Mohamed KhiderUniversity of Biskra
Science and TechnologyFaculty
Department of Mechanical Engineering

جامعة محمد خيضر بسكرة
كلية العلوم والتكنولوجيا
قسم الهندسةالميكانيكية

Plasticity and Damage in Metals

Exam

Exercise 1: 7pt

A cylindrical aluminum sample with a diameter of 15 mm and a length of 200 mm is subjected to a tensile force. The aluminum has an elastic modulus (Young's modulus) of 70 GPa. When a tensile force of 15,000 N is applied, it elongates by 2.5 mm.

Calculate:

1. The stress applied to the sample.
2. The elastic modulus from the given data.
3. The total strain energy stored in the entire volume of the cylindrical sample.

Exercise 2: 6pt

A crystalline copper sample is subjected to shear loading with the following properties: a Burgers vector of b=0.255 nm, an initial dislocation density of $\rho_{initial}=5\times10^{11}\ m^{-2}$, a shear modulus of G=48 GPa, and a dislocation interaction constant of α=0.25.

1. Calculate the shear stress resulting from the initial dislocation density $\rho_{initial}$.
2. Determine the new shear stress when the dislocation density increases to $\rho_{final}=5\times10^{13}\ m^{-2}$.
3. Compare the shear stresses and discuss how the increase in dislocation density affects the mechanical strength of the material.

Exercise 3: 7pt

A steel rod with a uniform cross-section is subjected to tensile loading, resulting in a non-uniform plastic strain distribution described by $\epsilon_p(x)=\epsilon_0\sin(yx)$, where $\epsilon_p(x)$ is the plastic strain at a distance x from the fixed end, ϵ_0 is the maximum plastic strain, and γ is a material constant related to the strain gradient.

1. Derive the plastic strain gradient $\frac{d\epsilon p}{dx}$ along the rod.
2. Calculate the value of the plastic strain gradient at x=0.5 m, using $\epsilon_0=0.03$ and $y=2\ m^{-1}$.
3. Determine the locations along the rod where $\frac{d\epsilon p}{dx}=0$.
4. Discuss the role of the plastic strain gradient in controlling deformation localization, and how it influences the material's strain-hardening behavior and overall strength.