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ME 495 - HW#2

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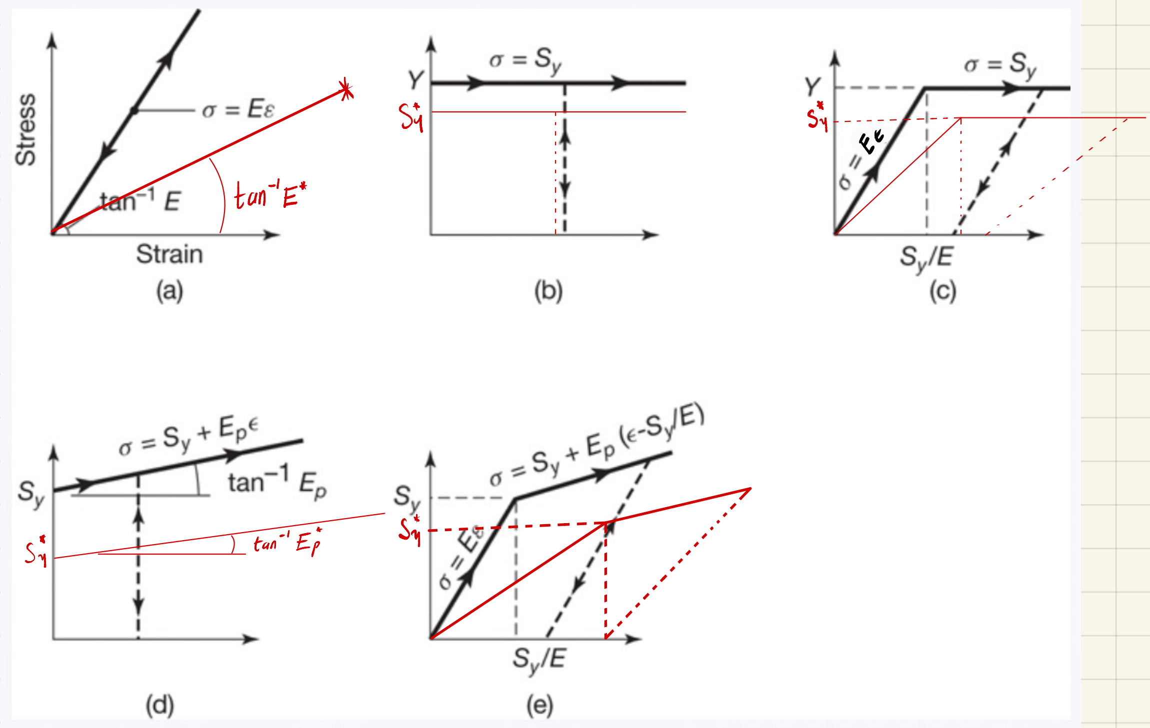
2.12 Modify the curves in Fig. 2.7 to indicate the effects of temperature. Explain your changes.



According to the Manufacturing Processes for Engineering, Increasing temperature usually lowers the Modulus of elasticity, yield Strength, and the ultimate tensile strength, and Increases ductility and toughness.

This is demonstrated in the Secondary markings in the figure above. The modulus of elasticity is lower, demonstrated by the less steep curve, the yield stress is also shown to be lower. The curve also shows a Larger area under the curve, showing an Increase in the toughness.

2.42 List the advantages and limitations of the stress–strain relationships given in Fig. 2.7

a. Perfectly elastic material

- Advantage: i) Simple relationship between the stress and the strain. Stress is proportional to the strain.
  ii) Material properties can be preserved if yield stress is not exceeded

- Limitation: i) Not suitable for applications that require permanent deformation
  ii) Material properties are not preserved after exceeding yield stress

b. Rigid, perfectly plastic

- Advantage: i) Since strains increase indefinite at the yield stress, the yield stress is the only parameter needed to describe this behavior (i.e simple constitutive equation)
  ii) Can be suitable for applications where elasticity is undesirable.

- limitation: i) Not suitable for applications that require strain hardening or elastic recovery

c. Elastic perfectly plastic
- Advantages: i) Could be suitable for applications that require elastic and plastic behaviors.
  ii) Could be suitable for applications that require elastic recovery
  iii) Relatively simple constitutive equation.

- limitation: i) Not suitable for application that require strain hardening.

d. Rigid, linearly strain-hardening
- Advantage: i) Suitable for applications where deformation before the yield stress is undesirable
  ii) Strain hardening can be a desirable characteristic for some application.
- limitation: i) Not suitable for applications where elastic recovery is desired.
  ii) Relatively more complex constitutive equation.

e. Elastic, linear strain hardening
- Advantage: i) Suitable for applications where an elasto-plastic (elastic & plastic) behavior may be desired

- limitation: i) A more complex stress-strain constitutive equation

2.58 Derive an expression for the toughness of a material represented by the equation $\sigma = K(\epsilon + 0.2)^n$ and whose fracture strain is denoted as ϵ_f.

Given: $\sigma = K(\epsilon + 0.2)^n$

Find: Derive an expression for the toughness

from eqn (2.14):

$$\text{Toughness} = \int_0^{\epsilon_f} \sigma \, d\epsilon$$

Using $\sigma = K(\epsilon + 0.2)^n$, the toughness eqn becomes:

$$\text{Toughness} = \int_0^{\epsilon_f} K(\epsilon + 0.2)^n \, d\epsilon$$

take $u = (\epsilon + 0.2)$

$du = d\epsilon$

$$= K \int_0^{\epsilon_f} u^n \, du$$

$$= K \frac{u^{n+1}}{n+1}$$

$$= K \frac{(\epsilon + 0.2)^{n+1}}{n+1} \Bigg|_0^{\epsilon_f}$$

$$= K \left[\frac{(\epsilon_f + 0.2)^{n+1}}{n+1} - \frac{(0 + 0.2)^{n+1}}{n+1} \right]$$

$$\text{Toughness} = \frac{K}{n+1} \left[(\epsilon_f + 0.2)^{n+1} - 0.2^{n+1} \right]$$ *

2.93 A metal has a strain-hardening exponent of 0.22. At a true strain of 0.2, the true stress is 80 MPa. (a) Determine the stress–strain relationship for this material. (b) Determine the ultimate tensile strength for this material.

Given: strain-hardening exponent, $n = 0.22$ $\qquad$ $S_{ut} = 65.6\,MPa$

true strain, $\epsilon = 0.2$
true stress, $\sigma = 80\,MPa$

a) Determine the stress-strain relationship for this material.
b) Determine the ultimate tensile strength for this material.

a) Stress - strain relationship.

from eqn (2.11) true stress - true strain is approximated by:

$$\sigma = K\epsilon^n$$

using the given parameters:

$$80\,MPa = K(0.2)^{0.22}$$

b) Ultimate tensile strength

from eqn(2.3):

$$S_{ut} = \frac{P}{A_o}$$

from eqn (2.10) we know that:

$$\epsilon = \ln\left(\frac{A_o}{A}\right)$$

and true stress is given as:

$$\sigma = \frac{P}{A} \quad \text{eqn (2.8)}$$

$$\text{So} \quad P = \sigma A$$

from eqn (2.10)

$$0.2 = \ln\left(\frac{A_o}{A}\right)$$

$$e^{0.2} = \frac{A_o}{A} = 1.2214$$

from eqn (2.3) and eqn (2.8)

$$S_{ut} = \sigma \frac{A}{A_0}$$

$$S_{ut} = (80\,MPa) \frac{1}{(1.2214)}$$

$$S_{ut} = 65.5\,MPa$$