In-tutorial Exercise # 3 **MECH 221** **Fall 2018**

Name:

Student ID:

Question 1 ***{5 marks}***

An Aluminum-Copper alloy initially containing 0.4 wt% Cu is placed and held in an atmosphere that gives a constant surface Aluminum concentration of 1.0 wt%. If after 43 h the concentration of copper is 0.55 wt% at a position 4.0 mm below the surface, determine the diffusion coefficient of copper in aluminum for the treatment conditions.

Non-Steady State Diffusion à $\frac{C(x,t) - C_0}{C_s - C_0} = 1 - erf\left(\frac{x}{2\sqrt{Dt}}\right)$

Solution

Data from the question:
C_0 = 0.4 wt%
C_s = 1.0 wt%
C_x = 0.55 wt%
t = 43 h
x = 4.0 mm = $4x10^{-3}$ m

$$\frac{C(x,t) - C_0}{C_s - C_0} = 1 - erf\left(\frac{x}{2\sqrt{Dt}}\right) \rightarrow \frac{0.55 - 0.4}{1 - 0.4} = 1 - erf(z)$$

$$\therefore erf(z) = 0.75$$

Now we must now determine from Table 5.1 the value of z for which the errors function is 0.75. An interpolation is necessary as follows:

z	$erf(z)$
0.80	0.7421
0.85	0.7707

$$\frac{z - 0.8}{0.85 - 0.8} = \frac{0.75 - 0.7421}{0.7707 - 0.7421} \rightarrow z = 0.81$$

Now solve for finding D:

$$\therefore D = \left(\frac{x^2}{4z^2t}\right) = \left(\frac{(4x10^{-3}m)^2}{4(0.81)^2(43\ h)}\right) \cdot \frac{1\ h}{3600\ s} = 3.94x10^{-11}\ m^2/s$$

Question 2 *{5 marks}*

The following data were collected from a 12.8 mm diameter test specimen of an Aluminum alloy (the gauge length, l_o = 50.800 mm). At fracture, the minimum diameter at the neck was 9.40 mm and fracture load was 36400 N. Using the given plot calculate:

a) The modulus of elasticity;
b) The 0.2% offset yield strength;
c) The tensile strength;
d) Ductility in terms of the % elongation;
e) The true stress at fracture; and
Briefly explain how each value is obtained.

Solution

a) The elastic modulus is the slope in the linear elastic region (Equation 6.10) as

$$E = \frac{\Delta\sigma}{\Delta\varepsilon} = \frac{200\ \text{MPa} - 0\ \text{MPa}}{0.0032 - 0} = 62.5 \times 10^3\ \text{MPa} = 62.5\ \text{GPa}$$

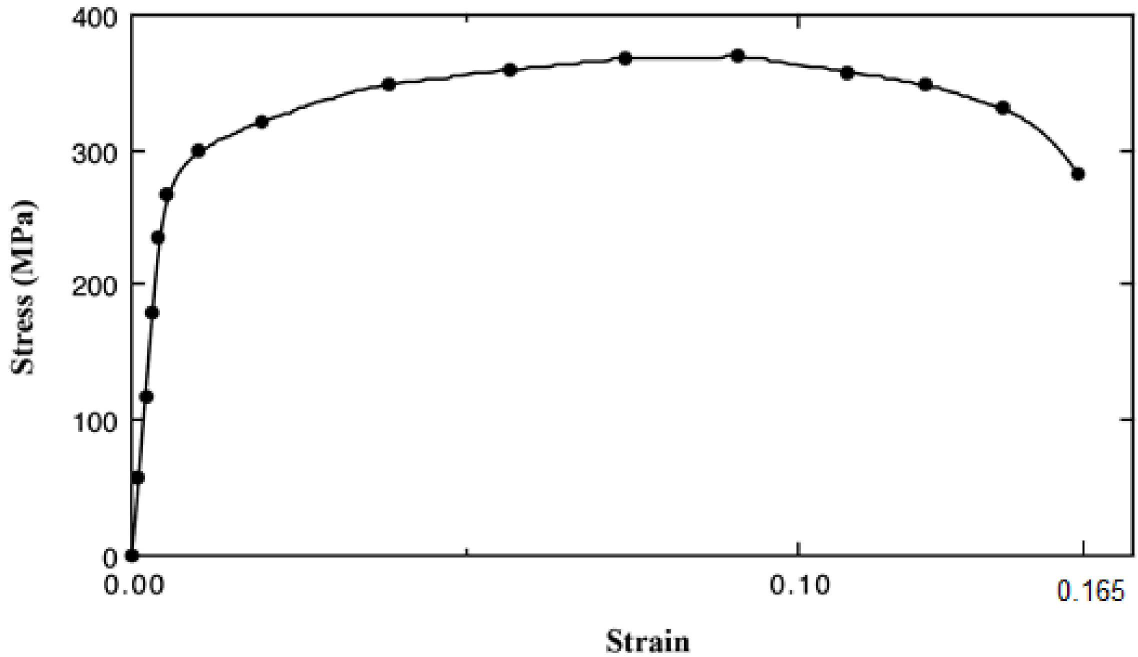
b) For the yield strength, the 0.002 strain offset line is drawn dashed. It intersects the stress-strain curve at approximately 285 MPa.

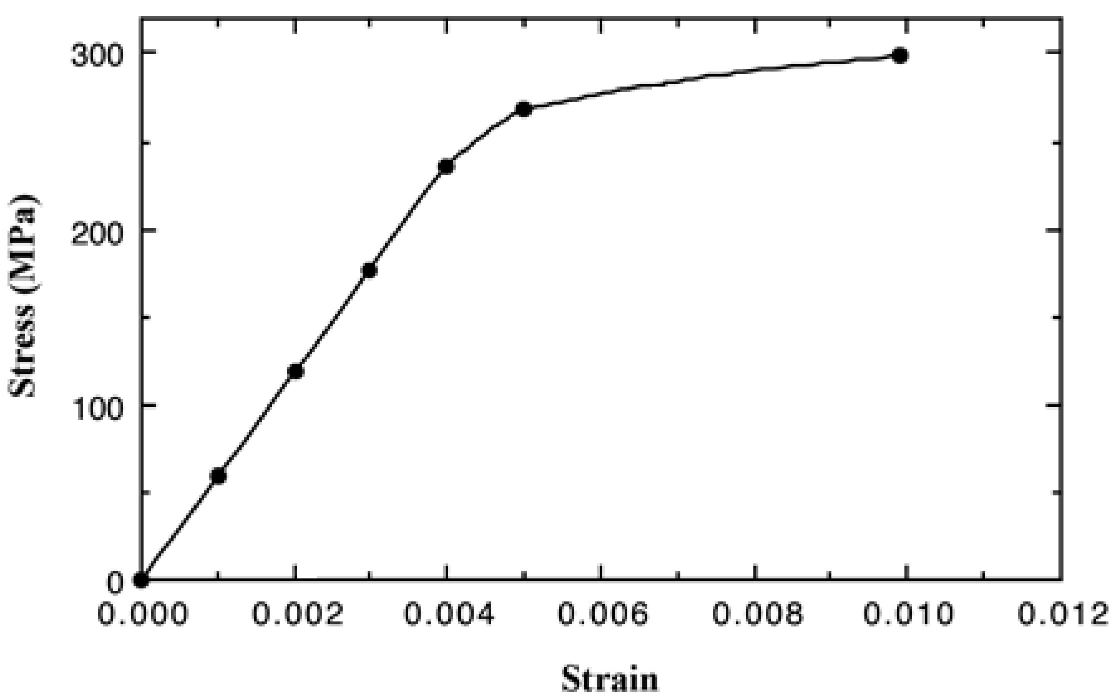
c) The tensile strength is approximately 370 MPa, corresponding to the maximum stress on the complete stress-strain plot.

d) The ductility, in percent elongation, is just the plastic strain at fracture, multiplied by one-hundred. The total fracture strain at fracture is 0.165; subtracting out the elastic strain (which is about 0.005) leaves a plastic strain of 0.160. Thus, the ductility is about 16%EL.

e) True stress at fracture:

$$\sigma_T = \frac{F}{A_i} = \frac{36400}{(\pi/4)(9.40)^2} = 524.51\ MPa$$


400
300
200
100
0
Stress (MPa)
0.00
0.10
0.165
Strain


300
200
100
0
Stress (MPa)
0.000
0.002
0.004
0.006
0.008
0.010
0.012
Strain