AML 883: Properties and Selection of Engineering Materials

Minor I

16 February, 2009

Instructions

- Please answer all the questions.
- Please answer the questions in your own words; out and out copying from your textbook will not get you any credits.
- For numerical examples, please give all the steps; wherever needed, draw neat diagrams and graphs with proper labelling; explain all the symbols; give the answers in proper units.
- This is an open book exam; use the book for data that might be needed (unless specified otherwise); write down the page number in brackets next to the data that you are taking from the book.
- The maximum points are 200.

Question 1 (**20 points**)

(a) The Young's modulus of Nickel is 193 G Pa and its lattice parameter is 3.52 Angstroms. Estimate the stiffness of the Ni-Ni bonds. (**5 points**)

(b) For an elastomer, it is given that the shear modulus is one third of its Young's modulus. What is its Poisson's ratio? What is its bulk modulus? (**15 points**)

Question 2 (6**0 points**)

A material is sought for a high-speed centrifuge. The objective is to achieve as high an angular velocity 'w' of the centrifuge disk as possible. The constraint is that the stress created by the centrifugal force must not exceed the yield strength of the material of which it is made. Derive an index to guide the choice of material to allow the maximum 'w'.

Question 3 (**60 points**)

(a) The lattice resistance of copper, like that of most FCC metals, is small. When 10% of nickel is dissolved in copper to make a solid solution, the strength of the alloy is 150 M Pa. What would you expect the strength of an alloy with 20% nickel to be? (**15 points**)

(b) A metal-matrix composite consists of aluminium containing hard particles of silicon carbide (SiC) with a mean spacing of 3 microns. The composite has a strength of 180 M Pa. If a new grade of the composite with a particle spacing of 2 microns were developed, what would you expect its strength to be? (**15 points**)

(c) Nanocrystalline materials have grain sizes in the range 0.01-0.1 microns. If the contribution of grain boundary strengthening in an alloy with grains of 0.1 microns is 20 M Pa, what would you expect it to be if the grain size were reduced to 0.01 microns. (**15 points**)

(4) What is Taylor factor? Is superposition of strengthening mechanisms applicable to the yield strength? (**15 points**)

Question 4 (**60 points**)

(a) Given the fracture toughness of an alloy is 58.7 M Pa . $m^{1/2}$. And, its Young's modulus is 69 G Pa. Calculate the critical strain energy release rate? (**10 points**)

(b) A component (of the shape shown below) made from a high-strength aerospace alloy Ti-6Al-4V whose SN curve is shown (for a stress ratio of -1), is loaded cyclically at a nominal range of +210 M Pa to -210 M Pa. How long will it last? (See p.224 of your text book for a clearer picture and plot). (**50 points**)