Properties of Materials

Metals Processing

Processing Metals

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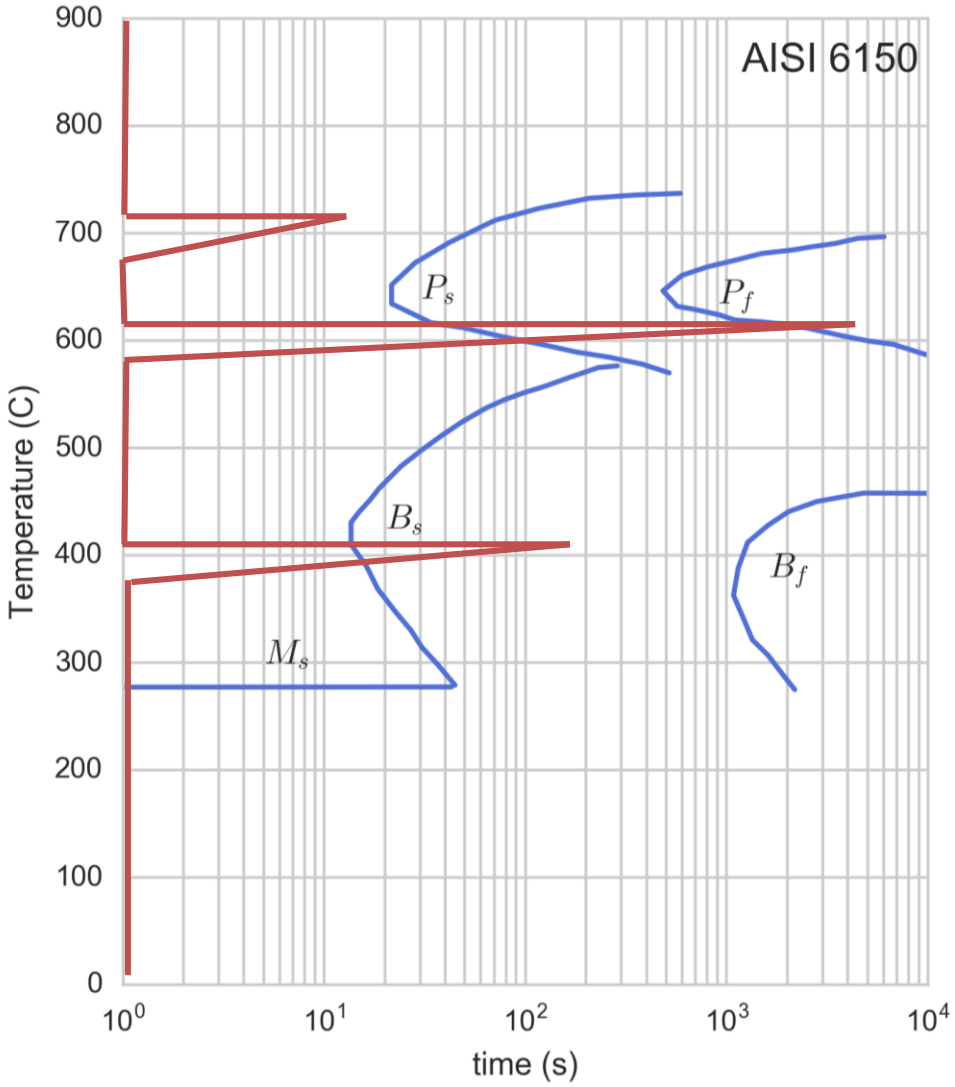
2.7 Queens Building

Preview

Intended Learning Outcomes	
Understanding	That many processes interact in complex ways in modern metals.
Skills	Able to combine phase, TTT and CCT diagrams to predict/diagnose problems.
Values	Acknowledge the limitations of such diagrams in the face of the real complexity.

- Predictions for steel and common forms of steel sections/components
  - Using TTT and CCT diagrams
- Chaining treatments together
  - Hot work, recrystallisation, heat treatment, cooling, quenching, tempering

Reading Steel TTT



"Rules"

All quenches are instantaneous (vertical lines)

All quenches happen at t=0 (restart reaction)

0% transformed if t < Ps/Bs

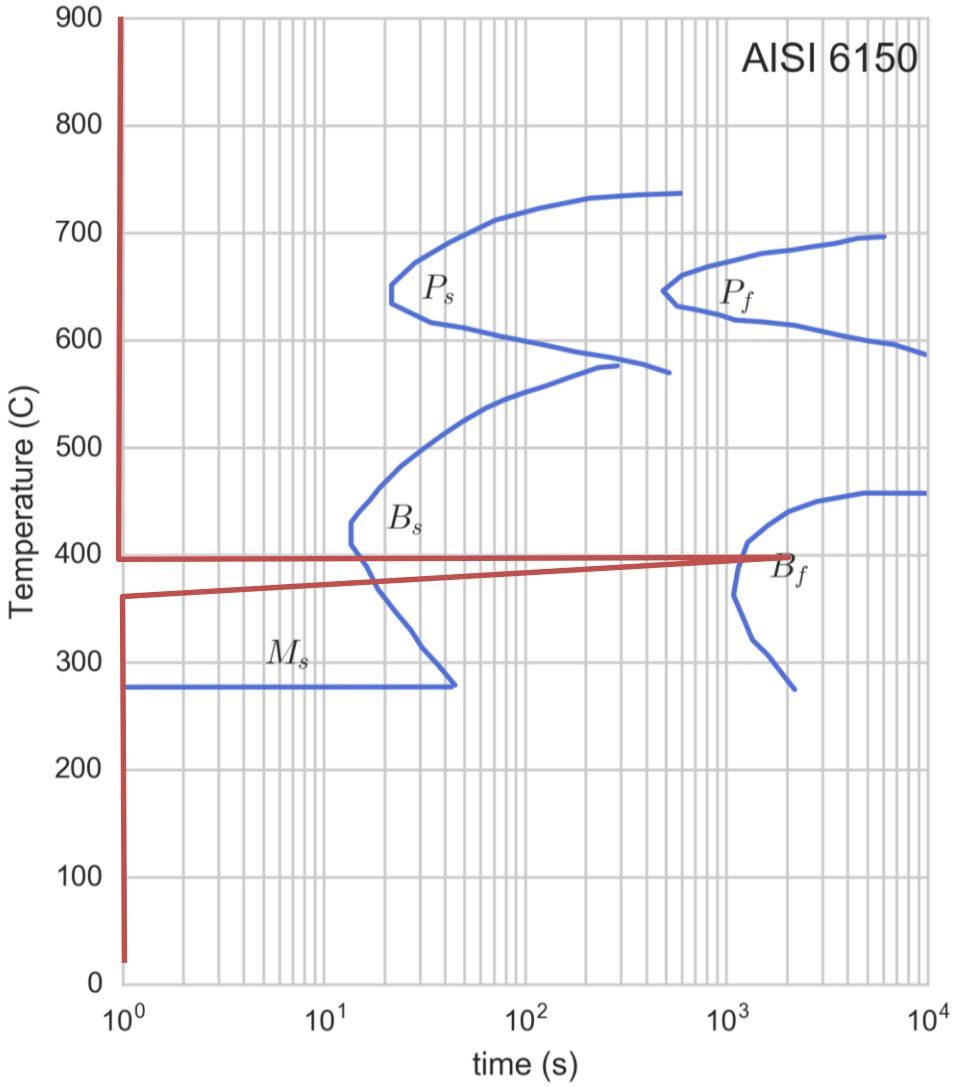
100 % transformed if t > Pf/Bf

$$\% \approx 100 \times \frac{\log(t) - \log(t_s)}{\log(t_f) - \log(t_s)}$$

if Bs/Ps < t < Pf/Bf

(but don't bother with equation)

Reading Steel TTT



Steel at 900°C
Quench to 400 ° C
Hold for 2000s
Quench to ambient (20 ° C).

What is the microstructure?

Quench 1:
Miss pearlite so 0% pearlite

Hold:
Pass bainite start and finish so 100% bainite

Quench 2:
Restart at t=0 and drop
No austenite to change to martensite

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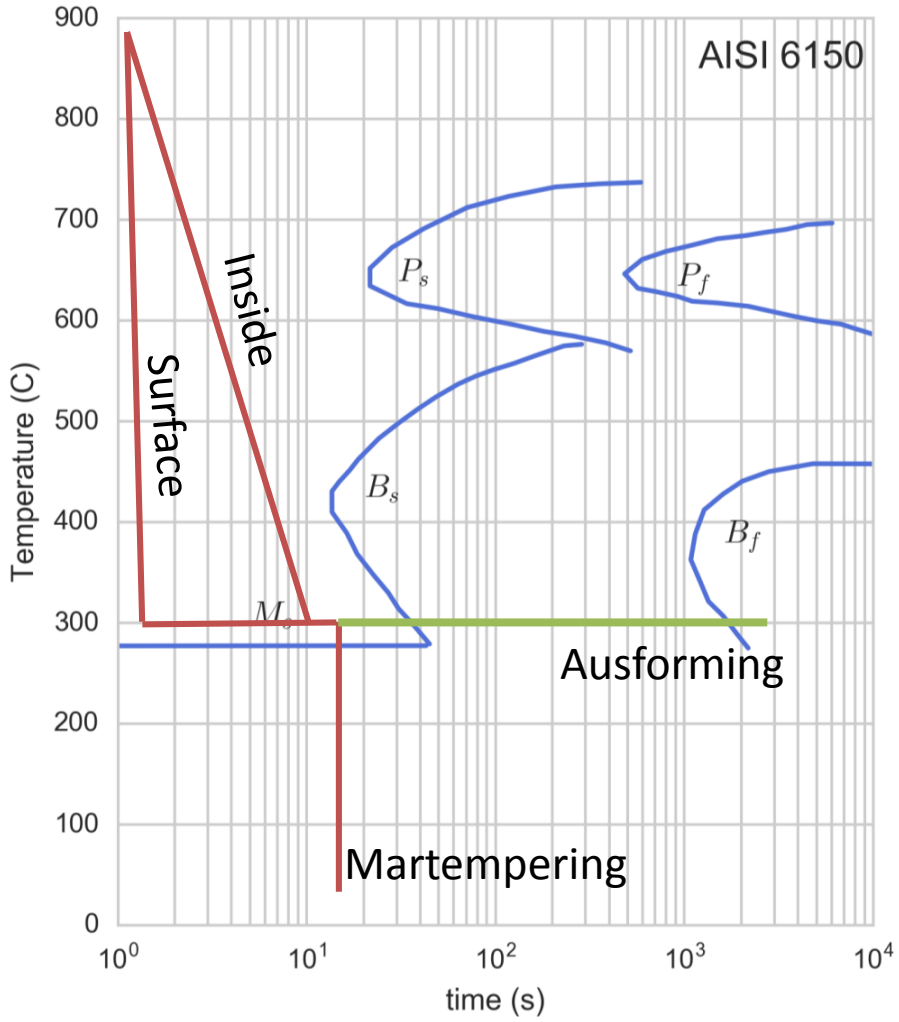
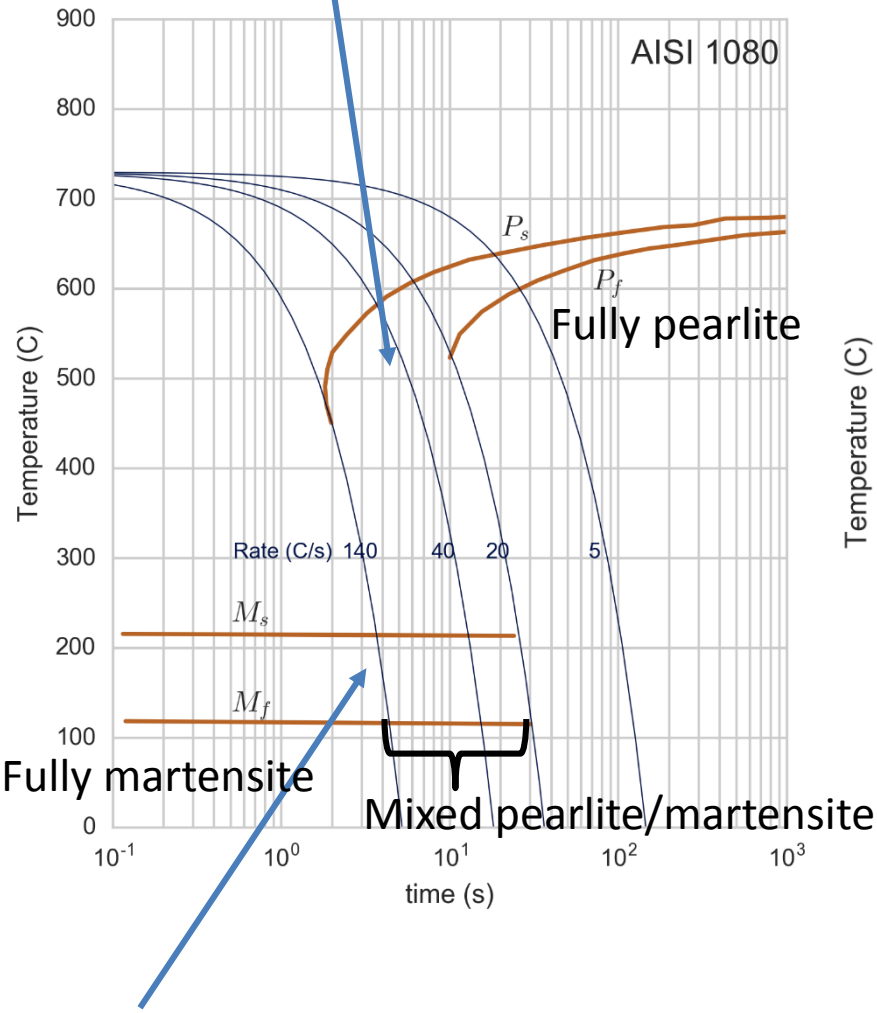
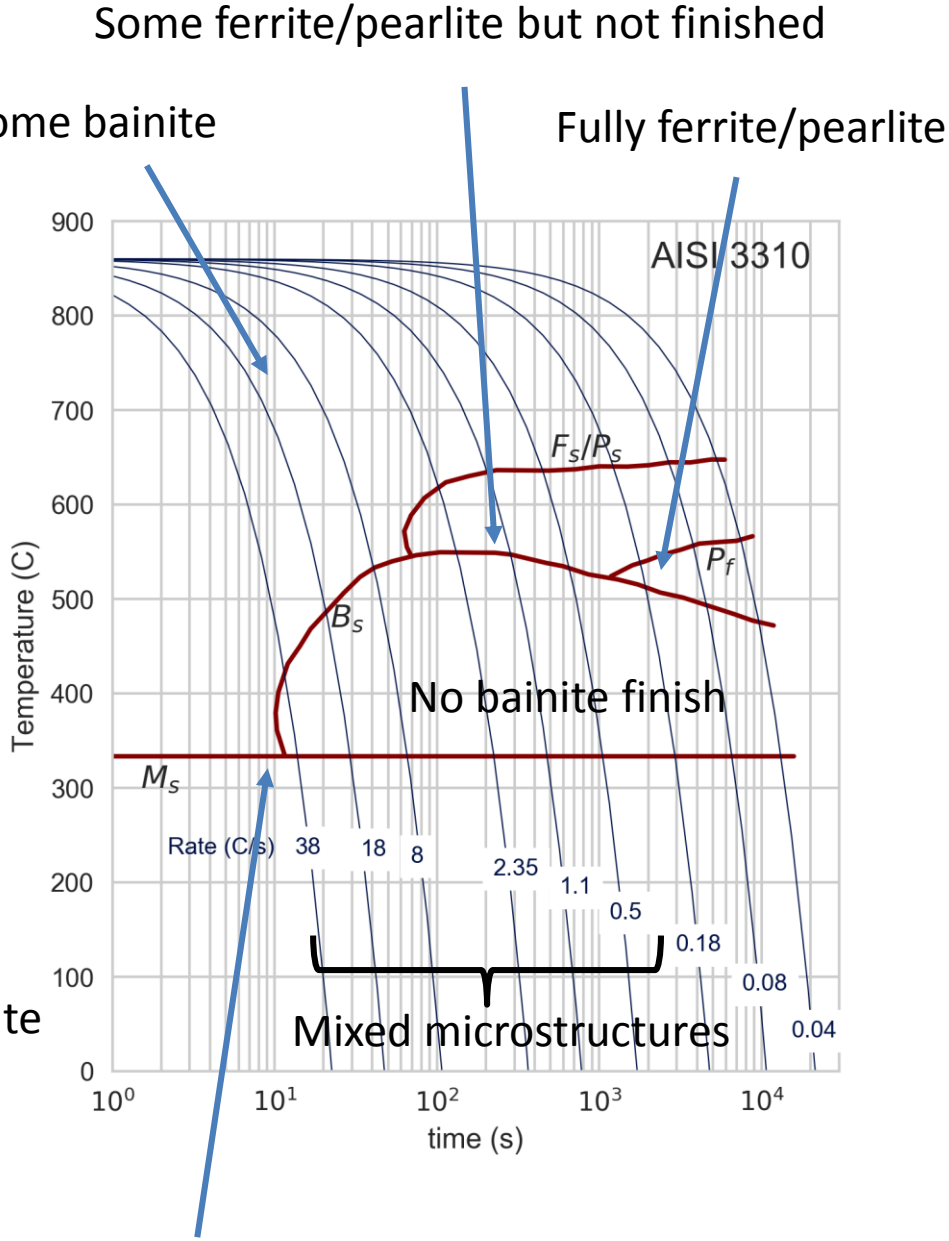
Martemper/Austemper



- Get thermal equilibrium before transformation
  - Reduce thermal misfit between surface and inside
  - Minimise chances of distortion

CCT





Critical Cooling Rate (CCR) very important – fast enough to produce 100% martensite

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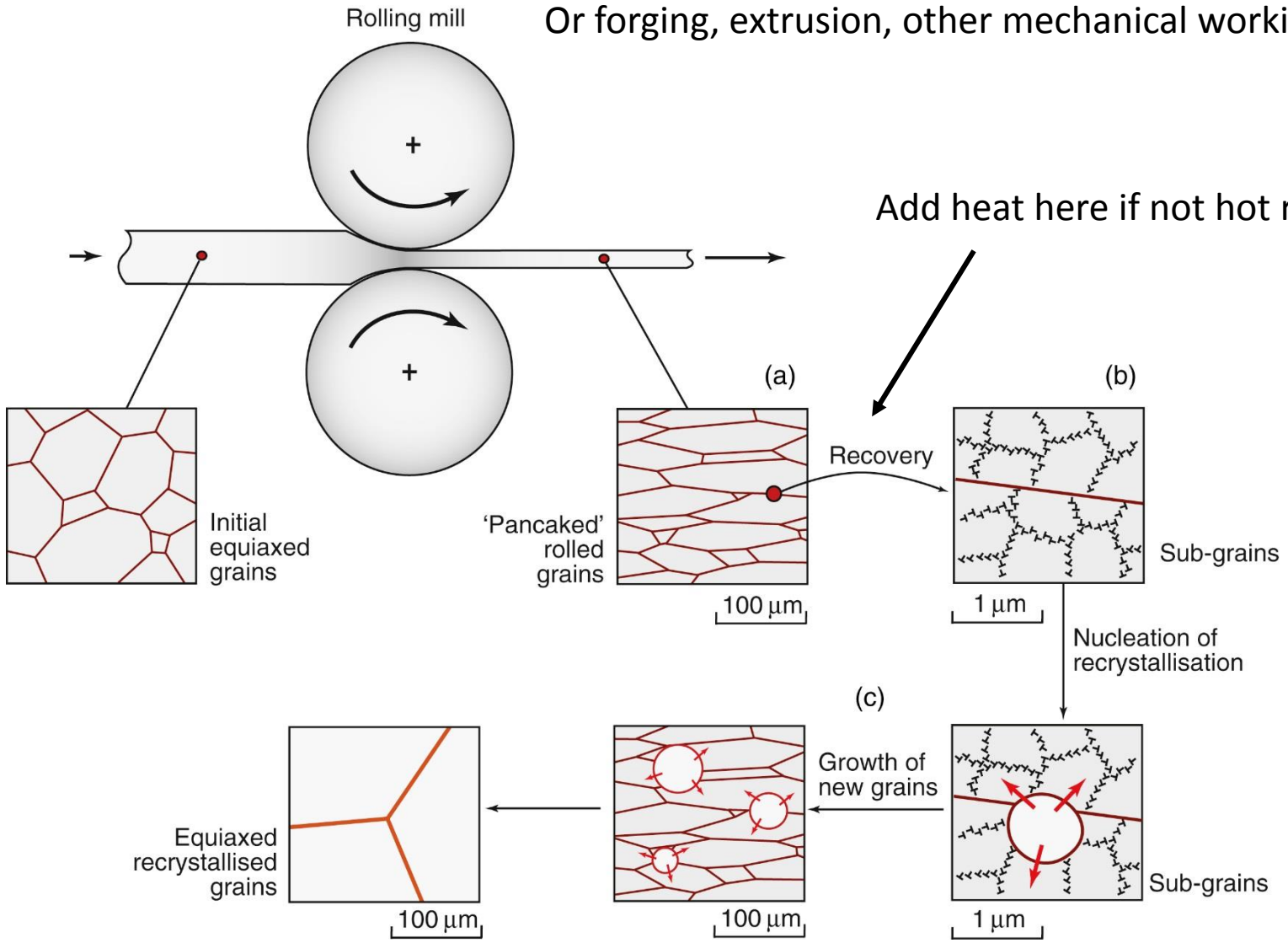
Forging and Recrystallisation



Forging and Recrystallisation

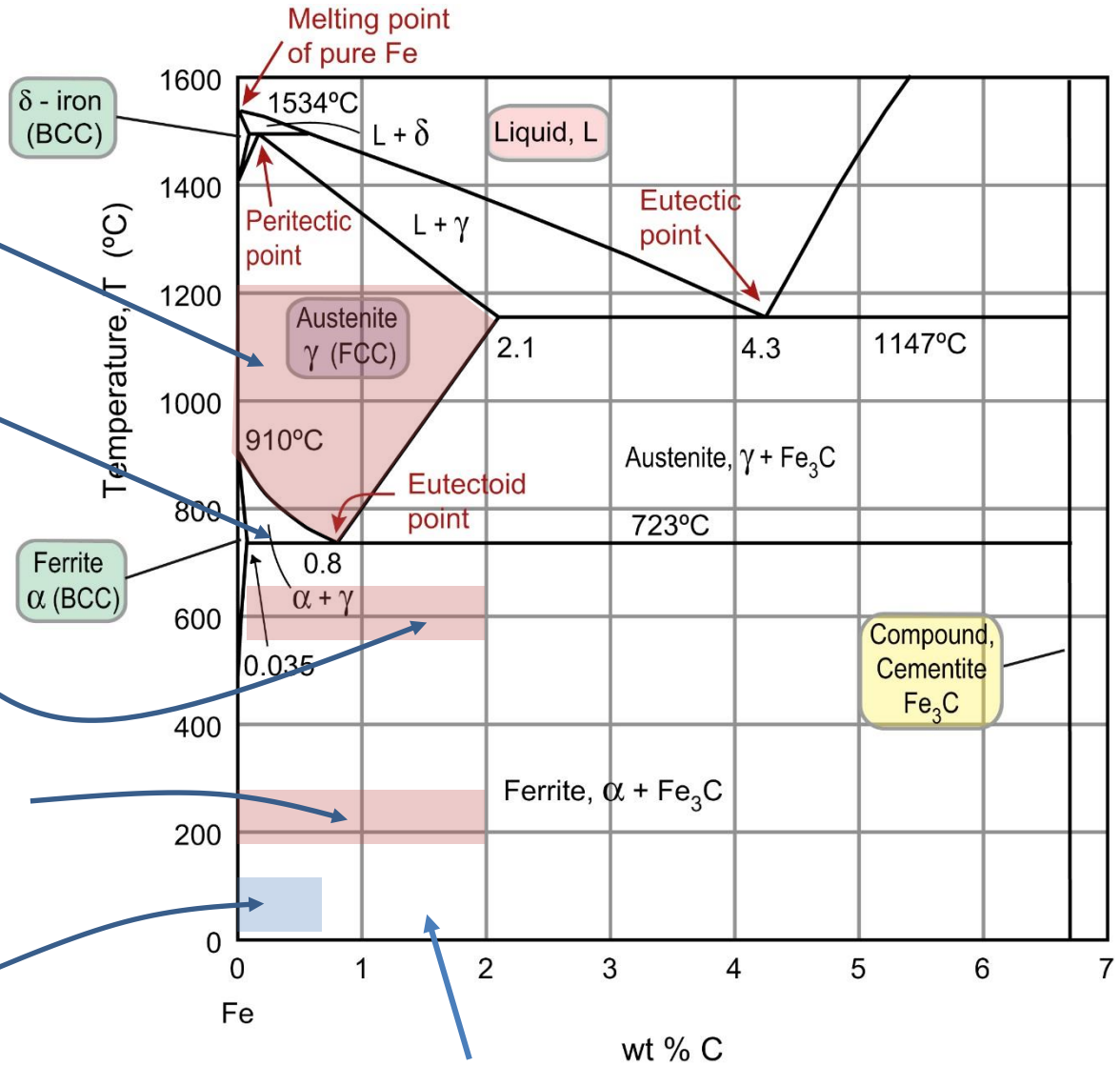
Forge in austenite region (recrystallises during forging)

Phase change replaces old microstructure

Recrystallise (if cold worked) or coarsen microstructure

Temper (if martensite)

Cold work (if ferrite and/or pearlite)

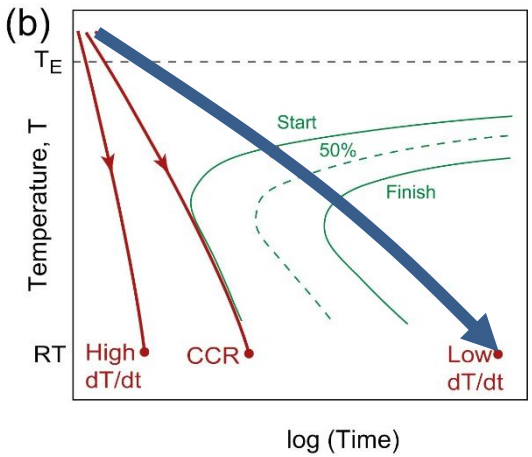


Hard to cold work high C steel

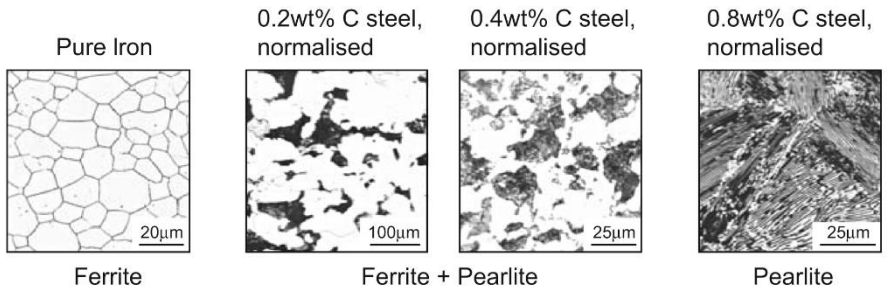
Forging

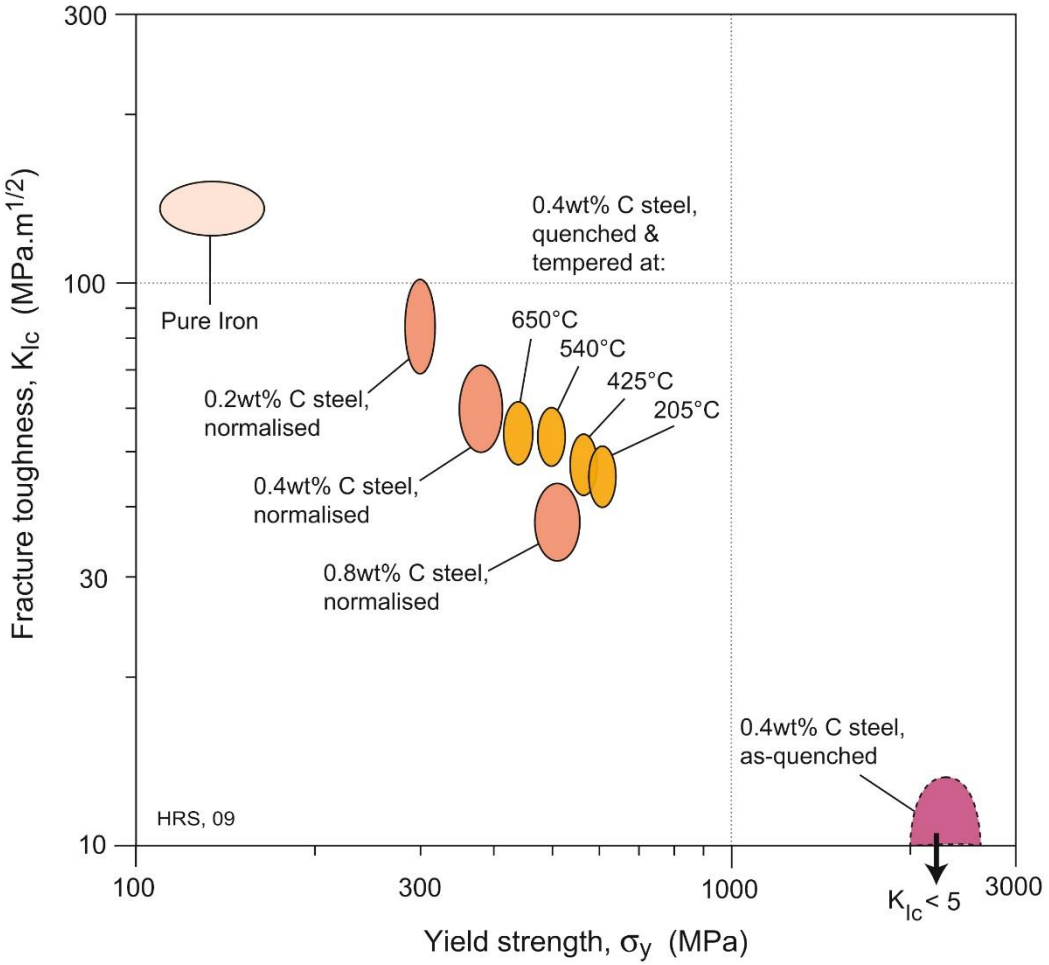
Steel

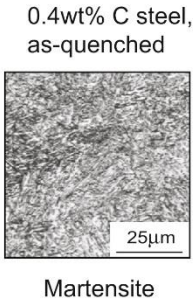
Normalising
(produce ferrite/pearlite)



Fast as feasible to reduce grain size, pearlite separation (better strength, toughness, ductility)







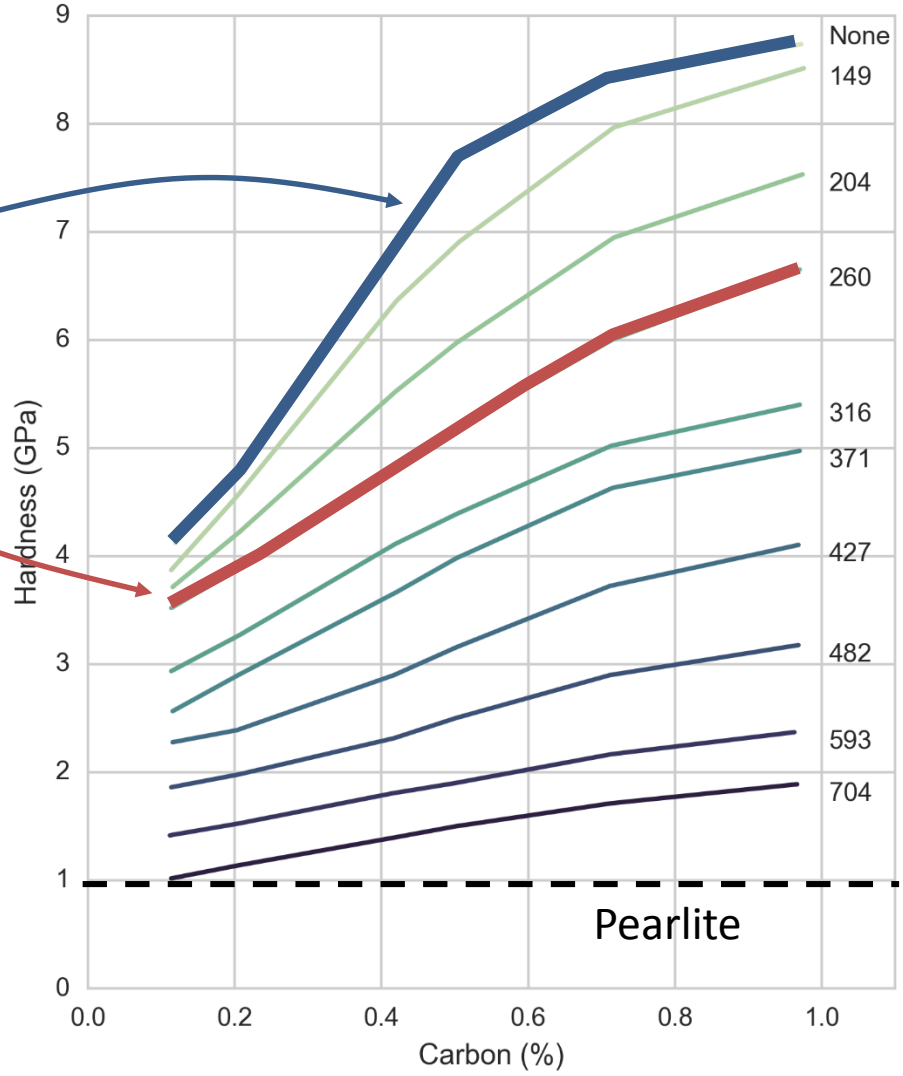
Tempering

(Figure in tutorial)

Hardness of 100% martensite

Hardness of 100% martensite after 1 hour at 260C

This only tells you the hardness of 100% martensite



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Polls

The steel was not heated to a high enough T during the final heat treatment.

Usually means no austenite, so no martensite (softer than expected)

The quench was too fast.

Get martensite if CCR exceeded. No change if faster. Might cause thermal stresses (cracking, distortion)

The quench was not fast enough.

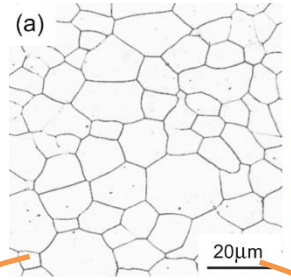
Slow cooling allows ferrite/pearlite to form instead

The tempering stage was not long/hot enough.

Tempering allows strong/brittle martensite to ‘relax’ but needs time and T. Too little = hard/brittle

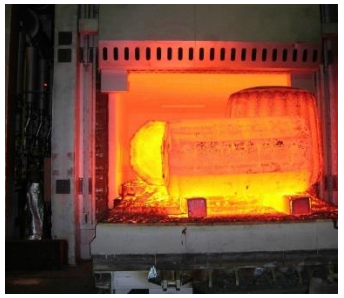
Treatments can chain up

Forge



Austenite

recrystallisation



Temp

eutectoid

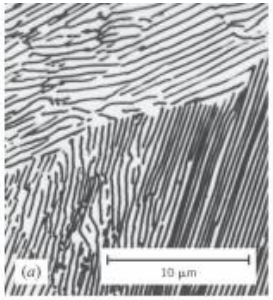
Slow cool

Slow cool

Quench

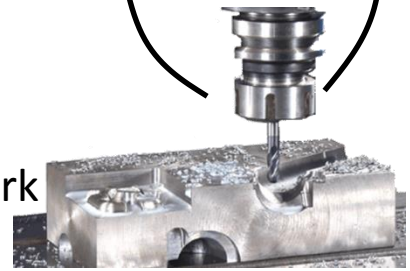
Temper/age

Time

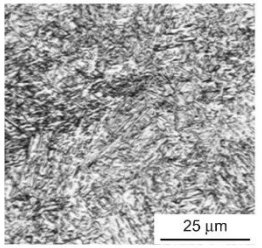


Soft pearlite

Various cold work



Hard martensite



Tougher martensite

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- **TRY QUESTIONS 13-17 BY NEXT LECTURE**