Module #21b

Comments on Development of Crystalline Solids for Maximum Strength

READING LIST

HOW DO WE "ENGINEER" AN ALLOY FOR OPTIMAL STRENGTH?

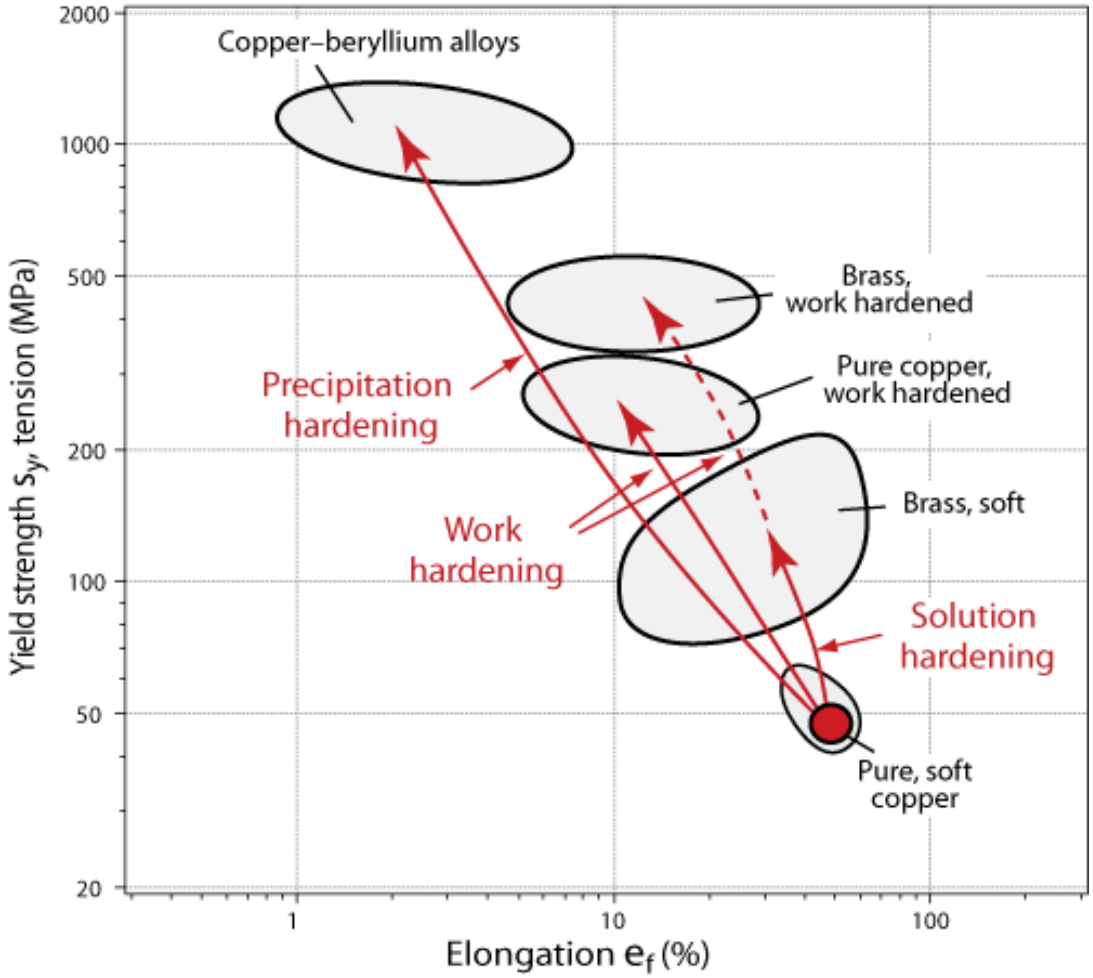
- **Use work-hardening to improve strength**
  - –Reduces toughness. Work hardening capacity is reduced.
  - –Can be annealed out at intermediate temperatures.
  - –Limited effectiveness in high strength materials as YS is near UTS
- **Use grain-size strengthening**
  - –Reduction in grain size can improve strength and toughness. Strength increase is limited (a few hundred MPa).
  - –Fine grains are bad at high temperature
    - Alloys susceptible to creep.
    - Grain boundaries are rapid diffusion pathways.
    - Grains will grow.
- **Use solid solution strengthening**
  - –Substitutional solutes can give moderate increase in strength (around a few hundred MPa). Effectiveness is limited by solubility. Solutes with big lattice misfits often have low solubility.
  - –Interstitial solutes can provide a low increase in strength for BCC metals (~70 MPa). You can quench in excess interstitial solutes such as C, or N into steels which will yield large strength increase (~1 GPa). However, this results in a large decrease in ductility.
- **Use precipitation hardening**
  - –Need very fine dispersion of hard precipitates to get large strength increase (~1 GPa).
  - –Dispersion of weak precipitates is not as effective.

HOW DO WE "ENGINEER" AN ALLOY FOR OPTIMAL STRENGTH?

- Use precipitation hardening
  - –Use as fine a dispersion of particles as possible. Particles should be as strong/hard as is possible.

- Use solid solution strengthening
  - –Solutes will generally be present anyway (even when you don't want them).
    - Can intentionally add elements to scavenge deleterious impurities (Ex., Mn, Si, Al in steel).
    - Can also slow down diffusional reactions.
    - Can provide corrosion resistance (Ex., Cr in steel)
    - To react with other elements to produce precipitates.

- Use grain-size strengthening
  - –Fine grain size is good to increase toughness and strength. Bad for high temperature performance.



[Ashby, Shercliff, & Cebon, p. 135]