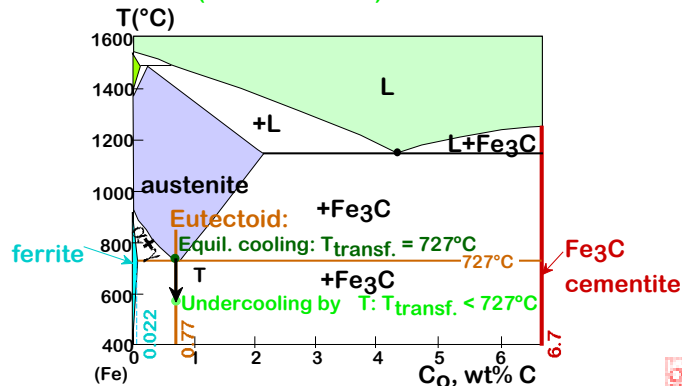
Callister, Fig. 10.2

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Transformations & Undercooling

- Eutectoid transf. (Fe-C System):
- Can make it occur at:
 - ...727°C (cool it slowly)
 - ...below 727°C ("undercool" it!)

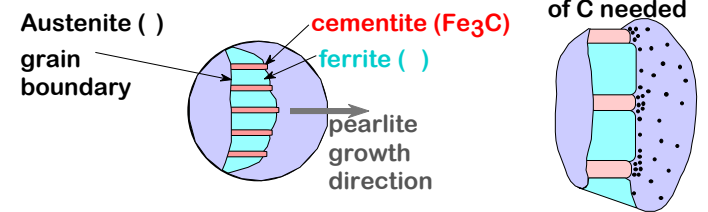


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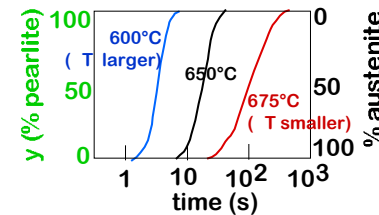


Eutectoid Reaction Rate ~ T

- Growth of pearlite from austenite:



- r as T
- reaction rate

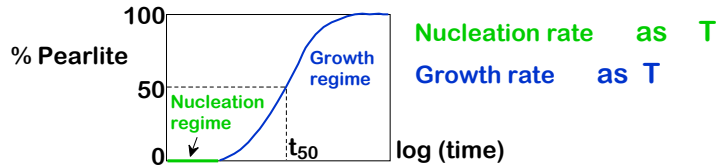


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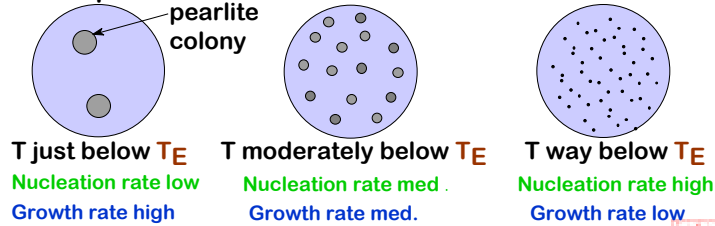



Nucleation and Growth

- r is a result of nucleation and growth of crystals



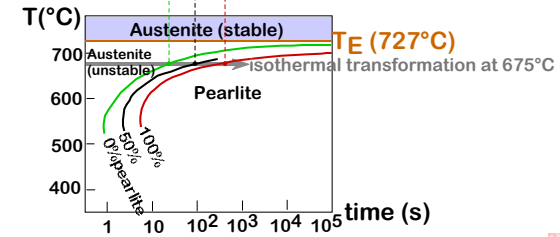
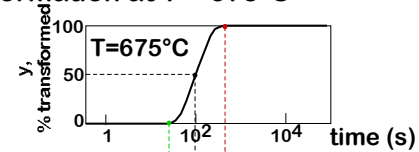
- Examples:




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Isothermal Transformation Diagrams

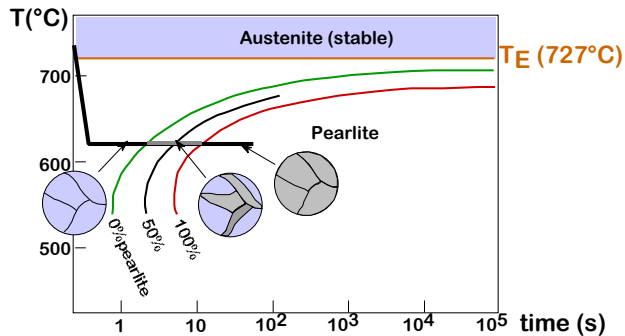
- Fe-C system, $C_0 = 0.77\text{wt}\%C$
- Transformation at $T = 675^\circ\text{C}$




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Example: Cooling History, Fe-C System

- Eutectoid composition, $C_0 = 0.77\text{wt}\%C$
- Begin at $T > 727^\circ\text{C}$
- Rapidly cool to 625°C and hold isothermally

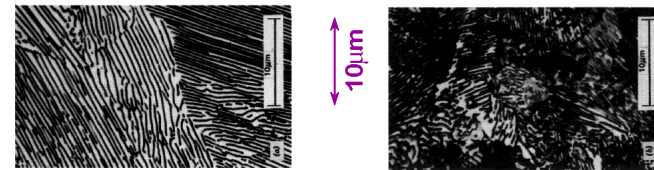


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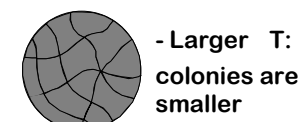
Pearlite Morphology


Two cases:

- T_{transf} just below T_E
 - Larger T: diffusion is faster
 - Pearlite is coarser
- T_{transf} well below T_E
 - Smaller T: diffusion is slower
 - Pearlite is finer



Callister, Figs. 10.6(a,b)

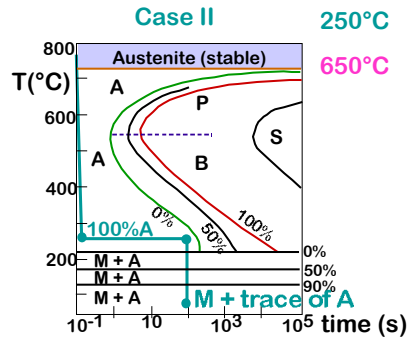


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Cooling Examples: Fe-C System

- $C_0 = C_{\text{eutectoid}}$ Rapid cool to: for: Rapid cool to: for: Rapid cool to:
- Three histories...

350°C 10⁴s T_{room}
 250°C 10²s T_{room}
 650°C 20s 400°C 10³s T_{room}



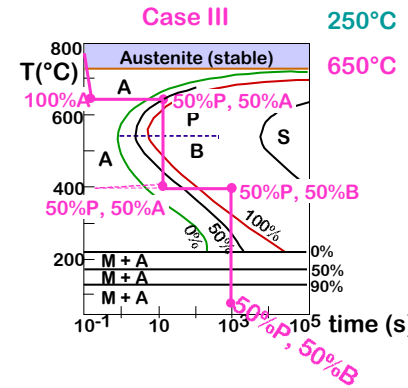
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Cooling Examples: Fe-C System

- $C_0 = C_{\text{eutectoid}}$ Rapid cool to: for: Rapid cool to: for: Rapid cool to:
- Three histories...

350°C 10⁴s T_{room}
 250°C 10²s T_{room}
 650°C 20s 400°C 10³s T_{room}

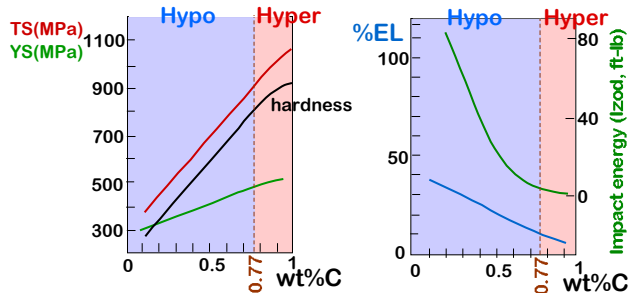
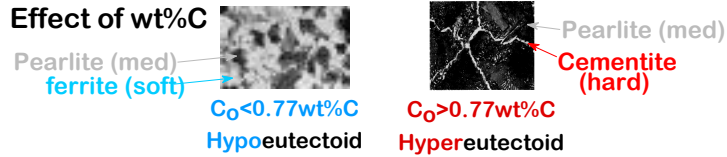


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Mechanical Properties: Fe-C System

- Effect of wt% C



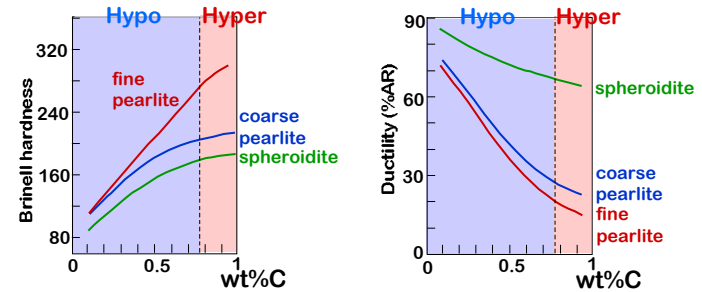
More wt% C: TS and YS, %EL

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Mechanical Properties: Fe-C System

- Fine vs coarse pearlite vs spheroidite



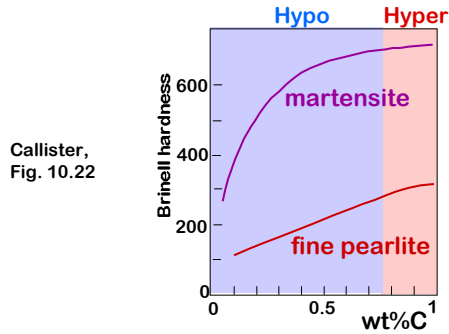
Hardness: fine > coarse > spheroidite
 %AR: fine < coarse < spheroidite

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Mechanical Properties: Fe-C System

- Fine Pearlite vs Martensite

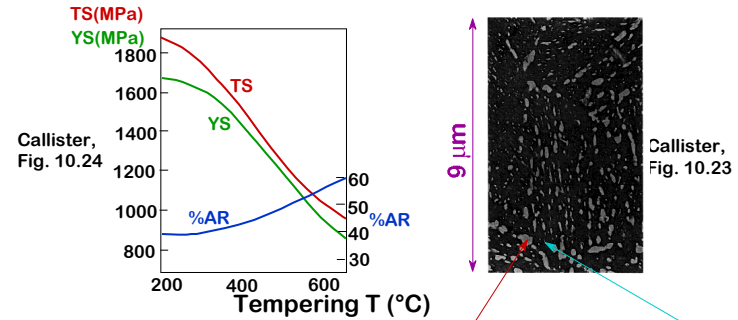


hardness: fine pearlite << martensite

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Tempering Martensite...

- reduces brittleness of martensite
- reduces internal stresses caused by quenching



- produces extremely small Fe_3C particles surrounded by
- decreases TS, YS but increases %AR

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Summary: Processing Options

