Tutorial 3 – Week 4
Aims:

Upon successfully completing these tutorial exercises, students should be able to:

- Understand the various strengthening mechanisms for materials
- Perform calculations to determine mechanical properties resulting from various materials processing methods and strengthening mechanisms

Part A – Cold Work

Exercise 3.1 The figure below shows the mechanical properties of type 204-Cu stainless steel as a function of cold work (%CW). The material is to be cold drawn in a single step into a circular wire of diameter 2.4 mm with yield strength in excess of 600 MPa.

a) What is the minimum diameter of the circular bar used as feedstock for the drawing process? Assume the bar feedstock is in the fully annealed condition.

b) What will be the ductility (%EL) of the final wire after this drawing process?

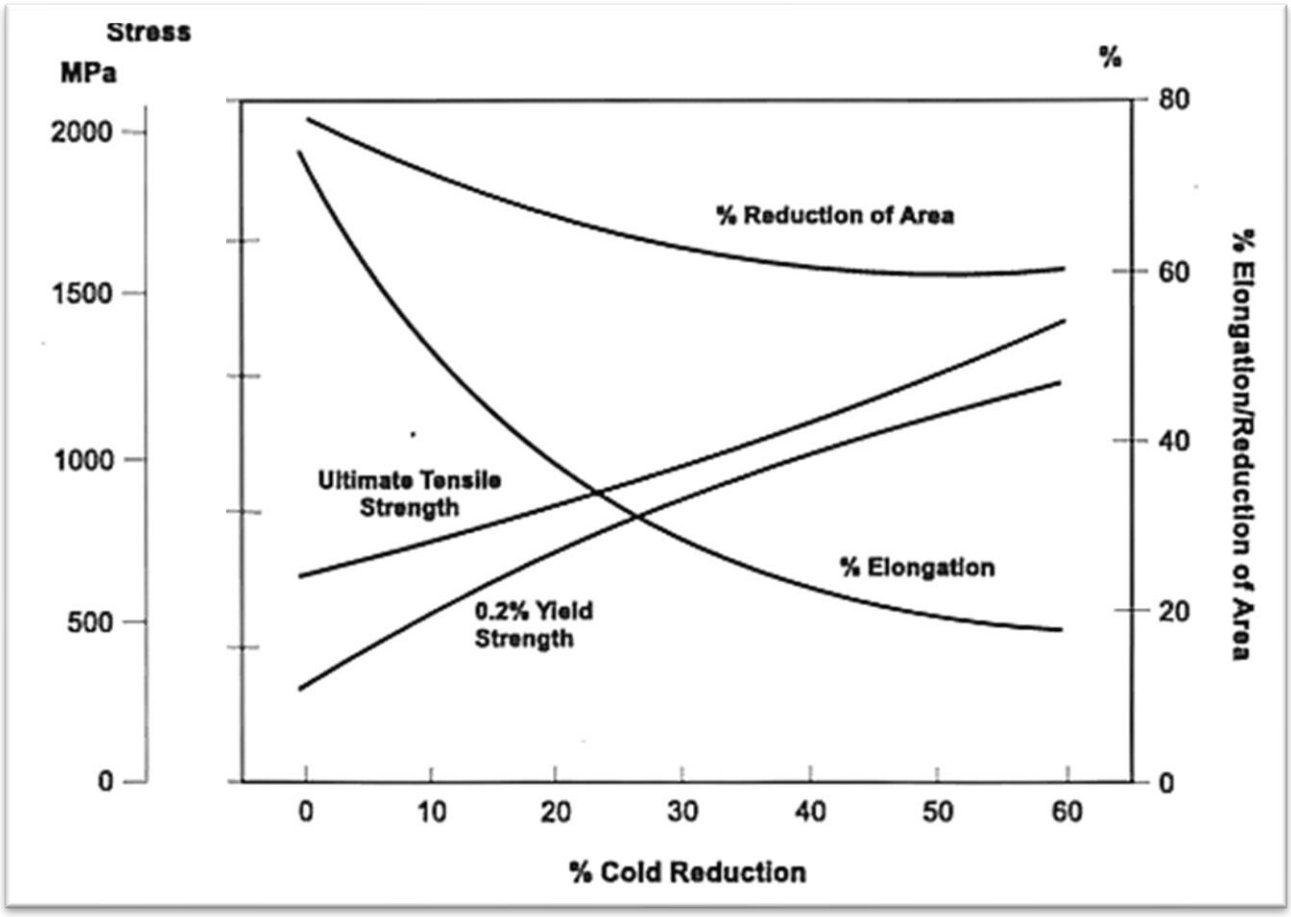

Figure 1

Exercise 3.2 With relation to the data presented in the Figure 2:

a) What level of cold work would be required to give brass with yield strength of 370MPa?

b) What would be the yield strength of copper cold worked to 42%?

c) 1040 steel is to be rolled in a 'cold strip mill' to sheet 1.2mm in thickness with yield strength of 700MPa. Assuming the width of the strip doesn't change during the rolling process, what is the minimum thickness of the plate feedstock for the rolling process if it is initially in the fully annealed condition.

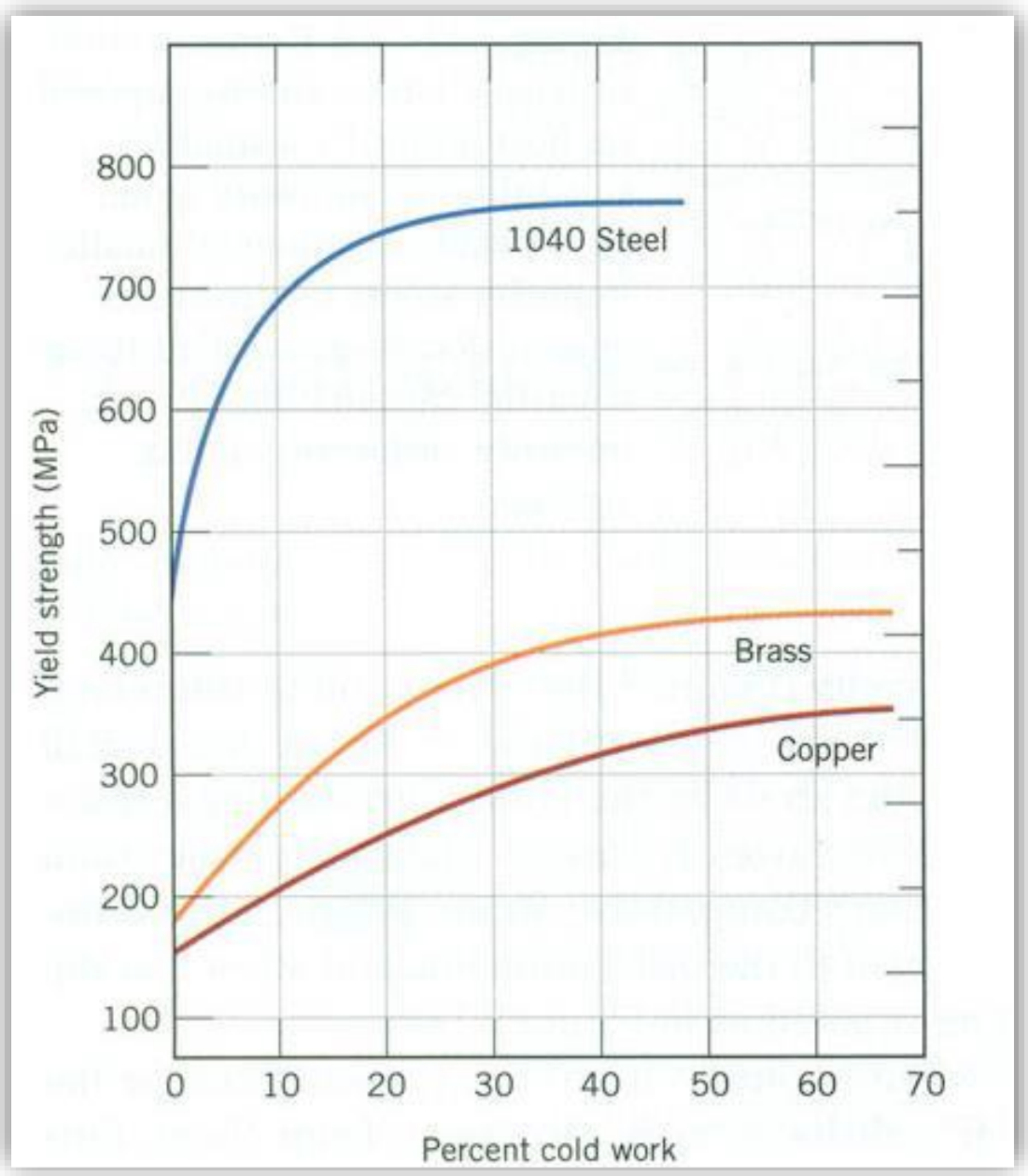

Figure 2: Yield strength against Percent cold work for different materials

Part B – Yield Strength – Grain strengthening

Hall-Petch Equation $\sigma_y = \sigma_0 + k_y d^{-0.5}$

σ_y = *yield strength (MPa)*

σ_0 = *intrinsic strength of lattice (MPa)*

k_y = *strengthening constant (MPa.m$^{0.5}$)*

d = *grain size (m$^{-0.5}$)*

Exercise 3.3 The yield strength (σ_y) of the AZ31 magnesium alloy is 75 MPa for an average grain size (d) of 90 µm. Reducing grain size to 10 µm increases the yield strength to 200 MPa. Assuming that grain boundary refinement is the only significant strengthening mechanism at play:

a) Determine the intrinsic strength (σ_0) and grain refinement constant (k_y) of the magnesium alloy.

b) Calculate the expected yield strength of AZ31 for an average grain size of 40 µm.