Drexel University, Department of Materials Science and Engineering

Materials Science and Engineering II – Winter 2008

MATE 221: Introduction to Mechanical Properties of Materials

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Homework 7

H7.Q1: Compare the data for strength and fracture toughness of a selection of copper and copper alloys (brass and bonze), both cast and wrought using a property chart (on log scales as usual. Use the chart to answer the following question:
(a) how do the cast and wrought alloys compare on fracture toughness, at comparable strength?
(b) rank the strengthening mechanisms (as indicated in the table) in order of effectiveness;
(c) do the trends observed in (a and b) follow a similar pattern to aluminum alloys (Fig. 8.15 in the textbook by Ashby, Shercliff and Cebon)?

Typical strength and fracture toughness data for copper alloys

Alloy	Process route	Main strengthening mechanism	Yield strength [MPa]	Fracture toughness [MPa.m$^{1/2}$]
Pure Cu	Cast	None	35	105
Pure Cu	Hot rolled	Work	80	82
Bronze (10% Sn)	Cast	Solid solution	200	55
Brass (30% Zn)	Cast	Solid solution	90	80
Brass (30% Zn)	Wrought + annealed	Wrought + annealed	100	75
Brass (30% Zn)	Wrought	Solid solution + Work	400	35
Cu – 2% Be	Wrought + heat treated	Precipitation	1000	17

H7.Q2: Use the Browse facility in CES to find
a) the record for the shaping process Injection molding, thermoplastics. What is its economic batch size? What does this term mean?
b) the machining process Water-jet cutting (records for machining processes are contained in the Shaping data table). What are its typical uses?
c) the joining process Friction-stir welding. Can it be used to join dissimilar materials?
d) the surface treatment process Laser hardening. What are the three variants of this process?

H7.Q3: Use the Search facility in CES to find
a) processes used for boat building
b) processes to make bottles

c) processes to make tail light assemblies
d) processes for decoration

H7.Q4: Casting processes require that the metal be melted. Vapor methods like vapor metalizing require that the metal be vaporized. Casting requires energy: the latent heat of melting is an absolute lower limit (in fact it requires more than 4 times this). Vaporization requires the latent heat of vaporization, again as an absolute lower limit. Values for both are contained in the Elements database. Make a plot of one against the other. Using these lower limits, find, approximately, how much more energy-intensive vapor methods are compared with those that simply melt.

H7.Q5: By what mechanisms do metals oxidize? What determines the rate of oxidation?

H7.Q6: What is meant by the standard reduction potential? A copper and a platinum electrode are immersed in a bath of dilute copper sulfate. What potential difference would you expect to measure between them? If they are connected so that a current can flow, which one will corrode?

H7.Q7: The self diffusion constants for aluminum are Do = 1.7 x 10-4 m2/s and Qd = 142 kJ/mol. What is the diffusion rate in aluminum at 400C?

H7.Q8: A steel component is nickel plated to give corrosion protection. To increase the strength of the bond between the steel and the nickel, the component is heated for 4 hours at 1000 C. If the diffusion parameters for nickel in iron are Do = 1.9 x 10-4 m2/s and Qd = 284 kJ/mol. how far would you expect the nickel to diffuse into the steel in this time?

H7.Q9: The diffusion coefficient at the melting point for materials is approximately constant, with the value D = 10-12 m2/s. What is the diffusion distance if a material is held for 12 hours at just below its melting temperature? This distance gives an idea of the maximum distance over which concentration gradients can be smoothed by diffusion.

H7.Q10: What are the requirements of a creep-resistant material? What materials would you consider for use at 550C?

H7.Q11: A stainless steel suspension cable in a furnace is subjected to a stress of 100 MPa at 700C. Its creep rate is found to be unacceptably high. By what mechanism is creeping? What action would you suggest to tackle the problem? The figure shows the deformation mechanism map for the material.

H7.Q12: When a solid vaporizes, the bonds between its atoms are broken. You might then expect that latent heat of vaporization , *Lv* , should be nearly the same as the cohesive energy *Hc* , since it is basic measure of the strength of the bonding. Plot one against the other, using CES Elements. How close are they?

H7.Q13: Give examples, based on your experience in sport (tennis, golf, swimming, skiing, rock climbing, hang-gliding…) of instances in which friction is wanted and when it is not.

H7.Q14: Now a more challenging one. Do the same based, again on your experience in sport, of instances in which wear is desirable and in which it is not.

H7.Q15: What are the characteristics of materials that are a good choice for use as brake pads?