Examples Class on Alloys

1. *300M* steel is used in the manufacture of aircraft undercarriage, in the quenched and tempered martensitic condition. It has the chemical composition

$$\mathrm{Fe} - 0.4\mathrm{C} - 0.7\mathrm{Mn} - 1.6\mathrm{Si} - 0.8\mathrm{Cr} - 1.8\mathrm{Ni} - 0.25\mathrm{Mo} \quad \text{wt.\%}$$

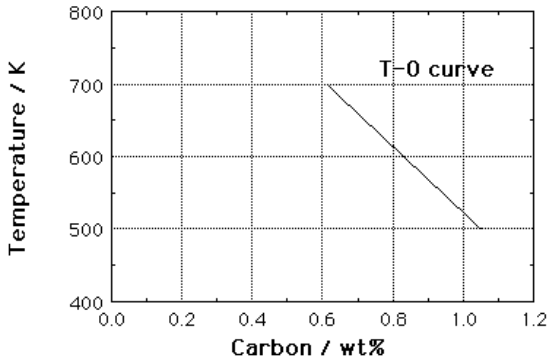
When transformed into bainite, its large silicon concentration prevents the precipitation of cementite, so that the bainite consists only of a mixture of bainitic ferrite and carbon–enriched residual austenite. Use the T_0 curve given below together with the empirical equation for the martensite–start temperature (M_S) to calculate:

(a) the maximum fraction of bainitic ferrite that can form during isothermal transformation at 400 °C (assume that the carbon concentration in ferrite is zero);

(b) the fraction of martensite (f) that forms when the remaining austenite is cooled to room temperature given that

$$1 - f = \exp\{-0.011(M_S - T)\}$$
$$M_S = 561 - 474 \times w_C - 33 \times w_{Mn} - 17 \times w_{Cr} - 17 \times w_{Ni} - 21 \times w_{Mo}$$

where w_i represents the concentration of element i in wt.% and T is the temperature.



2. Sketch, steregrams centered on $\{0\ 1\ 1\}_\alpha$, for the Kurdjumov–Sachs and Nishiyama–Wasserman orientation relationships. Hence deduce how one may be generated from the other (γ and α represent austenite and martensite respectively.)

Kurdjumov–Sachs

$$\{1\ 1\ 1\}_\gamma \| \{0\ 1\ 1\}_\alpha$$
$$< 1\ 0\ \overline{1} >_\gamma \| < 1\ 1\ \overline{1} >_\alpha$$

Nishiyama–Wasserman

$$\{1\ 1\ 1\}_\gamma \| \{0\ 1\ 1\}_\alpha$$
$$< 1\ 0\ \overline{1} >_\gamma \quad \text{about } 5.3^\circ \text{ from} < 1\ 1\ \overline{1} >_\alpha \text{ towards } < \overline{1}\ 1\ \overline{1} >_\alpha$$

3. Show diagramatically that it is not possible to obtain a fully coherent interface between austenite and martensite in steel.

4. How does atomic–ordering affect the mechanical properties of an alloy? State two alloy systems where ordered precipitates are used in large volume fractions for aerospace applications. How can the coherency of the precipitates with the matrix phase be controlled?