Aalto University
School of Engineering

COE-C2004 - Materials Science and Engineering

2020-2021 Autumn II

Assignment 2, 08.11.2021

General rules:

1. Learning Group work is encouraged for this course. You could form a group with max one additional peer to review the lecture/exercise content and discuss the tasks in the assignment. After discussion, please finish your assignment independently and submit your individual report. Please note the duplicate report is not accepted!
2. If you have a learning group, please indicate who your group member is in the submitted report. In addition, clearly state the individual contributions of each group member.
3. When required, always show the step-by-step derivation or calculation processes, without which hinting the number does not qualify for grades.
4. When required, always give a brief and concise explanation or description, without which hinting the right choice or answer does not qualify for grades.
5. Citation is necessary if you are using any figures/data that are not generated by yourself.
6. Handwriting/plotting is acceptable, just make sure that your handwriting/final photo in the system is clear enough, otherwise it may affect the grading for details/calculation process.
7. Only PDF type file is accepted for submission, please summarize all your answers/solutions in one PDF file for every assignment. It is appreciated to sort the PDF pages in the TaskNr order, which is helpful to speed up the evaluation process. Please name your assignment files with the assignment number and your first name and surname, and link them with short underlines: 'ANr_Firstname_Surname.pdf', e.g. for the first Assignment 'A1_Wenqi_Liu.pdf'.
8. Please make sure that you have confirmed your submission after uploading your assignments. The draft state will not be accepted.
9. Assignment 1 will take 7 points in the final grade system.

Prof. Dr.-Ing. Junhe Lian junhe.lian@aalto.fi Tel.: +358 50 477 0765
Adv. Manufacturing and Materials | Department of Mechanical Engineering | School of Engineering | Aalto University
Mail address: P.O. Box 14200, FI-00076 Aalto, Finland; Visiting address: Puumiehenkuja 3, 02150 Espoo, Finland

Task 1. Tensile properties (20 points, Lecture3)

1.1 For a bronze alloy, the stress at which plastic deformation begins is 271 MPa and the modulus of elasticity is 150 GPa. (a) What is the maximum load that may be applied to a specimen having a cross-sectional area of 270 mm^2 without plastic deformation? (b) If the original specimen length is 123 mm, what is the maximum length to which it may be stretched without causing plastic deformation? (Please give the detailed calculation process.)

1.2 Consider the brass alloy the stress-strain behavior of which is shown in Figure 1. A cylindrical specimen of this alloy 14 mm in diameter and 173 mm long is to be pulled in tension. Calculate the force necessary to cause a 0.0087 mm reduction in diameter. Assume a value of 0.33 for Poisson's ratio. (Please give the detailed calculation process.)

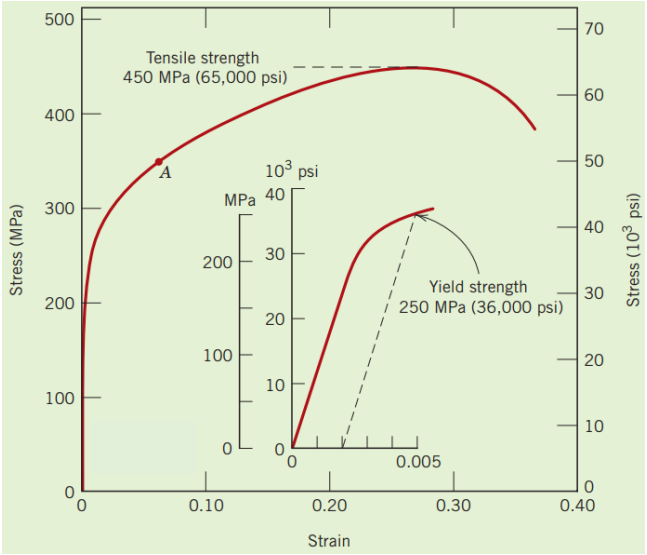

Figure 1 The stress-strain curve of a brass alloy. [1]

1.3 Prove the validity of the following equation for the end of the uniform elongation in tensile tests (Considère-construction): (Give the derivation process)

$$\frac{\mathrm{d}\sigma_T}{\mathrm{d}\varepsilon} = \frac{\sigma_T}{1+\varepsilon}$$

Where $\sigma_T$is the true stress; ε is the engineering strain.

Task 2. Plastic deformation and strength (55 points, Lecture4)

2.1 Name and explain three important possibilities for increasing the strength of pure metals and alloys.

2.2 (a) List, individually, the most possible slip systems in the fcc and bcc metals (Hint: 12 independent slip systems for each structure, ignoring the repeated inverse planes and antipodal directions, e.g. (111) and $(\bar{1}\bar{1}\bar{1})$ are the same plane, only (111) shall be taken into account; [111] and $[\bar{1}\bar{1}\bar{1}]$ are antipodal directions, only take [111] for calculation).

(b) Derive the Schmid law based on the schematic drawing of a single crystal under tensile loading (Figure 2), and define the Schmid factor.

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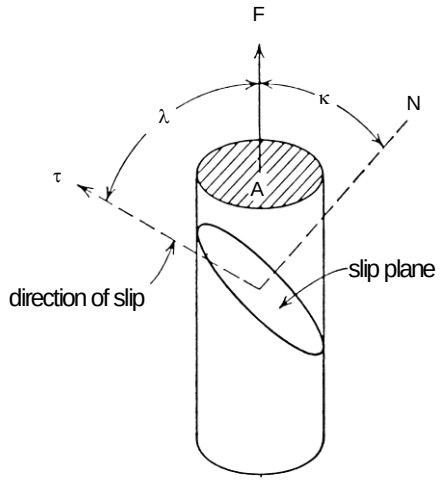

Figure 2 Schematic diagram of Schmid law. [2]

(c) The axis of a tensile specimen of an **fcc** Fe single crystal is parallel to the $[\bar{1}25]$-direction, based on the possible slip systems defined in Task2.2 (a), calculate the Schmid factor for every slip system. (Please give the detailed calculation process for at least one individual slip system.)

(d) In terms of the case in Task2.2 (c), among all these 12 slip systems, which one will be activated first? Why? If the critical resolved shear stress is 2.7 MPa, for plastic deformation, which tensile stress must be applied (in MPa)? (Please give the detailed calculation process.)

Task 3. Representative volume element (25 points, Exercise2)

(a) Explain what the representative volume element (RVE) is.

(b) Generate two RVEs with the following common parameters and different phase fraction values:

	Phase 1	Phase 2		Phase 1	Phase 2
Grain size, mu	3	2		0.3	0.7
Grain size, sigma	0.5	0.5			
Grain shape, alpha	15	5	×		
Grain shape, beta	1.5	30		0.7	0.3
Dimensions	(100, 100, 100)				
Resolution	(2, 2, 2)				
Origin	(0, 0, 0)				

(Hint: Generate RVEs with DREAM3D then plot them with ParaView. Please plot both grain and phase maps for the generated RVEs with legends. You can also use the threshold to display each phase. You can use the EulerAngles or IPFcolors as color coding for better presentation of the grain structure.)

Reference:

[1] W. D. Callister and D. G. Rethwisch, *Materials Science and Engineering: An Introduction, 8th Edition*, Wiley, 2009.

[2] G. Gottstein, *Physical Foundations of Materials Science*, Springer-Verlag Berlin Heidelberg, Berlin, Germany, 2004.

Due date: 18:00, 14.11.2021.

Contact: MyCourses 'General discussion' channel

Q&A: every Tuesday at 16:30-18:00 (via Zoom: https://aalto.zoom.us/j/62428835336).

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