27-302, Microstructure & Properties II, A.D. Rollett

Fall 2002

Homework 3, due Weds, Nov. 11^{th}

1. *Materials Design* - this work is preparation for the next discussion on Nov. 13^{th}, so it is not due on the 11^{th}.

Now that we have established a list of applications and required properties for Nitinol alloys, the next step is to investigate microstructure-property relationships in this material. For at least one of the properties named on the list(s) posted on the Discussion Board, look up some papers (or in a book) and come prepared with some information on microstructures in Nitinol alloys and how they affect the properties. Obviously there will be some aspects that I will cover in lectures on military transformations in general, and the shape memory effect in particular.

2. *TTT diagrams*
2a. Assume that the minimum nucleation rate required to be able observe precipitation is 10^{23}.s ^{1} find the minimum undercooling required for precipitation for the composition specified in Homework 2.

2b. In order to calculate KJMA curves and plot a TTT diagram, a simplification is required at this stage in order to obtain a nucleus density. The difficulty is that, although one can calculate a nucleation rate, it is less obvious how long nucleation continues or even whether the nucleation rate remains constant. Therefore we will follow Servi & Turnbull and make the simplification that the nucleus density is a factor of 100 times the initial nucleation rate as calculated in Hwk 2 . Note that Servi & Turnbull list values of the number density for 1.48 Co between 10^{18}.m ^{3} and 10^{22}.m ^{3} be careful of the conversion from cm^3 to m^3 so you can check your answers. The actual factor almost certainly varies with undercooling but this is a reasonable approximation to make. The output required for this section is to make a plot of nucleus density horizontal axis, log scale versus undercooling vertical axis, linear .

2c. For the temperatures 713°C, 704°C, 694°C, 685°C and 675°C, plot fraction precipitated as a fraction of the equilibrium volume fraction versus time linear scale for both axes . Assume that diffusion controlled growth with the linearized gradients approximation applies. You may need to make a separate plot for each temperature in order to obtain a reasonable time scale.

2d. For the same temperatures as in 2c, make KJMA plots of ln 1 f versus time log scale, both axes, following the examples in the Servi & Turnbull paper, and in the lecture . Obviously you can use the same data as before. Plot all five temperatures together. Compare to the Servi & Turnbull experimental result their fig. 6 .

2e. Based on the KJMA analysis derived in the lectures, calculate the time required for 10 and for 90 precipitation, as a *function of temperature* not undercooling . 100 means that the volume fraction is the equilibrium volume fraction determined by the level rule. Plot the results as a TTT diagram, i.e. the temperature vertical, linear scale versus time horizontal, linear scale . You should obtain "C" shaped curves that predict negligible precipitation above the critical undercooling.

3. *Heterogeneous Nucleation*
Answer question 5.5 on p. 380 of Porter & Easterling.

4. *Diffusion Controlled Growth*
Answer question 5.6 on p. 380 of P&E.

5. *KJMA Equation*
Answer problem 5.8, p. 380, P&E.