**L4. Plastic Deformation of Metals**

*1. A bar with an initial diameter of 12.83mm and length of 50.8mm is stressed beyond it yield point. In the uniform plastic deformation region following measurements are performed:*

|  |  |  |
| --- | --- | --- |
| *Load [kN]* | *Elongation at the load [mm]* | *Diameter change [mm]* |
| *122.320* | *5.34* | *12.19* |
| *120.096* | *11.25* | *11.60* |
| *114.314* | *17.77* | *11.03* |

*Using the Ludwik - Hollomon equation find the strength coefficient and the strain hardening exponent. Based on the value of the strain hardening exponent, infer the crystal structure of the metal.*

*!!!Remember to use true strain and stress in your computations!!!*

1. *Why do BCC metals and alloys show a lower strain hardening exponent than FCC metals and alloys?*

**1.**

Initial diameter d0=12.83 mm

Initial length L0=50.8 mm

#### Formulas:

**True strain: ε\_t = ln(1+ (**Δ**L)/L\_0)**

**True stress:** σ\_t = F/A , A = πd^2 / 4

a)

**ε\_t = ln(1+5.34/50.8) = 0.1**

**A =** π \* (12.19)^2/4 = 116.73 mm^2

F = 122320\*1000 = 122320 N

σ\_t = 122320\*116.73 = 1047.7 MPa

b)

**ε\_t = ln (1+11.25/50.8) = 0.1999**

**A =** π \* (11.6)^2/4 = 105.68 mm^2

σ\_t = 120096/105.68 = 1136.6 MPa

c)

**ε\_t = ln (1+17.77/50.8) = 0.3001**

**A =** π \* (11.03)^2/4 = 95.62 mm^2

σ\_t = 114314/95.62 = 1195.5 MPa

Formula :

σ = K \* **ε^n => ln(**σ) = ln(K) + n\*ln(**ε)**

|  |  |  |  |
| --- | --- | --- | --- |
| **ε\_t** | σ\_t | **ln(ε\_t)** | **ln(**σ\_t) |
| **0.1** | **1047.7** | **-2.302** | **6.956** |
| **0.1999** | **1136.6** | **-1.61** | **7.037** |
| **0.3001** | **1195.5** | **-1.204** | **7.085** |

Slope n = 0.22n

ln(K) = 7.48 => K = e^7.48 = 1773.6 MPa

Strain hardening component n = 0.22

Crystal Structure Inference:

Since n=0.22 and typical values are:

FCC metals → n between **0.2 and 0.5**

BCC metals → n between **0.05 and 0.2**

The material **most likely has a Face-Centered Cubic (FCC)** crystal structure.

## ****2.****

**BCC metals:**

* Have ****fewer active slip systems**** at room temperature.
* **Slip is more difficult** due to higher **Peierls-Nabarro stress** (resistance to dislocation motion).
* As a result, **plastic deformation is less uniform** and **strain hardening is limited**.

**FCC metals**:

* Have ****many active slip systems**** available at all temperatures.
* **Dislocation motion occurs more easily** → **more plastic deformation.**
* **Higher strain hardening** due to more significant interaction between dislocations.

BCC metals strain harden **less** effectively than FCC metals, leading to a **lower strain hardening exponent (n)**. FCC metals are more ductile and strain harden more significantly due to easier dislocation motion.